Cost Benefit Analysis Model

**The Final Cost Benefit Analysis (CBA) Recommendation**

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| The **Final CBA Recommendation** for the 33kV submarine electricity cable **Mainland - Jura** is Option 3A:   * Cable surface laid on the seabed – Approximately 8.111km * 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** **£4,417,121** versus the baseline installation.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. |

**Background**

On 20th November 2019 at 07:26, the existing submarine cable between Mainland and Jura faulted in service. The fault location was confirmed at 4.67km from the Mainland end and 3.33km from the Jura End. Various options have been considered to rectify the fault including attempting a piece in repair or replacement, with the latter being deemed the only viable option due to water depth and the significant mechanical stresses and fatigue which would be placed upon the existing cable if attempting to recover the cable for repair.

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 material risks and impacts identified by stakeholders for the Mainland - Jura submarine electricity cable.

The CBA model assigns financial values across the following key categories for each cable installation method and design:[[1]](#footnote-1)

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

These values are then aggregated to estimate the **‘societal value[[2]](#footnote-2)’** of each solution.

The output of the CBA model helps to demonstrate (to ourselves, our customers, our regulators and all users of the sea environment) that the method(s) proposed to deploy for installing this submarine electricity cable justifies the expenditure and provides best value[[3]](#footnote-3). The CBA model supports our marine licence application by illustrating how we consider the cumulative impact of our engineering design.

42 different CBA models were developed, across the three phases, to identify the best value solution i.e. the solution with the highest **societal value** which balances the risks, impacts and the needs of stakeholders. The number of valid models may be reduced following further surveys. Currently an assumption has been made that burial for protection may be achievable. The current cable has self-buried in sections however, the confirmed depth of cover would not be sufficient to carry out protection burial methods i.e. Jetting, Mass Flow Excavation or Ploughing. The current cable has been confirmed to have a maximum depth of cover of 1.04m through self-burial. For Jetting or Mass Flow Excavation to be feasible the minimum sediment depth required is 1.5m. It is yet to be confirmed if the sediment depth will be sufficient to allow burial to take place along the proposed route, this will be confirmed through further surveys which are not available at this time. Should burial not be achievable, 25 of the models will be discounted as burial won’t be feasible. Three models were run in phase three with adjusted sensitivity on the best identified solutions from phase 1 and 2.

**The process 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.

**Phase one:**

Phase one draws on the initial burial assessment[[4]](#footnote-4) 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[[5]](#footnote-5) is then used to identify the **Burial Scenario** using our three[[6]](#footnote-6) 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**.

**Phase two:**

The **Burial Scenario** is then input into phase two of the CBA model which uses the key assumptions around our three recognised protection methods to develop a **Hybrid solution(s)** which include elements of both burial and protection that are feasible. This phase seeks to address Factor 2 (a method to minimise impacts on the environment, sea bed 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 representsthe overall best value solution.

**Phase three:**

During the phase three analyses, a sensitivity analysis is carried out on key assumption 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 representsthe overall best value solution.

**Mainland - Jura: Phase one**

The input to phase one of the CBA analysis was standalone installation assessments for the Mainland - Jura cable. These included 100% of the route surface lay , 100% of the route Jetting, Surface lay with split pipe at shore ends, as well as 17% of the route buried via Ploughing, Jetting or Mass Flow Excavation.

SHEPD propose to consider burying sections of the route where feasible. This has not been stated within the project description because the information gathered during the 2018 cable inspection did not provide the actual depth of sediment present on the seabed. This means the data is not currently available to say if burial is feasible.

We are supportive of making our survey data available for scrutiny by stakeholders. Additionally, we commit to re-running the CBA model when we know the depth of sediment along the cable route. This will show where burial is feasible in accordance with the considerations applied within the cost benefit analysis.

Based on experience from previous projects in this area the seabed has been judged to be largely made up of sandy gravel with many rocky sections. The current route also goes down to a maximum depth of 200m with some very steep gradients resulting in a risk of cable suspensions which can be mitigated through effective route engineering and touch down monitoring during the cable installation.

**Table 1** Standalone protection method evaluation

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| --- | --- | --- | --- | --- |
| **Option** | **Scenario Methods** | **Total Societal Value** | **Net change (£)** | **Net Change (%)** |
| Base | Baseline Surface lay 77%, Mattress 6% Rock bag 17% (the installation method used for the cable we are replacing) | -£16,924,818.65 | £ - | - |
| 1A | Ploughing 17%, Surface lay 83% | -£9,079,243.42 | £7,845,575.23 | -46% |
| 1B | Jetting 17%, Surface lay 83% | -£9,110,446.83 | £7,814,371.82 | -46% |
| 1C | Mass Flow 17%, Surface lay 83% | -£9,150,685.04 | £7,774,133.60 | -46% |
| 1D | Surface lay 100% | -£8,847,411.07 | £8,077,407.58 | -48% |
| 1E | Split Pipe 6%, Surface lay 94% | -£19,500,755.23 | -£2,575,936.58 | 15% |
| 1F | Jetting 100% | -£9,035,345.79 | £7,889,472.86 | -47% |

Five of the six scenarios presented in Table 1 offer a provided a reduction in societal value verses the existing baseline installation. From Table 1 above, a surface lay 100% is identified as being the best societal value solution from phase 1.

**Mainland - Jura: Phase two**

Phase two of the analysis then sought to identify scenarios beyond the initial assessment scenarios (Phase 1 output) where burial 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 28 scenarios that were considered in this phase of the analysis.

**Table 2** Practicable and cost-effective burial and protection scenarios

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| --- | --- | --- | --- | --- |
| **Option** | **Scenario Methods** | **Total Societal Value** | **Net change (£)** | **Net Change (%)** |
| Base | Baseline Surface lay 77%, Mattress 6% Rock bag 17% (the installation method used for the cable we are replacing) | -£ 16,924,818.65 | £ - | - |
| 2A | Mass Flow 15%, Rock placement 23%, Surface lay 62% | -£ 10,173,375.46 | £ 6,751,443.19 | -40% |
| 2B | Mass Flow 15%, Mattressing 23%, Surface lay 62% | -£ 36,141,208.69 | -£ 19,216,390.04 | 114% |
| 2C | Jetting 15%, Rock placement 23%, Surface lay 62% | -£ 10,136,418.98 | £ 6,788,399.67 | -40% |
| 2D | Jetting 15%, Mattressing 23%, Surface lay 62% | -£ 36,104,252.22 | -£ 19,179,433.57 | 113% |
| 2E | Ploughing 15%, Rock placement 23%, Surface lay 62% | -£ 10,107,760.44 | £ 6,817,058.20 | -40% |
| 2F | Ploughing 15%, Mattressing 23%, Surface lay 62% | -£ 36,075,593.68 | -£ 19,150,775.03 | 113% |
| 2G | No Burial 0%, Rock placement 23%, Surface lay 77% | -£ 9,982,473.49 | £ 6,942,345.16 | -41% |
| 2H | No Burial 0%, Mattressing 23%, Surface lay 77% | -£ 35,950,306.73 | -£ 19,025,488.08 | 112% |
| 2I | No Burial 0% Rock placement 100%, Surface lay 0% | -£ 11,073,423.71 | £ 5,851,394.94 | -35% |
| 2J | No Burial 0%, Rock placement 17%, Split Pipe 6%, Surface lay 77% | -£ 20,132,929.83 | -£ 3,208,111.19 | 19% |
| 2K | No Burial 0%, Mattressing 17%, Split Pipe 6%, Surface lay 77% | -£ 39,123,913.75 | -£ 22,199,095.10 | 131% |
| 2L | Jetting 25%, Rock placement 17%, Split Pipe 6%, Surface lay 52% | -£ 20,320,522.03 | -£ 3,395,703.38 | 20% |
| 2M | No Burial 0%, Rock placement 6%, Surface lay 94% | -£ 9,350,298.89 | £ 7,574,519.76 | -45% |
| 2N | Jetting 17%, Rock placement 6%, Surface lay 77% | -£ 9,509,224.09 | £ 7,415,594.56 | -44% |
| 2O | Jetting 8%, Rock placement 15%, Surface lay 77% | -£ 9,761,570.72 | £ 7,163,247.93 | -42% |
| 2P | Jetting 8%, Rock placement 6%, Surface lay 86% | -£ 9,426,643.56 | £ 7,498,175.09 | -44% |
| 2Q | No Burial 0%, Rock placement 3%, Split Pipe 6%, Surface lay 91% | -£ 19,700,143.86 | -£ 2,775,325.21 | 16% |
| 2R | Jetting 9%, Rock placement 6%, Surface lay 85% | -£ 9,432,879.42 | £ 7,491,939.23 | -44% |
| 2S | Jetting 9%, Surface lay 91% | -£ 9,034,102.16 | £ 7,890,716.49 | -47% |
| 2T | Jetting 8%, Surface lay 92% | -£ 9,027,866.30 | £ 7,896,952.34 | -47% |
| 2U | No Burial 0%, Rock placement 3%, Surface lay 97% | -£ 9,150,910.26 | £ 7,773,908.39 | -46% |
| 2V | Jetting 8%, Rock placement 3%, Surface lay 89% | -£ 9,227,254.93 | £ 7,697,563.71 | -45% |
| 2W | Jetting 37%, Surface lay 63% | -£ 9,135,042.28 | £ 7,789,776.37 | -46% |
| 2X | No Burial 0%, Rock placement 37%, Surface lay 63% | -£ 9,896,372.16 | £ 7,028,446.48 | -42% |
| 2Y | Jetting 37%, Rock placement 6%, Surface lay 57% | -£ 9,533,819.53 | £ 7,390,999.11 | -44% |
| 2Z | No Burial %, Rock placement 43%, Surface lay 57% | -£ 10,295,149.42 | £ 6,629,669.23 | -39% |
| 2AA | Jetting 37%, Rock placement 23%, Surface lay 40% | -£ 10,165,994.14 | £ 6,758,824.51 | -40% |
| 2AB | Jetting 43%, Surface lay 57% | -£ 9,255,341.06 | £ 7,669,477.59 | -45% |

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

Within the twenty-eight scenarios considered in Table 2, twenty scenarios provided a reduction in the societal value of the baseline installation. However, none of the solutions provide a societal value which was greater than the 100% surface lay option 1D in phase 1. Some of the burial, hybrid options come close to matching the 1D option values, mainly options 2S, 2T, 2U and 2W. All of these options contain large portions of surface lay. It is still yet to be confirmed if options 2S, 2T and 2W are feasible due to taking an assumption on there being sufficient depth of cover for burial to be feasible.

Based on this analysis it was therefore identified that these eight scenarios were practicable and cost-effective. The two options with greatest societal benefit (Options 1D & 2T) were taken forward into Phase 3.

The process of identifying risks would normally be carried out during a number of stakeholder events which would be held and summarised within the *Pre-Application Consultation Report*, however due to the nature of this replacement and the very short window for turn around this has not been possible. Therefore, risks have been based upon historic project and SHEPD’s previous experience in carrying out submarine cable installations for this marine licence application.

The two **Scenarios** which were deemed the most suitable for installation were:

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| --- | --- |
| **Option** | **Scenario methods** |
| 1D | Surface Lay 100% (8.11km) |
| 2T | Jetting 8% (0.6km), Surface Lay 92% (7.5km) |

Although there is no rock placement protection in these scenarios, the engineering justification to stabilise the cable may require additional rock bag installation to prevent the cable from excessive movement. This can only be confirmed following an on-bottom stability assessment which is not available at this time.

**Mainland - Jura: 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 various sensitivity scenarios took the two best options from Phase 1 & 2 and then applied variances in the predicted lifecycle of the new cable as well as considering the need to decommission the existing submarine cable.

Table 3 shows the impact of an increase and decrease in the life expectancy of Option 1D as well as considering the effects of decommissioning the existing cable. Sensitivity testing was also done on Option 2T considering increases in the cable life and whether decommissioning of the existing cable had any effect, the results can also be seen in Table 3. Overall there is an increase in the societal value, as expected, if the cable life is extended. Consequently, there is a decrease in the societal value if the cable life is reduced. The results also show that there is a greater societal value by not decommissioning the existing cable.

**Table 3 Sensitivity testing**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Option** | **Scenario methods** | **Total Societal**  **Value** | **Net change^**  **(£)** | **Net Change^**  **(%)** |
| Baseline | Surface lay 77%, Mattress 6%, Rock bag 17% (the installation method used for the cable we are replacing) | -£16,924,819 | - | - |
| 3A | Surface Lay 100% (8.11km)  **[No Decommissioning of existing cable]** | -£4,417,120.51 | £12,507,698.14 | -74% |
| 3B | Jetting 8% (0.6km), Surface Lay 92% (7.5km)  **[No Decommissioning of existing cable]** | -£4,597,575.74 | £12,327,242.91 | -73% |
| 3C | Surface Lay 100% (8.11km)  **[Life expectancy set at 35 years]** | -£8,518,222.92 | £8,406,595.73 | -50% |
| 3D | Surface Lay 100% (8.11km)  **[Life expectancy set at 45 years]** | -£8,323,857.06 | £8,600,961.59 | -51% |
| 3E | Jetting 8% (0.6km), Surface Lay 92% (7.5km)  **[Life expectancy set at 35 years]** | -£8,676,997.63 | £8,247,821.01 | -49% |
| 3F | Jetting 8% (0.6km), Surface Lay 92% (7.5km)  **[Life expectancy set at 45 years]** | -£8,470,932.58 | £8,453,886.07 | -50% |
| 3G | Surface Lay 100% (8.11km)  **[Life expectancy set at 9 years]** | -£12,757,740.27 | £4,167,078.38 | -25% |
| 3H | Surface Lay 100% (8.11km)  **[Life expectancy set at 15 years]** | -£10,474,257.55 | £6,450,561.10 | -38% |

^The net change is compared to the baseline assumption.

**Interpretation of results**

Phase one of the CBA model shows surface laying the new Mainland - Jura submarine electricity cable results in the highest societal value (i.e. lowest net cost). When compared to the baseline of the original cable this shows a positive societal benefit.

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 still shows 100% surface lay as the scenario with highest societal value.

Phase three shows the impact of other possible outcomes to the recommended option(s) compared to the baseline. The sensitivity testing examined if the cable life expectancy was greater or lesser than expected what societal benefit this would produce. It also considered the need to decommission the existing submarine cable. The results from this were that as life expectancy increased the overall societal benefit also increased. Additionally, not decommission the existing submarine cable results in a higher societal value of the proposed options.

**Recommendation**

The CBA model considers the societal value of different installation methods for the Mainland - Jura 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 3A, 8.11km of surface lay with no decommissioning of the existing submarine cable, is put forward for further design consideration.

Under both options there may be the requirement for additional protection or burial for stability of the replacement cable. This information is not available at this present time.

We are supportive of making our survey data available for scrutiny and to re-run the CBA when we have accurate values of sediment depths and lengths, when these become available. This will show where burial is feasible in accordance with the considerations applied within the cost benefit analysis and to attempt to undertake this within 12 months from the date of installation of the cable.

1. The Submarine Electricity Cables Cost Benefit Analysis Method Statement can be found here: http://news.ssen.co.uk/media/266365/SSEN-CBA-Method-Paper-120pp-22336-WEB.pdf [↑](#footnote-ref-1)
2. 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. [↑](#footnote-ref-2)
3. 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. [↑](#footnote-ref-3)
4. 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. [↑](#footnote-ref-4)
5. The CBA tool methodology is available at <http://news.ssen.co.uk/submarinecables/information/> [↑](#footnote-ref-5)
6. The three methods commonly used by the industry to install cables are: Ploughing, Jetting and Mass Flow Excavation. A fourth installation method of horizontal directional drill (HDD) - can be used on submarine electricity cables shorter than 2km in length. [↑](#footnote-ref-6)