The Great Grid Upgrade

Eastern Green Link 5 (EGL 5)

Preliminary Environmental Information Report

Volume 2
Part 1
Appendix 4.B EGL 5 Heat Calculations Technical Report

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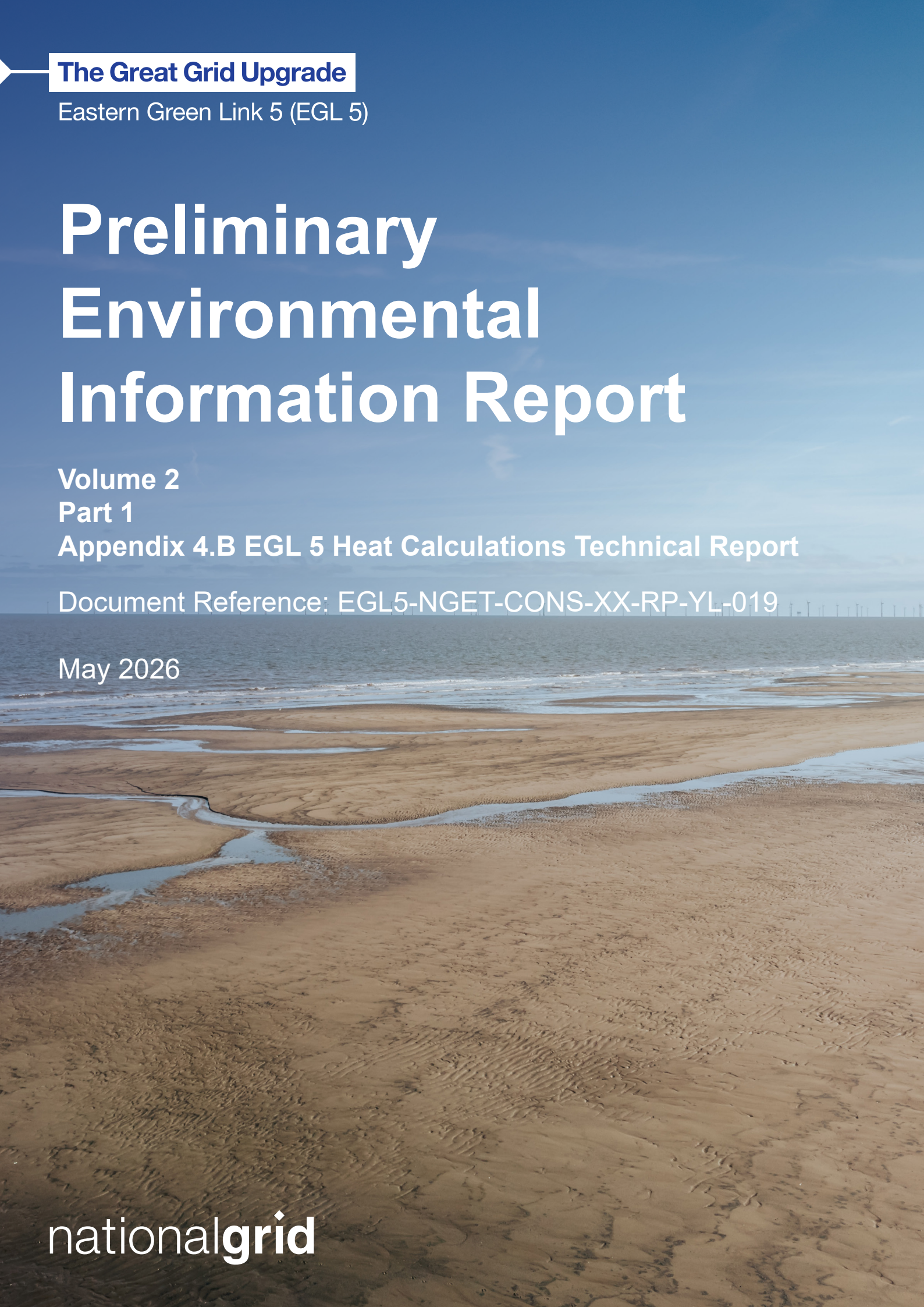
May 2026



nationalgrid

EGL5 Heat Calculations

For: National Grid Electricity Transmission (NGET)

Attention: Lauren James

Client	National Grid Electricity Transmission (NGET)
Client Reference	EGL5
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Revision	2
PSC Group Company	Power Systems Consultants UK Ltd
Prepared by	Sean McConnon
Date	06-02-2026

Document History

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0	18/11/2025	First Issue
1	02/12/2025	Updated to remove onshore cases from report. No other changes
2	09/12/2026	Updated based on provided comments from National Grid

Revision	Date	Author	Peer Review	Approved
0	18/11/2025	Sean McConnon	James Matthewman	Scott Murray
1	02/12/2025	Sean McConnon	James Matthewman	James Matthewman
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Appendices and Attachments

1. Introduction

National Grid Electricity Transmission (NGET) 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 5 (EGL5) to be used in their Environmental Impact Assessment (EIA) report. This report follows from similar works completed by PSC UK related to Eastern Greenlink 3 (EGL3) and Eastern Greenlink 4 (EGL4). For further details on these please see reports JK12352-0 EGL3 Heat Calculations and JK12352-0 EGL4 Heat Calculations.

This report has been provided to show indicative heat plots of the proposed 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 environments 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 EGL5 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.

2.1. Cable models

Two cable models were used for calculating the heat plots for each case/scenario, these are described in Table 2-1. 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 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 were based on the previous proposal and RfP document provided EGL3 and EGL 4 Heat Calculations Request for Proposal (RfP) - "C01494_NGET_INS_D0335 (Heat RFP).pdf :

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: 1.1, 1.7, 2.0 (Temperature Constraint) & 2.5 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)

Conditions for each case are summarised in Table 2-2.

Case	Description	Depth (m)	Ambient Temperature (°C)	Thermal Resistivity of Native Material (K.m/W)	Cable Used
1	Offshore	2	12	1.1, 1.7, 2.0 (Temperature Constraint)	Offshore Cable - 2500mm^2
2 and 3	Landfall	40	12	1.2, 2.5	Offshore Cable - 3000mm^2
7	Cables in Seabed below Sandwave	6	12	1.1, 2.5, 2.0 (Temperature Constraint)	Offshore Cable - 3000mm^2

Table 2-2: Summary of Assessed Conditions

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 “EGL5_Heat_Calculations_-_Results_and_Datasheets.zip”.

The results presented were modelled with a constraint for the current at 1930A and within the maximum allowable temperature of the conductor 90°C.

3.1. 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 3-1 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 $W \cdot m^{-1} \cdot K^{-1}$.

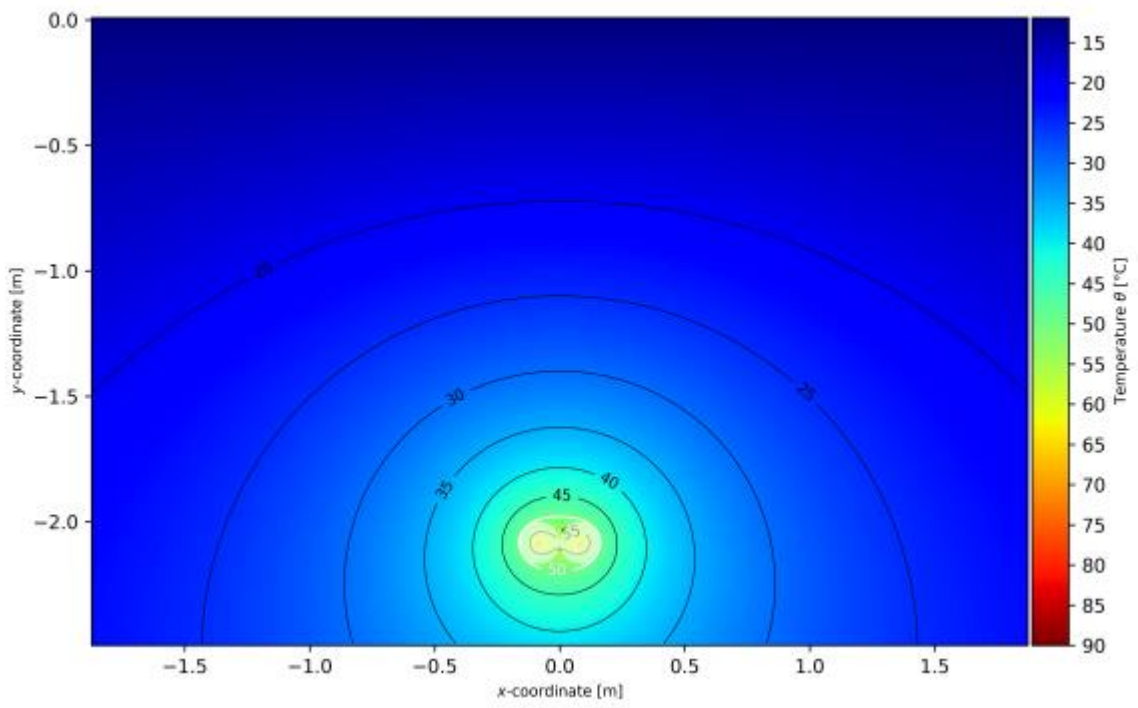


Figure 3-1: Heat Plot for Case 1 - Scenario A – Thermal Resistivity: 1.1

Figure 3-2 shows the cables at the same depth and ambient temperature, but with a thermal resistivity of 1.7 $W \cdot m^{-1} \cdot K^{-1}$. The cables in this model exceed the maximum operating temperature and therefore would de-rate the cable. The model has been left in to indicate this risk of higher thermal resistivity values if encountered in the route.

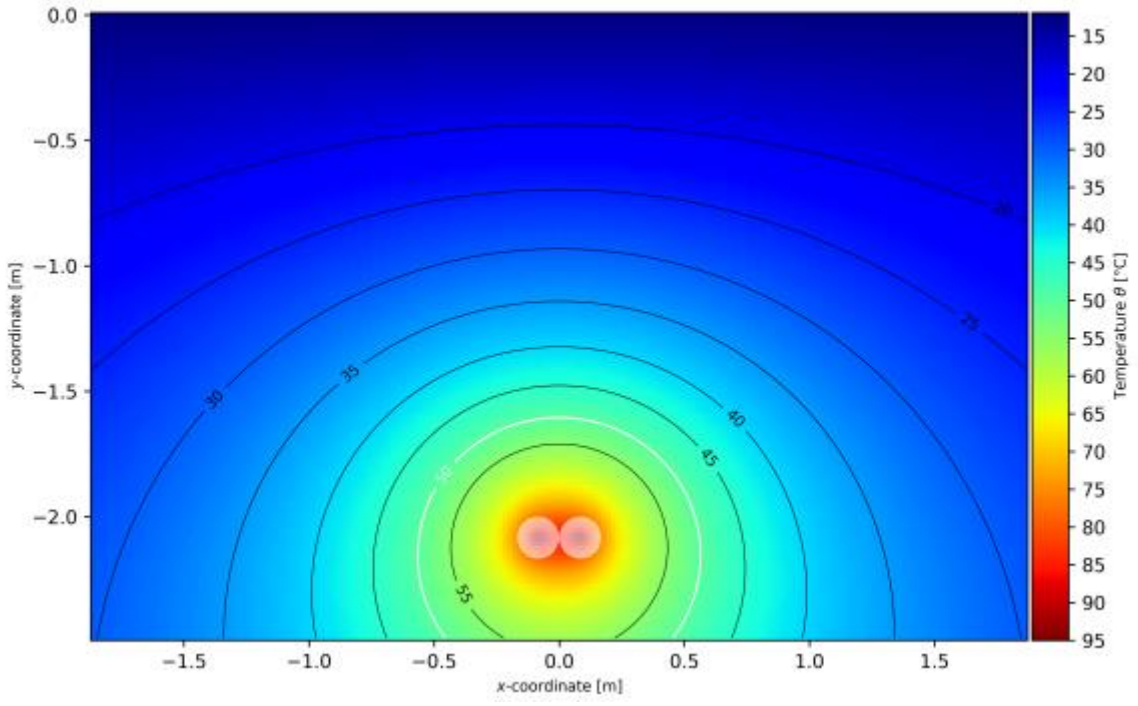


Figure 3-2: Heat Plot for Case 1 - Scenario B– Thermal Resistivity: 1.7

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] 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 3-3 shows the heat plot for the landfall cables with a thermal resistivity of 1.2 $W \cdot m^{-1} \cdot K^{-1}$.

In the case of a scenario with a thermal resistivity of 2.5 $W \cdot m^{-1} \cdot K^{-1}$, this is an unlikely parameter and the model would fail as it vastly exceeded the required 90°C limit imposed.

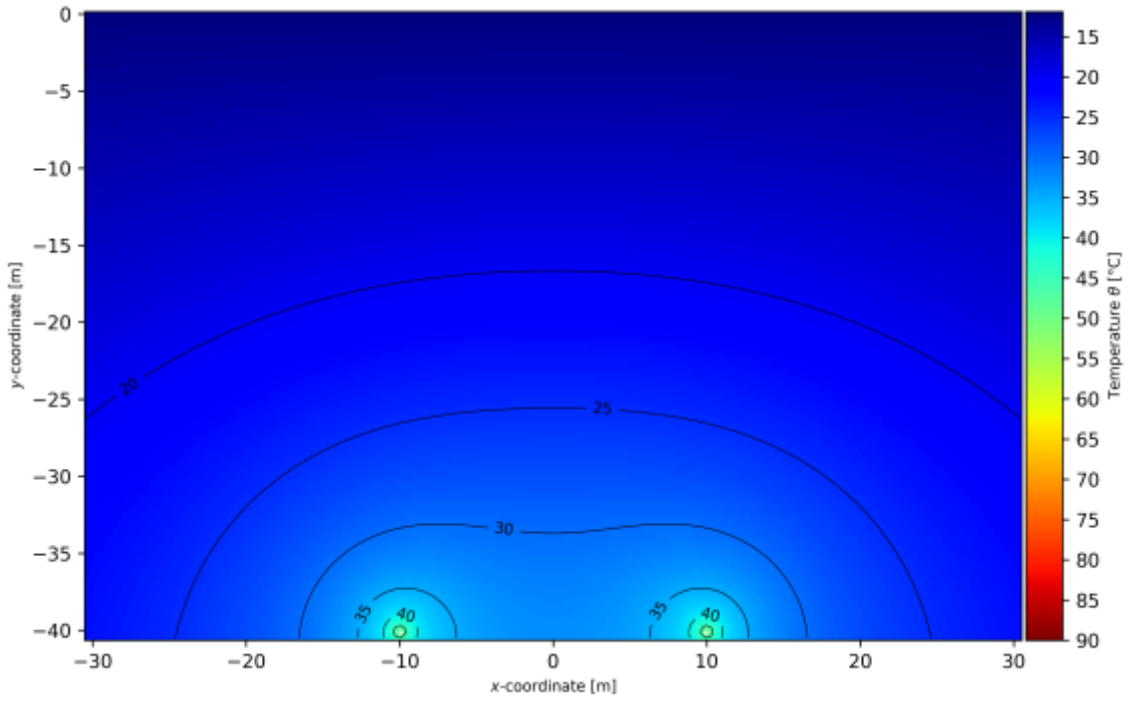


Figure 3-3: Heat Plot for Cases 2 and 3, Submarine Cable, Landfall – Thermal Resistivity: 1.2

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

3.1.3. Case 7 – Cables in Seabed below Sandwave

Figure 3-4 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.

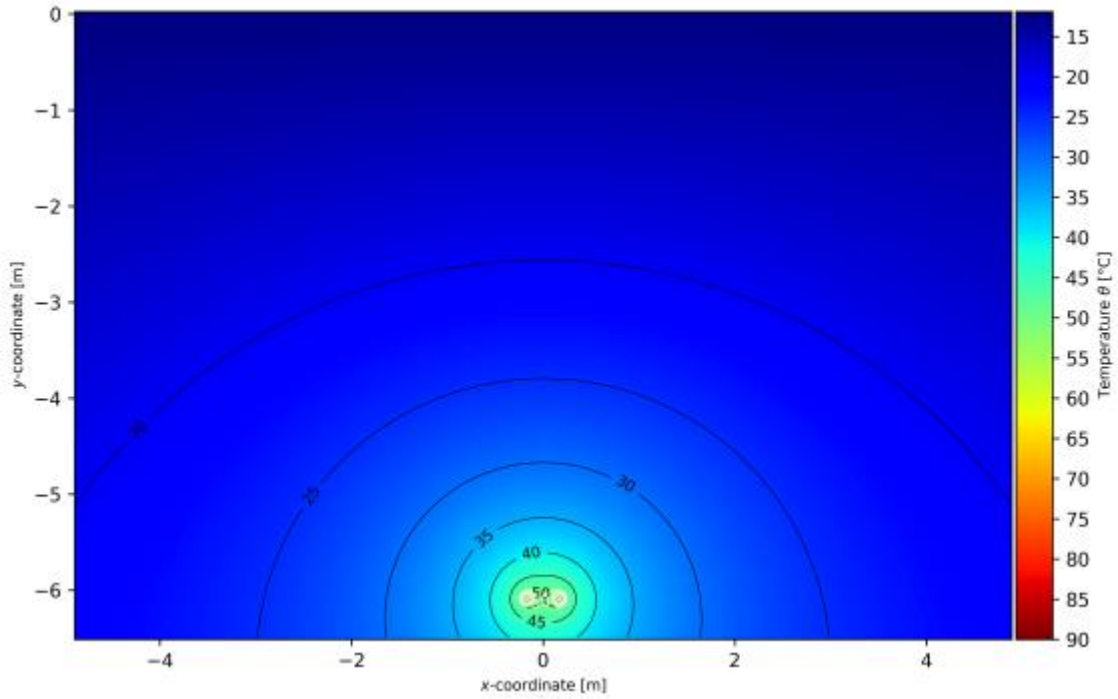


Figure 3-4: Heat Plot for Case 7 - Cables in Seabed below Sandwave – Thermal Resistivity: 1.1

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 represents the "worst-case" scenario of the cable system.

3.2.1. Case 1 – Offshore

Figure 3-5 shows the heat plot for the offshore scenario of 2m burial depth, a temperature of 12°C and a thermal resistivity of 2.0 $W \cdot m^{-1} \cdot K^{-1}$.

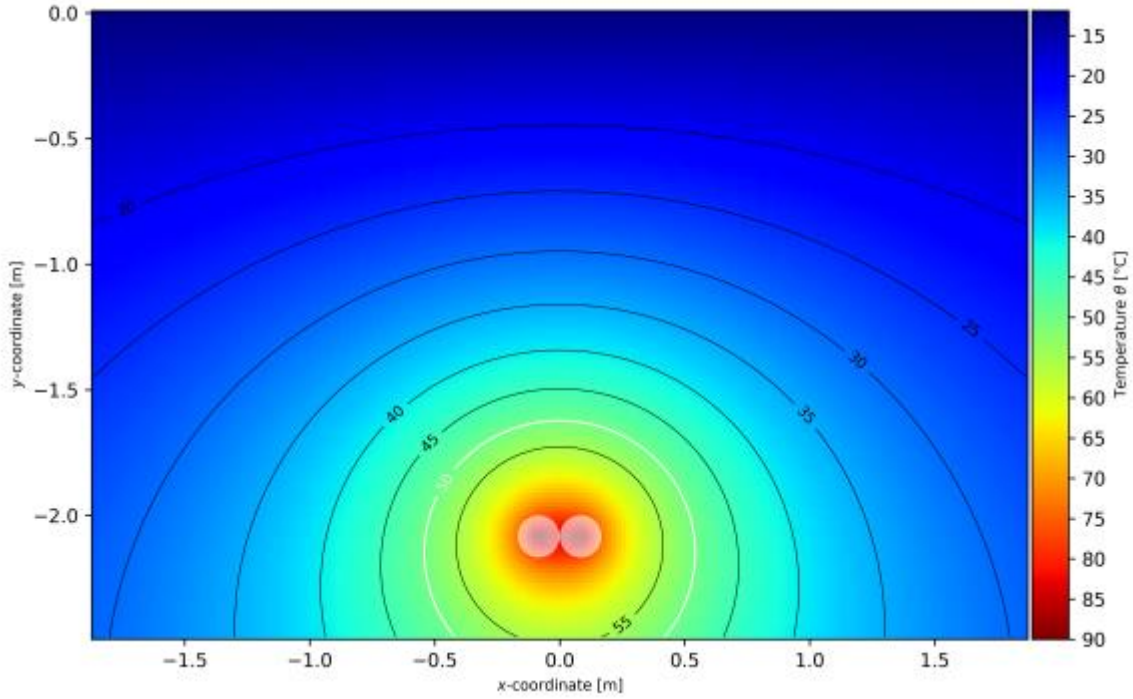


Figure 3-5: Heat Plot for Case 1 – Offshore – Temperature Constrained

3.2.2. Cases 2 and 3 – Landfall

Figure 3-6 shows the heat plot for the landfall scenario of 40m burial depth, a temperature of 12°C and a thermal resistivity of 2.5 $W \cdot m^{-1} \cdot K^{-1}$.

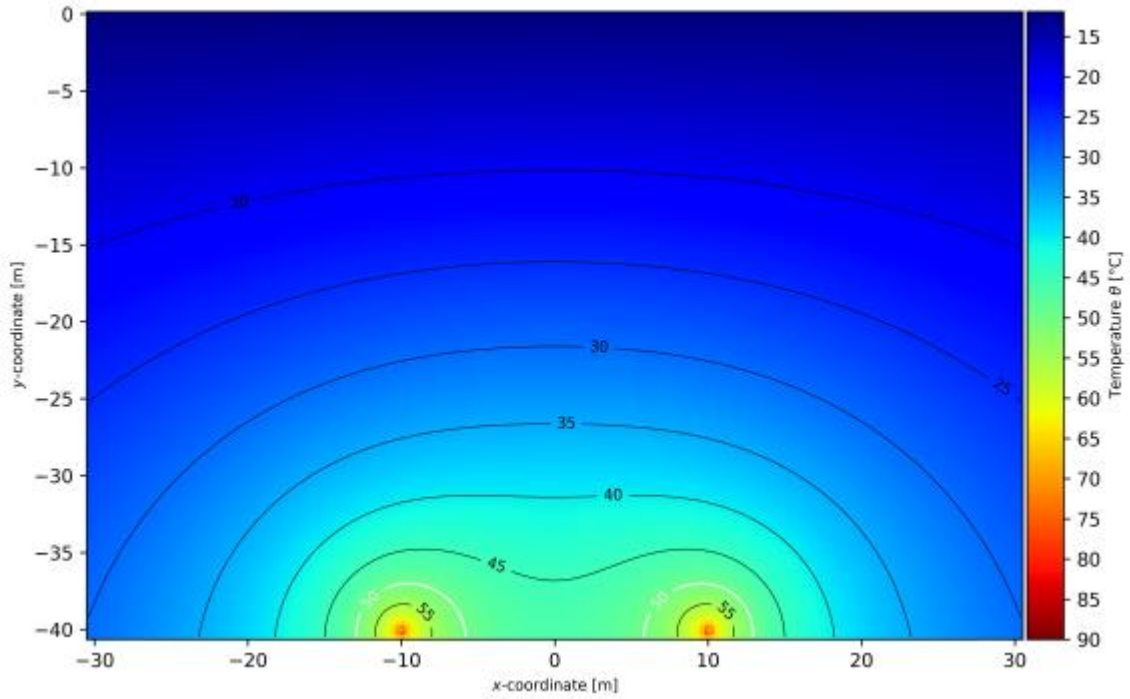


Figure 3-6: Heat Plot for Case 2 and 3 – Landfall – Temperature Constrained

3.2.3. Case 7 – Cables in Seabed Below Sandwave

Figure 3-7 shows the heat plot for the offshore scenario of 6m burial depth, a temperature of 12°C and a thermal resistivity of 2.0 $W \cdot m^{-1} \cdot K^{-1}$.

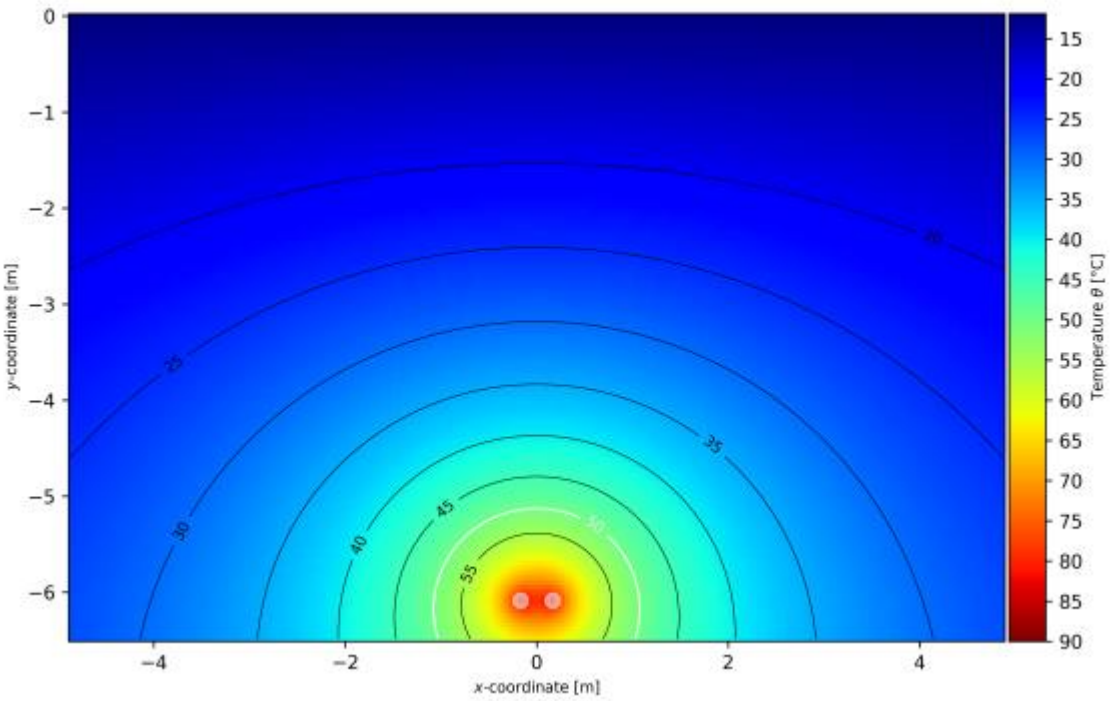


Figure 3-7: Heat Plot for Case 7 – Cables in Seabed Below Sandwave – Temperature Constrained

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. 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 included in this report 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.

Appendix A – Datasheets and Results References

A.1 Cable Datasheets Reference

Table 4-1 details the cable datasheets describing the modelled cables. The datasheets from Cableizer have been attached to this report within this appendix.

Table 4-1: Cable Datasheet Reference Table

Cable Reference	Description	Document Folder Name
A	Offshore Cable - 3000mm2	Cable A - Offshore - 3000mm2
D	Offshore Cable - 2500mm2	Cable D - Offshore - 2500mm2

A.1.1 Cable A (3000mm^2) Datasheet

Cable datasheet

Title	Offshore Cable - EGL5 - 3000mm2 Cu (#29195)
created	Date: 2026-02-10 Time: 18:41 Software version: de1f (2026-02-01)

Info! Electric stress is higher than recommended in NF-C33-253 ($U_n \geq 380$ kV).
CIGRE TB 880, guidance points 15, 20, 23, 25, 30, 32, 33, 34, 38, 39, 42, 44, 45

General Data

Rated line-to-line voltage	U_n	500 kV
Base voltage for tests	U_0	290 kV
Highest voltage for equipment	U_m	550 kV
Nominal system frequency	f	0 Hz
Number of conductors cable	n_c	1
Number of phases in a cable	n_{ph}	1

Cable elements

Conductor

Cross-sectional area conductor	A_c	1 x 3000 mm^2
Conductor material	M_c	Copper, round stranded
External diameter conductor	d_c	63.4 mm
Radius conductor	r_c	31.7 mm

$\frac{d_c}{2}$

Insulation

Insulation material	M_i	Crosslinked polyethylene (XLPE)
Thickness conductor shield	t_{cs}	2.7 mm
Thickness insulation	t_{ins}	30 mm
Thickness insulation screen	t_{is}	2 mm
Thickness insulation	t_i	34.7 mm

$t_{cr} + t_{cs} + t_{ins} + t_{is}$

A.1.2 Cable D (2500mm^2) Datasheet

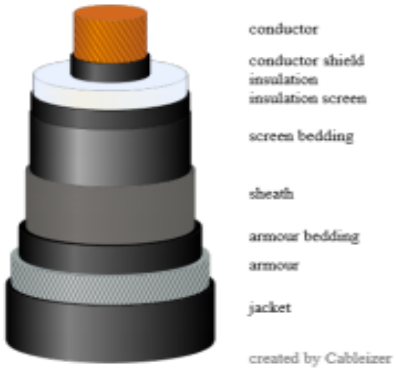
Cable datasheet

Title	Offshore Cable - EGL5 - 2500mm2 Cu (#29192)
created	Date: 2026-02-10 Time: 18:40 Software version: de1f (2026-02-01)

Info! Electric stress is higher than recommended in NF-C33-253 ($U_n \geq 380$ kV).
CIGRE TB 880, guidance points 15, 20, 23, 25, 30, 32, 33, 34, 38, 39, 42, 44, 45

General Data

Rated line-to-line voltage	U_n	500 kV
Base voltage for tests	U_0	290 kV
Highest voltage for equipment	U_m	550 kV
Nominal system frequency	f	0 Hz
Number of conductors cable	n_c	1
Number of phases in a cable	n_{ph}	1



Cable elements

Conductor

Cross-sectional area conductor	A_c	1 x 2500 mm^2
Conductor material	M_c	Copper, round stranded
External diameter conductor	d_c	58.1 mm
Radius conductor	r_c	29.05 mm

$\frac{d_c}{2}$

Insulation

Insulation material	M_i	Crosslinked polyethylene (XLPE)
Thickness conductor shield	t_{cs}	2.7 mm
Thickness insulation	t_{ins}	30 mm
Thickness insulation screen	t_{is}	2 mm
Thickness insulation	t_i	34.7 mm

$t_{cs} + t_{cs} + t_{ins} + t_{is}$

A.2 Results Reference

Table 4-2 details the calculated results sheets describing the heat losses for each case. The results sheet from Cableizer have been attached to Appendix A.3 for the current constrained results and Appendix A.4 for the temperature constrained results. Some of the results sheets have a graphical error in showing the preview image, where it is stated “There was a problem printing the preview. Please open the project and save again”, however, this is simply a preview showing the layout and does not affect the results, which can be seen on the next page of the results document.

Table 4-2: Results Reference Table

Case No.	Description	Document Folder Name
1	Offshore Cables	Case 1 - Offshore Cables - Scenario A
		Case 1 - Offshore Cables - Scenario B
2 and 3	Landfall	Cases 2 & 3 - Landfall
7	Cables in Seabed Below Sandwaves	Case 7 - Cables in Seabed Below Sandwave

A.3 Current Constrained Results

A.3.1 Results Sheet – Case 1: Offshore Cables (Scenario A)

Report

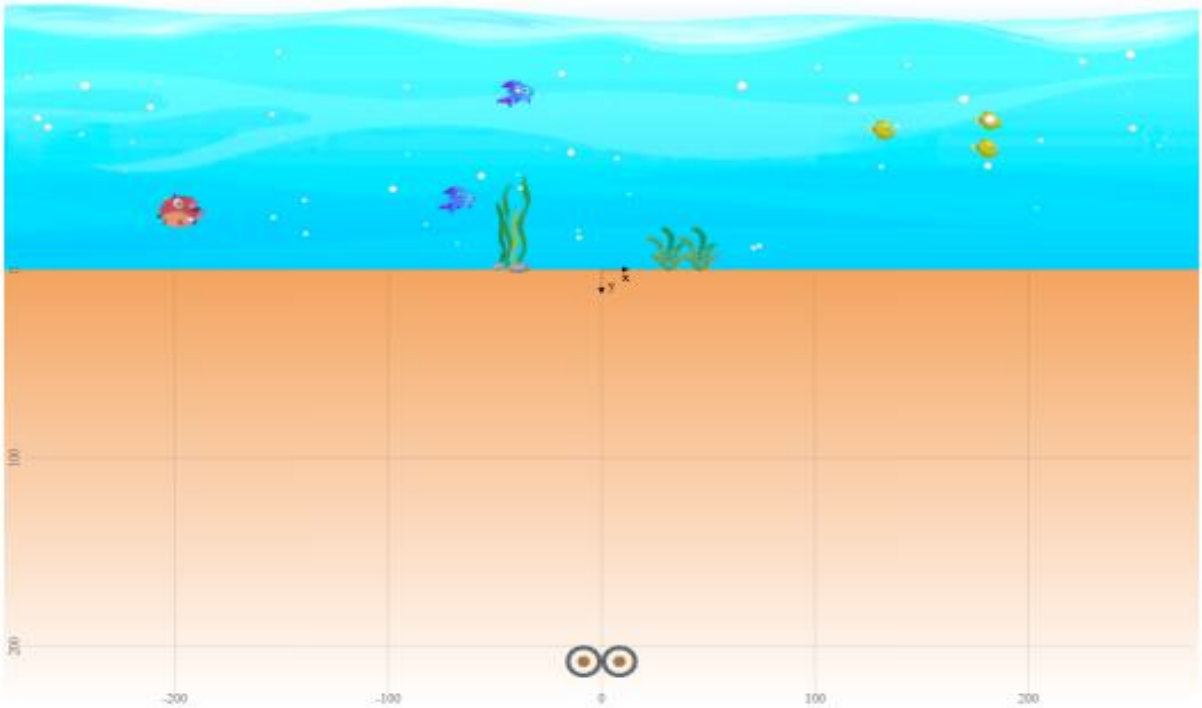
Title	Case 1 - Offshore Cables - Scenario A (EGL5)
Project	EGL5 Heat Calculations
Description	2m Burial Depth Temperature: 12degC Thermal Resistivity: 1.1 K.m/W
Created	Date: 2026-02-10 Time: 18:45 Software version: delf (2026-02-01)

Arrangement

Arrangement	**subsea project (#1965)**
Options	None
CIGRE TB 880, guidance points	02, 06, 09, 26, 31
Systems	A

Statistics

Number of iterations of the solver	N_{calc}	12
Calculation time		0.196 s
Sum of currents from all systems	I_{sum}	1930 A
Sum of average conductor temperatures from all systems	θ_{sum}	66.34 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	63.408 W/m



A.3.2 Results Sheet – Case 1: Offshore Cables (Scenario B)

Report

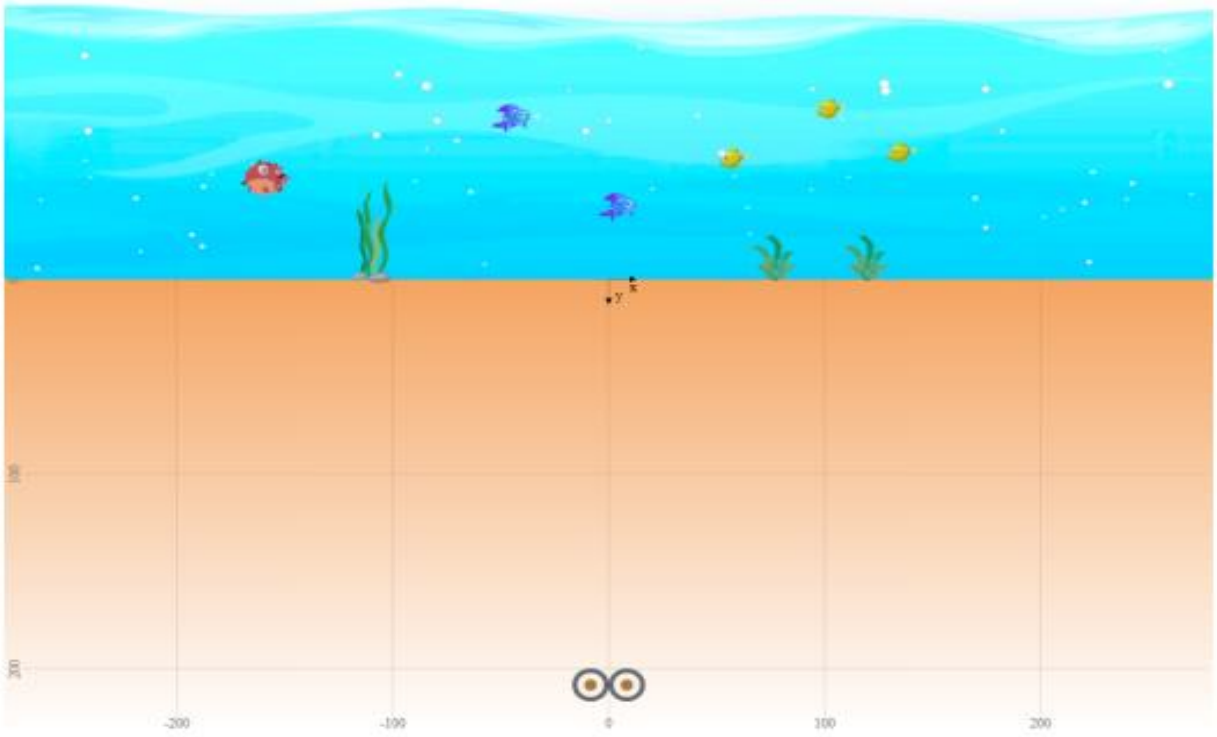
Title	Case 1 - Offshore Cables - Scenario B (EGL5)
Project	EGL5 Heat Calculations
Description	2m Burial Depth Temperature: 12degC Thermal Resistivity: 1.7 K.m/W
Created	Date: 2026-02-10 Time: 18:50 Software version: de1f (2026-02-01)

Arrangement

Arrangement	**subsea project (#1966)**
Options	None
CIGRE TB 880, guidance points	02, 06, 09, 26, 31
Systems	A

Statistics

Number of iterations of the solver	N_{calc}	15
Calculation time		0.218 s
Sum of currents from all systems	I_{sum}	1930 A
Sum of average conductor temperatures from all systems	θ_{sum}	94.23 °C
Number of overheated electrical systems		1
Sum of over-temperature from all systems	$\Delta\theta_{sum}$	4.23 °C
Overheated electrical systems		A
Sum of losses from all systems	W_{sum}	69.287 W/m



A.3.3 Results Sheets – Cases 2 and 3: Landfall

A.3.3.1 Thermal Resistivity: 1.2 K.m/W

Report

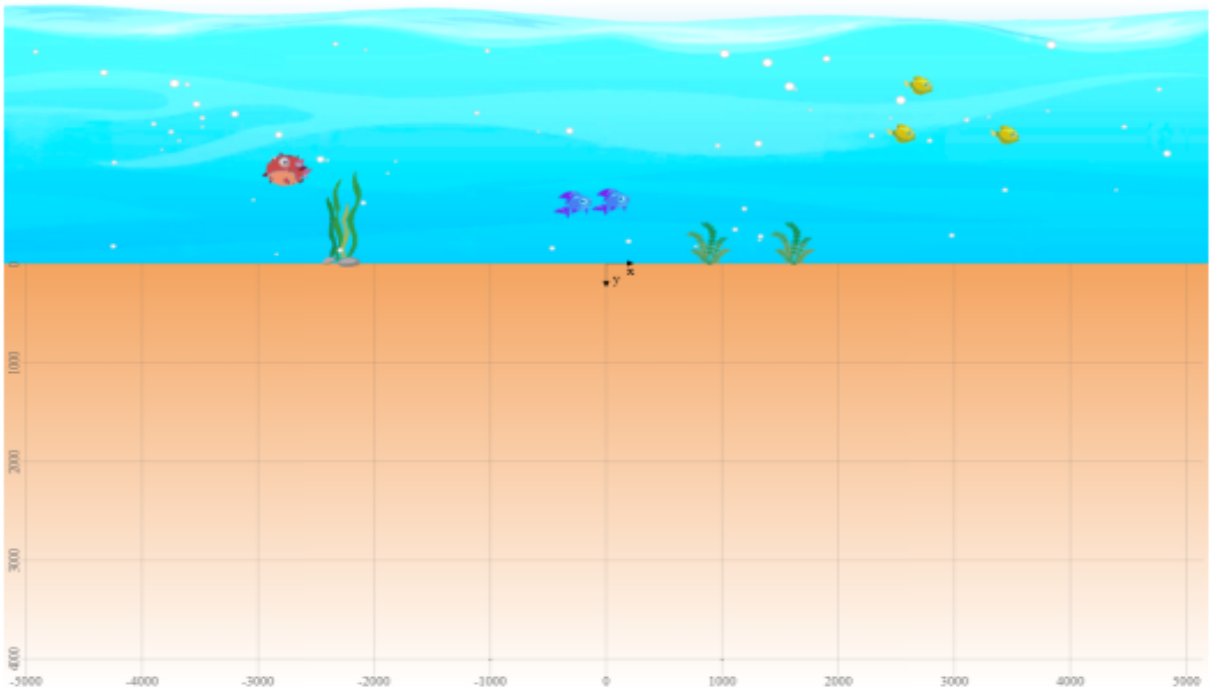
Title	Case 2 and 3 - Landfall - Offshore (EGL5)
Project	EGL5 Heat Calculations
Description	Offshore Burial Depth: 40m Temperature: 12degC Thermal Resistivity: 1.2K.m/W
Created	Date: 2026-02-10 Time: 18:53 Software version: de1f (2026-02-01)

Arrangement

Arrangement	**subsea project (#1967)**
Options	None
CIGRE TB 880, guidance points	02, 06, 09, 26, 31
Systems	A

Statistics

Number of iterations of the solver	N_{calc}	64
Calculation time		0.684 s
Sum of currents from all systems	I_{sum}	1930 A
Sum of average conductor temperatures from all systems	θ_{sum}	64.65 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	51.316 W/m



A.3.3.2 Thermal Resistivity: 2.5 K.m/W

Report

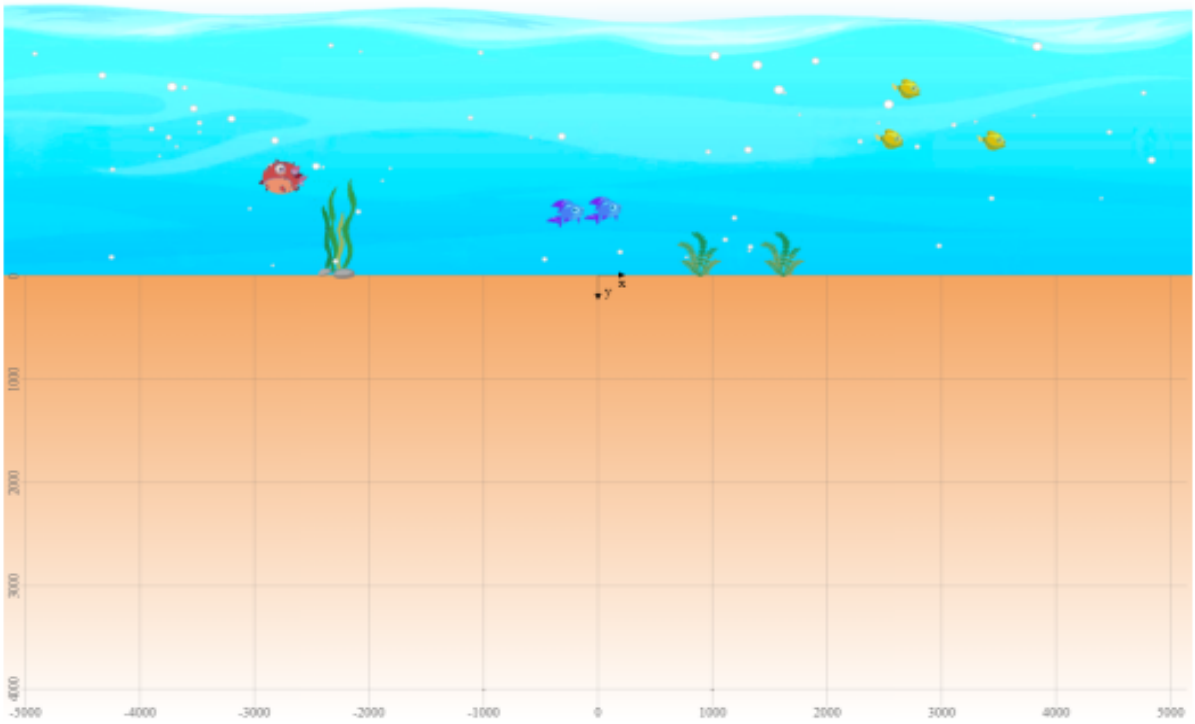
Title	Case 2 and 3 - Landfall - Offshore (EGL5)
Project	EGL5 Heat Calculations
Description	Offshore Burial Depth: 40m Temperature: 12degC Thermal Resistivity: 1.2K.m/W
Created	Date: 2026-02-11 Time: 15:36 Software version: de1f (2026-02-01)

Arrangement

Arrangement	**subsea project (#1967)**
Options	None
CIGRE TB 880, guidance points	02, 06, 09, 26, 31
Systems	A

Statistics

Number of iterations of the solver	N_{calc}	64
Calculation time		0.677 s
Sum of currents from all systems	I_{sum}	1930 A
Sum of average conductor temperatures from all systems	θ_{sum}	64.65 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	51.316 W/m



A.3.4 Results Sheet – Case 7: Cables in Seabed Below Sandwave

A.3.4.3 Thermal Resistivity: 1.2 K.m/W

Report

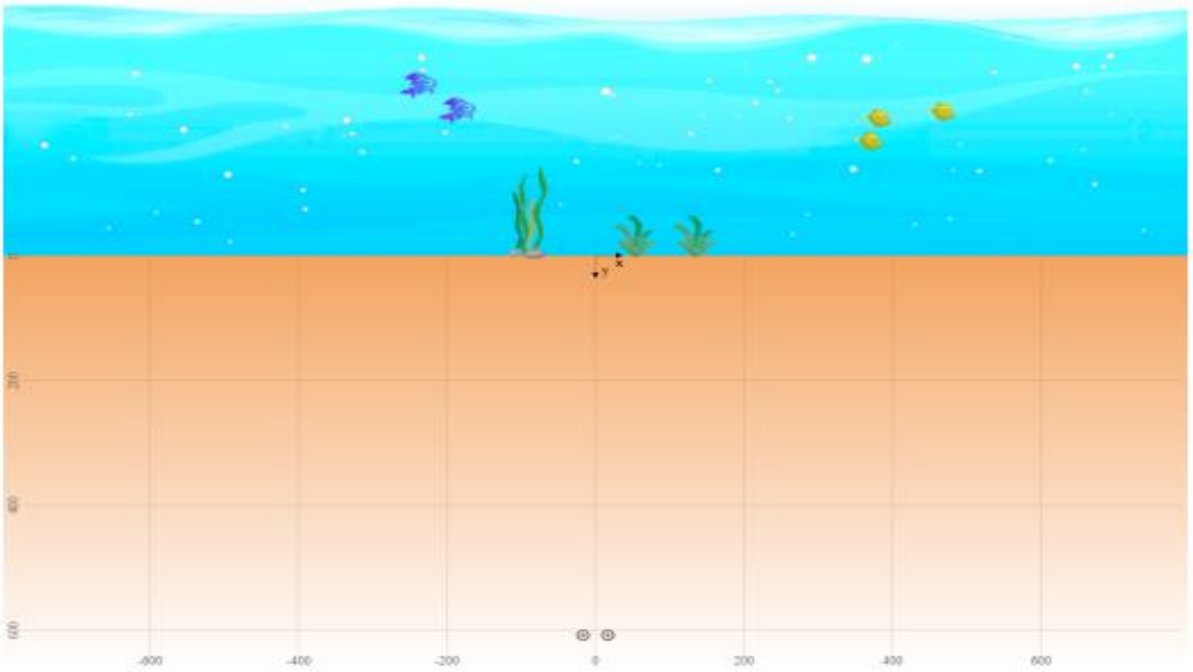
Title	Case 7 - Cables in Seabed Below Sandwave (EGL5)
Project	EGL5 Heat Calculation
Description	Burial Depth: 6m Ambient Temperature: 12degC Thermal Resistivity: 1.1 K.m/W
Created	Date: 2026-02-11 Time: 15:34 Software version: de1f (2026-02-01)

Arrangement

Arrangement	**subsea project (#1551)**
Options	None
CIGRE TB 880, guidance points	02, 06, 09, 26, 31
Systems	A

Statistics

Number of iterations of the solver	N_{calc}	70
Calculation time		0.697 s
Sum of currents from all systems	I_{sum}	1930 A
Sum of average conductor temperatures from all systems	θ_{sum}	62.18 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	50.892 W/m



A.3.4.4 Thermal Resistivity: 2.5 K.m/W

Report

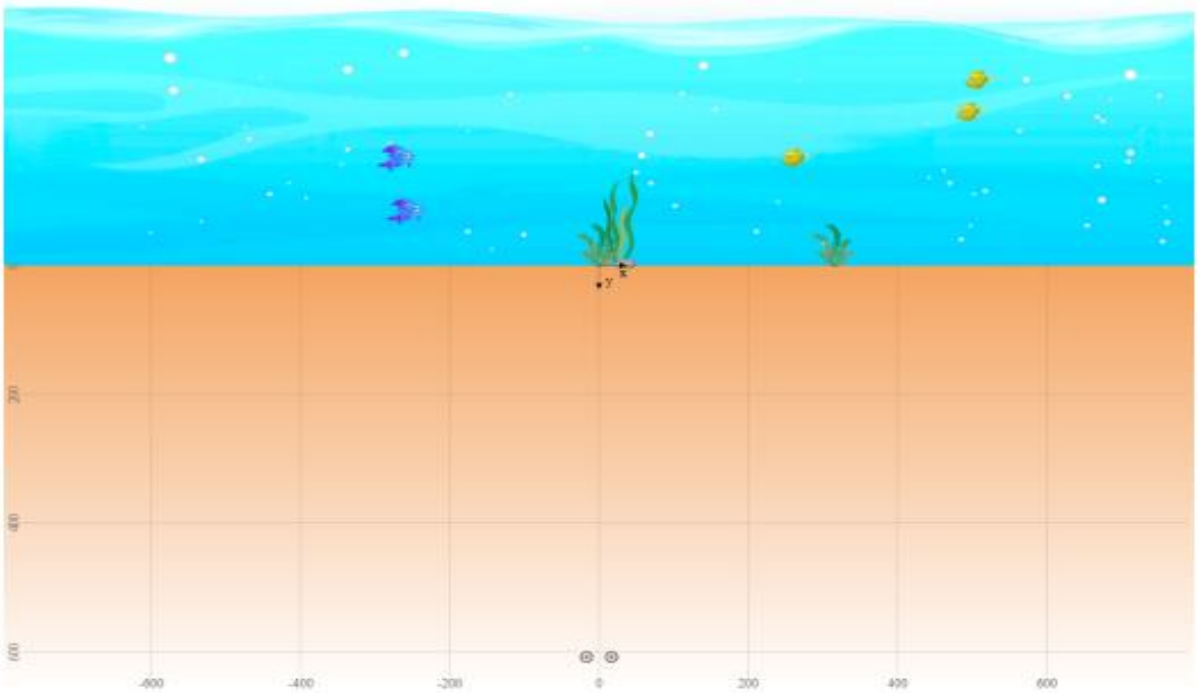
Title	Case 7 - Cables in Seabed... TR 2.5 (EGL5)
Project	EGL5 Heat Calculation
Description	Burial Depth: 6m Ambient Temperature: 12degC Thermal Resistivity: 2.5 K.m/W
Created	Date: 2026-02-11 Time: 15:53 Software version: de1f (2026-02-01)

Arrangement

Arrangement	**subsea project (#1969)**
Options	None
CIGRE TB 880, guidance points	02, 06, 09, 26, 31
Systems	A

Statistics

Number of iterations of the solver	N_{calc}	88
Calculation time		1.02 s
Sum of currents from all systems	I_{sum}	1930 A
Sum of average conductor temperatures from all systems	θ_{sum}	134.7 °C
Number of overheated electrical systems		1
Sum of over-temperature from all systems	$\Delta\theta_{sum}$	44.7 °C
Overheated electrical systems		A
Sum of losses from all systems	W_{sum}	63.334 W/m



A.4 Temperature Constrained Results

A.4.1 Case 1 – Offshore Cables

Report

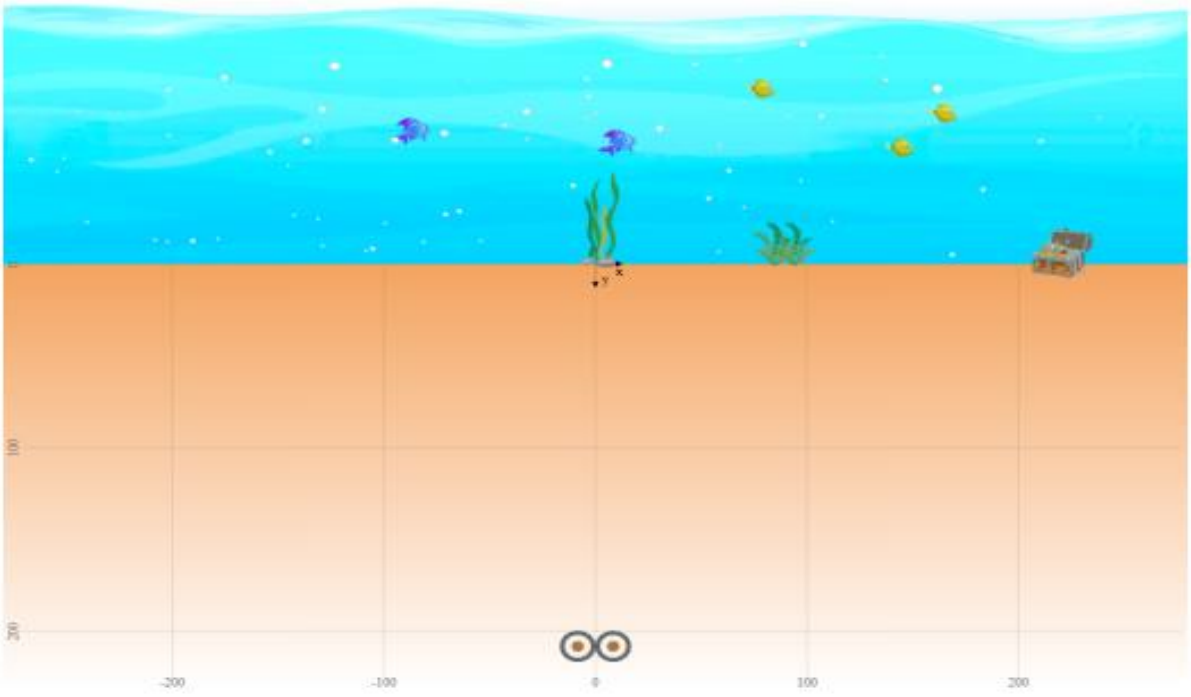
Title	Case 1 - Offshore Cables - (TC) (EGL5)
Project	EGL5 Heat Calculations
Description	2m Burial Depth Temperature: 12degC Thermal Resistivity: 2.0 K.m/W
Created	Date: 2026-02-11 Time: 15:32 Software version: de1f (2026-02-01)

Arrangement

Arrangement	subsea project (#1971)
Options	None
CIGRE TB 880, guidance points	02, 06, 09, 26, 31
Systems	A

Statistics

Number of iterations of the solver	N_{calc}	10
Calculation time		0.163 s
Sum of currents from all systems	I_{sum}	1772.75 A
Sum of average conductor temperatures from all systems	θ_{sum}	90 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	57.704 W/m



A.4.2 Case 2 and 3 – Landfall

Report

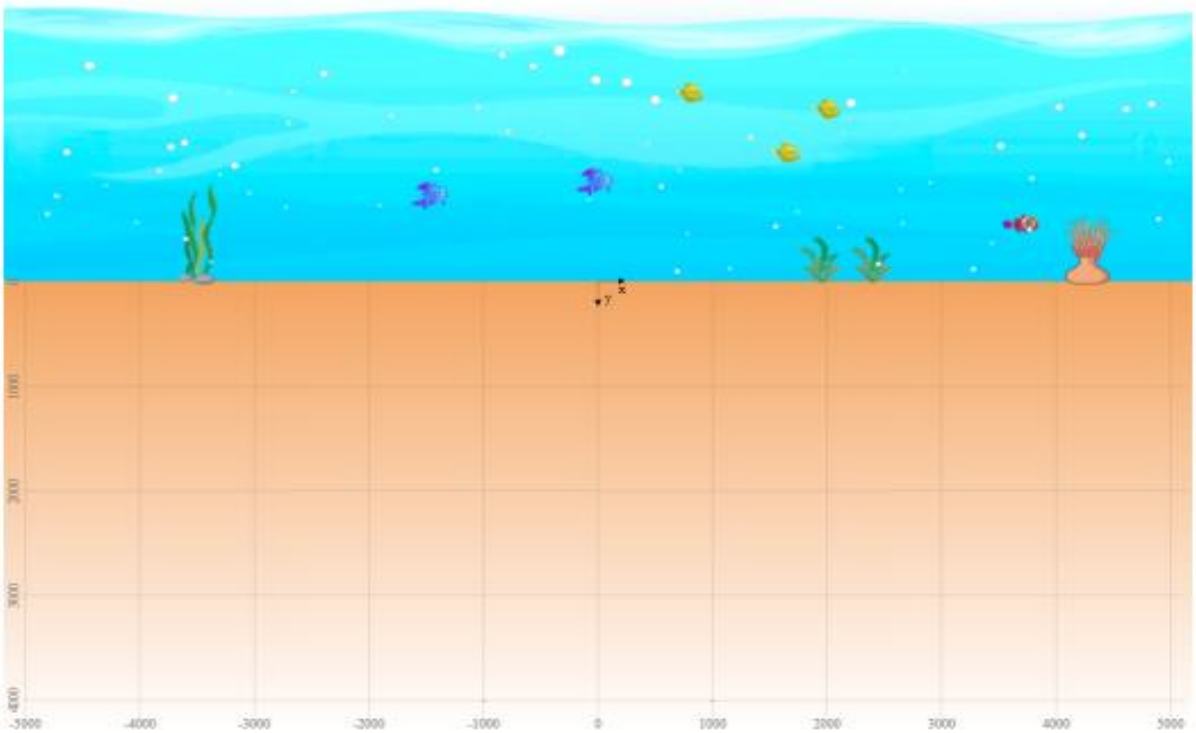
Title	Case 2 and 3 - Landfall - Offshore - TC (EGL5)
Project	EGL5 Heat Calculations
Description	Offshore Burial Depth: 40m Temperature: 12degC Thermal Resistivity: 2.5K.m/W
Created	Date: 2025-11-18 Time: 15:57 Software version: d354 (2025-11-17)

Arrangement

Arrangement	**subsea project (#1968)**
Options	None
CIGRE TB 880, guidance points	02, 06, 09, 26, 31
Systems	A

Statistics

Number of iterations of the solver	N_{calc}	53
Calculation time		0.545 s
Sum of currents from all systems	I_{sum}	1666.68 A
Sum of average conductor temperatures from all systems	θ_{sum}	90 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	41.512 W/m



A.4.3 Case 7 – Cables in Seabed Below Sandwave

Report

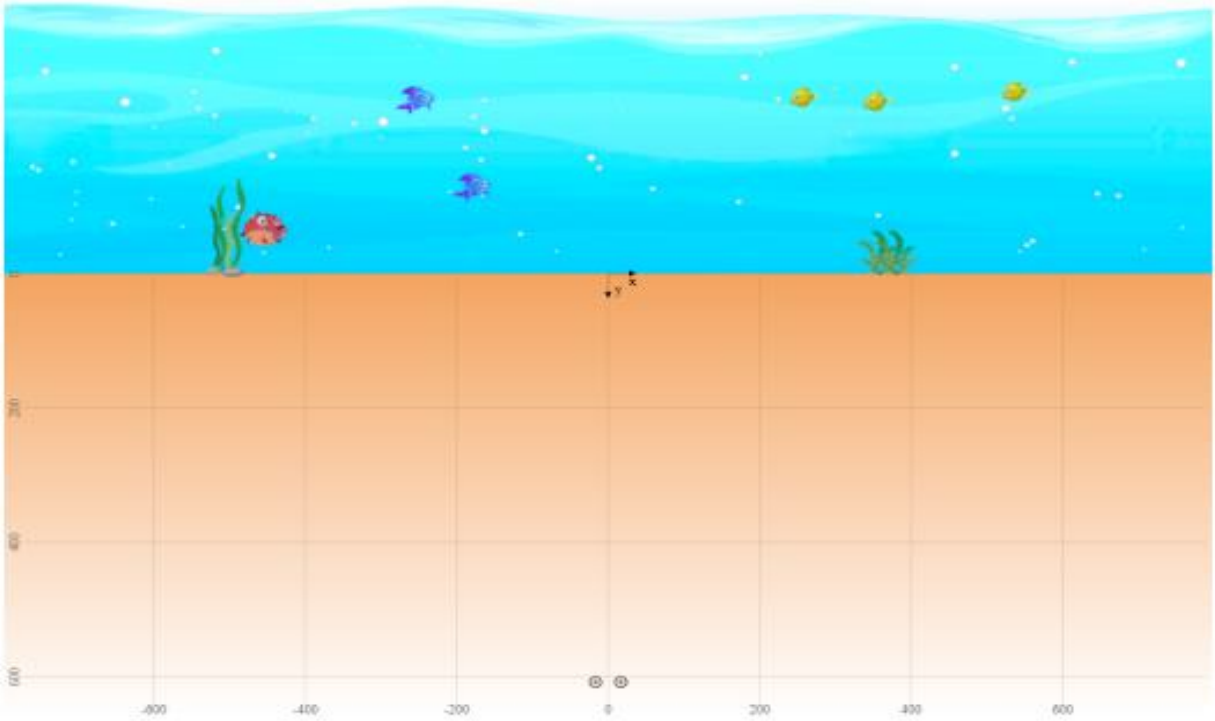
Title	Case 7 - Cables in Seabed... (TC) (EGL5)
Project	EGL5 Heat Calculation
Description	Burial Depth: 6m Ambient Temperature: 12degC Thermal Resistivity: 2.0 K.m/W
Created	Date: 2026-02-11 Time: 15:57 Software version: de1f (2026-02-01)

Arrangement

Arrangement	**subsea project (#1970)**
Options	None
CIGRE TB 880, guidance points	02, 06, 09, 26, 31
Systems	A

Statistics

Number of iterations of the solver	N_{calc}	43
Calculation time		0.486 s
Sum of currents from all systems	I_{sum}	1807.53 A
Sum of average conductor temperatures from all systems	θ_{sum}	90 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	48.825 W/m



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