WESTERN HVDC FINAL FUNDING REVIEW

A report to Ofgem

April 2012

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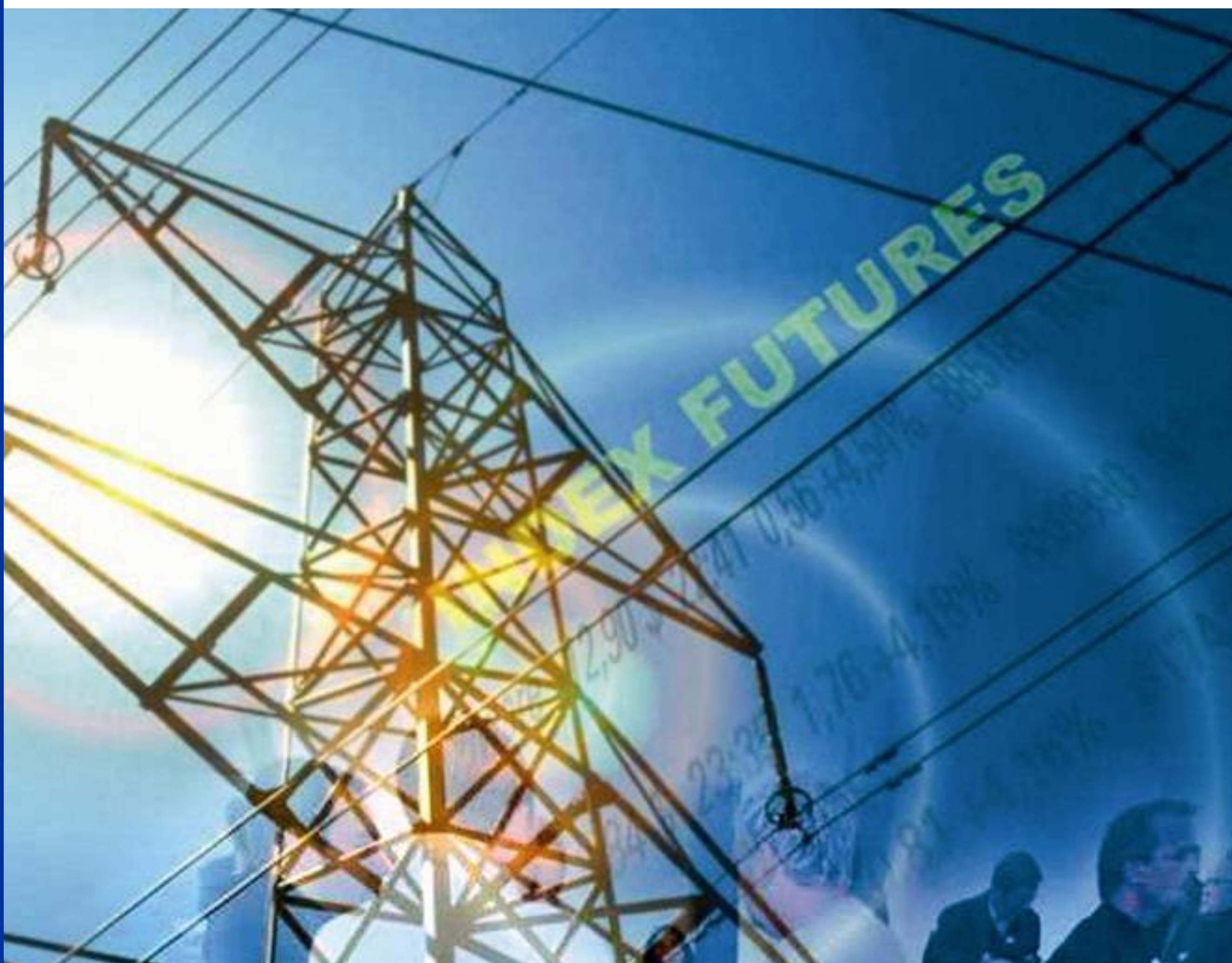
WESTERN HVDC FINAL FUNDING REVIEW



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EXECUTIVE SUMMARY

Introduction

The Western HVDC Link as proposed by NGET and SPT would be an undersea cable, running from Hunterston in Scotland to Deeside in England, providing c.2GW of additional transfer capability across the B6, B7 and B7a boundaries. The project is being funded under the Transmission Investment Incentives (TII) framework.

The project is currently being funded under the Transmission Investment Incentives (TII) framework until the end of March 2013. Thereafter, it will be subject to ongoing funding arrangements under the RIIO-T1 price control.

The objectives of this assessment are to support Ofgem in regard to the following three objectives:

- the final stage of Ofgem's assessment of funding request in relation to construction works on the HVDC component of the Western HVDC Link,
- the determination of appropriate funding provisions under TII and RIIO-T1 including any specific risk sharing arrangements to apply
- establishing unit cost benchmarks for wider application to similar projects under RIIO-T1.

Table 1 lists the specific outputs and deliverables requested by Ofgem, and is reflected in the structure of this report, which addresses each of the 'key outputs' in turn.

Table 1 – Project outputs and associated tasks

Key outputs	Key tasks in delivery of key outputs
1: Summary of final plans of the TOs which are used as the basis for determination of funding arrangements under TII and RIIO-T1	1. Consolidating detailed information on preferred solution / final contract: – final costs (with detailed breakdown by cost item and TO), design (including technical specification) and programme (with key milestones and dates); – treatment of project risks within contract and assumptions underpinning these; and – any additional risk allowances proposed by the TOs for factors not reflected in the contract costs. 2. Consolidating information on key risks from risk register and identifying any outstanding delivery risks with a bearing on the terms of the contract including any cancellation provisions 3. Highlighting key changes in the above since SKM's review
2: Review of final stages of TOs' process towards contract award	4. High level review of the final stages of the TOs' tender evaluation process against the planned process reviewed by SKM, and giving a view on extent to which the planned contracting strategy has been followed. 5. Reviewing the TOs' approach to managing outstanding delivery risks, and giving a view on the appropriateness of how this is reflected in terms of contract award as summarised in item 1.
3: Recommendations on risk sharing arrangements between TOs and consumers under TII and RIIO-T1	6. Assessing the risk profile of the project, identifying any material differences in characteristics compared to works funded under TII to date, and giving a view on implications for risk sharing arrangements under TII and RIIO-T1 7. Developing a risk methodology, using appropriate criteria, for identifying which risks should be: reflected in ex ante allowances; dealt with ex post; or borne by the TOs 8. Applying this risk methodology to key risks, and giving a view on the reasonableness of the costs assigned to those risks in item 1, taking into account expected likelihood and impact and TO methodology for developing risk-normalised costs

Key outputs	Key tasks in delivery of key outputs
4: Recommendations on annual ex ante funding allowances under TII and RIIO-T1	9. Proposing annual ex ante funding allowances for each TO under TII and RIIO-T1, with reference to the final costs identified in item 1 above and any specific adjustments to those costs, e.g. in line with recommendations under item 3 or to take account of overlaps with any existing funding
5: Recommendations on deliverables to be associated with funding allowances under TII and RIIO-T1	10. Proposing annual key project milestones which are consistent with the planned programme 11. Proposing technical output measures which are consistent with the final design and reflect the expected benefits (thermal, voltage and/or stability) across relevant system boundaries on completion of construction works
6: Recommendations on benchmarking of HVDC costs for wider application	12. Consolidating high level information on costs and design of all viable bids/combinations, and applying this and own data sources in proposing unit cost benchmarks at component level (convertor stations, DC cables, harmonic filters etc.), onshore civil work, undersea cable laying and by applied technology (e.g. Voltage Source Converter, Current Source Converter)
7: Identification of any limitations in the recommendations	13. Where applicable, identifying extent to which the depth of the review and resulting recommendations are limited by gaps or delays in provision of relevant information by the TOs

Recommendations

Our final recommendations on the methodology for risk-sharing arrangements are:

- cost allocation ratio of 70% (NGET) and 30% (SPT);
- RIIO-T1 sharing factors to be used for TII period;
- for both NGET and SPT, a sharing factor of 50% to be used, consistent with the treatment of the project as a single entity in the rest of the funding arrangements; and
- P=50 value from the residual risk distribution to be used in the calculation of ex-ante residual risk allowance, given existence of reopener provisions.

Our provisional recommended annual ex-ante allowances for each TO are shown in Table 2 – they reflect our findings for each Output and the data available to us as of the agreed data cut-off point for this report of 14 March 2012.

Table 2 – Provisional recommendations on ex-ante allowances by TO and by cost pot (£m, real 2009/10 money)

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	Total
Contract							
NGET	9.87	67.67	154.06	205.67	169.09	0.00	**606.35**
SPT	4.23	29.00	66.03	88.14	72.47	0.00	**259.87**
[redacted]							
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]							
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

We note (under Output 7) as some data issues remained unresolved at that point, we have described our recommendations on the allowances themselves as provisional. This is because they are based on the information available as of the data cut-off point for this report, and may be updated by Ofgem, in line with the methodology set out above. This will allow Ofgem to take account of updated data available at the final data freeze date (to be set by Ofgem) for determining the final annual ex-ante funding allowances.

We now discuss the supporting evidence for these recommendations.

Output 1

In our view, NGET/SPT overall provided a thorough and well justified explanation of:

- how final contract costs have been arrived at, relative to the August 2011 position;
- how project risks have been passed to the contractor, and the demonstrably positive impact of this on the overall project cost;
- how their understanding of risks not covered by the contract has evolved, with reduction in the 'best view but increase in the 'maximum' assumption driven by cable burial risks.

[redacted]

Output 2

NGET/SPT clearly faced a complex procurement in a constrained market with limited capacity. The procurement process appears to have been followed as designed and it is hard to conceive of an alternative process which would have been any significant improvement.

Overall it is our view that the process has led, ultimately, to an efficient outcome, based on the proviso that the 600 kV solution can be delivered at its full stated rating. Even were this not to be the case ultimately, the value of this as a potential option is such that it can be argued that it was worth the JV taking this path and taking on the technology risk in view of the potential benefits. We therefore consider that the JV took a reasonable and balanced approach to the costs and risks of the solution finally selected.

Our conclusion is that the principles applied to the approach of passing risk to the contractor during negotiations were appropriate, and that the JV have arguably negotiated as effectively as their position permits.

Output 3

Our recommendations on the areas of risk-sharing arrangements highlighted by Ofgem are described above.

Ofgem provided guidance that the capex efficiency incentive sharing factors to apply under RIIO-T1 are determined separately and could potentially differ between the TOs. It is Poyry's view that an alternative solution may better meet the principle to treat the project as whole. Different capex efficiency incentive sharing factors would mean that each TO has a different exposure to risk from this JV, although they do not necessarily differ in their ability to manage the risk faced by the JV. . Therefore, we would support a sharing factor of 50% for this project, in line with the Initial Proposals for SPT for RIIO-T1[1]. This would be consistent with the treatment of the project as a single entity in the rest of the funding arrangements.

The choice of the sharing factor for the Western Link project should not fetter Ofgem's ability to set a different sharing factor for NGET in RIIO-T1 as a whole. We acknowledge that it would not be ideal to have a separate sharing factor for Western HVDC Link as for other projects. However, the regulatory attention on the Western HVDC Link project means that there should be little risk of this distorting behaviour (e.g. through the TO being able to move costs between this project and general RIIO-T1 spend).

Output 4

Our provisional recommended annual ex-ante allowances for each TO are shown in Table 2 – they reflect the findings of the other Outputs of this project, and the data available to us at the data-cut off point for the purposes of this report (14 March 2012). The annual allowances are determined by the total cost figures for each cost category (contract, firm non-contract and ex-ante risk) and the assumed annual profile of each cost category.

We have based our provisional recommended allowances on the most recent appropriate costs provided by the JV before 14 March 2012, the cut-off date for data to be considered in this report. Therefore, these allowances are provisional as they will need to be updated based on the cost and risk position as of the data freeze point to be determined by Ofgem.

The annual profiles for the allowance for the JV in each funding category have been based on data provided by the JV on 16 February 2012 for non-risk costs, and 12 March 2012 for risk costs (although applying to risk totals provided on 18 February 2012).

Output 5

The programme proposed by NGET and SPT ("Western Link Construction Phase High Level Overview", "Project Development Plan update 2011 12 20" and "WHVDC Contract Prog 09032012") has been reviewed and appears reasonable to meet the contract completion date. NGET/SPT have indicated that they will review the project programme if required following the submission of a full planning application for the Kelsterton converter station site in May, following a planning rejection for this site. The following tasks are identified by NGET and SPT as being on the critical path:

- Civil construction of converter station at Hunterston
- Cable and converter station commissioning

We would also recommend that cable type testing, cable manufacture and deep water cable laying activities are included on the critical path.

We have proposed a set of annual project milestones based on the completion date for the link and the proposed programme provided by NGET and SPT, by financial year. These are supported by proposed technical output measures based on the boundary transfer requirements, the contracted link design and requirements of the AC transmission system.

[1] No Initial Proposals for RIIO-T1 are available for NGET as they are not going through the fast-track process.

Output 6

We have benchmarked unit costs at component level and for the overall project. Comparing costs across projects can be challenging (for example, the applicability of the cable materials unit cost will be influenced to an extent by the volatility of the price of copper and steel etc.), but we do provide a comparison of project costs for recent subsea transmission projects using HVDC LCC technology in Table 3, based on publically available information.

Table 3 – HVDC LCC Offshore Transmission Projects - Examples

Project Name	Capacity (GW)	Offshore Cable Length (km)	HVDC Cable Contract	HVDC Converter Contract	Contract Price Base	Total Cost	Year of Completion
Cometa bipole	0.4	250	€267m	€100m	07/08	€375m†	Est. 2012
Sapei bipole	1	420	€400m	US$180m	06/07	€750m‡	2011
Britned bipole	1	244	US$350m	€220m	07/08	€600m‡	2011
Fenno-Skan 2*	0.8	200	€150m	US$170m	08/09	€315m‡	2011
WHVDC Link bipole	2.25	386	[redacted]	[redacted]	11/12	[redacted]‡	Est. 2015

† Total contract price (in 2007/08 price base)
‡ Total outturn price (forecast outturn for WHVDC Link in 2009/10 price base)
* single cable

This provides a useful comparison to costs for the Western HVDC Link although there will be a dependence on seabed conditions and cable metal costs. For example, both COMETA and SAPEI involved subsea cable laying at water depths greater than 1000m. Also, the transmission links are less than half the capacity of the Western HVDC Link. The cable contract price also includes a small proportion of onshore cable costs.

Output 7

Whilst we have endeavoured to ensure we capture all relevant information and data required to provide Ofgem with a comprehensive and robust assessment covering all aspects of this work; in the timeframes for this project we were reliant on the nature of cooperation and information provision provided by the relevant TOs (NGET and SPT). We proactively worked with Ofgem and NGET/SPT to address any gaps identified.

By the time of the 14 March cut-off date the outstanding information gap and the impact it had on our assessment and resulting recommendations for the relevant affected Outputs can be summarised follows:

- We had not received requested set of self-consistent risk profile information based on updated/best knowledge as of early March, including accounting for Kelsterton and Hunterston planning application decisions.
- Consequently our assessment of the contracting position is based on the complete self-consistent set of information and data provided on 18 February 2012.
- Our recommendations for ex-ante funding allowances in Section 5 are also undertaken on this basis but also including a further adjustment that we have made to

correct an apparent error in the calculation of employer risk for cable burial, which we believe should be £2m lower.

- Our understanding is that the materiality of difference between risk related costs as presented 18 February 2012 versus that which might be expected as at March 2012 in the light of updated information will be very low. Specifically it suggests <£2m in absolute magnitude as measured at the P=50 point on the risk related cost distribution. This is <0.2% of overall cost of delivery of HVDC component of WHVDC link costs material provided; and barely measurable in the context of combined SPT and NGET RIIO-T1 capex programmes.

Thus we believe this information “gap” and our use of information as at 18 February does not have any impact on our assessment of the procurement process (Output 2), determination of funding approach (Output 3), assessment of milestones (Output 5) or benchmarking of costs (Output 6).

As indicated above we also believe it does not have a material impact on our assessment of costs (Output 2), our recommendations on the methodology to be adopted for determining funding and risk sharing arrangements (Output 3) or the (provisional) ex ante funding allowances derived from application of that methodology to the data available as of 14 March 2012 (Output 4)especially if viewed from the perspective of setting an annual funding profile for each of the two TOs within the WHVDC link joint venture across the full project timeframe. Consequently we believe our recommendations within this report including those for annual funding are robust to a reasonable level of accuracy, with the following conditions:

- If Ofgem wishes to pursue accuracy to the £10k level (or tighter) of risk-related costs at the P=50 point in ex-ante setting of agreed funding arrangements for the WHVDC link it will need to make minor adjustments to our provisional recommendations for annual funding figures.
- Also we are aware the contract NGET/SPT have put in place had a limited number of variable elements due to be locked down in early March; and it may be possible these change the contract cost from that we have used based on 18 February information and that Ofgem may need to adjust accordingly in determining final funding allowances[2].
- Where Ofgem chooses to apply a determination based on an updated set of information/data on final contract cost and view of risk-related costs we advise this is done based on a designated data freeze date; and any subsequent variations are captured by the agreed risk sharing mechanism (and if required) relevant reopener conditions.

[2] We note that on 9 March 2012, the JV provided an updated view of contract costs (but not of non-contract costs and thus not a coherent data set for basing our recommended allowances on), and these were subject to further change.

1. INTRODUCTION

1.1 Overview of the Review

The Western HVDC Link as proposed by NGET and SPT would be an undersea cable, running from Hunterston in Scotland to Deeside in England, providing c.2GW of additional transfer capability across the B6, B7 and B7a boundaries. The project is currently being funded under the Transmission Investment Incentives (TII) framework until the end of March 2013. Thereafter, it will be subject to ongoing funding arrangements under the RIIO-T1 price control.

The purpose of this assessment is to support Ofgem in regard to the delivering following three objectives:

- the final stage of Ofgem's assessment of funding request in relation to construction works on the HVDC component of the Western HVDC Link,
- the determination of appropriate funding provisions under TII and RIIO-T1 including any specific risk sharing arrangements to apply
- establishing unit cost benchmarks for wider application to similar projects under RIIO-T1.

1.1.1 Overview of the Western HVDC link project

The Western HVDC link project comprises three components:

- an HVDC cable, of capacity circa 2GW and about 400km in length, together with converter stations at each end;
- onshore works around the northern connection point, near Hunterston 400kV substation in SPT's transmission area, and
- onshore works around the southern connection point, near Deeside 400kV substation in NGET's transmission area.

However it is the intention of this project to focus on the aspect of the project highlighted in the first bullet highlighted above, namely the Western HVDC cable and convertors, subsequently referred to as "the HVDC component" of the overall Western HVDC link scheme.

1.1.2 Overview of the TII framework

In April 2010, Ofgem introduced the TII framework for providing interim funding , within the current transmission price control period (TPCR4, running to the end of 2011-12), for critical large-scale investments that the Transmission Owners (TOs) identify are required to support achievement of the Government's 2020 renewable energy targets. TII funding is provided on a capex basis via ex ante allowances specified for each year which are linked to defined deliverables.

The TII framework has been extended into 2012-13 under the one year adapted rollover of TPCR4. For all projects considered under TII, funding arrangements beyond March 2013 will be addressed as part of work on the next full transmission price control review, RIIO-T1.

1.1.2.1 Funding requests and previous consultancy reviews

The large-scale investments put forward for funding consideration under TII typically take the form of an overall project comprising a number of discrete components being developed over different timescales which, when taken together, are designed to achieve an overall aim of increasing transmission boundary capability in a given part of the network in response to anticipated future demands from network users.

In line with the “funding in stages” approach adopted under TII, the Transmission Owners (TOs) can submit TII funding requests for individual components of works they expect to take forward within the next year. Ofgem assesses such requests against criteria including the need for those works to proceed in the identified timescales and the readiness of the TOs to take forward those works. The funding decision is also subject to receipt of sufficient information from the TOs for Ofgem to determine appropriate ex ante funding allowances and deliverables with reference to the specific plans of the TOs over the period of TII funding.

Previous consultancy reviews under TII of the Western HVDC Link project[3,4,5] have considered the overall project (the Western HVDC Link) and the discrete components (the HVDC component, the associated onshore substation works at Deeside/Connah’s Quay, and the associated onshore substation works at Hunterston East).

This review focuses on the HVDC component in particular. Following previous consultancy reviews of the HVDC component of the project, in its August 2011 consultation[6] Ofgem had concluded that there was a case for proceeding with this component in line with the TOs’ planned programme towards delivery of the link in 2015. As such, for the purposes of this review, Ofgem did not require further assessment against the criteria adopted in previous consultancy reviews under TII. Rather, Ofgem required specific support relevant to the determination of the specifics of funding, i.e. the cost allowances to apply in each year for each TO and deliverables associated with those allowances, and the risk sharing arrangements to apply between the TOs and consumers.

1.1.2.2 Specific issues in relation to projects with materially different characteristics

A key point to note for this review is that the TII framework, as applied to all works funded under TII to date, reflects the treatment of capex in the prevailing price control, including the capex efficiency incentive, on the basis that their characteristics are similar. However, Ofgem has retained flexibility to vary the TII framework when funding projects of materially different characteristics to those funded to date.

For example, depending on the risk profile, and how this is reflected in the TOs’ cost submission, this may involve varying the risk sharing arrangements by:

- applying different level of incentivisation (the efficiency incentive rate, 25% under the price control arrangements that currently apply) in the capex efficiency incentive,

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3 http://www.ofgem.gov.uk/Networks/Trans/ElecTransPolicy/CriticalInvestments/InvestmentIncentives/Documents1/KEMA%20Final%20Report.pdf

4 http://www.ofgem.gov.uk/Networks/Trans/ElecTransPolicy/CriticalInvestments/InvestmentIncentives/Documents1/WesternHVDCLinkSKMStage1ReviewReportmFinalPublic.pdf

5, http://www.ofgem.gov.uk/Networks/Trans/ElecTransPolicy/CriticalInvestments/InvestmentIncentives/Documents1/SKM_Stage2_Public.pdf

6 Transmission Investment Incentives: consultation on minded-to position for Western HVDC link (“Western Bootstrap”), 1 Aug’11:

http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=10&refer=Networks/Trans/ElecTransPolicy/CriticalInvestments/InvestmentIncentives

- excluding or adjusting for certain risks when setting ex ante allowances,
- and/or introducing specific adjusting event provisions to deal with certain risks ex post.

With this in mind, Ofgem have indicated in their November 2011 update document[7] that the specific characteristics of the Western HVDC Link (and the HVDC component in particular) meant that it could be appropriate to adopt a different treatment to that used for works funded under TII to date.

Therefore the particular focus of this review is on the specific risk characteristics of the HVDC component. This issue is also relevant to consideration of ongoing funding arrangements in RIIO-T1.

1.2 Overview of requirements

As noted above, following previous consultancy reviews of the HVDC component of the Western HVDC Link project, Ofgem had concluded that there is a case for proceeding with this component in line with the TOs' planned programme towards delivery of the link in 2015.

Ofgem's November 2011 update[6] confirmed that, taking into account progress of the project and findings of a further consultancy review (SKM Stage 25), Ofgem had maintained its minded-to position, while also reaching a positive conclusion on the case for delivery in 2015. It also stated that the minded-to position remained subject to no material escalation of expected costs and that the remaining aspects of Ofgem's project assessment would require further review as the TOs firm up their plans, and this would be an input to consideration of the specifics of funding with reference to those plans.

This review therefore seeks to inform Ofgem's ongoing work to determine the specifics of funding both under TII and RIIO-T1. Thus, it provides specific assessment relevant to the determination of the details of funding, i.e. the cost allowances to apply in each year for each TO and deliverables associated with those allowances, and the risk sharing arrangements to apply between the TOs and consumers. This will take into account the contractual arrangements put in place for the delivery of the project – namely that NGET and SPT have set up a joint venture (JV) which signed one contract with a consortium of Prysmian and Siemens to deliver a 600kV/2.25GW HVDC link. This followed four rounds of design iterations, negotiations and bid re-submissions.

A key aspect of this review is on the specific risk characteristics of the HVDC component to understand whether it is appropriate to use the same treatment of capex as under the prevailing price control, as has been done for the award of funding for all projects to date under the TII framework.

In addition, the TII framework will be superseded on 1 April 2013 by the arrangements for wider works under RIIO-T1. Therefore, this review also provides information to inform Ofgem's decisions on appropriate funding arrangements for the Western HVDC link under both frameworks, in terms of the risk sharing arrangements to apply under each frameworks and the annual ex ante funding allowances and associated deliverables.

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7 "Transmission Investment Incentives: update on Western HVDC link ("Western Bootstrap"), 10 Nov'11: http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=20&refer=Networks/Trans/ElecTransPolicy/CriticalInvestments/InvestmentIncentives

Under RIIO-T1 funding allowances will be specified on a totex basis[8] and linked to deliverables and the same risk sharing arrangements, including efficiency incentive rate and uncertainty mechanisms, are expected to be used for all capex including that funded under the arrangements for wider works.

Therefore specific points for the RIIO-T1 assessment that are additional to the TII assessment are also addressed - including recommendations relating to the costs and deliverables for the RIIO-T1 years, and about unit cost benchmarks for use in future assessments of similar projects under RIIO-T1.

1.3 Project deliverables and associated tasks

Our proposed project approach and associated tasks are presented in Table 4 below (sourced from the Ofgem ITT for this review).

We have used this approach as the structure for this report, addressing each of the 'key outputs' in turn.

Table 4 – Project outputs and associated tasks

Key outputs	Key tasks in delivery of key outputs
1: Summary of final plans of the TOs which are used as the basis for determination of funding arrangements under TII and RIIO-T1	1. Consolidating detailed information on preferred solution / final contract: – final costs (with detailed breakdown by cost item and TO), design (including technical specification) and programme (with key milestones and dates); – treatment of project risks within contract and assumptions underpinning these; and – any additional risk allowances proposed by the TOs for factors not reflected in the contract costs. 2. Consolidating information on key risks from risk register and identifying any outstanding delivery risks with a bearing on the terms of the contract including any cancellation provisions 3. Highlighting key changes in the above since SKM's review
2: Review of final stages of TOs' process towards contract award	4. High level review of the final stages of the TOs' tender evaluation process against the planned process reviewed by SKM, and giving a view on extent to which the planned contracting strategy has been followed. 5. Reviewing the TOs' approach to managing outstanding delivery risks, and giving a view on the appropriateness of how this is reflected in terms of contract award as summarised in item 1.
3: Recommendations on risk sharing arrangements between TOs and consumers under TII and RIIO-T1	6. Assessing the risk profile of the project, identifying any material differences in characteristics compared to works funded under TII to date, and giving a view on implications for risk sharing arrangements under TII and RIIO-T1 7. Developing a risk methodology, using appropriate criteria, for identifying which risks should be: reflected in ex ante allowances; dealt with ex post; or borne by the TOs 8. Applying this risk methodology to key risks, and giving a view on the reasonableness of the costs assigned to those risks in item 1, taking into account expected likelihood and impact and TO methodology for developing risk-normalised costs*
4: Recommendations on annual ex ante funding allowances under TII and RIIO-T1	9. Proposing annual ex ante funding allowances for each TO under TII and RIIO-T1, with reference to the final costs identified in item 1 above and any specific adjustments to those costs, e.g. in line with recommendations under item 3 or to take account of overlaps with any existing funding
5: Recommendations	10. Proposing annual key project milestones which are consistent with the

[8] In practice, for the HVDC component of the Western Link Project, all spending would be counted as capex, and therefore, totex and capex allowances are equivalent.

Key outputs	Key tasks in delivery of key outputs
on deliverables to be associated with funding allowances under TII and RIIO-T1	planned programme 11. Proposing technical output measures which are consistent with the final design and reflect the expected benefits (thermal, voltage and/or stability) across relevant system boundaries on completion of construction works
6: Recommendations on benchmarking of HVDC costs for wider application	12. Consolidating high level information on costs and design of all viable bids/combinations, and applying this and own data sources in proposing unit cost benchmarks at component level (convertor stations, DC cables, harmonic filters etc.), onshore civil work, undersea cable laying and by applied technology (e.g. Voltage Source Converter, Current Source Converter)
7: Identification of any limitations in the recommendations	13. Where applicable, identifying extent to which the depth of the review and resulting recommendations are limited by gaps or delays in provision of relevant information by the TOs

* See Section 1.3.1 below

1.3.1 Additional Ofgem Guidance

Subsequent clarifications from Ofgem provided guidance that recommendations should be made on the following basis (and hence compatible with RIIO-T1 policy and Ofgem's Initial RIIO-T1 Proposals for SPT):

- for both TOs the re-openers applicable to this project are as set out in the Initial Proposals for SPT under RIIO-T1;
- SPT's capex efficiency incentive sharing factor for the HVDC component of the Western Link HVDC project should be the same as for other SPT projects, e.g. as set out in SPT's Initial Proposals under RIIO-T1;
- NGET's capex efficiency incentive sharing factor for the HVDC component of the Western Link HVDC project should be the same as for other NGET projects, with no initial proposals for this sharing factor under RIIO-T1 currently available as NGET is not going through the fast-track process.; and
- the Western Link HVDC project will be treated as a whole both ex ante and ex post, with pre-defined cost allocation ratios between the two TOs.

Ofgem noted that where Pöyry wanted to propose a different approach (e.g. on having different ratios for different component), there should be a discussion of the pros and cons of this approach versus the default position.

1.3.2 Sources

Unless otherwise attributed the source for all tables, figures and charts is Pöyry Management Consulting.

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2. OUTPUT 1 – SUMMARY OF FINAL PLANS

2.1 Overview of approach

This chapter provides a summary assessment of the final plans of the TOs which are used as the basis for determination of funding arrangements under TII and RIIO-T1. In this chapter we present:

- final costs (with detailed breakdown by cost item and TO), design (including technical specification) and programme (with key milestones and dates);
- treatment of project risks within contract, with underpinning assumptions;
- any additional risk allowances proposed by the TOs for factors not reflected in the contract costs;
- consolidating information on key risks from risk register and identifying any outstanding delivery risks with a bearing on the terms of the contract including any cancellation provisions; and
- highlighting key changes in the above since SKM's Stage 2 review[9].

SKM previously identified several key project risks in their Stage 2 report, notably: (i) cable supply and manufacture availability; and (ii) issues relating to consents and land purchase. This review addresses the extent to which NGET/SPT have managed to mitigate these risks, and explores the whole range of project risks more widely.

In addition, having reached this stage of the procurement process, we have reviewed the risk register in a more quantitative manner than was possible in previous stages, and assessed whether the specific risk items and their magnitudes are appropriate at this stage of the project.

2.2 Consolidation of details of final contract and non-contract costs:

The preferred contract option selected by NGET/SPT was the combined Prysmian/Siemens submission for a 600kV/2.25GW HVDC link, following four rounds of design iterations, negotiations and bid re-submissions. The proposed link has an overall length of 420km connecting convertor stations located in North Ayrshire (South-East Scotland) and Flintshire (North Wales) utilising 600kV Mass Impregnated Polypropylene Laminate (PPL) paper insulated cable, with a nominal rating of 2.25GW with a 6 hour overload capacity of 2.4GW – the first of its kind.

2.2.1 Final costs – High level breakdown of contract costs

Table 5 provides (as presented at the National Grid workshop on 01 February 2012) a high level breakdown of the cost submission for this project. The table compares data based on a January 2012 position to the previous submission on this project to Ofgem in August 2011. The risk cost category is based on a P=80 value from the risk distribution.

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9 http://www.ofgem.gov.uk/Networks/Trans/ElecTransPolicy/CriticalInvestments/InvestmentIncentives/Documents1/SKM_Stage2_Public.pdf

Table 5 – Overview of project cost (£m, real 2009/10 prices)

Project Costs Category (09/10 prices) – (£m)	2.25GW Option (August 2011)	2.25GW Option (January 12)
Cable & Convertor Contracted*	[redacted]	866
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
Total	1094	1072

[redacted]

We note that the JV supplemented this with further information on 16 February 2012 which included an annual profile and cost breakdown between NGET and SPT for various cost categories. The total project cost of [redacted] and total risk cost of [redacted] (P=80) were equal to the figures presented in Table 5 for the January 2012 data. However the remaining items were categorised differently compared to the Janaury 2012 data and this had to be taken into account when comparing the data from 16 February with previous iterations. Further, on 18 February the JV provided updated risk analysis based on updated input assumptions in response to Poyry questions (giving [redacted] at P=80 and [redacted] at P=50) . For the purposes of our recommendations set out in Output 4 we have adjusted these figures downwards by £2m to correct an error. This is discussed in more detail below and in Output 4.

The specific project costs for the Prysmian/Siemens bid are summarised in Table 6 below. The dominant cost item is the prime contract, the majority of which relates to the procurement and manufacture of plant (further detailed in Table 8).

[redacted]

At the start of the tender evaluation process, NGET/SPT stated that because of the relatively broad way the project scope had been designed they needed to undertake a 'levelling' analysis to ensure all bidders were compared on the same basis. This means that, for example, if one tenderer is priced in a specific risk and another left this risk to the employer, the second tenderer would have their offer adjusted by an amount judged by NGET/SPT to be their cost of mitigation, so that both were compared on the same basis.

In order to understand how NGET/SPT had approached this 'levelling' analysis, we tracked the evolution of the ultimately winning bid from initial offer (the initial tender returns in May 2011) to the final offer at standstill (in January 2012) of £866m (£1,012m in nominal prices).

NGET/SPT stated that as a result of these negotiations the contractors agreed to take on greater risk, which is reflected with an increment in the main contract price but, they argue, has in effect lowered the overall cost by decreasing the size of the anticipated risk allowance required.

As this is a turnkey contract the contractor was not obliged to provide cost breakdown information in any level of detail below this, therefore they had some flexibility to move margins between activity areas. Nevertheless some clear messages emerge overall, and the movements in the contract costs are driven by a combination of the following main factors:

- Contractor sharing weather risk – The contractor has agreed to take responsibility for up to 60 days of weather-related delays. For weather related delays between 60 and 120 days the costs are shared between contractor and employer. Beyond 120 days NGET/SPT are financially responsible in entirety.
- Results of geophysical and geotechnical surveys – The cable route has evolved following numerous surveys to avoid difficult ground conditions as far as reasonably possible. The final route corridor has subsequently improved but some potentially difficult areas remain. NGET/SPT identified 160km of potentially difficult terrain and agreed that the contractor will allow for 25km of rock dumping and trenching. There was some confusion about this figure in their modelling of residual risk which is discussed in Section 2.3 below.
- Type registration – NGET/SPT have proposed a period of sea trials shortly after manufacturing of the deep-sea cable has commenced. Should the cable not satisfy these tests i.e if the contractor delivers a link that is above 1.8 GW but below 2.25GW/600kV then the JV may accept the link and recover liquidated damages for the reduced performance.
- Commodity price changes – specifically a decrease in metal prices since initial offer.
- Identification of new/missing risks from original bid.
- Insurance – NGET/SPT insurance costs have decreased as substantial risks passed to contractor. We did query whether there was any overlap between risks covered by the insurance and other items in the risk model and was told verbally that there were not, as insurance covers general liabilities etc., which are not project risks as such.

2.2.2 Final Costs – Breakdown of other Costs

Aside from the main contract costs, a number of other individual cost items have also been identified. ('non-contract costs') outside of the risk modelling. The movement in these figures between the August 2011 position and the January 2012 position is shown in Table 7. No revised breakdown was provided by NGET/SPT for the February figures and so a breakdown cannot be presented for the latest cost figures.

[redacted]

Key issues to note are as follows:

- The Kelsterton land purchase figure had been double counted, with a figure of [redacted] for this item also remained in the risk/contingency calculation. NGET/SPT have adjusted their risk model to remove this double-count.
- [redacted]
- The non-contract project management budget has risen from [redacted] to [redacted], apparently due to a revised view by NGET/SPT as to the level of internal resource required.
- A new line item has been added for New Technology Development – this is an allowance for further testing of the 600 kV solution; notably further work on the voltage control scheme, tests on the impact of the cable cooling cycle on joints and terminations, increased levels of witness testing and quality assurance. This issue was not raised in the August 2011 submission and NGT/SPT admitted that this was effectively an oversight, in that the project team subsequently identified this as being

necessary for the 600 kV option. This set of activities is distinct from the type testing which would have to be carried out in any case.

2.2.3 *Final Costs – Split by TO*

At the workshop on 9 February 2012 the TOs presented us and Ofgem with a breakdown of the costs (split by TO). Clarification was sought as to how this split was derived and the following explanation was provided on 16 February 2012.

"Whilst the EPC Contract costs are relatively high level, they are sufficiently defined to allow a split of costs between the Stakeholders. For those costs that have not been defined in the required level of detail we are able to apply logical assumptions and methodology into the evaluation of the costs to provide a fair and reasonable estimation of the split between the Stakeholders".:

EPC Contract

"The Contractor has provided a detailed cashflow split into the generic tender milestones provided in the Invitation to Tender. These costs have been split notionally into either SPT or NGET costs for the purpose of allocation. Most costs were easily identifiable as occurring either at Hunterston or Kelsterton/Wirral (i.e. Converter, land cables) and could be fully apportioned in this manner, however certain costs were either occurring across boundaries (i.e. some marine campaigns, marine surveys, etc) or were generic cross project costs (Management costs, advance payment, etc.)"

The process for calculating the splits was therefore as follows:

- 100% attributable milestones were first allocated to either SPT or NGET.
- For cable laying activities milestones split between stakeholders were split on a pro-rata basis based upon length of cable under SPT and NGET control. This made no allowance whatsoever for particular site conditions/anomalies encountered in this area (i.e. Campaign 2 splits into 96km cable/48km route (86%) for SPT and 16km cable/8km route (14%) for NGET. Where costs relate generically to Converter Stations (i.e. Converter commissioning costs) a pro-rata split in line with capex costs was adopted.

At this stage totals were taken for each stakeholder and a percentage split was calculated. The figures arrived at were 67.6% for NGET and 32.4% for SPT.

- Finally, all other milestone costs not able to be split in this manner (i.e. Project Management) were allocated on a 67.6%/32.4% split.

Project Fixed Costs

Other Project costs were considered in isolation and split logically between the stakeholders wherever possible. If a split was not easily derived then the 67.6%/32.4% split was adopted. Specific splits used in the calculation were as follows:

- *Provisional sums – were clearly identifiable as being either for works at Hunterston or Kelsterton and were split accurately.*
- *Asbestos Removal – was for works at Kelsterton converter station site only and was fully allocated as such.*
- *Insurance costs – were split on a 67.6%/32.4% basis.*
- *Bonds – were split on a 67.6%/32.4% basis.*

- *Project costs – were split on a 67.6%/32.4% basis.*
- *New Technology Development – were split on a 67.6%/32.4% basis.*
- *Land purchase Kelsterton and Hunterston – Costs allocated to the appropriate Shareholder.*
- *Sea bed & crown estate leases – costs split on accordance with ratios of total cable (i.e. 76.67% NGET and 23.33% SPT).*

Risk Costs

Due to the nature of the simulation it is not possible to split risk outputs into each and every risk on the register as the output is a function of the many inputs. In addition it is not correct to simulate each and every input and add together. As a result a three stage operation was utilised to calculate the risk allocation.

- The entire cost register is run through the simulator to get a risk allowance at P=80.
- Risks were split between SPT and NGET and then 2 further simulations were run in isolation in order to get a percentage split between the Shareholders. In this case the split was 73%/27%. It should be noted that the sum of the individual P=80's is extremely unlikely to be equal to the earlier combined simulations but can be used for apportioning a risk pot.
- The combined simulation is multiplied by the Stakeholders percentages to get a risk sum for both SPT and NGET."

In order to assess whether this appeared reasonable an attempt was made to replicate this split using the 'nominal' costs presented by NGET/SPT in their budget breakdown.

It was our view that broadly the assumptions seemed reasonable, notably that:

- converter stations and associated costs, along with onshore cabling, would form part of the costs of the respective TO responsible;
- remaining cable costs would be split in proportion to the length of route lying in Scots/other waters;
  - combining these gives the ratio of prime costs per TO.
- other generic overheads would be likely to be split by the same proportion; and
- risks might be expected to split slightly differently, as the greater magnitude of risk lies with offshore cable related issues, and NGET has the greater proportion of the cable route.

NGET/SPT provided a table summarising the split of costs on the basis of the above, but there were some inconsistencies with the project fixed costs relative to other information provided. We therefore attempted to reconstruct this calculation using NGET/SPT's January 2012 standstill position as the starting point. Table 9 summarises the basis of our calculation of the split of contract costs, based on the final budget breakdown for the Best and Final Offer. The final budget breakdown is based on the movement in detailed procurement and construction costs described in Table 8, which was provided by NGET/SPT, and provides a breakdown of two of the cost categories shown in Table 6.

[redacted]

NGET/SPT have not directly provided data on the TO share of the submarine cable (the greatest single element of cost). However, NGET/SPT advised us during discussions about the split of costs, that they had split cable laying costs approximately 75%/25% between NGET/SPT. We have examined the information contained in the above tables to estimate the TO share of the submarine cable in Table 10 (based on the overall cost for submarine cable shown in Table 9).

The TO share of the contract element, in real 2009/10 prices, has been used to estimate the TO share in nominal prices by applying the same percentage split. The nominal values set out in Table 8 have been compared to the contracted costs and explained in Table 9, where the procurement and installation of the submarine cable itself is calculated to cost a total of [redacted]. NGET's share of the submarine cable can be deduced by subtracting the defined costs associated to NGET from the NGET share of the contract element, as illustrated in Table 10. Note that the data for Table 9 and Table 10 was provided by NGET/SPT in nominal prices.

[redacted]

[redacted]

The above calculations assume the same percentage split in 2009/10 prices and in nominal prices. Alternatively, using the approximate percentage suggested in discussions with NGET/SPT, the [redacted] of cable laying costs in this proportion gives the following overall split:

[redacted]

This gives a split approximately 67% to NGET and 33% to SPT.

In conclusion, the approach to splitting the contract costs is clear with NGET accounting for 75% of the submarine cable. The largest item of project fixed costs is project management, the remainder being comprised of the new technology development costs, plus a number of things such as land purchase which relate to specific converter station sites – we have therefore assumed that the NGET/SPT as JV partners have arrived at a split between them which they consider to be equitable. The split of risks was derived from the Monte Carlo model so it is not possible to replicate this exactly without re-running the model.

2.2.4 Design (including technical specification)

The proposed link has an overall length of 420km (386km offshore) connecting convertor stations located in North Ayrshire (Kelsterton) and Flintshire (Hunterston) utilising 2 x 2400mm^2 Mass Impregnated Polypropylene Laminate (PPL) paper insulated cables, designed to operate at 600kV with a nominal rating of 2.25GW with a 6 hour overload capacity of 2.4GW.

In many respects the design is similar to other HVDC schemes of this scale; the key innovations are the cable composition using PPL insulation, and the operation at 600 kV. The latter requires that the HVDC system has a voltage control system when de-loading the circuits from high levels of loading, in order to manage the electrical stresses on the insulation.

The cable will be first-of-a-kind in terms of the voltage it will be operated at (600kV). One impact of this includes the additional budget item for testing over and above normal type testing, another impact is the risk that if serious issues are brought to light during testing, the cable may need to be derated to some level between 600 and 500kV if type testing at 600kV is not successful.

The design may change if type testing at 600kV is not successful, to the lower rated voltage (500kV) which would also reduce the capacity to c.1.875GW. The cost impact of a lower rated capacity is borne by the manufacturer (as described below) as additional costs for reinforcement elsewhere in the system may be required in this case.

We asked NGET/SPT the impact such a situation would have commercially and contractually and NGET stated (on behalf of the JV) that:

"If the contractor does not deliver to specification and the link has a rating of less than 1.8 GW then the employer may ultimately terminate the Contract and reject the link if it so wishes and get his monies and certain costs refunded, subject to any relevant caps on liability.

If the contractor delivers a link that is above 1.8 GW but below 2.25GW/600kV then the Employer may accept the link and recover liquidated damages for the reduced performance or may ultimately terminate the Contract following a prolonged delay to completion for Contractor default and appoint a third party contractor to complete the Works.

In practice this commercial pressure is most likely to result in the payment of performance liquidated damages where the rating is above 1.8 GW or, where the rating is below 1.8 GW a negotiated settlement i.e. a reduced payment for the link if you assume the resulting system still has value to all parties including crucially consumers. If the system has no value or a value could not be agreed then rejection without payment is the ultimate sanction."

Other design issues still to be finalised include:

- filter design at the converter stations – this is because design would be optimised for the system configuration prevalent when the link is installed, which may change between now and 2014;

- exact circuit length, particularly if a new converter station site is chosen; and
- some localised design issues about converter station auxiliary supplies etc., and issues related to consenting (e.g. the physical appearance of buildings etc.).

Cost impacts for the first two issues are included as 'design' risks in the risk model; other consenting related issues are also included under the classification of 'consent' risks.

A summary of the project design costs is shown below in Table 11 – these costs were shown under a single category heading in Table 6.

[redacted]

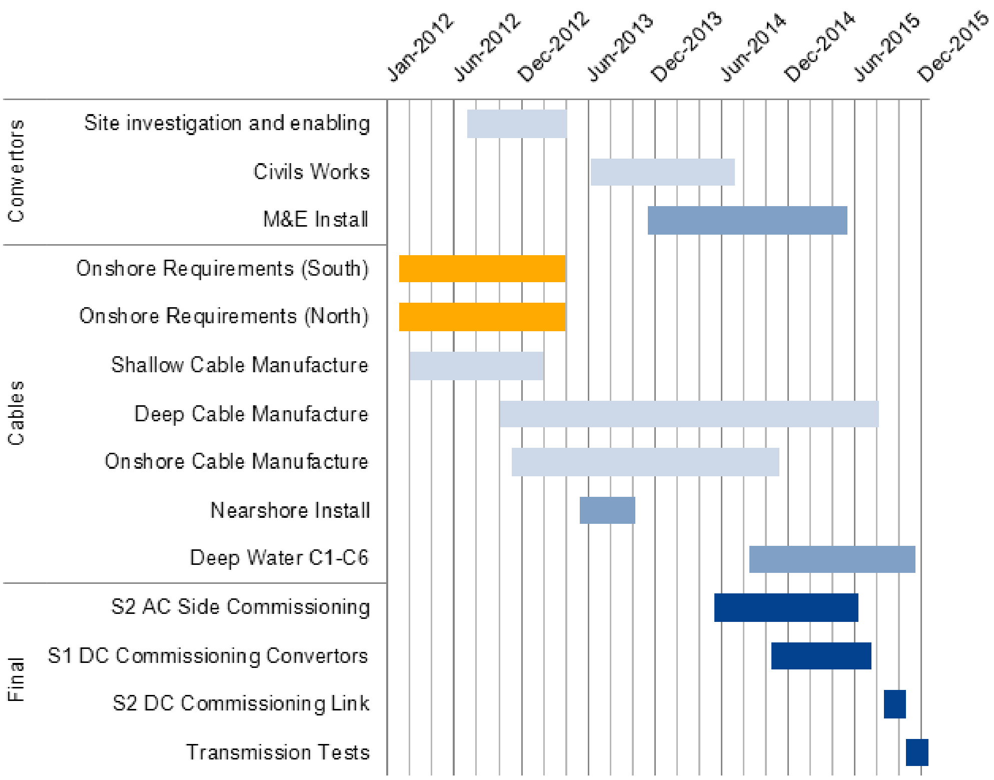
From a technical perspective, there are no restrictions preventing pairing the 600kV operation of the PPL cable with a convertor available from other manufacturers included in the tender process. However, as this 600kV option was not submitted standalone in Lot 2, NGET/SPT were contractually unable to split the Lot 3 bid. NGET/SPT did invite Lot 2 bidders to submit higher voltage operation but they declined – this issue is explained in more detail in Chapter 3.

The new PPL cable technology would be the first of its kind by operating at 600kV and will subsequently require operational verification of the cable, joints and terminations for which NGET/SPT have allocated approximately 9 months of Type Registration, starting September 2012. As this is the first HVDC link to be built by NGET/SPT as a TO (and such cable systems are bespoke and therefore a 'first of a kind' anyway) we assume that type registration would take a similar timescale regardless of whether the 600 kV or 500 kV solution were chosen. Through discussions NGET/SPT were confident that should the Type Registration of 600kV prove unsatisfactory the fall-back plan of operating nearer 500kV would be implemented. The management of this new technology risk is discussed in Section 2.3.

2.2.5 *Programme (with key milestones and dates)*

The critical path and principal deliverables of the project are summarised in Figure 1.

Figure 1 – Key programme areas (approximate timings)



Based on our analysis we highlighted three key issues with the programme:

- Firstly, it has become apparent that the most significant areas of project risk (by value) relate to the offshore cable installation (weather and seabed burial risks). This would therefore tend to load the bulk of the risk into the latter part of the programme.
- Secondly, the commissioning process relies on hitting a specific time window. Commissioning the link fully requires testing the link under some relatively extreme system conditions, and National Grid SO have stated to the project that this will only be likely to be possible in periods when other plant is not out for summer maintenance outages, and when the load on the system is not too great – i.e. either in Autumn before the clocks change or in the subsequent spring. A delay, therefore, of two months at the end of the project may result in an effective 6 month delay to full commissioning. Whilst the NGET/SPT project team have costed the impact on them (in terms of contractor downtime) they have not quantified the (indirect) cost of system constraints, as these lie with the SO. These issues are on the critical path regardless as the constraint on commencing the cable laying, and hence the commissioning, is the time to manufacture the offshore cable. In the event of a significant delay it may therefore occur quite late in the programme, and the SO would have to choose between waiting for the next commissioning window, or accepting the link into partial service with not all tests completed.
- Thirdly, during February the planning application for the converter station at Kelsterton was refused. The impact of this was discussed with NGET and they stated

that the planning process would have to slip by over 9 months before it puts the project end date at risk. It appears that enabling works at Kelsterton are not scheduled to start for 6 months, and that there is around 3 month float in the Kelsterton programme, so this statement aligns with the programme.

2.3 Evolution of Project Risks from Aug 11 to Jan 12 Position

In order to assess project risk, NGT/SPT conducted risk workshops at each stage of the procurement process, and undertook comparative risk modelling of all the tenders using a common approach.

The approach adopted involved listing all the identified risks and assigning each a least likely, most likely and worst case value, along with a percentage probability of that risk materialising. All the risks were fed into a Monte Carlo simulation which them produced a probability distribution curve. The Monte Carlo simulation used three-point probability distributions for each risk, the points being named 'minimum, most likely and maximum.' As each tenderer offered to take on different risks and had made different assumptions, this analysis was carried out separately for all tender offers as part of the evolving risk assessment and tender evaluation.

The risk allowance requested by NGET/SPT in August 2011 was split into [redacted] representing the P=80 (i.e. probability of being less than or equal to this level is 80%) point on this curve, plus an additional [redacted] for weather/seabed risk which TOs calculated separately and excluded from requested risk allowance on basis that is should be covered by a re-opener rather than ex ante allowance. The version presented to us at the commencement of this analysis indicated that once weather/seabed risk had been rolled into the Monte Carlo model the P=80 point had reduced to [redacted] (all numbers quoted based on 2009/10 figures).

NGET/SPT stated that the total risk allowance has been reduced as an outcome of negotiations whereby the contractors agreed to take a greater proportion of the project risk – i.e. simplistically an increase in contract value of [redacted] (2009/10 value) had been offset by a reduction of [redacted] of risk. At first sight this does not appear to be a reduction but the contractor has also taken on insurance (previously cost at [redacted]) so overall NGET/SPT appear to have driven a real cost reduction overall.

In addition to moving some risks into the contract, and therefore removing them from the risk register, the project team had stated that in other cases the cost of a risk had been calculated precisely – so, for example, if an additional piece of land needs to be purchased but the purchase price was known, this would have one single value. A fourth column (in addition to the 'minimum, most likely and maximum) was therefore added entitled 'base cost' which captured these items with a single value. This column was intended to cover risk items whose cost was known, but which had not moved into contract price.

The NGET/SPT project team had also changed a number of assumptions through the period August 2011 to January 2012 as their understanding of the issues improved (for example, as better survey data was made available and new delivery team members joined with relevant experience of previous projects). The major impact of this was in the weather and burial risks, where some risk had been absorbed into the contract price, but where the project team modified their assumptions as to the 'worst case' risk, such that the 'best view' number reduced but the 'maximum' number increased, making the risk curve more asymmetric.

We undertook a detailed audit of the evolution of risks for the winning tender, looking in detail at key risks and how they had evolved. For the most part NGET/SPT were able to give detailed account of the risk definitions, their underlying assumptions/calculations for the values, and how/why a given risk had evolved. They also demonstrated that periodic reviews had been carried out to remove any double counting. We were able to therefore form an independent view of where the key areas of risk lay in the project. The evolution of the 'best view' risks from August 2011 to the January 2012 version is summarised in Figure 2, with the magnitude of each column being the sum of the 'best view' risks (each having first been multiplied by its probability factor). Note however that where new risks were added NGET/SPT had not classified all risks, we did not have a firm definition of each risk category, so some level of interpretation had to be applied to the more recent (January) figures.

[redacted]

Notable movements were as follows:

- the 'best view' value for cable laying dropped significantly, as some of this risk was passed to the contractor (note however that the 'maximum' value went up, so care should be taken interpreting this movement);
- design risks were issues relating to uncertainty about the length of cable routes, which appear to have been resolved through re-surveying;
- a large element of the 'converter' risk in August 2011 related to risks of spend due to contaminated land, this risk has been better quantified and effectively passed to the contractor; hence the increase in 'contractor' risk in January 2012 to compensate; and
- some items were classed as 'converter risk' which were really related to land purchase and consenting, the risks in the January 12 figures have been reorganised somewhat compared to August 11 so that the 'consenting' risks have risen as a result.

Whilst the overall view was that this approach appeared thorough and well documented, the outcome of this audit produced several apparent issues:

- Land purchase at Kelsterton appeared in the risk modelling at [redacted] where it has been itemised separately as a non-contract project cost of [redacted]. NGET/SPT stated that the [redacted] was a double count and in the subsequent February submission corrected this.
- Results of geophysical and geotechnical surveys – The cable route has evolved following numerous surveys to avoid difficult ground conditions as far as reasonably possible. The final route corridor has subsequently improved but some potentially difficult areas remain. NGET identified 160km of potentially difficult terrain and agreed that the contractor will allow for 25km of rock dumping and trenching. Of the remaining 135km, NGET have stated that a further 10% is considered most likely in the risk register at [redacted] (deduced from Prysmian figures) with [redacted] for demobilisation, totalling [redacted]. The figure in the risk register is, however, [redacted] best view as the calculation is based on 15km of difficult terrain – which implies an arithmetic mistake has been made in this calculation.
- The impact of multiple delays has not been explicitly quantified – other than through addition of small risk contingency items to cover contractual basis for claims where more than one risk occurs. There has been no systemic assessment of the consequential risk of, say, cable burial delay triggering commissioning delay.

The nature of the Monte Carlo approach is such that it is not possible to add the risk items together simplistically to reproduce the risks. We therefore asked NGET/SPT to undertake the following analysis:

> *"We wish to understand the relationship between the overall project risk profile (covering all identified risks) and the residual project risk profile (i.e. that remaining given risk transfer to contract) and how that would compare at August 11 versus January 12. Please provide*
>
> *(a) a chart showing (i) the overall risk profile for the project as at August 11, (ii) the residual risk profile if you assumed "zeroing" of relevant August 11 risks since adopted by the contractor; and (iii) the overall risk profile if you added new items of risk (NOT changes of assumption for risks identified as at August 11) and deleted items of risks removed by January 11.*
>
> *(b) a chart showing (i) the residual risk profile as at January 12 derived from "zeroing" of relevant January 12 risk items adopted by the contractor, (ii) the overall risk profile for the project as at January 12 if you reinserted "zeroed" risk items with the latest assumptions at the time they were zeroed out; and (iii) the overall risk profile if you deleted new items of risk which were added after August 11 (NOT changes of assumption for risks identified as at August 11) and re- added items of risks removed by January 11*
>
> *Please provide in both tabular and graphical format in Excel. Please also provide discussion of the key drivers of difference between the three curves within each of the two charts."*

The results of the response to this request are shown in Figure 3 and Figure 4.

Figure 3 uses the August 2011 risk profile as a starting point and overlays the Monte Carlo plots for:

- the original August 2011 risk profile (solid red plot):
- the above with risks subsequently passed to the contractor between August 2011 and January 2012 removed, but no other changes of assumptions (solid blue plot);
- the original August 2011 profile, with no risk passed to the contractor, but all changes in assumptions made by the project team between then and January 2012 added in (solid green plot); and
- the January 2012 profile (purple line).

[redacted]

Figure 4 works back from the January 2012 plot as follows:

- the red curve is the same line as the purple line above (January 2012 profile);
- the blue curve adds back risks which were passed to the contractor between August 2011 and January 2012;
- the green curve assumes that any new assumptions added since August 2011 are zeroed out.

[redacted]

Considering these two graphs in figures 3 and 4 together the following observations can be made.

The response to Qn. 1a tells an overall story of the P=80 value of risk being reduced as well quantified risks are reduced, at the same time as the maximum value of risk is increased due to the project team's changes of assumptions. Together with the NGET/SPT technical team we spent time analysing this data and concluded that this increased asymmetry was almost entirely accounted for by the change of assumptions of seabed burial risk – a point which becomes clear on inspection of the response to Qn. 1b. We believe that this increased asymmetry is driven by:

- improved survey data, which the JV argue has indicated that their initial risk assessments were conservative; and
- the presence of new expertise in the team with substantial offshore installation experience, and consequently a change of perspective on the part of the delivery team in the light of this experience.

2.4 Evolution of Project Risk from Jan 12 to Feb 12 Position

Following our review of the risk registers, the double counting of numbers for land purchase at Kelsterton was corrected by NGET/SPT. In addition, the issues around planning consent at Kelsterton resulted in the risks related to converter station delivery being updated/revised by NGET/SPT. Monte Carlo plots for this revision were not provided to us, but a summary of the changes made was provided on a line-by-line basis. The tables below provide details of the changes made which are reflected in the updated risk analysis provided on 18 February referred to above in Figure 4. The further adjustment of £2m we made to correct an error is discussed in Output 4. Table 12 provides a summary of how the risk numbers have moved for the specific risk categories, and Table 13 provides a narrative explanation (this is NGET's own narrative from their risk register).

[redacted]

[redacted]

[redacted]

2.5 Consolidating information on key risks from risk register

In this section we consolidate information on key risks from risk register and identify any outstanding delivery risks with a bearing on the terms of the contract including any cancellation provisions

For the vast majority of the risks identified by NGET/SPT, they were able to explain what they had passed to the contractor, and where a portion of the risk was passed to the contractor and a portion remained with the employer they were able to clearly define the split. The governance process which led to the cancellation provisions is discussed further in Section 3.2 below. Although these risks were subsequently quantified by NGET/SPT (in Table 13), on 9 March 2012, the JV provided an updated view of contract costs (but not of non-contract costs) and confirmed that “there was no change in project costs as a result of the issues around consents”.

As explained in Section 2.2 above, the programme implies that a delay of over 9 months in this area would have a knock-on impact on commissioning, and hence potentially trigger other delays not specifically related to consenting.

2.5.1 Planning permission - Kelsterton

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

2.5.2 Planning permission - Hunterston

Outline planning permission approved by North Ayrshire Council at committee on 14 February 2012 (formal decision notice likely to be dated later).

For the discharge of the planning conditions and the subsequent implementation of the required works the key risks are as follows:

- There are several planning conditions that are required to be discharged (including submission of a number of detailed reserved matters) prior to the commencement of development. The majority require details to be submitted to the planning authority for approval with the preparation of the further details able to be undertaken at any time. However, there are some planning conditions, specifically Condition 5 and 6 that require work to be undertaken at specific times of the year. Condition 5 requires that prior to the commencement of development, including demolition works; bat and otter surveys shall be undertaken. A building check for bats can be undertaken at any time however if there is potential for a building to support bats survey work would need to be undertaken (one dusk and one dawn survey as a minimum between April – September). Otter survey can be undertaken at any time although preferably in spring. Condition 6 states that all ground / vegetation clearance shall take place outside the breeding season (April – July);
- Condition 8 relates to water management and pollution prevention procedures to avoid detrimental impacts to Portencross Coast or ground surface quality and requires long term monitoring of site discharges – this could be onerous and it is essential that 'long term' is quantified at an early stage as this could significantly increase costs;
- Potential for a delay in the preparation of the reserved matters and information required for the discharge of the other conditions;
- Potential for objections from key consultees, requests for further information or changes to design i.e. materials, access etc. could all result in delays to the approval of reserved matters or discharge of the planning conditions by the planning authority and other key stakeholders.

2.5.3 *Planning permission - Conclusion*

[redacted]

[redacted]

[redacted]

2.6 Highlighting key changes in the above since SKM's review

SKM's stage 2 report identified four top delivery risks and uncertainties with potential to impact on contract award. Each of these is discussed below:

- Cable may not be available in required timescales – this has effectively been mitigated by the contract being signed and Prysmian committing contractually to deliver;
- Delay to Ofgem committing to providing construction funding – this issue is arguably now no longer relevant as Ofgem has now published various documents setting out the position on funding (August 2011 minded-to consultation, November 2011 update, February 2012 update) and the contract has been signed;
- Consents not being granted – this issue is still 'live' with the planning issues at Kelsterton being the main concern. NGET/SPT also stated that various marine consents are also outstanding but they did not believe this would present any timescale risk as there was no material reason why they would not be granted (although costs are still included in the risk model for any conditions which might be applied).
- Land purchase for converter station sites – NGET/SPT stated that these issues are progressing and they did not believe they still present an issue.

2.6.1 Design Changes

At the time of the SKM report the design had not been finalised. The project cost estimate submitted at that time was, however, based on the maximum link capacity option (which was the eventual winning option). Since that point we understand that some additional survey work has been carried out to firm up cable routings, and the 600 kV solution has been finalised as the preferred option. Major elements of the design are therefore understood, although some detailed design (such as filter design and detailed level cable routing) will be carried out during the course of the programme.

2.7 Conclusions

NGET/SPT overall provided a thorough and well justified explanation of:

- How final costs have been arrived at, relative to the August 2011 position;
- How project risks have been passed to the contractor, and the demonstrably positive impact of this on the overall project cost;
- How their understanding of risks not covered by the contract has evolved, with reduction in the 'best view but increase in the 'maximum' assumption driven by cable burial risks.

It is also noted that in the overall risk curve, the risk is weighted towards the latter stages of the project.

We have identified several specific issues including:

- An apparent double count of purchase costs at Kelsterton, which has been corrected in the February 2012 submission (see Table 13);
- An apparent error in the calculation of employer risk for cable burial, which should arguably be £2m lower. NGET/SPT should be asked to re-run their risk model with this issue resolved, to ascertain what impact this has on the overall curve.

The key outstanding delivery risk without a clear mitigation path is the planning permission issue at Kelsterton. NGET/SPT have quantified this in their latest version of the risk model, but we believe that an assumption of 9 months' delay to secure planning permission is optimistic unless NGET pursue an alternative site in parallel. The NGET team did indicate that other sites options might exist, notably on the other side of the Dee Estuary, but further clarity from the JV may be required on these issues.

In addition to the above, we believe that NGET/SPT have somewhat under-estimated the Minimum costs related to the Hunterston consents, and a figure of £4m would be more appropriate – Best View and Maximum figures for this risk seem reasonable.

A delay in commissioning which results in the commissioning 'window' being lost could effectively delay the whole project by 6 months. As the cost of constraints on the GB system is borne by the SO the JV is not exposed to these risks in full. Given the concerns about the planning application, Ofgem may wish to review how the SO is accounting for these risks.

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3. OUTPUT 2 – REVIEW OF FINAL STAGES OF PROCESS TOWARDS CONTRACT AWARD

3.1 Overview of approach

In this chapter we have reviewed the final stages of TOs' process towards contract award. As such we have undertaken the following tasks:

- High level review of the final stages of the TOs' tender evaluation process against the planned process reviewed by SKM, and giving a view on extent to which the planned contracting strategy has been followed.
- Review of the TOs' approach to managing outstanding delivery risks, and giving a view on the appropriateness of how this is reflected in terms of contract award as summarised in item 1.

As part of the process review we have will considered two perspectives:

- a governance-focused perspective, i.e. a view on whether the stated governance processes reviewed by SKM in previous phases have been followed; and
- an independent expert view of the way delivery risks are being managed.

This second point builds on the quantitative analysis in delivering Output 1, but further explores whether NGET/SPT have passed appropriate commercial risks to the contractor, and whether the overall contractual approach aligns the interests of the supply chain and the TOs. Given the criticality of this project not just to the TOs but to the electricity market as a whole, and its magnitude, this is a wider question that simply the pricing of risk, as it includes a degree of subjective judgement as to whether the contract approach taken is going to result in the right combination of timeliness, quality and cost being optimised.

3.2 High level review of tender evaluation process

NGET/SPT's procurement strategy identified a limited number of suppliers in the market with the ability to provide the required cable and convertor technology. In order to maximise competition, NGET/SPT established a 'lotting' strategy with:

- Lot 1 relating to convertor stations only
- Lot 2 relating to cable system only
- Lot 3 relating to combined cable and convertor system.

A four stage technical evaluation process was designed and approved consisting of:

- Stage 1 - preliminary evaluation — May-June 2011
- Stage 2 – clarifications — July-August 2011
- Stage 3 – Negotiation — August-October 2011
- Stage 4 – Best and Final Offer from preferred bidder(s) — November 2011

At the time of the previous SKM review, stage 2 had already taken place. SKM found that the governance process for the procurement as a whole was satisfactory, so this review is focused on the manner in which stages 3 and 4 were conducted, with emphasis on the governance of the process.

The timescale for these stages slipped slightly in practice towards the latter part of the process, with the tenderer responses to the stage 2 evaluation being received on 19 September 2011, and two subsequent interim responses being received on 2 November 2011 and 19 November 2011. [redacted]

Recommendations were made to the JV Board in the latter part of December, with the original intention being to achieve project Board and Company Board sign-off during January and sign the contract on 25 January 2012. In practice, this signing date slipped into February because of the JV's concerns to get more clarity on the status of the planning applications at Hunterston and Kelsterton.

3.2.1 Overview of Stages 3 and 4

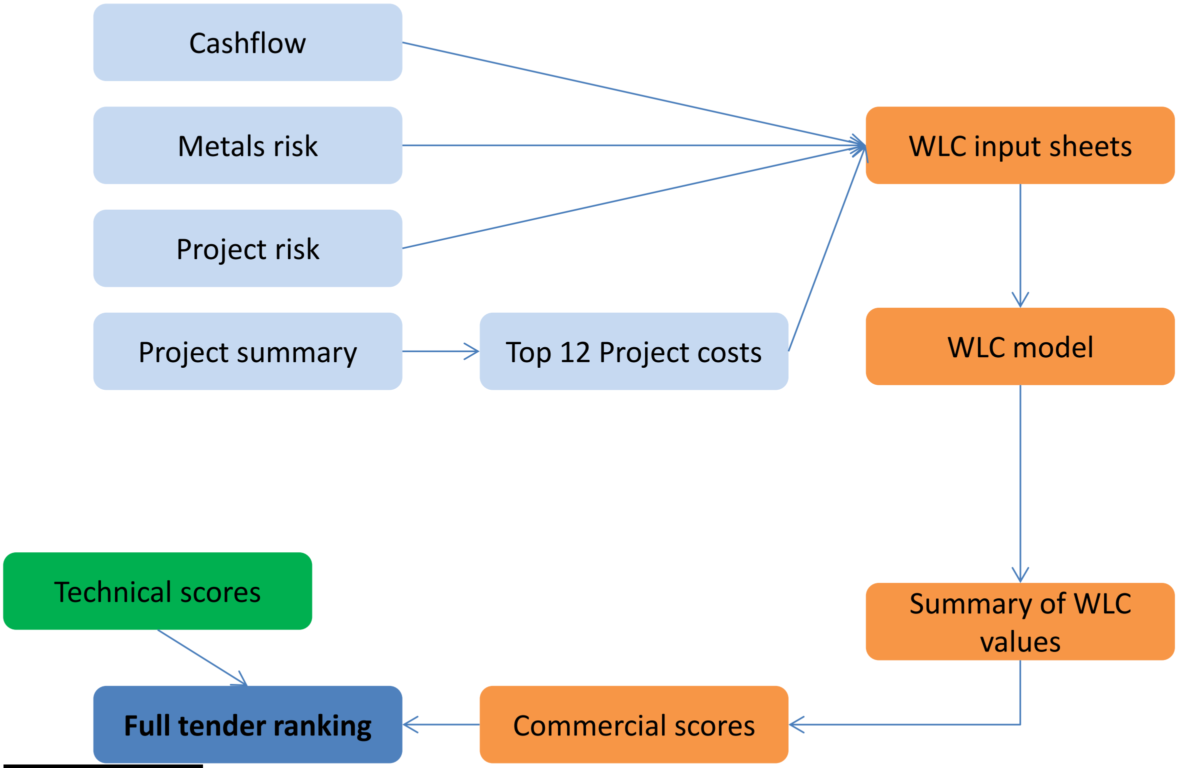
Having moved from clarification into tender evaluation, NGET/SPT stated that they were concerned to keep as many bidders engaged in the process for as long as possible (in order to keep the strongest negotiating position), whilst maintaining confidentiality and perceived fairness, in order to avoid any subsequent challenge to the process. As part of the clarification process a number of subject specific meetings were held with each bidder, followed by integrated global negotiation sessions, and this process was repeated three times before the Best and Final Offer stage. After each integrated meetings an internal Project Board was held, and the risk register updated. Two Company Board meetings took place during this process place, one part way through the process and the other at the stage of Best and Final Offer. The project team then conducted a final risk workshop, and prepared a final contract award recommendation, which was signed off at Project Board level on 13 January 2012, at Company Board level on 16 January 2012, and the standstill period was entered on 25 January 2012.

The evaluation was split into four discrete elements:

- Commercial.
- Technical.
- Programme and Schedule confidence.
- Management control confidence.

In Figure 5 we present a high level summary of the commercial evaluation process, and in Figure 6 we present a summary of the technical evaluation process. Both figures were provided by NGET/SPT.

Figure 5 – Overview of the commercial evaluation process



[redacted]

[redacted]

As part of the commercial evaluation, risks which individual tenderers were not prepared to accept were objectively costed and added to their tender to create a level playing field. These evaluation teams were based on four locations, with technical and commercial teams being kept separate to ensure objectivity. 70% of the evaluation weighting was around whole life cost, with 30% on technical criteria, with a minimum acceptable bar for the technical bids. The contract award criteria were published to the tenderers supported by a whole life cost economic model, so that all had sight of this.

Through the course of the stages of negotiation NGET/SPT produced an audit trail which demonstrated the movement in cost for all the bidders, and how the risk profile of each bid evolved at each stage. This has allowed us to back track from the August submission to Ofgem to the current position relatively easily. NGET/SPT stated that one reason for the staged approach was to ensure that tenderers whose initial technical offerings were marginal could be given guidance as to how they needed to improve, the intention being to keep them in the bid process as long as possible, and avoid ruling any options out too early where non-compliances could be easily addressed.

In addition to the four steps formally outlined in the process, tenderers also elected on occasions to submit supplemental cost positions.

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3.2.6 *Summary of findings*

NGET/SPT were clearly faced with a complex procurement in a constrained market with limited capacity. The procurement process appears to have been followed as designed

[redacted]

and it is hard to conceive of an alternative process which would have been any significant improvement. Notably:

- the deliberately wide technical scope, coupled with the 'lotting' process, meant that a large number of options were available to be evaluated until relatively late in the process, which arguably allowed NGET/SPT to preserve as much competitive pressure as possible given the small number of credible bidders;
- the large number of options allowed NGET/SPT to compare costs of the different project elements;
- the documentation of the evolution of the different tenders appears comprehensive, with risks evaluated at each stage, and the audit trail between the stages being clear; and
- there was no attempt by any tenderer to contest the validity of the process.

Overall it is our view that the process has led, ultimately, to an efficient outcome, based on the proviso that the 600 kV solution can be delivered at its full stated rating. Even were this not to be the case ultimately, the value of this as a potential option is such that it can be argued that it was worth the JV taking this path and taking on the technology risk in view of the potential benefits. We therefore consider that the JV took a reasonable and balanced approach to the costs and risks of the solution finally selected.

3.3 Review of approach to managing outstanding delivery risks

3.3.1 Impact of outstanding delivery risk considerations on contract award

As part of this assessment we undertook a thorough audit of all the issues within the risk register in August 2011, and how these compared with the current risk register. The information presented evidenced a thorough and systematic approach to assessing how risk had been passed to the contractor, with clear principles established to ensure that broadly, the party best able to manage a certain risk took liability for it (i.e. the contractor is broadly taking risks within their control and the employer taking risks outside the contact scope).

NGET/SPT had also clearly taken a view that where high impact, low probability risks were concerned, there were trade-offs between passing all of these risks to the contractor (and having them priced in as a firm price increase), and continuing to bear part or all of them themselves.

Our conclusion is that the principles applied to this approach were appropriate, and that NGET/SPT have arguably negotiated as effectively as their position permits.

3.3.2 Management of risks remaining with the employer

The major risks remaining with the employer are:

- high impact, low probability weather related risks – over 60 days the employer bears 50% of the risk and over 120 days the employer bears 100%;
- that element of cable burial risks which they were not able to pass to the contractor; and
- planning and consenting risks.

NGET/SPT stated that following recent offshore experience, prime contractors were willing to take only limited liability for cable burial & installation risk, particularly given the specific challenges of the Irish Sea marine environment, and that they believed they had driven a reasonable bargain in this regard.

NGET/SPT also stated that they are undertaking a number of activities (such as ROV surveys, trial installation of a section of cable) which will allow them to quantify and verify issues so that they can pro-actively identify any key problems prior to the main cable laying campaign.

It is also notable that, due to the cable manufacturing lead time, the above items are on the project critical path.

The planning and consenting area raises concerns in that planning permission for Kelsterton has been refused, and a delay of more than 9 months in resolving this may impact on the rest of the programme. We believe this timescale may prove optimistic and that NGET/SPT should be looking at an alternative site in parallel with attempting to resolve this issue. At this stage, NGET/SPT (on 9 March) have stated that the planning consents issues has had no impact on contract costs.

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4. OUTPUT 3 – RECOMMENDATIONS ON RISK SHARING ARRANGEMENTS

In this chapter, we present the recommendations on risk sharing arrangements between TOs and consumers under TII and RIIO-T1. The delivery of this output consists of three key activities:

- assessing the risk profile of the project, identifying any material differences in characteristics compared to works funded under TII to date, and giving a view on implications for risk sharing arrangements under TII and RIIO-T1;
- developing a risk methodology, using appropriate criteria, for identifying which risks should be: reflected in ex ante allowances; dealt with ex post; or borne by the TOs; and
- applying this risk methodology to key risks.

Our recommendations reflect the additional guidance provided by Ofgem on the framework within which we should work when considering risk sharing arrangements under RIIO-T1 (see Section 1.3.1).

Ofgem have specifically asked for Pöyry to provide recommendations on risk-sharing arrangements in the following areas:

- value of cost allocation ratio to use between TOs for ex ante allowances and ex post cost variances (driven by project being a JV);
- basis for the capex efficiency incentive sharing factor under TII (given differences highlighted between Western HVDC Link and other TII projects,
- appropriate statistic (P=80 vs. P=50 vs. mean vs. other) from residual risk distribution[11] to use for residual risk element of ex ante funding allowances (given asymmetric risk profile).

4.1 Assessing risk profile of the project

This task is focused on the assessment of the risk profile of the project. This is supported by an identification of any material differences in characteristics compared to works funded under TII to date, and giving a view on implications for risk sharing arrangements under TII and RIIO-T1.

As previously noted, the two key risks identified by SKM are the availability of the required HVDC cable, and issues related to land consents and purchases.

The exposure of this project to the availability of HVDC cable had distinguished it from other TII projects, making it more comparable to recent and ongoing subsea interconnector projects, such as BritNed (GB – Netherlands) and East-West (GB – Ireland). Now that the contract has signed, this risk should be borne by the contractor in terms of direct costs for the project (e.g. in case of delays). However, it is not clear whether there would be any account taken of the constraint costs to customers resulting from any delay.

11 Ofgem also asked Pöyry to review the inputs to the risk model to derive this distribution – this review was carried out under Output 1 (see Chapter 2).

The choice of cable has introduced a new risk feature that does not appear in the quantitative risk profile, namely that the project is using new cable technology to help it achieve a larger transfer capacity. Again, this risk should be borne by the contractor now that the contract has been signed.

The initial proposals for SPT under the RIIO-T1 process have identified three major risks as being eligible to trigger re-openers for any strategic wider works project under RIIO-T1. These are burial costs arising from seabed conditions (by far the largest risk), weather and planning and consents.

Figure 7 provides an overview of the residual risk distribution from the project, based on the results of the Monte Carlo risk modelling provided to us by the JV. This is based on the risk distribution as of January 2012, but the pattern is expected to be similar for the most recent risk distribution (although this was not provided by the JV in time for inclusion in this report), Figure 7 highlights the asymmetric distribution of risk with long upside tail driven by additional burial costs in what is described as very challenging area of the seabed.

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4.1.1 Comparison with other TII projects

There are several key differences between the Western HVDC Link project and other projects funded under TII:

- **Joint responsibility for project:** the Western HVDC Link is a JV between two TOs with different funding arrangements under RIIO-T, which introduces an additional challenge in determining funding arrangements that provide an appropriate set of incentives.
- **Cost:** the Western HVDC Link is a much more costly project, with project cost in excess of £1bn.

- **Size:** the Western HVDC Link is physically a much bigger project with 400km of offshore cable, making it the longest 2.2GW HVDC cable in the world[12].
- **Offshore works:** the other TII projects are not exposed to the risk of offshore works, and hence they have not had such an asymmetric distribution of risk with long upside tail driven by burial costs as the Western HVDC link project does.
- **New technology:** the Western HVDC Link project will be the first use offshore of the particular cable technology (designed to deliver higher transfer capacity).

These differences are consistent with the areas that Ofgem has asked us to particularly provide advice on .e.g. JV means that a decision is needed on cost allocation between TOs, and appropriate risk-sharing mechanisms given residual risk profile.

4.2 Developing a risk methodology

As previously noted, we have been asked by Ofgem to provide advice on the:

- allocation of costs (ex-ante and ex-post) between the two TOs; and
- on arrangements for sharing risk between the TOs and customers (through the capex efficiency incentive sharing factor and the determination of the residual risk element in the ex-ante funding allowance).

We recognise that a fundamental principle of the RIIO-T1 arrangements is that risk is best borne by the party able to influence it. Therefore, the key to our risk methodology is a consideration of the TOs ability to influence the risk – for example, through contracting arrangements (e.g. for HVDC cable), or hedging strategies, or consideration of alternative solutions (e.g. in response to consenting difficulties).

This methodology will then help us to assess the costs that TOs have assigned to risks in their final plans (as reviewed under Output 1 in Section 2), and how they align with where TOs can have biggest influence on risk management.

The rest of this section is focused on the sharing of additional[13]costs incurred by the TO(s) as a result of the materialisation of a specific risk. We do not consider the impact of risks for customers that won't necessarily be associated with additional costs/savings directly for the TO(s) – e.g. the impact of the timing of delivery and the impact on constraint costs (as explained in Section 4.2 and 4.3).

4.2.1 Allocation of costs between the TOs

The Western HVDC Link project is being delivered as a JV between NGET and SPT. Therefore, the allocation of costs (ex-ante and ex-post) between the TOs is a key issue not found in other TII projects, which are the responsibility of a single TO.

The regulatory arrangements for cost allocation between the TOs should have regard to the principle that risk is best borne by the party able to influence it. It should also consider what arrangements, if any, the TOs have already put in place for the sharing of costs, in order to avoid introducing undue complexity or distortions.

12 'Siemens and Prysmian win £1bn Scotland-England subsea link', Utility Week, 16 February 2012.

13 The residual risks only relate to additional costs that the TSOs would incur, in excess of the ex-ante contract cost because of the realisation of particular risks. Our understanding is that there is no scope for the TOs to benefit from lower contract costs than the upfront costs if 'favourable risks' materialised that enabled the contractor to deliver at lower cost.

There are a number of aspects of the project costs for consideration:

- contract cost (actual cost fixed upfront);
- non-contract (non-risk) costs (mixture of actual and forecast costs);
- costs of residual risks not covered by the contract (ex-ante allowance based on forecast costs, with ex-post reopener provisions for specified differences between forecast and actual costs).

The simplest approach is to apply a single cost allocation ratio across all of these costs. In general, differential sharing arrangements should be used only to reflect differences in the ability of the individual TOs to influence a particular risk.

4.2.2 Sharing risk between the JV and customers

In this section, we set out a proposed risk methodology for identifying appropriate mechanisms for sharing risk between JV and customers. Ultimately, the aim of this is to develop funding arrangements that balance incentives on the TOs to reduce risks and hence costs for consumers, and increasing the riskiness and hence cost of capital for consumers.

There are a number of potential risk-sharing mechanisms, such as ex-ante allowances, reopeners or ex-post adjustments, pass-through and sharing factors. These differ both in who bears the consequences of a risk materialising and whether an allowance for the risk is determined ex-ante or ex-post. It is also important to note that in practice these mechanisms represent different points on a spectrum rather than discrete mechanisms – e.g. fixed ex-ante allowances effectively represent one extreme approach to sharing factors.

Ex-ante funding allowances are a key part of any package (but only part along with uncertainty mechanisms for example) for incentivising efficient TO behaviour. It is important to strike the right balance between risk and reward sharing and monitoring, and administrative expense (on all sides). For example, if there is uncertainty about the exact level of funding required but there is relative certainty that some would be, it is better to set the ex-ante allowance at somewhere around the expected level than zero, in terms of minimising unnecessary ex-post adjustment.

In proposing the ex-ante funding allowances, it is important to consider the impact of the ex-ante funding arrangements on the level of risk. For example, timeliness may be key in managing the risks – if there are additional delays introduced in establishing whether additional funding is available, then this could lead to either higher costs (in terms of higher cable prices) or delays if the factory slot is missed.

We have identified three key criteria which should be used to inform the decision on which funding mechanisms are most appropriate for which risks from the perspective of sharing of risk between the JV and customers (rather than between parties within the JV which is addressed elsewhere in this report:

- likelihood of risk materialising;
- impact of risk materialising; and
- controllability by the JV - to what extent are they able to take cost-effective actions to mitigate the likelihood and/or impact of the risk materialising?

Between them, these criteria indicate both the materiality of the risk (and hence the extent to which it might be justified to develop specific risk-sharing mechanisms), and whether or not the TOs are well-placed to mitigate the materiality of the risk.

Table 16 sets out how these can be used to identify appropriate risk-sharing mechanisms. It is designed to be illustrative and is therefore deliberately kept simple (in binary form) with the criteria being high or low. In practice, the different criteria can be quantified to enable a more detailed decision given the spectrum of choices available (e.g. sharing factors between 0 and 100%).

Table 16 – Criteria for identifying appropriate risk-sharing mechanisms

Impact	Likelihood	Controllability	Funding mechanism
Low	Low	Low	Ex-ante allowance
Low	Low	High	Ex-ante allowance
Low	High	Low	Pass-through
Low	High	High	Sharing factor
High	Low	Low	Reopener
High	Low	High	Reopener (with sharing factor)
High	High	Low	Pass-through
High	High	High	Sharing factor

In summary, each funding mechanism is best used in the following circumstances:

- **Fixed ex-ante allowance** (i.e. TO(s) bears all risk)– best used when there is (very) low materiality of the risk, and hence it is not appropriate to design additional mechanisms to stop the TO being fully exposed to downside and upside.
- **Ex-ante sharing factors** (i.e. TO(s) bear some risk) **–** appropriate for material risks when the TO has high control, and hence can be incentivised to take actions to reduce the likelihood and/or impact of risk materialising – the degree of sharing will primarily depend on the level of controllability. However, impact and/or likelihood are also important – e.g. low impact and low likelihood, then we use ex-ante allowance (i.e. sharing factor of 100% for TO).
- **Ex-post reopeners** (i.e. TO(s) could bear some risk with sharing determined ex-post) **–** these are best used for high impact but low likelihood events, which may not justify or be able to be captured in ex-ante arrangements (and when it is not appropriate to wait until end of the funding/price control period to resolve). Where the TO has control, there may not be complete pass-through of costs.
- **Pass-through arrangements** (i.e. TO(s) bears no risk)– best used when the TO has little control over the risk materialising, (and hence little benefits to consumers from incentivising the TO to try to mitigate the risk) and the likelihood of the risk is high enough to justify agreeing specific circumstances for cost pass-through.

4.3 Applying this risk methodology to key risks

In this section, we describe our recommendations in the three areas of risk-sharing arrangements requested by Ofgem (as noted in Section 4):

- allocation of costs between TOs;
- capex efficiency incentive sharing factors to be used for TII period; and
- basis for calculation of ex-ante residual risk allowance.

These recommendations are in line with the additional guidance provided by Ofgem on the framework within which we should work when considering risk sharing arrangements under RIIO-T1 (see Section 4.2.2).

4.3.1 Allocation of costs between TOs

Our initial recommendation is that costs be allocated using the following ratio – 70% (NGET) and 30% (SPT). This recommendation is consistent with the:

- principle that differential (or complicated) sharing arrangements should be used only to reflect differences in the ability of the TO to influence a particular risk (discussed in Section 4.2.1);
- the split of overall project costs that could potentially be allocated differentially to TOs, such as the convertor stations and cable costs (described in Section 4.3.1), which would result in split of 67.6% (NGET) and 32.4% (SPT); and
- the deemed split of residual risk costs (described in Section 4.3.3), which would result in split of 73% (NGET) and 27% (SPT).

Ofgem has provided guidance that the project should be considered as a whole. This is consistent with the present situation that a single contract fee has been agreed between the JV and the successful contractor.,

Therefore, it would seem appropriate to use a simple cost allocation ratio that could be reflected in internal arrangements between the TOs (as our understanding is that no formal arrangements are yet in place).

A single simple cost allocation ratio also reflects the fact that whilst the cable burial is by far the largest of the residual risks, but it is not clear that the TOs differ in their ability to influence this risk. Although some risks (e.g. around the convertor stations) may be more TO-specific, their materiality means that there would not seem to be a net benefit for customers in introducing a more sophisticated sharing arrangement for the risks.

This recommendation is informed by the answers provided by the JV (NGET/SPT) in response to our questions on the allocation of costs and risks within the JV as described in Section 4.2.2.

4.3.2 Capex efficiency incentive sharing factor in TII

Our initial recommendation is that the RIIO-T1 sharing factors also be used for the TII period.

This reflects the fact that the Western HVDC Link project is quite different in its risk exposure to other TII projects. In practice, only a very small percentage of the proposed overall project spend would occur during the TII period based on the figures provided by the JV.

We also note that the decision on the sharing factors applicable to the Western HVDC Link project raise challenges for consistency in three dimensions

- over time – TII v RIIO (as addressed above);
- between JV parties - SPT v NGET; and
- consistency between Western HVDC Link and RIIO-T1 settlement for each TO.

Ofgem have provided guidance that the sharing factor to be used for each TO under RIIO-T1 will be determined separately under the IQI process for RIIO-T1. The value for SPT is 50%, the value for NGET is still to be determined but will lie somewhere in the range 40%-50% (with their proposed value to be set out in its March 2012 business plan submission).

Ofgem has given guidance that the sharing factor for this project under RIIO-T1 is out of scope of this review. Therefore, we have been asked to work within a framework in which the sharing factor may be expected to differ between the two TOs depending on the outcome of NGET's IQI process.

In summary, Ofgem's guidance is that consistency of the sharing factor between the Western HVDC Link project and the RIIO-T1 settlement takes precedence over having the same sharing factor for **this project** for each TO.

Ofgem provided guidance that the capex efficiency incentive sharing factors to apply under RIIO-T1 are determined separately and could potentially differ between the TOs. It is Poyry's view that an alternative solution may better meet the principle to treat the project as whole. Different capex efficiency incentive sharing factors would mean that each TO has a different exposure to risk from this JV, although they do not necessarily differ in their ability to manage the risk faced by the JV. Therefore, we would support a sharing factor of 50% for this project, in line with the firm proposals for SPT as no firm proposals are available for NGET.

Although it would not be ideal to have a separate sharing factor for Western HVDC Link as for other projects, the regulatory attention and the nature of the Western HVDC Link projects means that there should be little risk of the TO being able to move costs between this project and general RIIO-T1 spend.

4.3.3 Ex-ante allowance with residual risk

Our initial recommendation is that a P=50 value is used to set the ex-ante residual risk allowance.

The P=50 value should be taken from the residual risk distribution as at the data freeze point set by Ofgem for the purposes of fixing ex-ante allowances. In Output 4, we have provided provisional recommendations on ex ante funding allowances based on application of this methodology to the relevant data available at the data cut off date (14 March 2012) we specified for this report.

We note (in Chapter 8) that some data issues remained unresolved at that point, and hence we have described our recommendations on the allowances themselves as provisional. They may be updated by Ofgem, in line with the above methodology, to take account of updated data available at the final data freeze date to be set by Ofgem for determining the final level of ex-ante funding allowances.

There is a long upside tail in the residual risk distribution for the Western HVDC Link project (as discussed in Section 4.1). This is mainly driven by the major project risk of cable burial being made harder than expected by seabed conditions. Using our criteria set out in Section 4.2), this risk can be described as:

- high impact;
- low-medium likelihood; and
- low controllability.

Our proposed methodology would suggest that it is appropriate to use a re-opener provision to deal with this risk, given the assessed level of likelihood. As previously noted, a reopener mechanism covering seabed burial risk has been included for strategic wider works, including this project, in the fast-tracking proposals for SPT for RIIO-T1. Ofgem asked us to include recommendations which are consistent with the assumption that for this project, the reopener mechanism applying to SPT will also apply to NGET, so that we could provide recommendations which are compatible with the Initial Proposals for SPT Under RIIO-T1 and treatment of the project as a whole. Ofgem also noted that it is open to Poyry to provide alternative recommendations based on relaxation of these assumptions, if these could be justified.

We note Ofgem's guidance that the determination of the ex-ante allowance for the residual risk should strike an appropriate balance between the respective likelihood of TOs or consumers paying for risks which may or may not arise[14]. In general, the starting position would be to use a P=50 value for setting the residual risk allowance as this would mean that there is perceived to be an equal probability of costs turning out higher or lower than the ex-ante allowance.

The use of P=80 value means that there is an 80% probability that the TOs will have to spend less on residual risk than they have been given in their ex-ante allowance. This would only be appropriate where there is significant upside risk, which needs to be balanced by a higher P-value.

The Western HVDC Link project does have significant upside risk, given asymmetric risk distribution and high costs. However, this has already been addressed by the re-opener mechanism set out in the Initial Proposals for RIIO-T1 for SPT. Therefore, we do not believe that additional protection from the upside risk by setting P>50 is appropriate for this project.

The JV provided some analysis of the interaction between the reopener mechanism and the residual risk distribution. Although this was based on an ex-ante allowance set at the P=80 value and an January 2012 update of the risk model producing this risk distribution, we would expect the main conclusions to be broadly similar if the analysis was repeated for an ex-ante allowance set at the P=50 value and the final ex-ante residual risk distribution (e.g. given the low value of the upside costs associated with planning consents in the original analysis). This analysis suggested that there was little probability of both conditions for the reopener being satisfied:

[14] We note that some risks are borne by the contractor, and hence are included in the contract cost, which will be paid by consumers whether or not the risks actually arise. In Section 4.2.2, we note that the JV has overall provided a thorough and well justified explanation of how project risks have been passed to the contractor, and the demonstrably positive impact of this on the overall project cost.

- total project cost exceeding (base cost[15] + agreed risk cost) + [10% of (base cost + agreed risk cost)]; and
- where the 10% element can be attributed wholly to one of the three specified risks: weather, seabed or consents.

The use of a lower ex-ante risk allowance would slightly reduce the threshold for total project cost but only by about £3m (equals [redacted] reduction in ex-ante risk allowance as a result of move from P=80 to P=50).

[redacted]

[redacted]

[redacted]

In fact, the JV stated that given their finding of very low probability of the re-opener being triggered, and the complex interaction between risks, they would propose a simpler approach of establishing re-openers at +/-10% around an ex-ante residual risk allowance of P=80. However, this would not be consistent with the guidance on the reopener that Ofgem have provided to us (as described in Section 1.3).

4.4 Summary

Given this, our recommendations are as follows:

- cost allocation ratio of 70% (NGET) and 30% (SPT);
- RIIO-T1 sharing factors be used for TII period; and
- P=50 be used for calculation of ex-ante residual risk allowance, given existence of reopener provisions.

Ofgem provided guidance that the capex efficiency incentive sharing factors to apply under RIIO-T1 are determined separately and could potentially differ between the TOs. It is Poyry's view that an alternative solution may better meet the principle to treat the project as whole. Different capex efficiency incentive sharing factors would mean that each TO has a different exposure to risk from this JV, although they do not necessarily differ in their ability to manage the risk faced by the JV. . Therefore, we would support a sharing factor of 50% for this project, in line with the Initial Proposals for SPT for RIIO-

15 Base cost is the sum of the contract cost and non-contract (non-risk) cost (i.e. project management costs incurred by the JV).

T1[16]. This would be consistent with the treatment of the project as a single entity in the rest of the funding arrangements.

This would be consistent with the treatment of the project as a single entity in the rest of the funding arrangements. The choice of the sharing factor for the Western Link project should not fetter Ofgem's ability to set a different sharing factor for NGET in RIIO-T1 as a whole. We acknowledge that it would not be ideal to have a separate sharing factor for Western HVDC Link as for other projects. However, the regulatory attention on the Western HVDC Link project means that there should be little risk of this distorting behaviour (e.g. through TO being able to move costs between this project and general RIIO-T1 spend).

[16] No Initial Proposals for RIIO-T1 are available for NGET as they are not going through the fast-track process.

5. OUTPUT 4 – RECOMMENDATIONS ON ANNUAL EX-ANTE FUNDING ALLOWANCES

5.1 Overview of approach

In this section we present the recommendations on annual ex ante funding allowances under TII and RIIO-T1. The delivery of this output consists of proposing annual ex ante funding allowances for each TO under TII and RIIO-T1. These allowances reflect the:

- relevant guidance provided by Ofgem (as described in Section 4.3);
- our assessment of final costs under Output 1 (as described in Section 4.3)
- the annual profile of non-risk costs and risk costs provided by the JV;
- our relevant recommendations on risk-sharing arrangements under Output 3 (as explained in Section 4.3) – cost allocation ratio of 70% (NGET) and 30% (SPT); and
- the P=50 value be used for determining ex-ante residual risk allowance.

5.2 Recommended ex-ante allowances

Our provisional recommended annual ex-ante allowances for each TO are shown in Table 17, with the overall annual allowances for the JV shown in Table 18. The annual allowances are determined by the total cost figures for each cost category (contract, firm non-contract and ex-ante risk) and the assumed annual profile of each cost category.

We have based our provisional recommended allowances on the the findings of the other Outputs of this project and the most recent appropriate provided by the JV before 14 March 2012, the cut-off date for data to be considered in this report. Therefore, these allowances are provisional as they will need to be updated based on the cost and risk position as of the data freeze point to be determined by Ofgem. Further information on the source of each data is provided after Table 18.

Table 17 – Provisional recommendations on ex-ante allowances by TO and by cost pot (£m, real 2009/10 prices)

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	Total
Contract							
NGET	9.87	67.67	154.06	205.67	169.09	0.00	**606.35**
SPT	4.23	29.00	66.03	88.14	72.47	0.00	**259.87**
[redacted]							
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]							
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 18 – Initial recommendations on ex-ante annual allowances for JV (£m, real 2009/10 prices)

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	Total
Total	**24.08**	**119.60**	**240.17**	**328.93**	**302.03**	**29.26**	**1044.07**
Contract – total	14.10.	96.67	220.09	293.81	241.55	0.00	**866.22**
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

5.2.1 Derivation of total costs for JV

This means that our total costs for each category reflect the results of Output 1 and 3 as follows:

- total of contract and non-contract (non-risk) costs is as provided at the project workshop on 1 February 2012);
- split between total contract and non-contract costs is as per the figures provided at the project workshop on 1 February2012 ; and
- risk allowance equals the P=50 value of the residual risk distribution calculated on 18 February 2012 (taking into account the planning decision at Kelsterton[17]) with a deduction of £2m for an apparent error in the calculation of the Most Likely Value for the JV's risk for cable burial (as described under Output 1).

[redacted]

Output 1, we noted an apparent error in the calculation of employer risk for cable burial, for which the Most Likely value should arguably be £2m lower. By the data cut-off date for this report (14 March 2012), the JV had not provided results from a re-run of their risk model with this issue resolved. Therefore, we have made a manual adjustment to the ex-ante risk allowance by using the expected change in the Most Likely value, which should be a reasonable proxy for the change in the P=50 value based on the overall risk distribution. Therefore, the ex-ante risk allowance is £2m lower than the most recent P=50 value provided by the JV.

[17] Our understanding is that as of the data cut-off point, the planning decision at Kelsterton had not had material impact on the contract and firm non-contract costs. On 9 March 2012, the JV provided an updated view of contract costs (but not of non-contract costs and hence not a coherent data set for basing our recommended allowances on), and confirmed that "there was no change in project costs as a result of the issues around consents".

5.2.2 Derivation of annual cost profile

The annual profiles for the allowance for the JV in each funding category have been taken from the following sources:

- contract costs – annual profile of total contract costs provided by the TOs on 16 February 2012;
- firm non-contract costs – annual profile of total firm non-contract costs provided by the TOs on 16 February 2012; and
- residual risk allowance – annual profile of the risk costs at P=50 value provided on 18 February 2012[18].

5.2.3 Split of costs between TOs

- We have noted the framework for the treatment of the project as a whole, and set out our recommendation of a single ratio for splitting costs between the TOs across the funding categories Therefore, we split the total for each year with 70% for NGET and 30% for SPT.

[18] The annual profile of the risk costs was provided by the JV on 12 March 2012.

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6. OUTPUT 5 – RECOMMENDATIONS ON DELIVERABLES TO BE ASSOCIATED WITH FUNDING ALLOWANCES

6.1 Overview of approach

This chapter sets out our recommendations on deliverables to be associated with funding allowances under TII and RIIO-T1. The technical and programme deliverables are based on consideration of transmission network requirements and technical and programme details of the preferred solution / final contract. As part of this assessment we set out the following outputs:

- Annual key project milestones consistent with the planned programme and with timing requirements for additional network capacity to be provided by the Western HVDC Link. The key deliverability risks identified in Output 1 and potential economic impact of late delivery, such as network constraint costs, will also be addressed.
- Technical output measures consistent with the final design and reflect the expected benefits (thermal, voltage and/or stability) across relevant system boundaries on completion of construction works.
- Identification and assessment of any additional technology risks relating to deliverables.

6.2 Key project milestones

The optimum timing requirements for the HVDC link depends on the background generation scenario and the associated cost-benefit analysis (CBA). Previous analysis of these issues is summarised below to provide some background on project completion requirements.

The future growth of renewable generation in Scotland to meet increasing demand to the South will require higher boundary transfer capacities. Key boundaries include Boundary 6, Boundary 7 and Boundary 7a. The SKM Stage 1 Review[19] verified the technical and economic case for the Western HVDC Link to reinforce these key system boundaries.

Future boundary capabilities were evaluated in the SKM Stage 1 Review, based on a link capacity range of 1.8 to 2.2GW with the maximum rating of 2.2GW used in CBA. For the SKM Stage 2 Review, a 6 hour maximum rating was used as the headline figure for the CBA for an upper and lower maximum rating of 2.4GW and 2.0GW respectively. This is because the boundary capabilities are determined on an n-2 basis.

The findings are summarised below based on three generation scenarios; Slow Progression – (SP), Gone Green (GG) and Accelerated Growth (AG):

- Boundary 6: SPT to NGET (Cheviot) is non-compliant in all scenarios from 2013 with a second link required by 2018 for both GG and AG; SP is compliant throughout the period with the Western Link only.
- Boundary 7: Upper North is non-compliant in all 3 scenarios from 2014, GG is non-compliant between 2019 and 2023 with only the Western HVDC Link and SP compliance is restored from 2015 with the Western Link.

19 http://www.ofgem.gov.uk/Networks/Trans/ElecTransPolicy/CriticalInvestments/InvestmentIncentives/Documents1/WesternHVDCLinkSKMStage1ReviewReportmFinalPublic.pdf

- Boundary 7a: Upper North south of Penwortham is non-compliant in all 3 scenarios from 2014; compliance is restored with the Western Link. By 2016, the Eastern Link is also needed for compliance. In GG, compliance is restored from 2024 without the additional Eastern Link. SP is compliant throughout the period with the Western Link only (except for 2015).

Based on this analysis, the requirement for the Western HVDC Link is 2013 for GG; however 2015 is given by NGET and SPT as the earliest completion date for the link. The contractual date given for link completion is 31 December 2015.

The CBA reported in the SKM Stage 2 Review with updated scenarios, for link capacities with a maximum 6 hour rating between 2.0 and 2.4GW indicates that for GG and SPT, the optimum timing is 2015 and 2017/18 respectively. However, the regret costs for commissioning the Western HVDC Link in 2015 and a subsequent SP generation growth scenario is much lower (circa £34m excluding losses due to forwarding of capital costs) than if the link is commissioned in 2017/18 and the generation growth scenario follows the GG forecast (circa £170m due to increased constraint costs). Thus, a delivery date of 2015 is the optimal timing given the forecast range of background generation scenarios. Including the cost of losses reinforces this view.

Key deliverability risks may lead to delivery of the link beyond the contracted completion date of end of December 2015. These risks include delays due to planning and consents, cable type testing delays, delays to offshore cable-laying due to unforeseen weather conditions or seabed conditions, or other delays in the critical path that result in pushback or increased duration of cable-laying activities.

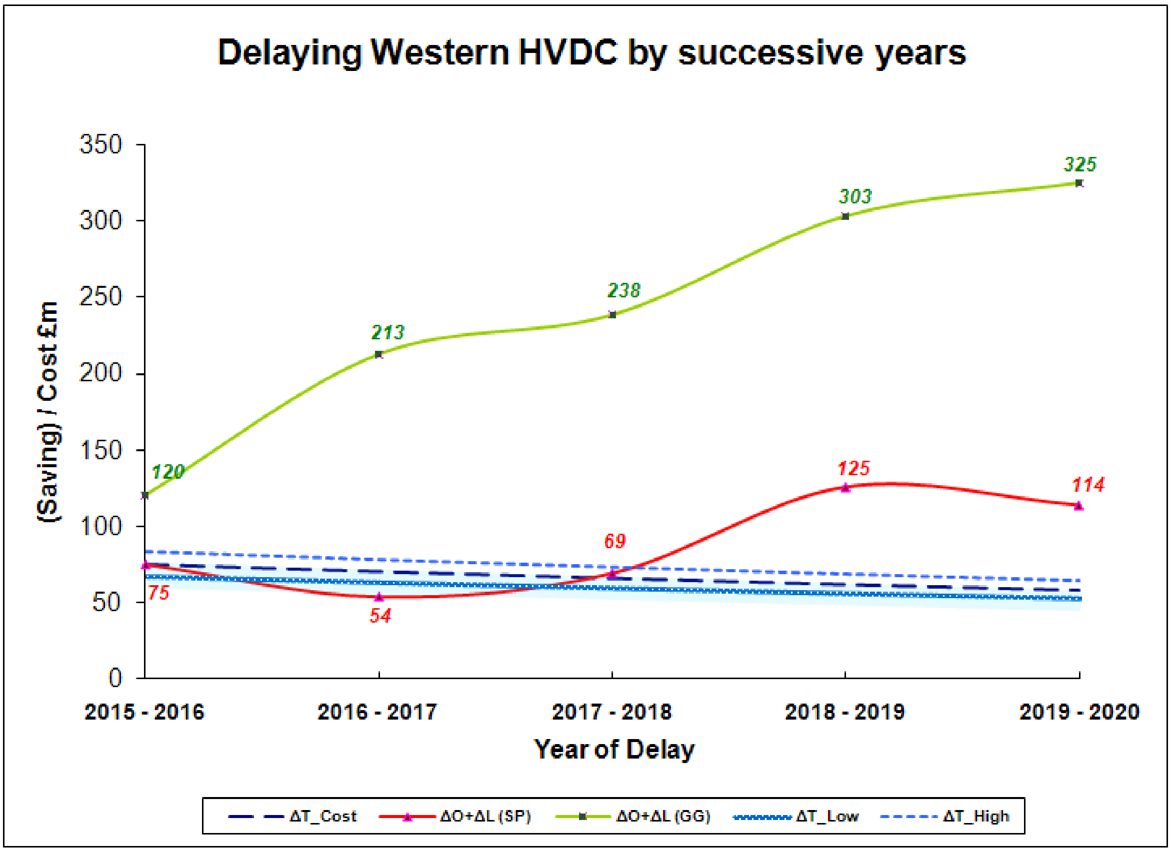
The link design is based on a 600kV cable, as this will be a first-of-a-kind, it will be required to undergo type registration testing which would not be required for a lower voltage cable with an operational track record and thus, existing type registration. This carries a risk that the cable may take longer than anticipated to pass type registration testing which would impact the commencement of cable manufacturing and subsequently cable installation activities. The seabed along the route is technically challenging and has been sampled every 5km however there is a risk that conditions between sample points could be unfavourable. In addition, extreme weather conditions may delay cable laying activities, particularly near-shore which are most vulnerable to weather.

If the background generation scenario follows a growth path similar to the GG scenario, generation constraints costs may be incurred as the Western HVDC link may not have the required capacity to meet security requirements across the relevant boundaries. In the Link Contract Award Criteria, for the Total Cost of Ownership - Whole Life Cost Model, it was stated that a cost per week of £1.6m will be added for each week the contractual delivery date is late from the Time for Completion of 31 Dec 2015. To date, we have not had view of the final JV contract but have assumed that this will be representative of the direct liquidated damage to the contractor for late delivery that is not attributable to risks addressed in the risk model.

This is consistent with the regret costs due to increased constraint costs for a two year delay in Link completion in the SKM Stage 2 Review (£170m). Constraint costs over short timescales will be subject to greater variation depending on load and generation requirements across the network.

The SKM Stage 2 Review illustrates constraints costs (including losses), shown in Figure 8 for the GG and SP scenarios (green and red lines) for successive delays by a year against the capital cost saving (dark blue dashed line) with a tolerance (blue shaded area) that gradually reduces due to discounting. This is representative of the selected tender which has a maximum capacity of 2.4GW.

Figure 8 – Cost Comparison for Delaying Commissioning (2.4GW Link)



Source: Western HVDC Link SKM Stage 2 Review Report Final

6.2.1 *Annual project milestones*

The programme proposed by NGET and SPT ("Western Link Construction Phase High Level Overview", "Project Development Plan update 2011 12 20" and "WHVDC Contract Prog 09032012") has been reviewed and appears reasonable to meet the contract completion date. This reflects the latest programme following the rejection of planning at the Kelsterton converter station site. NGET/SPT have indicated that they will review the project programme if required following the submission of a full planning application for the Kelsterton converter station site planned for May.

The programme critical path is key to identifying and mitigating potential bottlenecks and assessing the likely impact of delays. The following tasks are identified by NGET and SPT as being on the critical path:

- Civil construction of converter station at Hunterston
- Cable and converter station commissioning

We would also recommend that cable type testing, cable manufacture and deep water cable laying activities are included on the critical path.

The following annual project milestones are proposed based on the contracted completion date for the link and the proposed programme provided by NGET and SPT, by financial year. Please note that the milestones do not provide an indication of activity interdependencies.

Cables

2011/2012

- Appointment of key personnel.
- Kickoff meeting.
- Submit DIDs for cable manufacture and cable route onshore and offshore.
- Award Environmental Management Plan.

2012/2013

- Cable detailed design complete.
- Offshore surveys complete.
- Cable manufacturing commences.

2013/2014

- Onshore and offshore cable routing design complete.
- Nearshore cable installation complete.
- Onshore licensing, consenting and surveys complete.

2014/2015

- Full cable type registration obtained.
- All onshore cable manufactured.
- Deepwater cable-laying campaigns 1 to 2 complete.

2015/2016

- All cable manufactured.
- Deepwater cable-laying campaign complete.
- Onshore cable installation complete
- All installation and commissioning complete and operational.

Converters

2011/2012

- Kickoff meeting.
- Draft Kelsterton and Hunterston Converter DID
- Award Environmental Management Plan.
- Safety, Health, Environment (SHE) Design Risk Assessment complete.

2012/2013

- Issue DIDs.
- Complete HVDC design studies.

- Complete primary design and engineering.

2013/2014

- System design and civils design complete.
- All site investigations and enabling works complete.

2014/2015

- Detailed design of all electrical systems complete.
- All electrical equipment manufactured.
- Type registration of all electrical equipment complete.
- All civils at Kelsterton and Hunterston complete.

2015/2016

- Installation complete.
- Commissioning complete and operational.

6.3 Technical output measures

The selected Western HVDC link bid is a bipolar bi-directional HVDC scheme combining line commutated convertor (LCC) station technology with 600kV mass impregnated polypropylene laminate (PPL) cable technology to deliver a nominal 2.25GW continuous capacity and a 6 hour short term overload capacity of 2.4GW. The 6 hour short time overload capacity of 2.4GW is achieved with redundant cooling assuming a pre load condition of no more than 1920MW. After the 6 hour period, the link must revert to nominal rating (2250MW) or less.

For the SKM Stage 2 Review, SKM evaluated the CBA case for links with a 6 hour maximum rating between 2.0 and 2.4GW. This indicated a clear technical and economic benefit for increasing the boundary transfer capabilities of Boundary 6, Boundary 7 and Boundary 7A, for all background generation scenarios. The greatest benefit was achieved with the 2.4GW link. The selected Western HVDC Link design is consistent with the link capacity required to achieve the maximum expected boundary transfer benefits.

6.3.1 Proposed technical output measures

The following technical output measures are proposed for the link based on the boundary transfer requirements, the contracted link design and requirements of the AC transmission system. These are consistent with "WS5202814/LN/10 - Western HVDC Link Lot 3 – Converter & Cable, Employers Requirements – Technical Specifications" provided by NGET/SPT on the 3rd of February 2012 which gives further detail of technical requirements.

Suitable compliance tests will need to be developed to ensure that the following key technical specifications are achieved once the link is commissioned:

- The link shall be able to achieve 2250MW net continuous rating taking all link losses into consideration.
- The link shall be able to achieve a 6 hour short time overload of 2400MW for a pre load condition of no more than 1920MW. After the 6 hour period, the link must revert to the nominal rating of 2250MW or less.

- The solution and components offered will be capable of being type registered to comply with NGET/SPT requirements.
- The link shall be able to operate bi-directionally in line with the technical requirements.
- The reactive power consumption of the HVDC link shall be fully compensated during bi-polar and mono-polar operation in line with the technical specification requirements for reactive exchange with the system.
- Each of the HVDC converters at Hunterston and at Kelsterton shall remain operational and connected to the GB transmission system for a range of balanced and unbalanced faults.
- Harmonic filters will be designed and operated to meet network harmonic performance requirements under all operational configurations.
- Dynamic compensation at Hunterston has been designed and operated to support the network voltage from network faults.
- Control and protection shall comply with relevant National Grid Technical Specifications (NGTS) and National Grid Transmission Plant Specifications (TPS).
- Any sub-synchronous resonance torsional interactions between converter stations, series compensation and generators connected to the transmission system will be damped or eliminated through a damping controller connected to the HVDC control system.
- Power oscillation damping will be provided with the converter station to damp electromechanical oscillations between 0.4 and 0.8Hz.
- Converter station reliability and availability shall comply with NGTS 2.31 and its associated technical specifications with conditions as follows;
  - The Energy Availability (EA) shall not be less than 97% per annum;
  - The Scheduled Energy Unavailability (SEU) shall not be greater than 1.5% per annum;
  - The Forced Energy Unavailability (FEU) shall not be greater than 1.5% per annum;
  - The mono-polar outage rate shall not be greater than 5 per annum; and
  - The bipolar outage rate shall not be greater than 1 per annum.
- The risk of cable failure shall be no greater to less than one in ten years over the 40 years of anticipated link life.

The HVDC converter stations and their associated equipment and HVDC cables shall also comply with all the requirements specified in the Western HVDC Link Technical Specifications, all relevant National Grid Technical Specifications, Scottish Power Technical Specification and relevant British, European or International standards.

In the event that the 600kV HVDC MI PPL cable does not achieve type registration, NGET/SPT may accept the link and operate the cable at 500kV for which it is type tested. However, the continuous rating and short-term overload rating of the transmission link will be reduced. In this case, all technical output measures listed above remain relevant apart from the continuous rating and short-term overload rating.

6.4 Additional technology risks

The key technology risk for the Western HVDC Link is the HVDC cable. This is a 600kV 2400mm^2 mass impregnated (MI) polypropylene laminate (PPL) cable capable of delivering a nominal 2.25GW continuous and a 6 hour short term overload capacity of 2.4GW. The cable will be first of a kind and has yet to undergo type registration to ensure that its use on NGET/SPT electricity transmission systems is compliant with NGET/SPT technical and operational requirements and legal obligations. This includes demonstation that the cable capability has been properly assessed and that it is suitably designed for the environment in which it will operate.

Prysmian has advised that as for every mass impregnated paper cable, the most critical condition (due to the risk of a possible electrical breakdown) is during cable cooling after the cable has been heated to high temperatures and consequently only offer the cable if used in combination with the implementation of a voltage reduction scheme. Whilst PPL cables contain less compound than conventional MI and hence the risk of cable electrical breakdown is expected to be lower, the voltage reduction scheme was however considered prudent. The proposed voltage reduction scheme is a two stage process subject to preload. Where the preload is neither above 1920MW or the post load condition does not fall below 1600MW then voltage reduction does not apply.

NGET and SPT intend to implement the cable technology on the basis of a risk managed approach with extended Cigré type testing including verification testing and accelerated aging tests for long term performance of PPL. As a mitigation measure, should the cable not be able to meet the voltage requirements of 600kV then it could still be used at a reduced voltage (to which it is successfully type tested) and the whole link derated. A 500kV PPL link would be expected to have a continuous rating of circa 1.875GW and a 6 hour short term overload rating of circa 2GW. However, this may lead to the need for investment at other locations in the transmission system earlier than required for a link that meets specifications.

In terms of contractual arrangements, if the contractor delivers a link that is above a continuous rating of 1.8 GW but below 2.25GW/600kV then NGET/SPT may accept the link and recover liquidated damages for the reduced performance or may ultimately terminate the contract. If the link is not to specification and has a continuous rating of less than 1.8 GW then NGET/SPT may ultimately terminate the Contract and reject the link or negotiate a settlement for a reduced payment for the link if the resulting system still has value to all parties including consumers.

The approach that will be used to achieve voltage derating if required is not specified. Derating may be associated with system performance risks such as additional harmonics emission and it is not clear whether these risks have been identified and mitigated.

The link design solution proposes the same cable type and size from end to end both for the land section and offshore. This has advantages in that:

- No additional joints are required to provide the transition between two different sizes.
- Logistics & manufacturing are optimised.
- Lower losses due to larger than necessary cable, running at lower temperature.
- Large available design margin in the subsea section in particular which would allow for unexpected conditions.
- Optimised spares.

The disadvantage is increased cost as the cable size is prescribed by the shoreline sections and may be over-engineered for the offshore route.

The 600kV HVDC LCC converters of this capacity are a mature technology with marginal associated technical risk.

NGET/SPT have included a risk cost of £3.9m for new technology development which is in part due to additional testing and control requirements of the PPL MI cable as well as potential for enhancements or changes that may be required for design and includes:

- Optimisation of control system design
- Optimisation of filter performance and design
- Additional testing required during the design assurance process

However, this does not address the impact of delays on cable manufacturing and deep-water cable laying due to longer than expected cable type testing for example. Also, technology risks should be limited to risk associated with the Western HVDC Link and any technology risks associated with mitigating changes to the GB system should be sourced from business-as-usual funding arrangements.

The HVDC cable will be one of the largest subsea cables installed and this may require modifications to cable-laying equipment and horizontal directional drilling (HDD) equipment. Sea trials will be carried out to prove equipment with cable installation risks of this nature borne by the cable supplier.

It should be noted that there will be innovation benefits associated with the successful type testing and installation of a 600kV PPL MI cable and with the design of the control and protection systems for the transmission link that could be applied to future transmission links.

7. OUTPUT 6 – RECOMMENDATIONS ON BENCHMARKING OF HVDC COSTS

7.1 Overview of approach

This chapter sets out our recommendations on benchmarking of HVDC costs for wider application. The benchmarking of costs for HVDC transmission provide valuable metrics to industry for improved characterisation of costs and reduced uncertainty at feasibility and conceptual design stages. As part of this assessment we set out the following outputs:

- Consolidating high level information on costs and design of all viable bids/combinations, and applying this and own data sources in proposing unit cost benchmarks at component level (convertor stations, DC cables, harmonic filters etc.), onshore civil work, undersea cable laying and by applied technology (e.g. Voltage Source Converter, Current Source Converter).
- Benchmark unit costs in £m/MW for HVDC transmission links based on design of all viable bids/combinations and own data sources including consideration of cost sensitivity of specific project characteristics, and of design efficiency in achieving expected benefits. This will also include converter station benchmark costs (equipment and works) in £m/MW and HVDC cable costs (equipment and works) in £m/MW/km.

7.1.1 Component unit costs

HVDC link sizes with continuous ratings between 1.8GW and 2.25GW have been tendered for the Western HVDC link. Average unit costs for HVDC link cost components i.e. materials, civil works, design and project management, have been compiled from all bid price details (in pounds) for Lots 1, 2 and 3 and are provided in Table 19. Materials and civil works unit costs are broken out separately for HVDC converters, offshore and onshore cables.

Please note that unit costs have been calculated for all tendered link ratings from 1.8GW to 2.25GW (and across all tendered link voltages from 500kV to 600kV) and are based on continuous link ratings rather than 6 hour short term overload ratings. Unit costs have also been calaculated for link offerings at each tender stages and then averaged across all tendered link ratings and tender stages. This should provide unit costs that are broadly representative of a link within this range of capacity. Unit cost variability provides a metric for possible variation around the average unit cost based on assessment of bid price details for the link. This captures unit cost variability due to different link ratings and voltages, manufacturers etc. Unit cost sensitivities and the design efficiency of the WHVDC link are considered in more detail below.

HVDC converter station unit costs are given per pair of bipole converter stations (for bipole converter stations at either end of the WHVDC Link). The unit cost per bipole converter station can be obtained by dividing this unit cost by 2.

HVDC cable unit costs are given per km based on 386km of offshore cable and 34 km of onshore cable for the Western HVDC Link as indicated by NGET/SPT. The HVDC cable for the Western HVDC Link comprises two conductors for bipole system configuration so all unit costs for cables are given per bipole or per pair of cables.

[redacted]

Please note that the applicability of offshore and onshore cable materials unit costs will be influenced to an extent by the volatility of the price of copper and steel etc. as metals are a large component of the cable materials cost. Cable materials costs account for 40-50% and 50-70% of onshore and offshore cables, respectively for the WHVDC Link. Onshore cables will require jointing bays every 500 to 1000m which will influence the unit cost for oshore cable materials and civil works. The number of onshore cable jointing bays per km was not available.

Unit costs for offshore cable-laying (contained within offshore cable civil works unit costs) will be highly coupled to the features of the cable route such as seabed terrain which will determine the techniques that can be used for cable trenching and protection as well as cable lay configuration (burial in a common trench or in twin trenches). Offshore cable-laying is a mix of spaced and close laying for the Western HVDC Link.. Any rock cutting will increase costs and there may be additional costs associated with any modifications required to cable lay vessels and/or trenching and burial equipment. Unit costs will increase for short cable lengths due to fixed costs such as vessel mobilisation/demobilisation which are independent of cable length.

The unit cost of onshore civil works for onshore cables and converter stations will be dependent to an extent on the specific details of the site. Unit costs for onshore cable installation will be dependent on ground conditions and number of jointing bays which is not closely coupled to link capacity but rather cable type. Mass Impregnated (MI) cables are much more time consuming and expensive to joint than XLPE cables and require a cable joint approximately every 750m onshore. Onshore cables are located in the same trench for the Western HVDC Link.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

7.1.1 *Total unit costs*

Total HVDC converter and cable unit costs have been calculated and are given in Table 20. This is inclusive of all design, project management and civil works costs for HVDC converters, offshore cables and onshore cables to give an indication of total unit cost per major equipment item. We have also provided our benchmark unit cost range based on HVDC LCC technology and MI HVDC cables. These TNEI benchmark costs are based on confidential communications with manufacturers, costs for recent similar projects such as Britned, review of publically available unit cost measures such as the 2010 Offshore Development Information Statement[20] and TNEI in-house experience with HVDC transmission equipment and works. However, it should be noted that cable materials cost data is based on extrapolation from lower voltages and capacities as the WHVDC Link has a higher operating voltage and rating than previous subsea transmission links.

Please note that materials unit costs for HVDC converter substations are generally inversely proportional to the rating as shown above. Converter materials costs are the largest cost element and comprise approximately 60% of the total cost so this dependency will also influence total unit cost to an extent for varying converter ratings. Converter station civil works unit costs have a similar dependency.

Cable materials unit costs and civil works unit costs for the WHVDC Link are not highly coupled to cable rating in the range assessed, as shown in Figure 10 for cable materials unit costs. HVDC cable benchmark unit costs are also provided in £m/km in Table 20, this metric will vary depending on the complexity of offshore cable-laying activities (routing, cable lay configuration) as installation costs can be between approximately 20 to 50% of the total cost.

[20] National Grid, 2010 Offshore Development Information Statement, 2010.

It should be noted that the HVDC cable has been sized based on the horizontal direct drilling (HDD) section of the route at landfall which has the most thermally onerous conditions. Thus, the offshore HVDC cable has been oversized which increases cost and is a less efficient design. However, it does provide additional margin for uncertainties in the offshore cable routing which may lead to higher than assumed thermal resistivity, and removes the requirement for a transitional joint (which would be new technology not yet designed) between the offshore and onshore cables.

Unit costs for onshore cables are also presented in £m/km, installation costs are highly dependent on the onshore cable route and associated planning and consenting costs which can be a major cost element. This metric will vary depending on the complexity of the route and planning and consenting issues.

Unit costs compiled for the Western HVDC Link and the TNEI benchmark unit costs generally show good agreement. It should be noted that TNEI benchmark costs for cable materials are based on extrapolation from lower voltages and capacities. Comparison of WHVDC onshore cable unit costs are somewhat higher than TNEI benchmark costs, these costs can be sensitive to onshore planning and consents, ground conditions, laying details. This comparison provides some cross-verification of WHVDC Link unit costs and TNEI benchmark unit cost ranges as well as increased resolution of unit costs for future cost estimates. It is recommended that the WHVDC Link unit costs are adopted as benchmark unit costs representative of HVDC transmission links within the range of 1.8 to 2.25GW continuous rating. However, the applicability of these benchmark unit costs should be limited to transmission links of a similar magnitude rating and voltage with comparable offshore and onshore cable routing conditions otherwise there will be increased uncertainty.

[redacted]

A comparison of benchmark unit costs for HVDC LCC and VSC technology is provided in Table 21. This includes a comparison of MI HVDC cables and XLPE cables suitable for HVDC LCC and VSC transmission technology respectively. Unit costs were based on costs for HVDC link capacities in the magnitude of 2GW and 500kV to 600kV. HVDC LCC unit costs are associated with less uncertainty because HVDC LCC converter technology at this rating and MI PPL cables close to this rating are commercially available and thus costs are more defined. HVDC VSC converter and XLPE cable technology unit costs are projections of unit costs based on active projects at lower ratings and future technology developments and are indicative only. Unit costs are comparable however HVDC LCC is the only technology commercially available at this capacity in the timeframe of the Western HVDC Link construction.

Project costs for recent subsea transmission projects using HVDC LCC technology are given in Table 22, based on publically available information. This provides a useful comparison to costs for the Western HVDC Link although there will be a dependence on seabed conditions and cable metal costs. For example, both COMETA and SAPEI involved subsea cable laying at water depths greater than 1000m. Also, the transmission links are less than half the capacity of the Western HVDC Link. The cable contract price for all projects also includes a small proportion of onshore cable costs.

Table 21 – HVDC Converter and Cable Technology (2010/2011 price base)

Total Costs	Range
HVDC VSC Converter Stations Unit Cost (£m/GW)	100-200
HVDC LCC Converter Stations Unit Cost (£m/GW)	150-170
Offshore XLPE Cable Unit Cost (£m/km) (bipole)	1.5-2.3
Offshore MI Cable Unit Cost (£m/km) (bipole)	1.7-2.5

Table 22 – HVDC LCC Offshore Transmission Projects - Examples

Project Name	Capacity (GW)	Offshore Cable Length (km)	HVDC Cable Contract	HVDC Converter Contract	Contract Price Base	Total Cost	Year of Completion
Cometa bipole	0.4	250	€267m	€100m	07/08	€375m†	Est. 2012
Sapei bipole	1	420	€400m	US$180m	06/07	€750m‡	2011
Britned bipole	1	244	US$350m	€220m	07/08	€600m‡	2011
Fenno-Skan 2*	0.8	200	€150m	US$170m	08/09	€315m‡	2011
WHVDC Link bipole	2.25	386	[redacted]	[redacted]	11/12	[redacted]	Est. 2015

† Total contract price (in 2007/08 price base)
‡ Total outturn price (forecast outturn for WHVDC Link in 2009/10 price base)
* single cable

8. OUTPUT 7 – IDENTIFICATION OF ANY LIMITATIONS IN THE RECOMMENDATIONS

In this chapter we have identified any limitations in the recommendations. Whilst we have endeavoured to ensure we capture all relevant information and data required to provide Ofgem with a comprehensive and robust assessment covering all aspects of this work; in the short timeframes for the project we were reliant on the nature of cooperation and information provision provided by the relevant TOs (NGET and SPT). We undertook this assessment through:

- identification of relevant information gaps at the Project Kick Off meeting, with reference to previous assessments of the WHVDC link and related data/information;
- discussion around pre-identified key issues with NGET and SPT at two workshops at NGET in Warwick; including identification of key documents, tools, information and data we wished to obtain and have access to;
- associated Q&A process initiated from the first workshop in the light of discussions, our own analysis and emerging issues we wished to clarify/resolve.
- identification (within the Interim Report) of relevant information gaps at the time of the delivery of the Interim Report – which we then sought to address with NGET/SPT via Q&A process before our information provision deadline set as 14 Mar prior to completing our Final Report .

By the time of the 14 March cut-off date the outstanding information gap and the impact it had on our assessment and resulting recommendations for the relevant affected Outputs was as follows:

- We had not received requested set of self-consistent risk profile information based on updated/best knowledge as of early March - accounting for Kelsterton and Hunterston planning application decisions and related amendments to contract subsequently signed 16 February; as well as an error we identified in the risk modelling – similar to that provided for January 2012 position
- Consequently our assessment in Section 2.3 is based on the complete self-consistent set of information and data for the position as at January 2012 received from NGET in February and a partial set of updated information provided by NGET on 18 February.
- Our assessment of funding levels in Section 5 are also undertaken on this basis but also including a further adjustment that we have made for correction of an apparent error in the calculation of employer risk for cable burial, which we believe should be £2m lower (as identified in Section 2.3).
- Changes to risks exposure and associated costs post the Kelsterton planning application rejection which we believe represents the most material change to the January 2012 risk profile were captured in the incomplete material received from NGET on 18 February and additional information received by us before the 14 March deadline. The movement in the P=50 risk-related cost was circa £2m before our further adjustment for the model error for cable burial.
  - This indicates that the materiality of difference between risk related costs as presented 18 February 2012 versus that which might be expected as at March 2012 in the light of updated information will be very low. Specifically it suggests <£2m in absolute magnitude as measured at the P=50 point on the risk related cost distribution. This is <0.2% of overall cost of delivery of HVDC component of WHVDC link costs material provided; and barely measurable in the context of combined SPT and NGET RIIO-T1 capex programmes.

Thus we believe this information “gap” and our use of information as at 18 February does not have any impact on our assessment of the procurement process (Output 2), determination of funding approach (Output 3), assessment of milestones (Output 5) or benchmarking of costs (Output 6).

As indicated above we also believe it does not have a material impact on our assessment of costs (Output 2), our recommendations on the methodology to be adopted for determining funding and risk sharing arrangements (Output 3) or the (provisional) ex ante funding allowances derived from application of that methodology to the data available as of 14 March 2012 (Output 4)especially if viewed from the perspective of setting an annual funding profile for each of the two TOs within the WHVDC link joint venture across the full project timeframe.

Consequently we believe our recommendations within this report including those for annual funding are robust to a reasonable level of accuracy, with the following conditions:

- If Ofgem wishes to pursue accuracy to the £10k level (or tighter) of risk-related costs at the P=50 point in ex-ante setting of agreed funding arrangements for the WHVDC link it will need to make minor adjustments to our provisional recommendations for annual funding figures.
- Also we are aware the contract NGET/SPT have put in place had a limited number of variable elements due to be locked down in early March; and it may be possible these change the contract cost from that we have used based on 18 February information and that Ofgem may need to adjust accordingly in determining final funding allowances[21].
- Where Ofgem chooses to apply a determination based on an updated set of information/data on final contract cost and view of risk-related costs we advise this is done based on a designated data freeze date; and any subsequent variations are captured by the agreed risk sharing mechanism (and if required) relevant reopener conditions.

[21] Indeed, we note that on 9 March 2012, the JV provided an updated view of contract costs (but not of non-contract costs and hence not a coherent data set for basing our recommended allowances on), although these were subject to further change.

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