The Great Grid Upgrade

Eastern Green Link 3 (EGL 3) and
Eastern Green Link 4 (EGL 4)

Preliminary environmental information report (PEIR)

Volume 2, Part 1, Appendix 1.4.B EGL 3 Heat Calculations

May 2025

nationalgrid

EGL-WSP-CONS-XX-RP-YC-034

Contents

1.4.B EGL 3 Heat Calculations

1.4.B.1 Overview

1.4.B.1.1 The following technical report has been prepared by Power Systems Consultants Ltd to inform the preliminary environmental assessments for the development of the English Offshore Scheme.

Contents

Appendices and Attachments

Room 301, Maling Exchange, Hoults Yard, Walker Road Newcastle upon Tyne, NE6 2HL, United Kingdom
P: +44 7967 228 064 W: https://www.pscconsulting.com

1. Introduction

Scottish and Southern Electricity Networks have engaged Power Systems Consultants UK Ltd (PSC) to carry out a series of heat calculation studies related to the HVDC cables for Eastern Greenlink 3 (EGL3) to be used in their Environmental Impact Assessment (EIA) report.

This report has been provided to show indicative heat plots of the proposed offshore cable system. The heat plots within this report aim to imitate the worst case installation parameters which may be required for this project.

This report is not a cable system rating report aimed at optimising the cable system design or selecting the cable size required to meet the continuous current of the system.

The cable sizes in this report are based on generic cable sizes within the industry which would be expected to be utilised on this project.

2. Methodology

To assess the temperature at the seabed resulting from electromagnetic losses converting into heat within the cables, modelling and calculation was used to determine heat plots for each scenario. The methodology from IEC 60287 has been used, a trusted and widely used standard for evaluating the thermal and electrical performance of cable systems under varying environmental and operational conditions.

The cables to be modelled will be selected based on their physical dimensions and thermal and electrical properties, using data from cables similar to those anticipated for the EGL3 project. This modelling process ensured that the results reflect realistic cable behaviour under the specified conditions. Details of the specific cable models used are described in the following section.

It is worth noting that a current value of 1930A was adopted in opposition to 1905A mentioned in the Request for Proposal (RfP) as discussed with NGET. The adopted values are more applicable to what the cable system will experience during peak operation.

2.1. Cable models

Four cable models were used for calculating the heat plots for each case/scenario, these are described in Table 3-1. All cables had the following common parameters:

- **Number of cores:** 1
- **Material of conductor:** Copper
- **Material of insulation:** XLPE
- **Voltage:** 525kV

Table 2-1: Details of Cable Models used in Heat Plot calculations

Cable Reference	Description	Construction of Conductor	Material of Sheath	Diameter of Conductor (mm)	Diameter of Insulation (mm)	External Diameter (mm)
A	Offshore Cable - 3000mm^2	Round, Stranded	Lead	63.4	128.8	173.8
D	Offshore Cable - 2500mm^2	Round, Milliken	Lead	58.1	123.5	167.9

To calculate the temperature distribution around the cables, the Cableizer cable rating software tool will be utilised. This tool applies the IEC 60287 methodology to produce detailed heat plots that visualize the temperature rise around the cables. These plots will depict thermal contours for each modelled scenario, offering insights into the cable system's performance under varying environmental and operational conditions. The analysis will include example plots for the offshore HVDC systems.

2.2. Conditions

A series of scenarios incorporating various environmental conditions will be conducted to evaluate the thermal performance of the cables. The conditions reflect the environments to which the cables are likely to be exposed and are outlined as follows:

2.2.1. Offshore conditions

The following conditions were used for offshore cable modelling, as described in the proposal document.

- Water depth: 100 m
- Ambient temperature: 12 °C
- Seabed thermal resistivity: 0.8, 1.1 and 2 K·m/W
- Cable laying arrangement:
  - Directly buried in bundle
  - In ducts (Landfall HDD)
- Depth of burial (to the top of ducts/cables):
  - 1, 2 and 6 m (offshore)
  - 20, 30 and 40 m at (Landfall HDD)

3. Results

The results presented in this section use the parameters described in the Section 2.2. The results shown are the heat plot outputs from Cableizer, the full results are included in the appendix and provided as an attachment titled "EGL3_Heat_Calculations_-_Results_and_Datasheets.zip".

3.1. Temperature and Current Constrained Results

In this section, the calculations were modelled with a constraint for the current at 1930A and within the maximum allowable temperature of the conductor 90°C.

The following section, 3.2 shows the results when the temperature of the conductor is set to 90°C, which gives the maximum influence heat impact of the cable as they are not designed to operate above this temperature.

3.1.1. Case 1 – Offshore Cables

Figure 1 shows the heat plot for the offshore cables, at 2m burial depth with an ambient temperature of 12°C and thermal resistivity of 1.1 $W \cdot m^{-1} \cdot K^{-1}$.

Figure 1: Heat Plot for Case 1 - Scenario A – Thermal Resistivity: 1.1

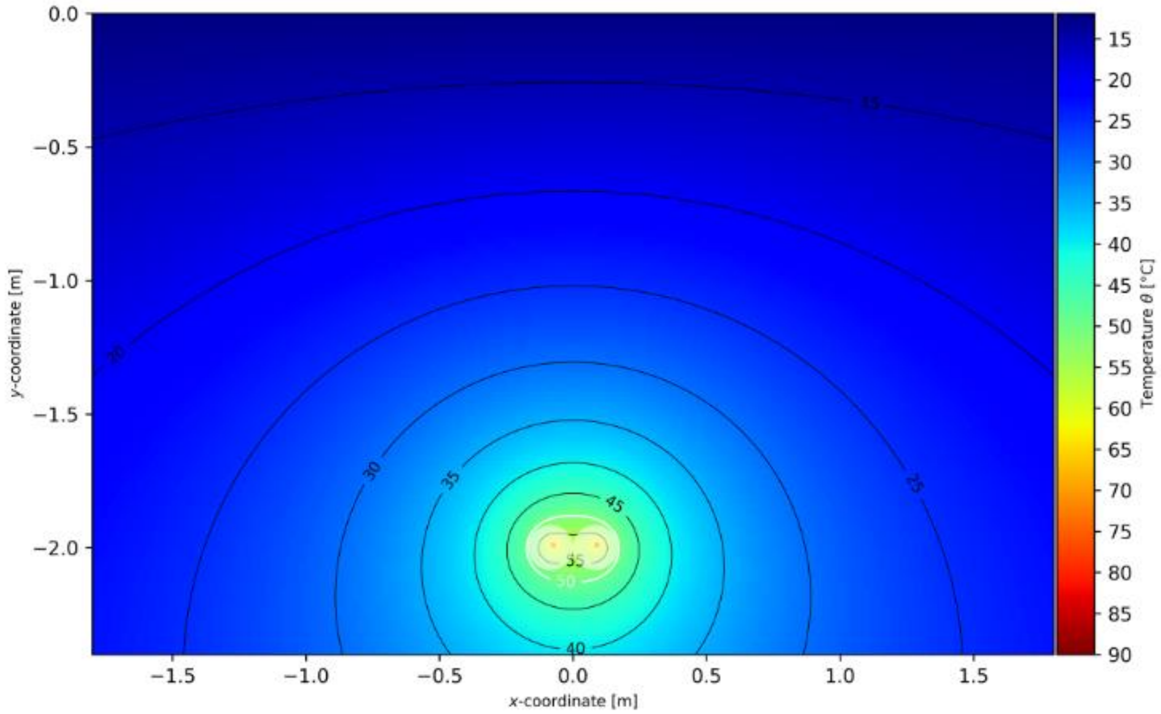
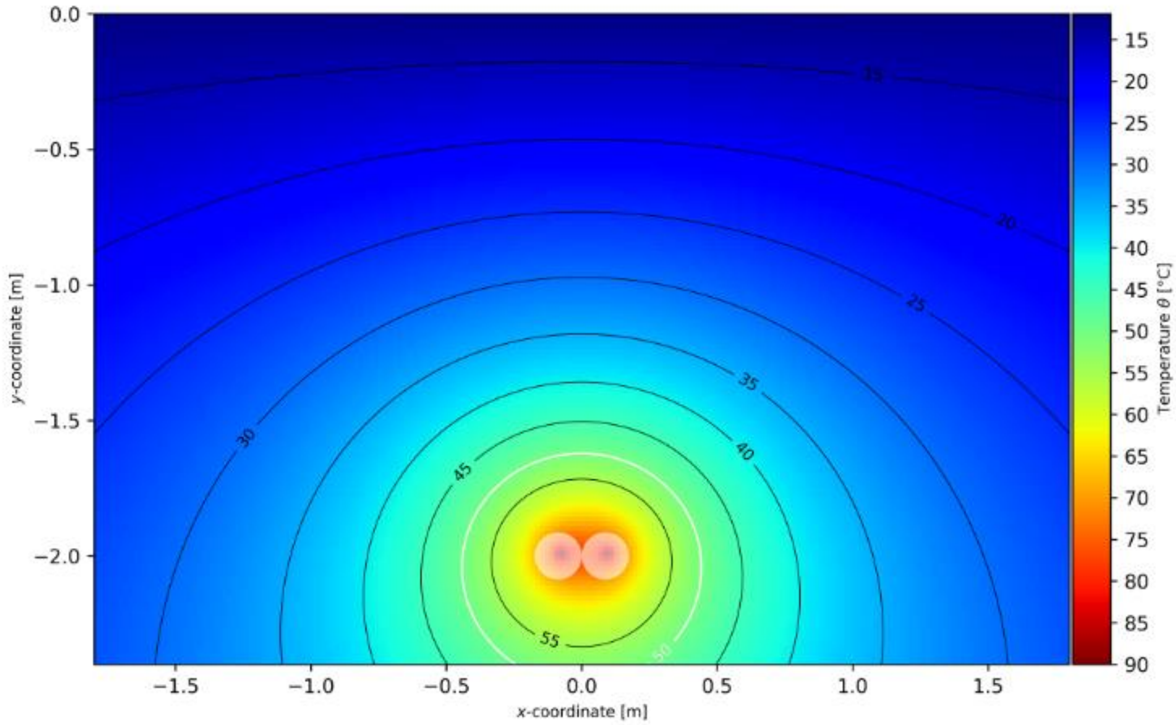


Figure 2 shows the cables at the same depth and ambient temperature, but with a thermal resistivity of 1.8 W·m^{-1}·K^{-1} respectively.

Figure 2: Heat Plot for Case 1 - Scenario C – Thermal Resistivity: 1.8



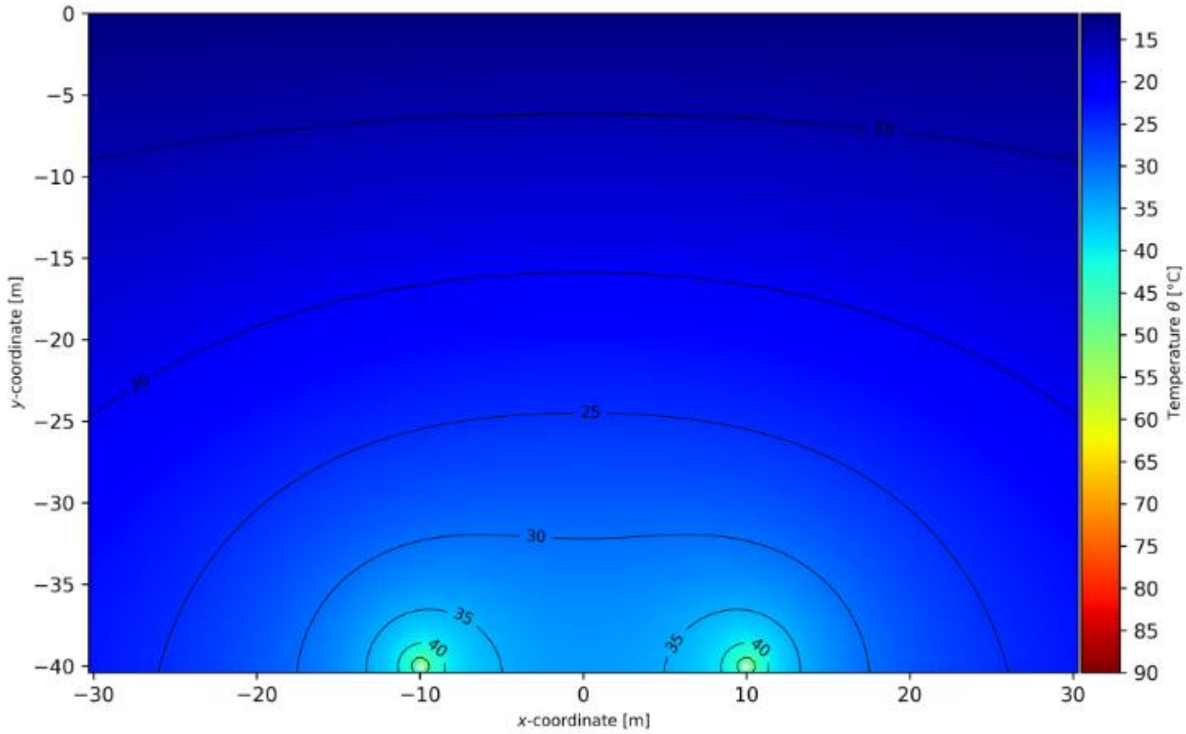
3.1.2. Case 2 and Case 3 – Landfall Scotland/England

As the parameters were identical for both England and Scotland landfall, all scenarios in this case represent both landfall sections. Due to the depth of burial, the equivalent depth method was utilised with a lifespan of 40 years, to simulate deep burial thermal inertia. Cableizer uses the IEEE transactions on power delivery paper 'Ampacity Calculation for Deeply Installed Cables'[1] by E. Dorison, G.J. Anders, and F. Lesur, dated 2010 as a basis for this calculation. All scenarios for this case were modelled with a burial depth of 40m, ambient temperature of 12°C.

Figure 3 shows the heat plot for the landfall cables with a thermal resistivity of 1.2 W·m^{-1}·K^{-1}.

In the case of a scenario with a thermal resistivity of 2.5 W·m−1·K−1, this is an unlikely parameter and the model would fail as it vastly exceeded the required 90°C limit imposed.

Figure 3: Heat Plot for Cases 3 and 4, Submarine Cable, Offshore – Thermal Resistivity: 1.2

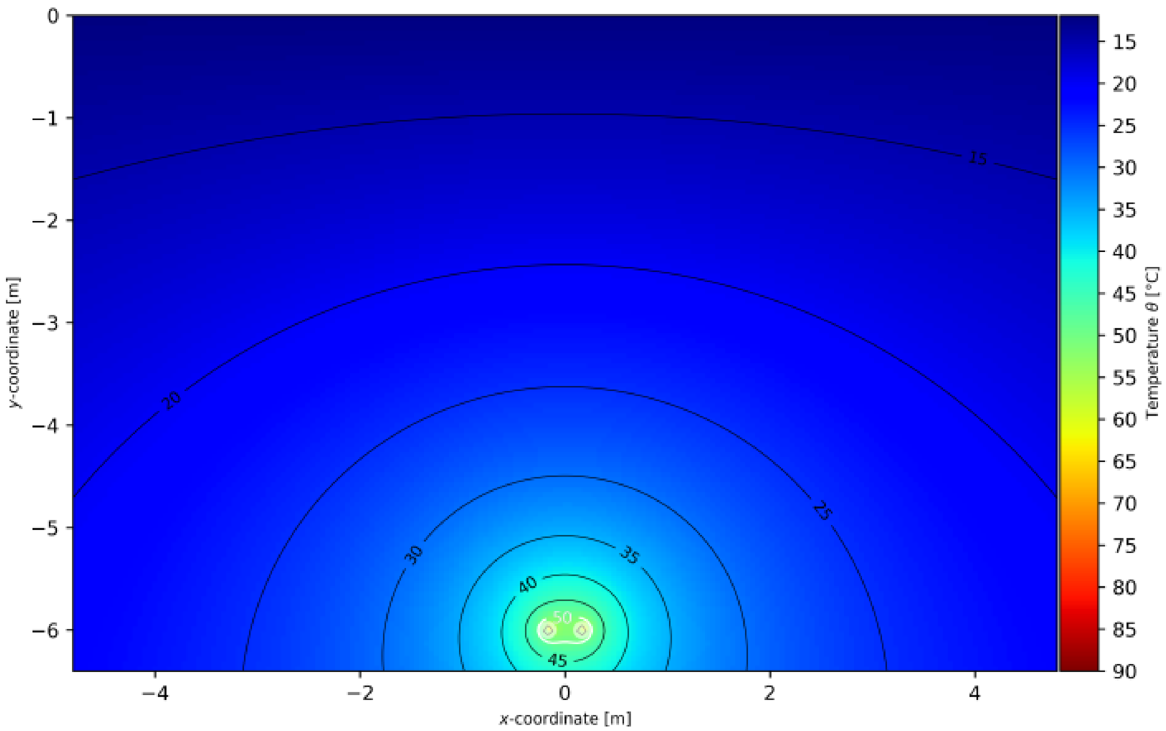


[1] Ampacity Calculations for Deeply Installed Cables | IEEE Journals & Magazine | IEEE Xplore

3.1.3. Case 7 – Cables in Seabed below Sandwave

Figure 4 shows the heat plot for the offshore cables buried in the seabed below sandwaves, with a burial depth of 6m, ambient temperature of 12°C and thermal resistivity of 1.1W·m^{-1}·K^{-1}. In the case of a scenario with a thermal resistivity of 2.5 W·m^{-1}·K^{-1}, this is an unlikely parameter and the model would fail as it vastly exceeded the required 90°C limit imposed.

Figure 4: Heat Plot for Case 7 - Cables in Seabed below Sandwave – Thermal Resistivity: 1.1



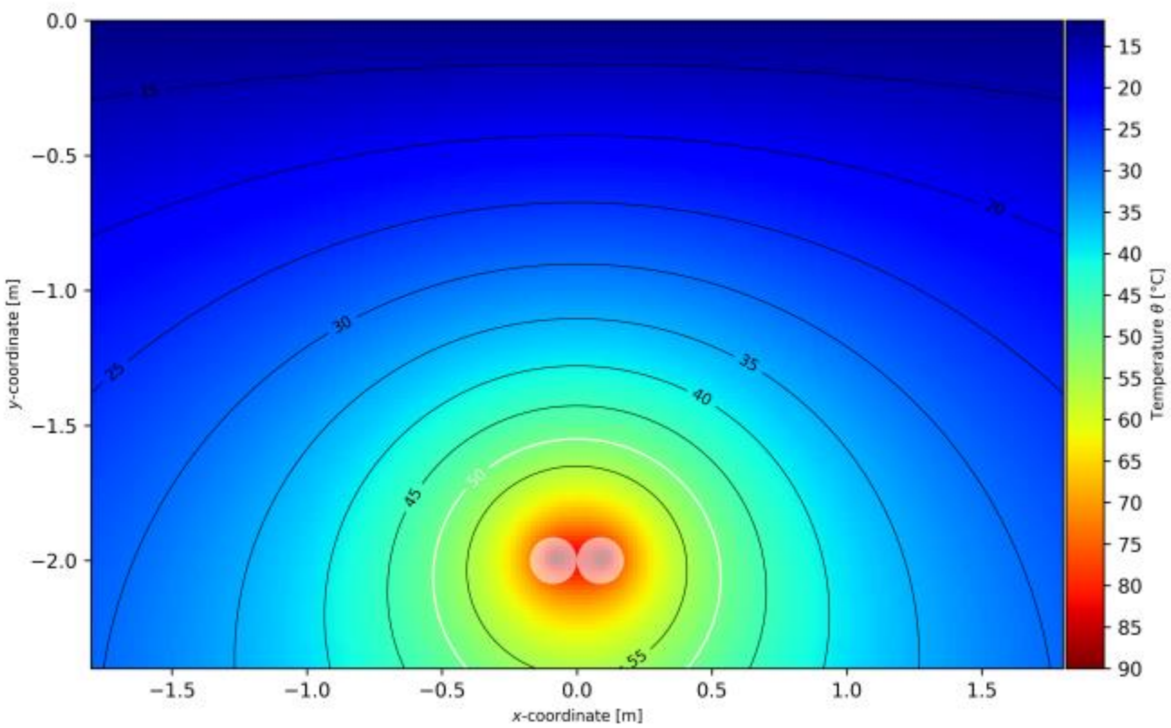
3.2. Temperature Constrained Results

In this section, the calculations were modelled with the cables represented as heat set to a temperature of 90°C. Each model in this section presents the “worst-case” scenario of the cable system.

3.2.1. Case 1 – Offshore

Figure 5 shows the heat plot for the offshore scenario of 2m burial depth, a temperature of 12°C and a thermal resistivity of 2.0 W·m^{-1}·K^{-1}.

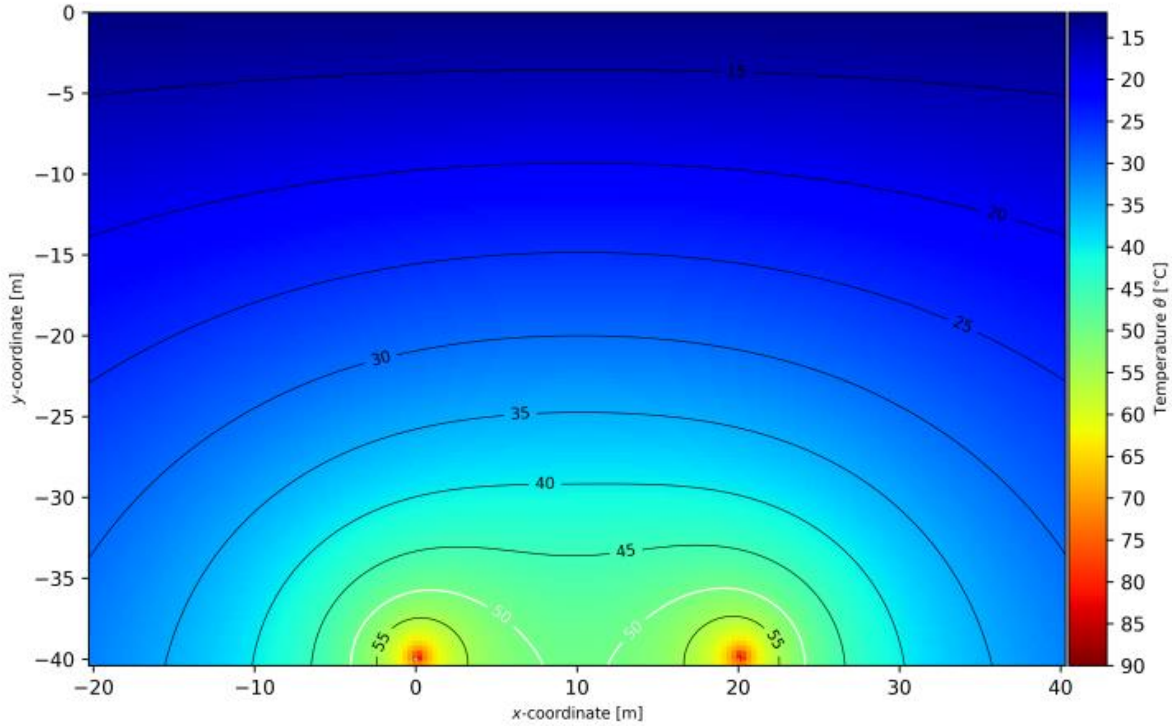
Figure 5: Heat Plot for Case 1 – Offshore – Temperature Constrained



3.2.2. Case 2 and 3 – Landfall

Figure 6 shows the heat plot for the onshore scenario of 40m burial depth, a temperature of 12°C and a thermal resistivity of 2.5 W·m^{-1}·K^{-1}.

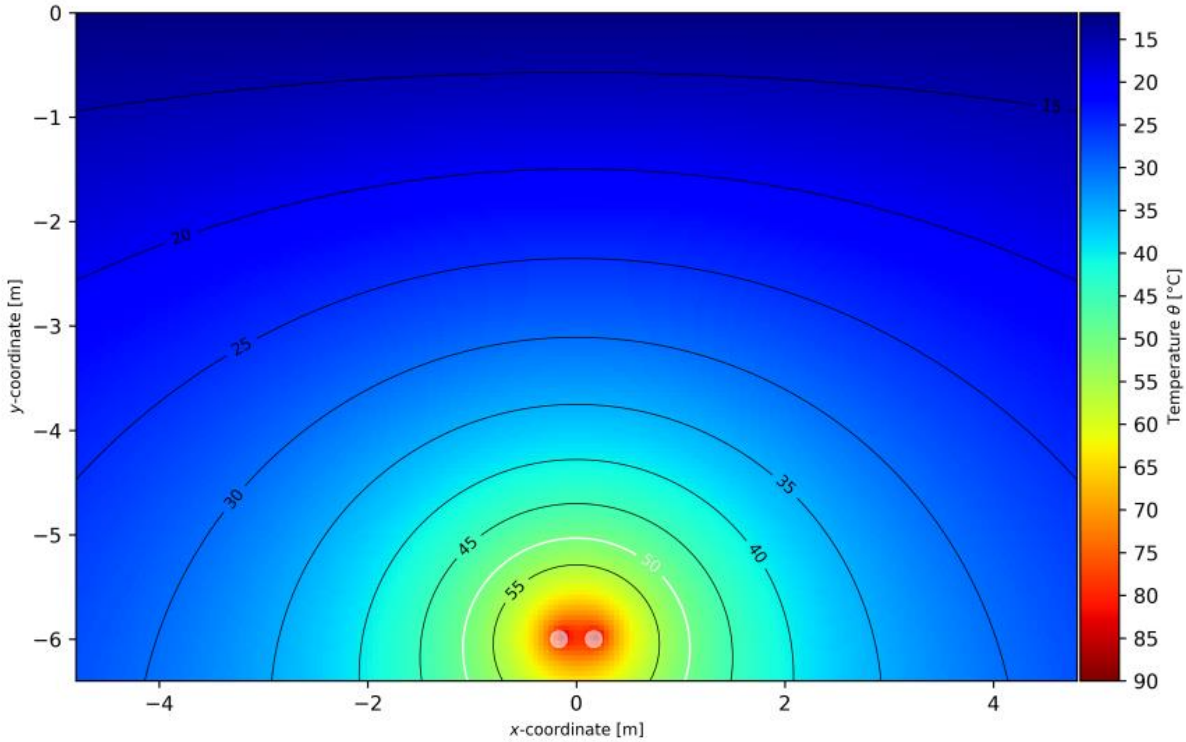
Figure 6: Heat Plot for Case 2 and 3 – Landfall (Onshore) – Temperature Constrained



3.2.3. Case 7 – Cables in Seabed Below Sandwave

Figure 7 shows the heat plot for the offshore scenario of 6m burial depth, a temperature of 12°C and a thermal resistivity of 2.0 $W \cdot m^{-1} \cdot K^{-1}$.

Figure 7: Heat Plot for Case 7 – Cables in Seabed Below Sandwave – Temperature Constrained



4. Conclusions and Recommendations

The heat plots shown in this report under the various models and scenarios are representative of the cables under full load, in section 3.1 or at maximum operating temperature in section 3.2. Therefore represent the worst case heat plots for the cable system when in operation. It should be noted that these are representative of the proposed systems and that the actual installation once detailed design has been completed may differ.

As can be seen in the heat plots throughout this report the temperature below ground (not at ground level or above, these are not included in the heat plots) around the cables has increased in temperature and reduces further from the cables. The heat plots and isotherms below ground are heavily dependent on the depth of the cables & thermal resistance values used. The thermal resistance values in this report, especially in section 3.2 are highly conservative to represent a worst case scenario. During project development ground investigation works will be carried out to determine the actual ground thermal resistance properties which could well be lower than those used in this report.

The actual system is unlikely to reach these temperatures as the system would have to operate at full load continuously for an extended period of time (months/years) to meet these temperatures. In reality the system will not be at full load for this long and therefore the temperature will fluctuate and be unlikely to reach these maximums.

Room 301, Maling Exchange, Hoults Yard, Walker Road Newcastle upon Tyne, NE6 2HL, United Kingdom
P: +44 7967 228 064 W: https://www.pscconsulting.com

Appendix A – Datasheets and Results References

A.1 Cable Datasheets Reference

Table 4-1 details the cable datasheets describing the modelled cables.

Table 4-1: Cable Datasheet Reference Table

Cable Reference	Description	Datasheet Filename
A	Offshore Cable - 3000mm2	Cable_A_Offshore_3000
D	Offshore Cable - 2500mm2	Cable_D_Offshore_2500

A.2 Results Reference

Table 4-2 details the calculated results sheets describing the heat losses for each case.

Table 4-2: Results Reference Table

Case No.	Description	Document Reference(s)
1	Offshore Cables	Case_1_-_Offshore_Cables_-_Scenario_A
		Case_1_-_Offshore_Cables_-_Scenario_B
2 and 3	Landfall	Case_2_and_3_-_Landfall_-_Scenario_B_-_Offshore
7	Cables in Seabed Below Sandwaves	Case_7_-_Cables_in_Seabed_Below_Sandwave

A.3 Updated Results Reference

Table 4-3 details the updated results (dated 5th March 2025) to include a lower bound for the isoline, for the cases where the ambient temperature was set at 12°C, the minimum isoline used was 15°C. For the cases where the ambient temperature was set at 15°C, the minimum isoline used was 16°C.

Table 4-3: Updated Results Table

Figure No.	Case No.	Model Parameter	Ambient Temperature (°C)	Minimum Isoline (°C)
Figure 1	Case 1	Thermal and Current Constraint	12	15
Figure 2	Case 1	Thermal and Current Constraint	12	15
Figure 3	Case 2 and 3	Thermal and Current Constraint	12	15
Figure 7	Case 7	Thermal and Current Constraint	12	15
Figure 9	Case 1	Thermal Constraint	12	15
Figure 10	Case 2 and 3	Thermal Constraint	12	15
Figure 12	Case 7	Thermal Constraint	12	15

National Grid plc
National Grid House,
Warwick Technology Park,
Gallows Hill, Warwick.
CV34 6DA United Kingdom

Registered in England and Wales
No. 4031152
nationalgrid.com