

**The Great Grid Upgrade**

Eastern Green Link 5 (EGL 5)

# Preliminary Environmental Information Report

Volume 2

Part 1

Appendix 4.A Electromagnetic Field (EMF) Study

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# Eastern Green Link (EGL) 5

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# 4.A. Electric and Magnetic Field Compliance Report

## 4.A.1 Introduction

- 4.A.1.1 This document provides an assessment of electric and magnetic fields (EMFs) associated with the proposed Eastern Green Link (EGL) 5 Project. The EGL 5 Project is needed to increase network capability to connect the numerous new offshore wind farms that are being developed, and transport new clean green energy to the homes and businesses where it is needed.
- 4.A.1.2 The Project is a transmission reinforcement electrical link between Scotland and England, with associated onshore infrastructure allowing this to connect to the existing transmission infrastructure. EGL 5's subsea offshore cables would run from Scotland and make landfall on the Lincolnshire coastline at Anderby Creek.
- 4.A.1.3 Once onshore, the underground high voltage direct current (HVDC) cables would route to a single proposed converter station located to the north-east of Bilsby within East Lindsey District Council.
- 4.A.1.4 From the converter station, the high voltage alternating current (HVAC) underground cables would route to and connect into the proposed Lincolnshire Connection Substation-B (LCS-B) near Bilsby, East Lindsey that is being proposed as part of NGET's separate Grimsby to Walpole project.
- 4.A.1.5 This report describes EMFs produced by the operation of the proposed converter station, the associated High Voltage Direct Current (HVDC) bipole cables and 50 Hz underground Alternating Current (AC) cables connecting the proposed converter station to the proposed National Grid connection Substation (LCS-B), in the onshore and offshore environments.
- 4.A.1.6 All equipment that generates, transmits, distributes or uses electricity produces EMFs. In the UK electricity is normally generated, transmitted, distributed and consumed as AC. The UK power frequency for AC is 50 Hertz (Hz), which is therefore the principal frequency of the EMFs produced, also known as Extremely Low Frequency (ELF) EMFs. The Project will use DC transmission which has a frequency of zero Hertz (0 Hz) and will produce static EMFs. The proposed converter station will then convert DC transmission to AC 50 Hz transmission which can be connected to the existing National Grid transmission system.
- 4.A.1.7 The key English elements of our proposals for consultation include:
- One subsea cable circuit to the Anderby Creek Landfall location, whereby only the English aspects are being consulted on;
  - Offshore HVDC circuit from transition joint bay to onshore at the Anderby Creek Landfall on the Lincolnshire coastline;
  - From the Anderby Creek Landfall, the underground HVDC cable circuit would run to the proposed new converter station;
  - One new converter station;

- Onshore underground High Voltage Alternating Current (HVAC) cables, to connect the proposed converter station to the proposed Lincolnshire Connection Substation – B which is being consented by the separate Grimsby to Walpole Project.

4.A.1.8 All static and alternating fields can have different effects, but in both cases, there are exposure limits set by independent organisations, designed to prevent all established effects of EMFs on people.

## 4.A.2 Electric Fields

4.A.2.1 Electric fields depend on the operating voltage of the equipment producing them and are measured in V/m (volts per metre). The voltage applied to equipment is a relatively constant value. Electric fields are shielded by most common building materials, trees and fences and diminish rapidly with distance from the source.

4.A.2.2 As a consequence of their design, some types of equipment do not produce an external electric field. This applies to underground cables (both AC and DC) and gas insulated switchgear (GIS), which are enclosed in a metal sheath (a protective metal layer within the cable) and have solid metal enclosures respectively. These screen the electric field and as such electric fields are not considered further for these types of equipment.

4.A.2.3 In the marine environment the movement of the sea through the magnetic field will result in a small localised electric field being produced. The induced electric fields that occur in the sea will be assessed in Section 5.3.

## 4.A.3 Magnetic Fields

4.A.3.1 Magnetic fields depend on the electrical currents flowing, which vary according to the electrical power requirement at any given time and are measured in  $\mu\text{T}$  (microtesla). They are not significantly shielded by most common building materials or trees. Magnetic fields diminish rapidly with distance from the source.

4.A.3.2 Magnetic fields are found in all areas where electricity is in use (e.g., offices and homes), arising from electric cabling and equipment in the area. In UK houses, typical ELF magnetic fields will be in the range of 0.01 – 0.2  $\mu\text{T}$ , with higher values in localised areas close to electrical appliances.

4.A.3.3 The earth also produces its own DC magnetic field, which in the UK is around 50  $\mu\text{T}$ , but this can vary due to geomagnetic material such as rocks.

4.A.3.4 The Project uses both AC and DC technology, so both static and alternating EMFs will be produced. The underground cables entering the proposed converter station will use DC, so they will produce steady EMFs that always point in the same direction. There will also be a section of AC cables installed between the proposed converter station and LCB-B Substation which will operate at 50 Hz.

4.A.3.5 The proposed converter station will contain specialist electrical equipment which will produce both DC and AC fields which are assessed in this report.

4.A.3.6 The Project will be developed as an HVDC cable circuit. Where the cables come onshore, converter station and HVAC cabling and substation will be required to enable the power to connect to the existing transmission system.

4.A.3.7 This report will assess the EMF from the project and any mitigation to be considered.

## 4.A.4 Legislation and Policy

### Policy and assessment guidelines for the Protection of People

4.A.4.1 At high enough levels, EMFs can cause biological effects, which depending on the frequency of the fields can impact nerve function or blood flow. Whilst there are no statutory regulations in the UK that limit the exposure of people to power-frequency EMFs, responsibility for implementing appropriate measures for the protection of the public lies with the UK Government. Government has a clear policy on the exposure limits and other policies they expect to see applied, restated in January 2024 and incorporated in NPS EN-5 (Ref 2.1). Practical details of how the policy is to be implemented are contained in Codes of Practice<sup>1</sup> agreed between industry and the Government.

4.A.4.2 In the absence of any specific Scottish Government guidelines, those set by the UK Government remain applicable for the EGL 5 Project. UK Government policy on EMF requirements for all electricity infrastructure projects is given in NPS EN-5.

4.A.4.3 The key provision is in section 2.11.9:

*“...Government has developed with the electricity industry a Code of Practice, “Power Lines: Demonstrating compliance with EMF public exposure guidelines – a voluntary Code of Practice published in February 2011 that specifies the evidence acceptable to show compliance with ICNIRP (1998) in terms of the EU Recommendation. Before granting consent to an overhead line application, the IPC should satisfy itself that the proposal is in accordance with the guidelines, considering the evidence provided by the applicant and any other relevant evidence.”*

4.A.4.4 The ICNIRP (Ref 2.2) guidelines are based on the avoidance of known adverse effects of exposure to EMF at frequencies up to 300 GHz, which includes the 50 Hz EMF associated with electricity transmission. This equates, at 50 Hz, to public exposure limits for uniform exposure of:

- 9.0 kV/m for electric fields; and
- 360  $\mu$ T for magnetic fields.

4.A.4.5 The EU recommendation (Ref 2.3) adopts ICNIRP guidelines (Ref 2.4) for static magnetic field exposure. Acute public exposure should not exceed 40,000 $\mu$ T (40 millitesla). However, ICNIRP’s 1994 guidance (Ref 2.4), states that there are potential indirect effects, such as injuries due to flying ferromagnetic objects and potential interactions with implantable medical devices which could occur at levels below the exposure limits. These limits are detailed in **Table 4-A-1**.

4.A.4.6 Therefore, a lower restriction of 500  $\mu$ T should be considered where indirect effects may be an issue. The assessment would demonstrate a significant impact if non-compliance with the EMF exposure limits was demonstrated using the principles set out in Codes of Practice ‘Power Lines: Demonstrating compliance with EMF public exposure guidelines – a voluntary Code of Practice’ (Ref 2.5).

Table 4-A-1 Recommended Values for Power Frequencies

Public Exposure Levels	Electric fields	Magnetic fields
<b>AC</b>		
Basic restriction (induced current density in central nervous system)		2 mA/m <sup>2</sup>
Field corresponding to the basic restriction	9,000 V/m	360 µT
<b>DC</b>		
Exposure limit	No limit*	40 000 µT

\*No DC electric field limits are provided in the guidelines, but 20 kV/m is recommended by the IEEE to prevent spark discharges (Ref 2.6)

## Policy Framework for the Protection of Marine Life

4.A.4.7 National Policy Statement EN-3 (Ref 2.7) for renewable energy infrastructure provides the primary basis for decisions by the Infrastructure Planning Commission (IPC) on applications it receives for nationally significant renewable energy infrastructure. There are no limits or guidelines for EMF exposure in the marine environment, but potential impacts on marine life should be assessed.

4.A.4.8 The key provision in Paragraph 2.8.310 states:

*“The use of external cable protection has been suggested as a mitigation for EMF (by increasing the distance between fish species and individual cables). However, the Secretary of State should also consider any negative impacts from external cable protection on benthic habitats, and a balance between protection of various receptors must be made, with all mitigation and alternatives reviewed.”*

4.A.4.9 The mitigation methods suggested in NPS EN-3 include the use of armoured cables for inter-array and export cables. Armoured cables are proposed for the EGL 5 project. Burial depth can reduce the magnetic fields at distance but to a lesser extent than cable bundling or compact phase arrangements. Therefore, mitigation of EMF from offshore cables can also occur by reducing the separation of the cables in each bipole system. The closer the cables, the more cancellation of the field occurs and the lower the fields.

4.A.4.10 This report will provide the EMF details to inform the marine impact assessments.

## Effects on Magnetic Compasses

4.A.4.11 Magnetic compasses, whether traditional magnetic needle designs or alternatives such as fluxgate magnetometers, operate from the Earth’s magnetic field, and are susceptible to any perturbation to the Earth’s magnetic field by other sources.

4.A.4.12 This is a potential issue with direct current (DC) conductors or cables, which produce a static magnetic field that perturbs the geomagnetic field. These are assessed in Section 5.4.

4.A.4.13 High voltage AC cables produce 50 Hz magnetic fields. These oscillate far too quickly (50 times per second) for a magnetic compass needle to be affected. Fluxgate magnetometers are capable of responding to 50 Hz fields, but, when used as a compass, always have filtering to eliminate unwanted frequencies including 50 Hz. They can cease working correctly if saturated by a high-enough field, but the field required is orders of magnitude higher than would be produced by the Project. Magnetic compass impacts do not occur where AC cables are installed, so there will be no impact from these assets.

## 4.A.5 Baseline Environment

### Onshore

4.A.5.1 All equipment that generates, distributes or uses electricity produces EMFs. The UK power frequency is 50 Hz, which is the principal frequency of the EMFs produced, although HVDC circuits are also present which will be a source of additional DC fields.

4.A.5.2 Electric and magnetic fields both occur naturally. The Earth's magnetic field, which is caused mainly by currents circulating in the outer layer of the Earth's core, is approximately 50  $\mu\text{T}$  in the UK. This field may be distorted locally by ferrous minerals or by steelwork such as in buildings or bridges.

4.A.5.3 As detailed earlier in this report, the Earth's natural electric and magnetic fields are static, and the power system produces alternating fields. In homes in the UK that are over 100 m from high-voltage overhead lines or underground cables, the average "background" power-frequency magnetic field (the field existing over the whole volume of the house) ranges typically from 0.01 – 0.2  $\mu\text{T}$  with an average of approximately 0.05  $\mu\text{T}$ , normally arising from currents in the low voltage distribution circuits that supply electricity to homes. The highest magnetic fields to which most people are exposed in the home arise close to domestic appliances that incorporate motors and transformers. For example, close to their surface, fields can be 2000  $\mu\text{T}$  for electric razors and hair dryers, 800  $\mu\text{T}$  for vacuum cleaners, and 50  $\mu\text{T}$  for washing machines. The electric field in most homes is in the range 1 – 20 V/m, rising to a few hundred V/m close to appliances.

4.A.5.4 There is also a natural static electric field everywhere on the surface of the earth with an intensity of about 100 V/m. This varies significantly and are very dependent on atmospheric conditions. When a thunderstorm approaches, the electric field reaches much higher values, of the order of 10 kV/m to 20 kV/m at ground level.

### Offshore

4.A.5.5 The current offshore environment where the EGL 5 cables are proposed (within the English Offshore draft Order Limits), has naturally occurring DC magnetic fields, which again is around 50  $\mu\text{T}$ .

4.A.5.6 The Earth's magnetic field can induce an electric field in sea water. The movement of the sea through the magnetic field will result in a small localised electric field being produced. It has been stated that the magnitude of the electric field induced will be dependent upon magnetic field strength, sea water chemistry, viscosity and its flow velocity and direction relative to the lines of magnetic flux. Given the background geomagnetic field of around 50  $\mu\text{T}$ , the background induced electric field could range between 5.0 and 65  $\mu\text{V/m}$  in tidal velocities ranging between 0.1 m/s and 1.35 m/s.

## 4.A.6 Assessment Methodology

- 4.A.6.1 In order to demonstrate compliance with the exposure guidelines, Industry and Government have published a Code of Practice, "Power Lines: Demonstrating compliance with EMF public exposure guidelines. As part of the Code of Practice, the Energy Networks Association maintains a list of types of equipment where design is such that it is not capable of exceeding the ICNIRP exposure guidelines. This list includes all substations which do not contain any air-cored reactors. At the substation perimeter fence, the highest fields are invariably produced by any overhead lines or underground cables at transmission voltages entering the substation; the compliance of these items of equipment is considered on a case-by-case basis.
- 4.A.6.2 For the assessment of effects from a DC system, NGET are required to provide evidence of compliance for the proposed converter station and underground cables. In line with the Code of Practice, this report sets out the technical specifications of the proposed converter station and substations to demonstrate how the development complies with EMF exposure guidelines and provides a calculation of the maximum magnetic fields directly over the underground cable route.
- 4.A.6.3 These calculations assume that there is no attenuation of magnetic fields from any surrounding material (e.g., seabed, earth, grout mattresses, etc.) and that there are no unbalanced currents flowing along the outer sheaths of the cables.

### Assessment of Effects

- 4.A.6.4 The English Onshore Scheme of the Project would be assessed as having an adverse effect if non-compliance with the EMF exposure limits was demonstrated, using the principles set out in Codes of Practice (Ref 2.2). Conversely, as specified in NPS EN-5 (Ref 2.1) if the proposed projects comply with the exposure limits, EMF effects are assessed as not significant, and no mitigation is necessary.
- 4.A.6.5 For the English Offshore Scheme, total field values are produced and compared to the requirements of NPS EN-3 and used to assess potential impacts to marine life. The impact of EMF on marine life will be covered within **Volume 1, Part 3, Chapter 18 Intertidal and Subtidal Benthic Ecology**, and **Volume 1, Part 3 Chapter 19 Fish and Shellfish** of the Preliminary Environmental Information Report (PEIR) and Environmental Statement (ES). The impact of EMF on the freshwater environment will be covered within **Volume 1, Part 2, Chapter 6 Biodiversity** of the PEIR and ES.

## 4.A.7 Assessment of English Offshore scheme EMF

- 4.A.7.1 The Project will be formed of a new primarily offshore High Voltage Direct Current (HVDC) electrical link operating at 0 Hz (DC) and will consist of a bipole system with 2 cables.
- 4.A.7.2 The installation and electrical design of the transmission link will impact the EMFs produced. The vast majority of the route will be a bundled bipole design. Where cables transition to land, cables are installed via a trenchless installation from a transition joint bay at landfall. Currently the trenchless solution for EGL 5 has not been finalised and is awaiting further design and survey work. The trenchless section, which will be approximately 300-400 m in length has been excluded from assessment but will be updated in the EIA stage when designs are finalised. The cable design included within the offshore EMF assessment is included in **Table 4-A-2** and has been used for the EMF assessment.

4.A.7.3 The bundled cables are assumed to have a 0.2 m separation installed within a single trench.

Table 4-A-2 EGL 5 cable geometries and calculation parameters for all electrical designs

Cable configuration	No. cables	No. trenches	Power per cable	Max. current per cable	Voltage
Bundled	2	1	1 GW	1944A	± 525kV

4.A.7.4 The magnetic field produced by the cables will depend on the current flowing in the cables, the separation of the cables, and the distance from the cables. A bipole system will result in a cancellation of the magnetic fields when the cables are close together.

4.A.7.5 The magnetic field produced by the cables will in turn induce electric fields in sea water passing through the field, due to the sea waters conductivity. This will be proportional to the magnetic field and the velocity of the water.

## Magnetic Field Assessment

4.A.7.6 All calculations were performed assuming minimum burial depth, and 100% load giving a worst-case scenario. The maximum magnetic fields from the bundled cables are provided in **Table 4-A-3** for the cable only. The magnetic field from the cables will also combine with the earths geomagnetic field and these combined fields are provided in **Table 4-A-4**. For information, calculations were additionally performed for 50 % load, which are presented in **Annex A, Table A1**.

4.A.7.7 The maximum magnetic field was calculated at vertical distances of 0 to 20 m from the seabed, and horizontal drop off along the seabed. A minimum burial depth of 1 m was used for all bundled cables, to represent a worst case. The average burial depth is expected to be 1.5 m along the route and is subject to further geotechnical surveys.

4.A.7.8 **Table 4-A-2** gives the maximum magnetic field at vertical distances from the cables only and the distance from the cables that the magnetic field produced by the cables reduces to below 49.6  $\mu$ T, the Earth’s geomagnetic field in the area.

4.A.7.9 **Plate 4-A-1** shows the maximum magnetic field from the cable only and the total magnetic field when combined with the geomagnetic field for the bundled cable sections of route. **Table 4-A-3** gives the total magnetic field when combined with the geomagnetic field for the bundled cables.

Table 4-A-3 Calculated maximum cable magnetic fields at vertical distances from the seabed for the bundled offshore cable circuit design.

<b>Magnetic field (<math>\mu\text{T}</math>)</b>								
	Distance above seabed (m)							Distance for magnetic field to reach background geomagnetic field (m)
	Seabed	0.5 m	1 m	2 m	5 m	10 m	20 m	
Bundled cables	77.0	34.4	19.4	8.6	2.16	0.64	0.18	0.25 m above seabed

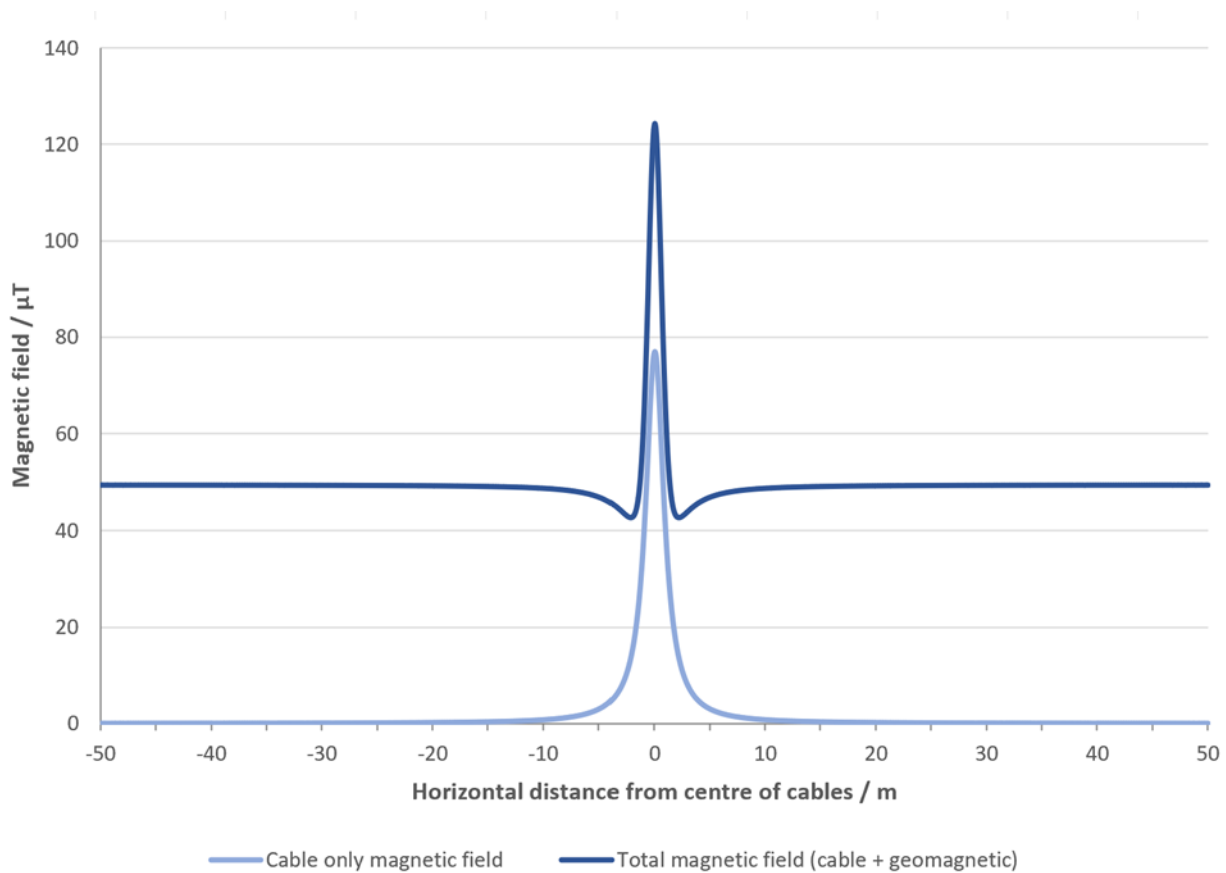
Bundled cables are buried 1 m below the seabed. Distance for the magnetic field to fall below the background geomagnetic field.

Table 4-A-4 Calculated maximum cable magnetic fields at vertical distances from the seabed for the bundled offshore cable circuit design combined with the earths geomagnetic field.

<b>Magnetic field (<math>\mu\text{T}</math>)</b>							
	Distance above seabed (m)						
	Seabed	0.5 m	1 m	2 m	5 m	10 m	20 m
Bundled cables	124.3	82.5	67.9	57.6	51.6	50.2	49.7

Bundled cables are buried 1 m below the seabed.

Plate 4-A-1 Calculated maximum magnetic fields horizontally along the seabed for bundled cable design.



4.A.7.10 In **Calculated maximum** magnetic fields horizontally along the seabed for bundled cable design. the light blue line shows the maximum magnetic field from the cables only. The dark blue line shows the total magnetic field when the magnetic field from the cables is combined with the Earth’s geomagnetic field.

4.A.7.11 The calculated magnetic fields are greatest on the seabed and reduce rapidly with vertical and horizontal distance from the circuits (**Table 4-A-1** and **Plate 4-A-1**). The maximum magnetic fields calculated at the seabed were 77.0  $\mu\text{T}$  for bundled cables. It is important to note that these levels do not take account of shielding factors of the cable sheath which would further reduce the fields.

## Induced Electric Fields

4.A.7.12 The HVDC cable will produce a magnetic field which decreases with distance from the cables and current flowing through the cables. The movement of the sea through the magnetic field will result in a small localised electric field being produced. A background electric field will be present in the sea due to the geomagnetic field and localised magnetic anomalies. The strength of this field varies continuously due to the strength, speed and direction of the tide.

4.A.7.13 The convention for calculating induced electric fields for the Basslink, BritNed HVDC and Western Link connections is:

$$\text{Induced electric field } (\mu\text{V/m}) = \text{Velocity (m/s)} \times \text{Magnetic field } (\mu\text{T})$$

4.A.7.14 This is a vector cross product which means that the strength of the electric field is proportional to the component of the velocity perpendicular to the magnetic field and is in a direction perpendicular to both. In the absence of information of tidal velocity at the cable's locations, calculations are evaluated for values up to 1.35 m/s, as was used for the Western Link cable assessment.

4.A.7.15 The average geomagnetic field along the EGL 5 route is approximately 50  $\mu\text{T}$ , which is used to calculate the background induced electric field. This background magnetic field induces an electric field that could range between 5.0 and 65.0  $\mu\text{V/m}$  in tidal velocities ranging between 0.1 m/s and 1.35 m/s. This does not take account of localised magnetic anomalies, which could result in higher localised electric fields, or of greater tidal velocities. Direction of water flow is also an important consideration, which has been assumed to be in the worst-case scenario for calculations.

4.A.7.16 Table A2 in **Annex A** gives the calculated induced electric field for the bundled cable design at four representative tidal velocities.

4.A.7.17 Calculations indicate the electric field is highly dependent on the tidal velocity and that the effects around the cables are localised. For both cable installation methods, the induced electric field are a similar magnitude to that occurring naturally. Magnetic fields are highest closest to the seabed, here water velocity will be lower due to friction, so calculations at maximum velocities would not occur in practice.

## Compass Deviations Along Route

4.A.7.18 The magnetic field from the cables, if large enough, will combine with the Earth's magnetic field causing a compass to indicate north in a different direction to the magnetic north pole.

4.A.7.19 It is the horizontal component of the geomagnetic field that is used for navigation, and this varies between 49.62  $\mu\text{T}$  in East Scotland area and 49.57  $\mu\text{T}$  in the Lincolnshire area<sup>2</sup>. A value of 49.6  $\mu\text{T}$  is used for the studies here.

4.A.7.20 The Marine Management Organisation (MMO) have previously provided the following guidance for projects with a similar design:

*"In relation to Electromagnetic deviation on ships' compasses, the MMO would be willing to accept a three-degree deviation for 95% of the cable route. For the remaining 5% of the cable route no more than five degrees will be attained. The MMO would however expect a deviation survey post the cable being laid; this will confirm conformity with the consent condition. This data must be provided to the UKHO (UK Hydrographic Office) via a hydrographic note (H102), as they may want a precautionary notation on the appropriate Admiralty Charts."*

4.A.7.21 The magnetic fields and compass deviation at the sea's surface were calculated for the EGL 5 bundled sections of cable route. The exact location of the transition joint bay where the cables begin their transition to onshore via trenchless installation are subject to further design and survey work, as is the trenchless design. This will be approximately

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<sup>2</sup> Taken from British Geological Society website  
[https://geomag.bgs.ac.uk/data\\_service/models\\_compass/wmm\\_calc.html](https://geomag.bgs.ac.uk/data_service/models_compass/wmm_calc.html)

300 m to 400 m from the shoreline. Compass deviations for the anticipated bundled cable section of route only have been included in the assessment, from KP0.4 to KP396.8.

- 4.A.7.22 The assessments were performed using cable orientation and depth from Bathymetry data. The orientation of the cables to north, separation, sea depth, as well as the current flowing in the cable, will all impact the extent a compass is deviated from the Earth's magnetic north.
- 4.A.7.23 The maximum compass deviation for each route has been calculated along the bundled section of the English route for the maximum circuit current. The results are shown in Plate B-1, **Annex B**. The compass deviation is shown as a solid purple line for the main route. If the Project is not operating at full capacity, the compass deviation will be smaller. The depth of the cables from the water surface is shown as the red line.
- 4.A.7.24 The depth of the cable, used for the calculation of compass deviation, is deeper than the seabed depth by the 1 m burial depth, although this is likely to be deeper across the majority of the route, so represents a worst-case. The compass deviation is calculated at the level of the sea surface. In practice the draught of any vessels will limit the sea depth that applies, and the compass is likely to be situated above the water line, both of which will reduce the compass deviation found in practice.
- 4.A.7.25 **Table 4-A-4** gives the percentage of the EGL 5 bundled route section resulting in compass deviations at the sea surface of less than 3 degrees and 5 degrees. For this aspect, the parts of the cable which come ashore, where depth of the seabed becomes zero or negative, are excluded. The change in compass deviation of the bundled section of route is provided in **Annex B**,

**Table 4-A-5 Percentage of the EGL 5 bundled route section resulting in compass deviations of less than 3° and 5° variations.**

Proportion of route within compass deviation threshold	
Bundled cable design	
EGL 5 route	
Less than 3° deviation	100%
Less than 5° deviation	100%

## EGL 5 Route

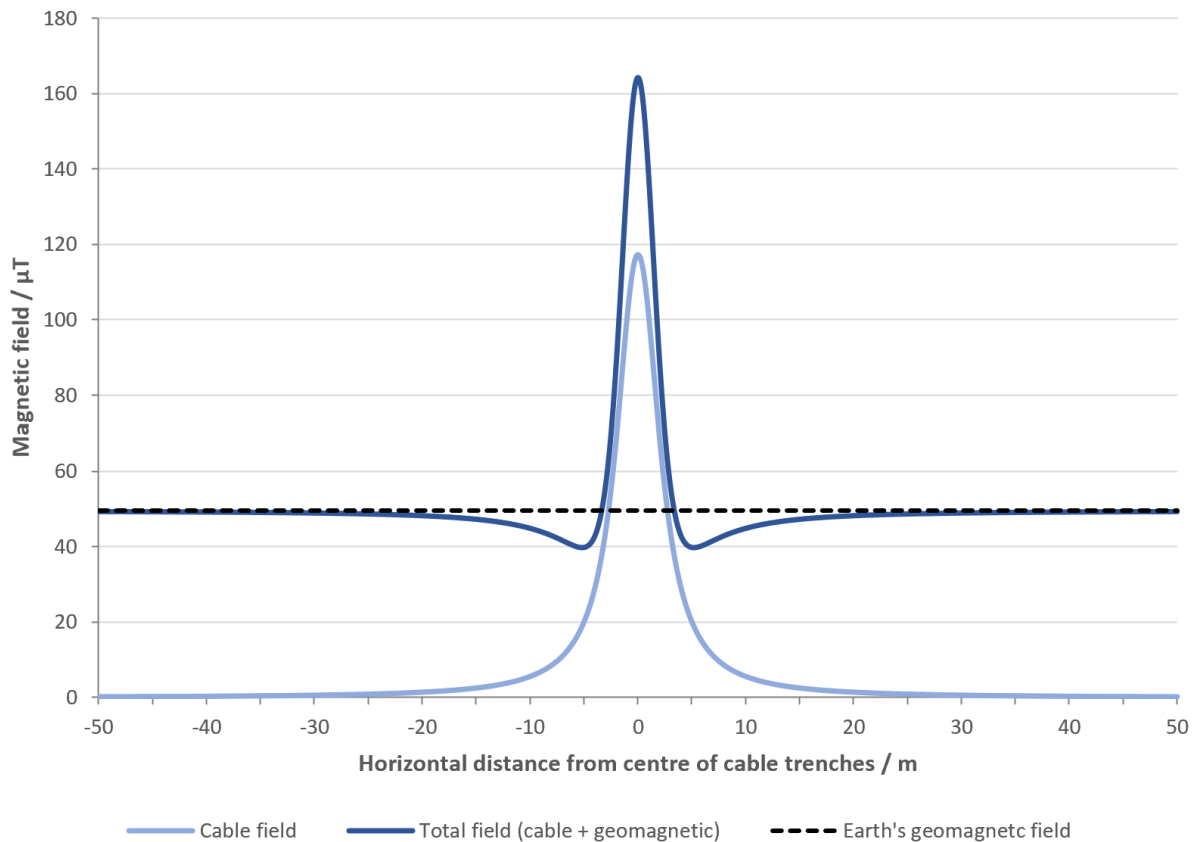
- 4.A.7.26 Very low compass deviation occurs over bundled section of the English Onshore Scheme cable route. The bundled section of cable route has one point greater than 3 degrees at KP0.4, but below 5 degrees. The remaining bundled section results in compass deviations all below 3 degrees. The nearshore region from KP0.4 has not been included within the assessment as a design is yet to be finalised. This will be included at the EIA stage.

## 4.A.8 Assessment of English Onshore Scheme EMF

### DC Cables

- 4.A.8.1 The onshore HVDC circuit proposed for the project consisting of two cables which operate as a bipole system. This installation design was assessed as a worst-case situation in line with the principles of the Governments Code of Practice.
- 4.A.8.2 The depth of the cables would vary, subject to the outcome of soil Agricultural Land Classification (ALC), agricultural land drainage, engineering and ground investigation surveys. The minimum depth coverage would be 900 mm to the cable protective tiles, with cables being located at a depth below the protective tiles. Where justified, it may be laid deeper. The depth of installation would also be deeper at locations where trenchless methods e.g., HDD, are required. For this assessment a minimum burial depth of the cables was taken as 1.1 m to represent a worst-case condition. The cables will typically be installed in a trench with an assumed 1.5 m separation.
- 4.A.8.3 As the cables operate as a bipole system, the current in each cable runs in opposition to the other leading to a significant cancellation of the magnetic field. The magnetic field for each design has been calculated using the maximum current rating of the cable and at 1 m above ground.
- 4.A.8.4 The earthed metallic shield that is applied over the insulation of HVDC cables ensures that the electric field will be contained entirely within the insulation, and no external electric field will be emitted. The proposed underground cables produce no external electric fields, so are not considered further.
- 4.A.8.5 The DC magnetic fields from the cable itself were calculated in accordance with the provisions of the Code of Practice. These magnetic fields will also combine with the earths geomagnetic field. The magnetic fields from the cables themselves and the combined cable and geomagnetic fields are presented in **Table 4-A-6** and **Plate 4-A-2**. All calculations were performed assuming maximum load, minimum cable separation and minimum burial depth, giving a worst-case scenario.

## Plate 4-A-2 Maximum calculated magnetic fields from onshore HVDC cable circuits



4.A.8.6 In **Plate 4-A-2** the magnetic field from the cable alone is demonstrated by the light blue line and the total combined field with the geomagnetic field shown by the dark blue line. The dotted black line represents the background geomagnetic field.

4.A.8.7 The maximum calculated magnetic fields were 117.3  $\mu\text{T}$  from the cable and 164.3  $\mu\text{T}$  when combined with the earth's geomagnetic field. These magnetic fields are compliant with ICNIRP 1994 public static magnetic field exposure limits (40 000  $\mu\text{T}$ ). The magnetic fields reduced quickly with distance from the cables as shown in **Plate 4-A-2**.

4.A.8.8 For indirect effects such as on implanted medical devices or forces on ferromagnetic objects ICNIRP suggest restrictions as low as 500  $\mu\text{T}$ . The maximum magnetic field produced by the cables are significantly below this level.

### AC Cables

4.A.8.9 Two 400 kV 50 Hz underground cable circuits will be installed as part of the Project. The depth of the cables would vary, subject to the outcome of soil Agricultural Land Classification (ALC), agricultural land drainage, engineering and ground investigation surveys. The minimum depth coverage would be 900 mm to the cable protective tiles. Where justified, it may be laid deeper. The depth of installation would also be deeper at locations where trenchless methods e.g., HDD, are required. The cables conductors themselves will be at a minimum of 1.1m below ground, which has been used for the calculations representing a worst case.

4.A.8.10 Each circuit will have 1 cable per phase, three cables in total with typical 1 m phase separation and assumed 18.6 m circuit separation (centre to centre). The HVAC cables

will connect the proposed converter station to the proposed Lincolnshire Connection substation B.

4.A.8.11 The magnetic field for each design has been calculated using the maximum continuous current rating of the cable (1550 Amps) and at 1 m above ground. The maximum magnetic field calculated at 1m above ground is 104.3  $\mu\text{T}$  directly above the cables. Magnetic fields reduce quickly with distance from source and **Table 4-A-6** sets out the magnetic field strength at various distances from source. **Plate 4-A-3** shows the magnetic field at 1m above ground and how the magnetic fields reduce with distance from the cables.

Plate 4-A-3 Maximum calculated magnetic fields from onshore 400 kV cable circuits. Two peaks represent each of the cable circuits. Two peaks represent each of the cable circuits

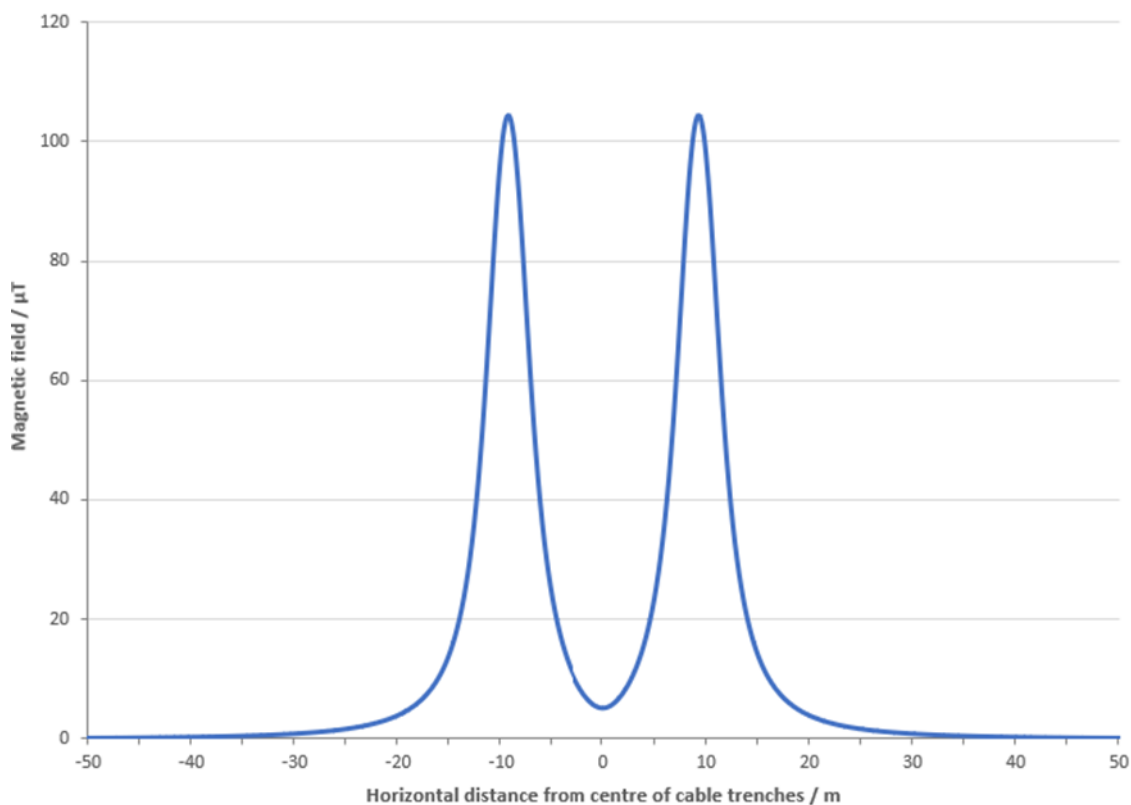


Table 4-A-6 Maximum calculated magnetic fields form onshore AC and DC cables only.

		<b>Magnetic field (<math>\mu\text{T}</math>)</b>				
	ICNIRP Exposure Limits	0 m	5 m	10 m	25 m	50 m
AC onshore cables	360 $\mu\text{T}$	104.3	18.7	1.91	0.58	0.10
DC onshore cables	40 000 $\mu\text{T}$	117.3	20.1	5.61	0.93	0.23

0m represents directly on top of cables, for AC circuits it represents the maximum above one of the cable circuits, so peak field.

## Converter Station

4.A.8.12 The proposed converter station will use Voltage Source Converter (VSC) technology. The proposed converter station will contain air-cored reactive equipment and as such compliance with the ICNIRP public exposure guidelines needs to be demonstrated, as per the Code of Practice. Specific EMF design criteria were incorporated into the proposed converter station’s technical specification to ensure that the finalised design is compliant with public exposure limits at and beyond the converter station boundary. These specifications will ensure the following criteria are employed in the design:

- Static magnetic fields at the boundary fence of the proposed converter station site will not exceed the ICNIRP public exposure limits defined above; and
- AC magnetic fields at the boundary fence of the proposed converter station site shall not exceed the general public exposure limit defined above.

4.A.8.13 The proposed converter station may have some bare conductors in the central portion of the site which will operate at 50 Hz. These will produce an electric field which will diminish quickly with increasing distance from source. The palisade security fencing and buildings, however, will screen the electric field at the boundary of the site. These types of bare conductors have been demonstrated to be inherently compliant with exposure guidelines. As such, electric fields have not been considered further in the assessment.

## 4.A.9 Conclusions

### Offshore

4.A.9.1 National Policy Statement EN-3 (Ref 2.7) states that “Where it is proposed that mitigation measures of the type set out in paragraph 2.6.76 below are applied to offshore export cables to reduce electromagnetic fields (EMF) the residual effects of EMF on sensitive species from cable infrastructure during operation are not likely to be significant. Once installed, operational EMF impacts are unlikely to be of sufficient range or strength to create a barrier to fish movement”.

4.A.9.2 The Project proposes to use armoured cables which mitigates both the direct electric fields and to an extent the magnetic fields. Cables are expected to be buried to a minimum depth of 1 m below the seabed with an average across the route of 1.5 m (other than

areas where surface lay may with rock protection be required due to geological conditions), which further reduces the magnetic fields and is a suggested mitigation technique in NPS EN-3.

- 4.A.9.3 Bundled cables produced the lowest magnetic fields and is the most effective mitigation for the total route length, except for a very short length where cables transition to land. In these locations, cables will be installed via a trenchless technique to come ashore, the magnetic fields, where cables become further apart but deeper. The trenchless installation is subject to further design and has been excluded from this stage of the assessment. As electric fields are proportional to the magnetic fields produced by the cables, the above statements also apply to the induced electric fields for both installation techniques.
- 4.A.9.4 The cable design proposed result in very low compass deviation compass deviations to occur across the majority of the EGL 5 route. Only the bundled English route has been assessed excluding 400 m in the near shore route. This will be included in the next stage of assessment when the trenchless design solution is finalised. The bundled cable route results in compass deviations below 3 degrees with the exception of KP0.4 where a 3.6-degree deviation is calculated. The bundled section of the EGL 5 route meets MMO's requirements (Section 5.4.3), however the nearshore section of route will be included within the finalised report to complete the assessment.
- 4.A.9.5 There are no formal limits for EMF exposure which apply to the marine environment, but the proposed bundled design reduces magnetic fields significantly compared to other installation methods.

## Onshore

- 4.A.9.6 For onshore HVDC cables, the maximum magnetic fields produced is less than the relevant ICNIRP exposure limit detailed in Section 2.1. Therefore, all installation options are compliant with the policies in place in the UK to protect public health and are assessed as having no significant adverse effects.
- 4.A.9.7 All of the HVAC electrical connection options assessed produced magnetic fields significantly below the ICNIRP public exposure limits in worst-case conditions. All other operating conditions result in lower magnetic fields.
- 4.A.9.8 All magnetic fields produced by the project will be significantly below the interference thresholds for active implantable medical devices, such as pacemakers.
- 4.A.9.9 The Government, acting on the advice of authoritative scientific bodies, has put in place appropriate measures to protect the public from EMFs. These measures comprise compliance with the relevant exposure limits, and one additional precautionary measure, optimum phasing, applying only to high-voltage overhead power lines. These measures are set out in a Written Ministerial Statement, National Policy statement EN-5, and various Codes of Practice.
- 4.A.9.10 All of the proposed onshore cable designs and convertor station would be fully compliant with the Government policy. Specifically, all the fields produced would be below the relevant exposure limits. Therefore, there would be no significant EMF effects resulting from this proposed development.
- 4.A.9.11 No mitigation measures for this cable design are necessary as both technology options have been demonstrated to comply with the current public exposure guidelines as detailed in NPS EN-5. If these requirements are met NPS EN-5 states that "*no further mitigation should be necessary.*"

## Bibliography

Ref 2.1 Department of Energy and Climate Change, (2025). National Policy Statement for Electricity Network Infrastructure (EN-5). London: The Stationary Office.

Ref 2.2 International Commission on Non-Ionising Radiation Protection, (1998). Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields. Health Physics.

Ref 2.3 European Council (1999) Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC). Brussels.

Ref 2.4 International Commission on Non Ionising Radiation Protection, (1994). Guidelines on limits of exposure to static magnetic fields, Health Physics.

Ref 2.5 Department of Energy and Climate Change, (2012). Power Lines: Demonstrating compliance with EMF public exposure guidelines. A voluntary Code of Practice. London.

Ref 2.6 IEEE standard for safety levels with respect to human exposure to radio frequency electromagnetic fields, 0 Hz to 300 GHz, IEEE-C95.1, NY, USA, 2019

Ref 2.7 Department of Energy and Climate Change. National Policy Statement for Renewable Energy Structure (EN-3). London: The Stationary Office, 2024. Exposure to static magnetic fields, Health Physics.

# Annex A

**Table A1:** Calculated magnetic field at 50% load for the two offshore HVDC design options for EGL 5. Calculations are provided for increasing vertical distance from the seabed and maximum current load. All calculations were performed for a minimum burial depth of 1 m.

Maximum magnetic field: cable magnetic field only						
Distance above seabed	At seabed	0.5m	1m	5m	10m	20m
Bundled pair	38.50	17.20	9.70	1.08	0.32	0.09

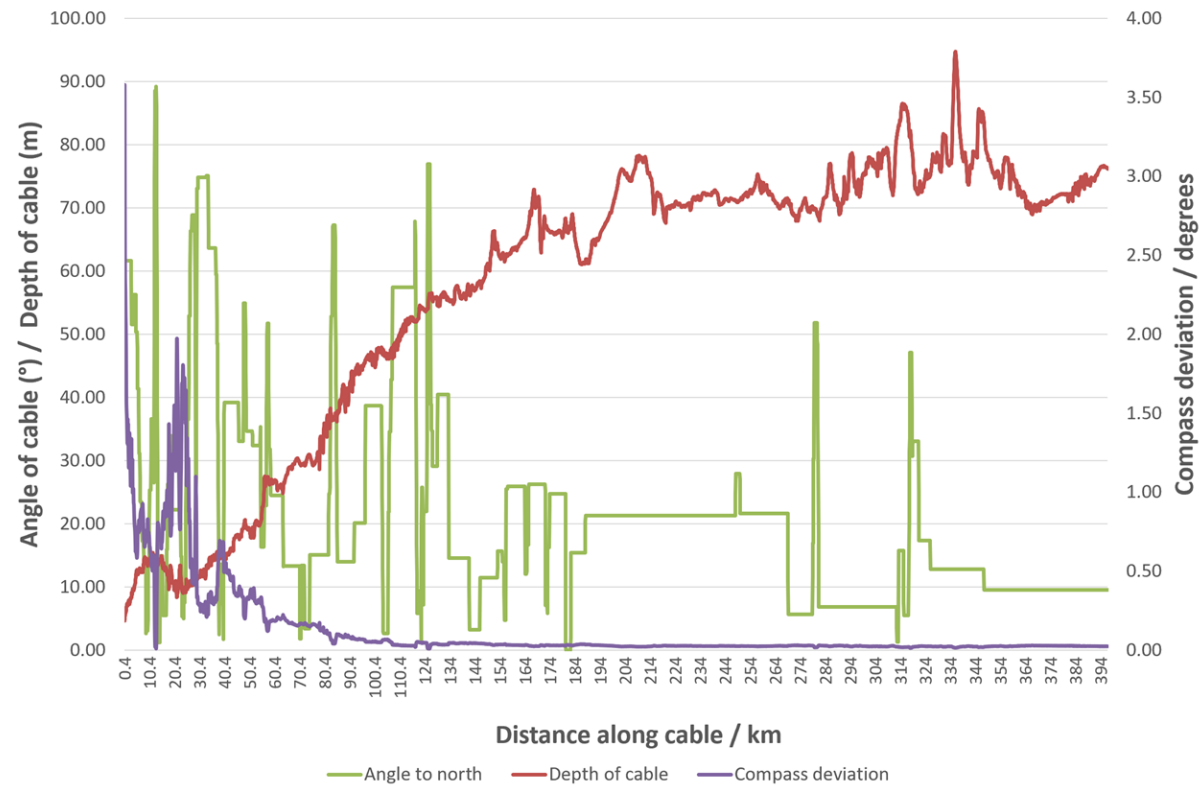
**Table A2:** Calculated induced electric field for each cable design using the calculated magnetic fields provided in **Table 5.2**. The induced electric field was calculated for a range of tidal velocities at increasing vertical distances from the cables for both cable designs being proposed.

Induced electric field ( $\mu\text{V/m}$ )						
Tidal velocity	Distance above seabed	Field $\mu\text{T}$	0.1 m/s	0.3 m/s	0.75 m/s	1.35 m/s
Bundled pair	Seabed	77.0	7.70	23.1	57.75	96.25
	0.5 m	34.4	3.44	10.3	25.80	43.00
	1 m	19.4	1.94	5.82	14.55	24.25
	5 m	2.16	0.22	0.65	1.62	2.70
	10 m	0.64	0.06	0.19	0.48	0.80
	20 m	0.18	0.02	0.05	0.14	0.23

# Annex B

## Compass Deviation Calculations

Plate B-1: Calculated compass deviations for the Project with bundled design from KP0.4 to KP396.8. Compass deviations at sea level were calculated along the bundled sections of route using the chart datum depth to seabed and cable angle to vertical for each station mark.



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