Scottish & Southern Electricity Networks

Cost Benefit Analysis Model

The Final Cost Benefit Analysis (CBA) Recommendation

The **Final Recommendation** for the 33kV submarine electricity cable **Mainland Orkney – Hoy Centre** is Option 2A:

- Cable surface laid on the seabed – Approximately 4.32km
- Split pipe protection carried out at shore ends – Approximately 0.4km
- Rock filter bags installed for cable stabilisation – Approximately 0.05km*
  **Length of cable covered, not length of cable stabilised*
- Concrete Mattresses installed for cable stabilisation and cable crossings – Approximately 0.1km**
  ***Length of cable covered, not length of cable stabilised*
- No decommissioning carried out on the existing cable
- New cable is decommissioned at end of economic life

This was deemed to be the best value solution based on the available information:

The **Final CBA Recommendation** scenario has an overall societal value of **minus £9,542,136.** This includes consideration of impacts on health and safety, socio-economic, environmental, and wider economic and engineering impacts.

It should be noted that the **Project Description** and final engineering design may not fully reflect the CBA recommendation which is developed to inform the design process and highlight where societal value is impacted. The granularity of the CBA model does not permit modelling of exact lengths of protection which may have been identified in the project description and therefore the results output provides indicative results of similar install scenarios.

The final recommendation is the preferred installation method, given the information available from the cable route engineering, On Bottom Stability Study (OBSS) and when considering the National Marine Plan. The preferred option has a lower value to society that some of the other options, but based on the information available at the point of modelling allows for protection & stabilisation of the cable and includes shore end protection which has been determined to be essential for the mechanical protection of the cable in prolonging cable life, although it does have an impact on the societal value of the solution. This solution also takes into consideration views of stakeholders and anticipated licence requirements regarding limits on water depth alteration.

Introduction

The Mainland Orkney – Hoy Centre submarine cable has been identified as being in a Critical condition during SHEPD submarine cable inspections. Various options have been considered to rectify the critical conditioned cable including attempting a future piece in repair should the cable fault or replacement prior to such an event, with the latter being deemed the only viable option for this specific cable.

As such this CBA model has been developed to help in selecting how the replacement submarine electricity cable will be installed in the marine environment. 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:

- Cables should be suitably routed to provide sufficient requirements for installation and cable protection.
- 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.
- 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.
- 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.
- 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.

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[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:

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, cost effective.

Phase three:

Hybrid solution(s) are refined and then entered 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.

Modelling Mainland Orkney – Hoy Centre

12 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 any of the cable along the proposed route, except for the onshore sections back to the onshore network connection point. The baseline option is of the current installation which is approximately 200m shorter than the new proposed route.

Mainland Orkney – Hoy Centre: Phase one

The input to phase one of the CBA analysis was standalone installation assessments for the Mainland Orkney – Hoy Centre cable. This involved only 1 scenario which was 100% of the route to be surface laid.

Based on the initial outputs of the route surveys it has been determined that there is insufficient sediment depth to allow for burial of the proposed subsea cable. The route is more fully described in the Project Description.

Therefore, within phase 1, a single scenario of 100% surface lay of the new proposed cable and route has been modelled.

Table 1 Standalone protection method evaluation

Option	Scenario Methods	Total Societal Value	Net change (£)	Net Change (%)
Base	Baseline Surface lay 100% (the installation method used for the cable we are replacing)	-£4,195,679	£ -	-
1A	Surface lay 100%	-£4,843,473	-£647,794	15%

The scenario presented in Table 1 has an increased length over the baseline which accounts for the majority of the decrease in societal value verses the existing baseline installation. There is an increase in the cost to society with a net change of 15%.

Mainland Orkney – Hoy Centre: Phase two

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

Table 2 provides an overview of the 7 scenarios that were considered in this phase of the analysis.

Table 2 Practicable and cost-effective protection scenarios

Option	Scenario Methods	Total Societal Value	Net change (£)	Net Change (%)
Baseline	Baseline Surface lay 100% (The installation method used for the cable we are replacing)	-£4,195,679	£ -	-
2A	No Burial 0%, Rock Bagging 1.03%, Mattressing 2.05%, Split pipe both shore ends 8.22% & Surface lay 88.70%	-£9,542,136	-£5,346,457	127%
2B	No Burial 0%, Rock Bagging 2.05%, Mattressing 1.03%, Split pipe both shore ends 8.22% & Surface lay 88.70%	-£9,396,261	-£5,200,582	124%
2C	No Burial 0%, Rock Bagging 1.03%, Mattressing 4.19%, Split pipe both shore ends 8.22% & Surface lay 86.56%	-£10,406,367	-£6,210,688	148%
2D	No Burial 0%, Rock Bagging 4.19%, Mattressing 2.05%, Split pipe both shore ends 8.22% & Surface lay 85.54%	-£10,372,566	-£6,176,888	147%
2E	No Burial 0%, Mattressing 2.05%, Split pipe both shore ends 8.22% & Surface lay 89.73%	-£9,140,256	-£4,944,578	118%
2F	No Burial 0%, Split pipe both shore ends 8.22% & Surface lay 91.78%	-£8,177,006	-£3,981,327	95%
2G	No Burial 0%, Mattressing 6.24%, Split pipe both shore ends 8.22% & Surface lay 85.54%	-£10,967,737	-£6,772,058	161%

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

Within the seven scenarios considered in Table 2, no scenarios provided a reduction in the societal value of the baseline installation or when considered against option 1A (100% surface lay with new longer route). Following on from detailed design investigation it has been confirmed that split pipe protection will be required on both shore ends to protect the cable from damage due to abrasion. Additionally, this split piping will stabilise the cable.

The cable on bottom stability study (OBSS) also confirms that the proposed cable installation is deemed to be unstable, therefore stabilisation will be required to prevent movement of the installation. This eliminated option 2F as a plausible install method.

Additionally, given the water depth along the proposed route, rock bags are also not feasibly in many locations as they have the potential to alter the depth by 5% or more. Therefore, concreate mattresses are proposed as a substitute where rock bags may have been considered.

When comparing options 2A and 2B I can be seen that higher percentages of mattresses have a higher negative effect on the overall societal value when compared with rock bags. However, in this installation location, higher percentages of mattresses cannot be avoided.

Based on the OBSS and the challenges associated with insufficient sediment for burial and the likelihood of exceeding the change in water depth by more than 5% if using rock filter bags for stabilisation along most of the route, Option 2A represents most closely, the level of protection/stabilisation which is recommended from the OBSS and engineering studies. Although not the best societal value it is the best engineering and feasible solution in this location.

Option 2E could have been considered, which would have provided a higher societal value, however rock filter bags will be required at the ends of the split pipe protection and therefore cannot be removed completely as per option 2E's proposal.

Stakeholder consultation has also informed this process, this feedback has been summarised within the *Pre-Application Consultation Report*.

The **Scenario** which is deemed the most suitable for installation was:

Option	**Scenario methods**
2A	No Burial 0%, Rock Bagging 1.03%, Mattressing 2.05%, Split pipe both shore ends 8.22% & Surface lay 88.70%

Mainland Orkney – Hoy Centre: 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** is 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 and a consideration of decommissioning the existing install as well as measuring the effects on societal value that the new increased cable length will have.

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Table 3 shows the impact of an increase in the life expectancy, effects of decommissioning the existing cable and the effects increasing the cable life has against the baseline. Currently any protected section of cable is predicted to last 45 years with unprotected sections lasting as long as the current install. In reality the whole cable will likely last the length of time of the protected sections, as based on the engineering analysis and design the protected areas are the areas most at risk of damage. Unprotected sections are less likely to be damaged, so options 3A looks at modelling all sections of the cable with a life expectancy of 45 years as per the protected sections. Option 3B considers the inputs of option 2A but looks at what societal benefit is lost or gained if the existing cable is decommissioned. Finally, due to the new installation predicted to be longer than the existing install, option 3B shows what effect this additional length has on societal value by taking option 1A and modelling the new cable type but with the original cable length.

Overall, there is an increase in the societal value, as expected, if the cable life is extended.

It is reasonable to assume that the life expectancy of the new cable could be extended beyond the current installed cable, which is 38 years old, when considering that the existing cable was installed with no protection or stabilisation and that the route would not have been micro routed for the optimum cable lay location along the route.

Table 3 Sensitivity testing

Option	Scenario methods	Total Societal Value	Net change^ (£)	Net Change^ (%)
Baseline	Surface lay 100% (The installation method used for the cable we are replacing)	-£4,195,679	£-	
3A	No Burial 0%, Rock Bagging 1.03%, Mattressing 2.05%, Split pipe both shore ends 8.22% & Surface lay 88.70% **[Life expectancy of whole cable - 45 years]**	-£9,082,432	-£4,886,754	116%
3B	No Burial 0%, Rock Bagging 1.03%, Mattressing 2.05%, Split pipe both shore ends 8.22% & Surface lay 88.70% **[Decommission existing cable]**	-£10,158,688	-£5,963,009	142%
3C	Surface lay 100% **[New cable type but original cable length]**	-£4,757,002	-£561,324	13%

^The net change is compared to the baseline assumption.

Option 3B can be compared to Option 2A and shows that should SHEPD decommission the existing subsea cable installation, this will have a negative impact on societal value in the region of £616k

Option 3C indicates that the increase in cable length for the new installation on results in a 2% increase from the baseline, with the additional 13% reduction in societal value being attributed to the new cable type and installation. Therefore, the increase in cable length doesn't have a material impact on the changes in societal value against the baseline.

Interpretation of results

Phase one of the CBA model shows that due to no burial being achievable along this route, surface laying the new Mainland Orkney – Hoy Centre submarine electricity cable as the only option. This results in a 15% net decrease in societal value against the baseline, option 3C confirms only 2% of this change is to do with the increase in cable length of the new install.

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 2F to have the lowest cost to society, however option 2A is deemed to be the preferred installation method based on the design process undertaken up to this point.

When applying sensitivity testing to Options 2A in phase three, the impact of an increase in expected lifecycle shows option 2A could have a lower cost to society than anticipated, if all sections of the cable in the model have cable life expectancy set at 45 years instead of 38 years for unprotected sections. This phase of the analysis also shows that decommissioning the existing cable will result in a negative impact on the overall value to society of the solution. Therefore, should not be undertaken unless absolutely necessary.

Recommendation

The CBA model considers the societal value of different installation methods for the Mainland Orkney – Hoy Centre 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 2A, Rock Bagging 0.05km, Mattressing 0.1km, split piping both shore ends 0.4km & Surface lay 4.32km is put forward for final design consideration.

As stated previously in the CBA summary, there may be the requirement for additional protection of the replacement cable, which will be determined upon conclusion of the detailed design and engineering process. Any additional protection requirements can be remodelled in the CBA if required to show the difference in societal value.