Cost Benefit Analysis Model

The Final Cost Benefit Analysis (CBA) Recommendation

The **Final Recommendation** for the 33kV submarine electricity cable between **Aultbea and Ullapool** is Option 1A:

- Cable surface laid on the seabed – Approximately 1.5km
- Split pipe protection on both shore ends – Approximately 0.4km
- New cable is decommissioned at end of economic life

The **Final CBA Recommendation** scenario has an overall societal value of **minus £10,394,655.** This includes consideration of impacts on health and safety, socio-economic, environmental and wider economic and engineering impacts.

It should be noted that the final **Project Description** may not fully reflect the CBA recommendation which is developed to inform the design process and highlight where societal value is impacted. Any deviations from the CBA recommendation will be justified within the engineering design and reflected in the project description. Also given the granularity of the CBA model it is not possible to model exact lengths of protection which may be included in the project description and therefore results give indicative results of a generic installation approach.

The final recommendation is the preferred installation method, given the information available from the Cable Burial Risk Assessment (CBRA), On Bottom Stability Study (OBSS) and when considering the National Marine Plan. The preferred option has the highest value to society against all other modelled options and includes for shore end protection. The shore end protection has been determined to be essential for the mechanical protection of the cable in prolonging cable life. This solution also takes into consideration views of stakeholders.

Introduction

Scottish Hydro Electric Power Distribution plc (SHEPD) holds a licence under the Electricity Act 1989 for the distribution of electricity in the north of Scotland including the Islands. It has a statutory duty to provide an economic and efficient system for the distribution of electricity and to ensure that its assets are maintained to ensure a safe, secure and reliable supply to customers.

As part of this remit, it has identified a need to reinforce the network between Aultbea and Ullapool. Within this project there is the requirement to install a new submarine cable across Loch Broom to connect the networks which serve Aultbea in the South and Ullapool in the North. The submarine cable element of the project is essential in ensuring project success.

As such this CBA model has been developed to help select the way in which the new submarine electricity cable should be installed in the marine environment across Loch Broom. The model was designed to help identify the best value method of cable installation, burial, protection, inspection and maintenance which satisfies all current legislation. It allows modelling of the perceived material risks and impacts at this point in the project.

Background

SHEPD collaborated with stakeholders to develop the CBA model. The model helps SHEPD understand the impacts that different engineering decisions around cable installation can have on the safety of mariners, energy costs for communities we serve, on local and national economic activity and on the natural environment[1].
The CBA Model allows us to make informed judgements guided by a clear set of values - ensuring that every decision is as ethical, responsible and as balanced as it can be. The CBA model assigns financial values across the following key categories for each cable installation method and design[2]:

- Health and safety
- Socio-economic
- Environmental
- Wider economic and engineering

These values are then aggregated to estimate the **'societal value[3]'** of each solution. The best value[4] solution becomes the option that we recommend in this summary.

Approach taken to arrive at the final recommendation

The starting point for the CBA process is Scotland's National Marine Plan (NMP) (2015) which highlights the following policies, in Chapter 14, which need to be considered on a case by case basis for reaching a decision regarding the development and activities involved in installing a submarine electricity cable:

Factor 1:	Cables should be suitably routed to provide sufficient requirements for installation and cable protection.
Factor 2:	New cables should implement methods to minimise impacts on the environment, seabed and other users, where operationally possible and in accordance with relevant industry practice.
Factor 3:	Cables should be buried to maximise protection where there are safety or seabed stability risks and to reduce conflict with other marine users and to protect the assets and infrastructure.
Factor 4:	Where burial is demonstrated not to be feasible, cables may be suitably protected through recognised and approved measures (such as rock or mattress placement or cable armouring) where practicable and cost-effective and as risk assessments direct.
Factor 6:	Consideration of the need to reinstate the seabed, undertake post-lay surveys and monitoring and carry out remedial action where required.

Based on the need to comply with the Scotland's National Marine Plan the following three phases of work with regards to the CBA model have been carried out as part of this marine licence application.

[1] For details of why and how the Cost Benefit Analysis Model was created see http://news.ssen.co.uk/media/266234/CBA-Model-Statement-Executive-Summary.pdf
[2] The Submarine Electricity Cables Cost Benefit Analysis Method Statement can be found here: https://www.ssen.co.uk/CBAFULL/
[3] Societal value is the cost or benefit to society which includes the private costs / benefits plus any external costs / benefits. Private costs / benefits in the CBA model would be regarded as the Economic and Engineering category and the external costs would be noted as the Health and Safety, Socio-economic and the Environment categories.
[4] We define best value as the method(s) of installation which satisfy all current legislation and provides a sustainable balance of economic, safety and wider social and economic impacts, but which is not always lowest cost.

Phase one:

Phase one draws on the initial burial assessment[5] and the ScotMap National Marine Plan Interactive Map to address Factor 1 and identify a suitable route against which the impacts included within the CBA model categories can be compared. The CBA model[6] is then used to identify the **Burial Scenario** using our three[7] recognised burial methods and to provide evidence to address Factor 3 (cables should be buried to maximise protection where there are safety or seabed stability risks and to reduce conflict with other marine users). The output of this phase of analysis is described as the **Burial Scenario**.

This looks at the parameters which permit different types of installation. Each scenario is developed based on the installation methods permitted by the seabed type and depth of sediment. At this point only one method is applied within each section of the model.

Phase two:

Hybrid solution(s) are then modelled which include elements of both burial and protection that are feasible. A process of engagement is then conducted to identify if these scenarios are practicable and cost effective.

This phase seeks to address Factor 2 (a method to minimise impacts on the environment, seabed and other users) and Factor 4 (where burial is demonstrated not to be feasible, cables may be suitably protected where practicable and cost-effective and as risk assessments direct).

A process of engagement is then conducted to identify if these scenarios are practicable, cost effective and address the possible risks. The **Final CBA Recommendation** will then be made for the scenario which represents the overall best value solution.

Phase three:

Hybrid solution(s) are refined and then entered into the CBA model to obtain estimated societal value. During the phase three analyses a sensitivity analysis is carried out on key assumption to understand how the value of impacts may vary.

The **Final CBA Recommendation** will then be made for the scenario which represents the overall best value solution.

Based on the process of engagement, including the pre applications consultation events, the phase 1 and 2 solution(s) can be refined and then entered into the CBA model to obtain estimated societal value. During phase three a sensitivity analysis is carried out on key assumptions to understand how the value of impacts may vary. Phase three also provides the evidence base to support consideration of Factor 5 which examines the need to reinstate the seabed, undertake post-lay surveys and monitoring and carry out remedial action on an ongoing basis. The **Final CBA Recommendation** will then be made for the scenario which represents the overall best value solution.

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[5] The initial burial assessment is the output of the process which SSEN has carried out in conjunction with stakeholders to identify a suitable route and obtain the required environmental surveys of the seabed and benthic habitats on which to carry out the cost benefit analysis.

[6] The CBA tool methodology is available at http://news.ssen.co.uk/submarinecables/information/

[7] The three methods commonly used by the industry to install cables are: Ploughing, Jetting and Mass Flow Excavation. A forth installation method of horizontal directional drill (HDD) - can be used on submarine electricity cables shorter than 2km in length.

Modelling Aultbea - Ullapool Submarine Cable

Nine different CBA models, including the baseline, have been developed across the three phases to identify the best value solution. Recent survey data indicates that there is no potential to bury the cable along the proposed route.
From a technical and operational perspective, the following parameters (used in the cost benefit analysis following agreement with stakeholders) identify where burial is achievable by:

- Jetting and Mass Flow Excavation where there is a minimum sediment depth of 1.5 metres for 50 metres along the seabed
- Ploughing where there is a minimum sediment depth of 2 metres for 500 metres along the seabed

The above statements indicate where it is deemed feasible to undertake burial activities using the stated methods as part of the CBA. The depths indicated do not represent the depths at which a cable must be covered to be deemed "buried" as part of the analysis. The minimum depth of cover which is required to deem the cable "buried" is where the top of the cable is covered by layers of sediment no less than 0.6m deep.

The CBRA and OBSS will provide recommended minimum depths of burial/cover at given locations along the route based upon the perceived risks to the cable and marine users. For the purposes of the CBA, cable burial of 0.6m or greater will be deemed "Buried". Any depth shallower than 0.6m will be deemed as surface laid.

These depths of sediment have not been found to be present along this route and therefore no burial scenarios have been considered.

The outputs from the CBRA have also determined there to be low risk to the cable from anchor strike and fishing and that the installed cable presents a low risk to marine users.

From initial site investigations it has been confirmed that split pipe protection will be required on both shore ends, for all installation scenarios. This will provide additional protection in the inshore area and minimise damage from abrasion. This will also increase cable stability. As such, all install scenario models show split pipe protection on both shore ends. Due to the confirmation that split piping will be required, this has been taken as the base case scenario in which to compare all other options. The base case shows both shore ends with split pipe protection with the remainder of the cable being surface laid.

Aultbea - Ullapool: Phase one

The input to phase one of the CBA analysis was standalone installation assessments for the Aultbea - Ullapool cable. This involved only 1 scenario which was split piping on both shore ends with the remainder of the cable to be surface laid along the route, this option is the same as the baseline. This has occurred as there is no existing cable installation to compare against but is the minimum required level of protection on the cable install.

Based on survey work undertaken by the project team in this area the seabed has been judged to be largely made up of a thin layer of mud and sand with gravel and boulders.

Table 1 Standalone protection method evaluation

Option	Scenario Methods	Total Societal Value	Net change (£)	Net Change (%)
Basecase	0.4km of split piping (20.73%) 1.5km of surface lay (79.27%)	-£10,394,655	£-	
1A	0.4km of split piping (20.73%) 1.5km of surface lay (79.27%)	-£10,394,655	£-	0%

Scenario 1A presented in Table 1 has is the same as the base case and therefore there is no net change between this option and the base case. No burial options were considered due to insufficient sediment along the route.

Aultbea - Ullapool: Phase two

Phase two of the analysis then sought to identify scenarios beyond the initial assessment scenarios (Phase 1 output) where surface lay with split piping was the only consideration, by adding additional protection which may be practicable, cost-effective and address marine user and cable risk.

Table 2 provides an overview of the 5 scenarios that were considered in this phase of the analysis.

Table 2 Practicable and cost-effective burial and protection scenarios

Option	Scenario Methods	Total Societal Value	Net change (£)	Net Change (%)
Basecase	0.4km of split piping (20.73%) 1.5km of surface lay (79.27%)	-£10,394,655	£-	
2A	0.4km of split piping (20.73%) 0.2km of rock bagging (10.36%) 1.3km of surface lay (68.91%)	-£11,417,128	-£1,022,472	10%
2B	0.4km of split piping (20.73%) 0.2km of rock bagging (10.36%) 0.2km of concrete mattress (10.36%) 1.1km of surface lay (58.54%)	-£12,380,593	-£1,985,938	19%
2C	0.4km of split piping (20.73%) 0.4km of rock bagging (20.73%) 1.1km of surface lay (58.54%)	-£12,439,600	-£2,044,945	20%
2D	0.4km of split piping (20.73%) 0.2km of concrete mattress (10.36%) 1.3km of surface lay (68.91%)	-£11,358,121	-£963,465	9%
2E	0.4km of split piping (20.73%) 0.4km of concrete mattress (20.73%) 1.1km of surface lay (58.54%)	-£12,321,586	-£1,926,931	19%

^The net change is compared to the baseline assumption of the existing cable.

Within the five scenarios considered in Table 2, no scenarios provided a reduction in the societal value of the baseline installation. Option 2D is the closest to the baseline from the initial assumptions. Throughout the design stage of this project the design analysis has assessed that the cable should be stable and with low risks

from fishing and anchors minimal levels of cable protection are anticipated to be required. As such, the scenarios presented in section two are believed to sufficiently cover potential additional protection requirements for the purposed of this protection CBA analysis. This also incorporated stake holder feedback who have raised no concerns with the proposed cable route design.

None of the scenarios within phase two of this analysis improve upon the societal value from option 1A (Basecase).

The process of identifying risks was carried out during a number of stakeholder events and will be summarised within the *Pre-Application Consultation Report*. Additionally, risks have been based upon historic projects and SHEPD's previous experience in carrying out submarine cable installations.

The **Scenario** which is deemed the most suitable for installation following phases 1 and 2 was:

Option	Scenario methods
1A	0.4km of split piping (20.73%) 1.5km of surface lay (79.27%)

It should be noted that there may be engineering justification to stabilise the cable which could require additional rock bag or concrete mattresses to prevent the cable from excessive movement, however it is not anticipated to be required at this stage of the project design. Any further requirements will be detailed in the project description.

Aultbea - Ullapool: Phase three

The best solution(s) are refined and challenged to identify the best value solution using the societal value as an indicator of value before a **Final CBA Recommendation** was made.

Sensitivity analysis was conducted to help identify the key variables which have a major influence on the cost and benefits of a submarine electricity cable project. These are:

- Age: Life expectancy of the cable
- Full life cycle costs
- Social costs
- Decommissioning costs
- Health and safety risk

The sensitivity scenarios took the best option from Phase 1 & 2 and then applied variances in the predicted lifecycle of the new cable.

Table 3 shows the impact of an increase or decrease in the life expectancy of Option 1A. Currently any protected section of cable is predicted to last 45 years, with all unprotected (surface laid) sections predicted to last 25 years which may not be the case after installation.

Table 3 Sensitivity testing

Option	Scenario methods	Total Societal Value	Net change^ (£)	Net Change^ (%)
Baseline	0.4km of split piping (20.73%) (45 year) 1.5km of surface lay (79.27%) (25 year)	-£10,394,655	£-	
3A	0.4km of split piping (20.73%) 1.5km of surface lay (79.27%) **[Life expectancy of whole cable - 25 years]**	-£10,394,655	£-	0%
3B	0.4km of split piping (20.73%) 1.5km of surface lay (79.27%) **[Life expectancy of whole cable - 45 years]**	-£9,591,741	£802,914	-8%

^The net change is compared to the baseline assumption.

It was noted that by reducing the sections with split pipe to a 25 year life expectancy the overall societal value remained the same, this being due to over all the cable was anticipated to last 25 years due to the unprotected sections. However, it is reasonable to assume that the life expectancy of the new cable would be extended beyond the standard 25-year design life as the cable route has been properly engineered with adequate protection placed on the cable in areas where damage would usually be anticipated, such as cable shore ends.

Therefore, by protecting the vulnerable areas of the cable, which are then anticipated to last 45 years, the whole cable in fact should last this anticipated time. Given cable route engineer indicates no additional protection or stabilisation is required for the other sections of the cable route. Therefore, the unprotected sections (surface laid) are also modelled to last 45 years in option 3B. The 25-year design life of a cable assumed a full surface laid install.

Interpretation of results

Phase one of the CBA model shows surface laying the new Aultbea to Ullapool submarine electricity cable, with both shore ends protected by split piping. This scenario is taken to be the baseline option given the requirement for shore end protection and having no existing install to compare against.

Phase two shows combinations of protection scenarios in compliance with the National Marine Plan hierarchy of installation and the need to consider the views of other stakeholders and marine users. After these considerations the CBA shows Option 1A to still have the lowest cost to society.

When applying sensitivity testing to Options 1A in phase three, the impact of an increase or decrease in expected lifecycle shows option 1A could have a lower cost to society than anticipated should cable protection of the shore ends extend the whole cable life to 45 years.

To date SHEPD do not currently have any cables which have been protected for a period of 45 years to confirm if this assumed life expectancy is reasonable. However, with the majority of existing subsea cable installs across SHEPD mainly being surface laid and having lasted on average 25 years, it is reasonable to assume that a new cable with more mechanical protection could have an extended life expectancy. These assumptions have been considered when concluding the recommendation from the CBA.

Recommendation

The CBA model considers the societal value of different installation methods for the Aultbea - Ullapool submarine electricity cable. We understand that other externalities not modelled need to be considered. These include marine planning policy, final engineering design requirements including shore end protection and the cumulative impact of our submarine electricity cables on other legitimate marine users.

Therefore, SHEPD propose that option 1A, 0.4km of split piping (both shore ends protected) and 1.5km of surface lay is put forward for final design consideration.

As stated previously, there may be the requirement for additional protection for stability of the cable, but any requirement will be detailed in the project description.