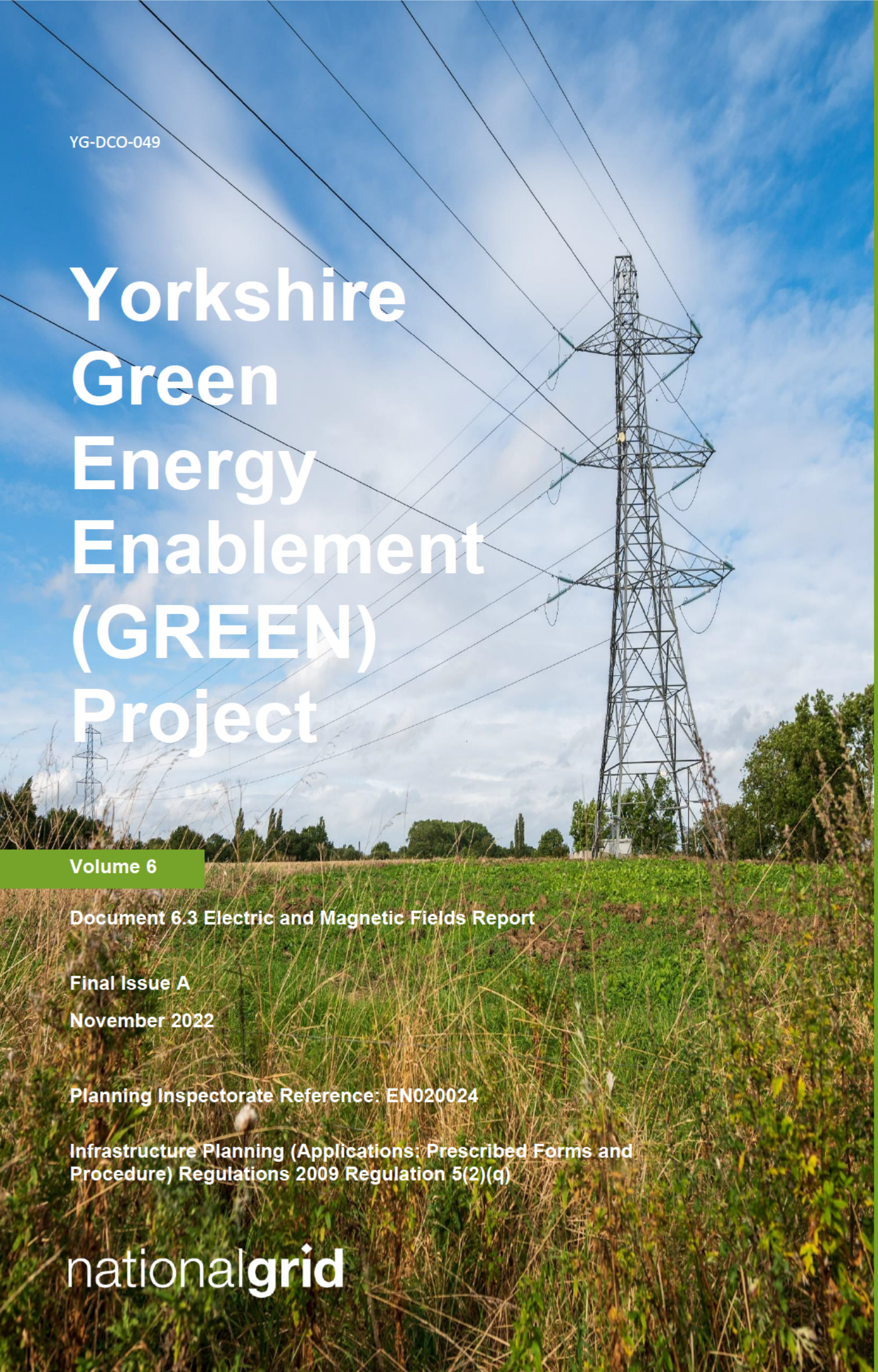
YG-DCO-049

Yorkshire Green Energy Enablement (GREEN) Project



Volume 6

Document 6.3 Electric and Magnetic Fields Report

Final Issue A

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Yorkshire GREEN Project
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Version History

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1. Introduction

1.1 The applicant and an overview of the Yorkshire GREEN Project

1.1.1 The Yorkshire Green Energy Enablement (GREEN) Project ('the Project') is a proposal by National Grid Electricity Transmission plc (National Grid) to upgrade and reinforce the electricity transmission system in Yorkshire. This reinforcement is needed to improve the transfer of clean energy across the country. It will support the UK Government's commitment to quadruple the UK's offshore wind capacity by 2030. In June 2019, legislation requiring the UK Government to reduce the UK's net emissions of greenhouse gases by 100% relative to 1990 levels by 2050 was implemented[1].

1.1.2 The increase in renewable energy generation, in line with the UK Government's Net Zero targets, is driving a need to expand the capacity of National Grid's transmission system. The Project will support growth green energy in Scotland and the north-east of England by providing the capability to efficiently manage substantially increased power flows in Great Britain and increased energy demand, which the Climate Change Committee (CCC) predicts will double by 2050.

1.1.3 Further information about the Project need is provided in **Chapter 2: Project Need and Alternatives, Volume 5, Document 5.2.2**.

1.1.4 The Project will comprise both new infrastructure and works to existing transmission infrastructure and facilities. The Project is divided into six sections for ease of reference as indicated in **Figure 1.2, Volume 5, Document 5.4.1** and described below.

- **Section A (Osbaldwick Substation):** Minor works would take plan at the existing Osbaldwick Substation to facilitate the connection of new infrastructure with existing infrastructure.
- **Section B (North west of York Area):**
  - reconductoring of 2.4km of the 400kV Norton to Osbaldwick (2TW/YR) overhead line and replacement of one pylon on this overhead line;
  - the new 400kV YN overhead line (2.8km), north of the proposed Overton Substation;
  - the new Shipton North and South 400kV cable sealing end compounds (CSECs) and 230m of cabling to facilitate the connection of the new YN 400kV overhead line with the existing Norton to Osbaldwick YR overhead line;
  - a new substation (Overton 400kV/275kV Substation) approximately 1km south of Shipton by Beningbrough;

[1] UK Government (2019). The Climate Change Act 2008 (2050 Target Amendment) Order 2019

- two new sections of 275kV overhead line which would connect into Overton Substation from the south (the 2.1km XC overhead line to the south-west and the 1.5km SP overhead line to the south-east);
- works to 5km of the existing XCP Poppleton to Monk Fryston overhead line between Moor Monkton in the west and Skelton in the east comprising a mixture of decommissioning, replacement and realignment. To the south and south-east of Moor Monkton the existing overhead line would be realigned up to 230m south from the current overhead line and the closest pylon to Moor Monkton (340m south-east) would be permanently removed. A 2.35km section of this existing overhead line permanently removed between the East Coast Mainline (ECML) Railway and Woodhouse Farm to the north of Overton.

- **Section C (Moor Monkton – Tadcaster - existing 275kV overhead line north of Tadcaster (Section D):** Works proposed to this existing 275kV overhead line include replacing existing overhead line conductors, replacement of pylon fittings, strengthening of steelwork and works to pylon foundations.
- **Section D (Tadcaster Area):** Two new CSECs would be installed approximately 3km south-west of Tadcaster and north-east of the A64/A659 junction where two existing overhead lines meet. One pylon on the existing 275kV Tadcaster Tee to Knaresborough (XD/PHG) overhead line would be replaced.
- **Section E (Tadcaster – Monk Fryston** - existing 275kV overhead line south of Tadcaster (Section D): Works proposed to this existing 275kV overhead line include replacing existing overhead line conductors, replacement of pylon fittings, strengthening of steelwork and works to pylon foundations
- **Section F (Monk Fryston Area):** A new substation would be constructed to the east of the existing Monk Fryston Substation which is located approximately 2km south-west of the village of Monk Fryston and located off Rawfield Lane, south of the A63.A 1.45km section of the 275kV Poppleton to Monk Fryston (XC/XCP) overhead line to the west of the existing Monk Fryston Substation and south of Pollums House Farm would be realigned to connect to the proposed Monk Fryston Substation. East of the existing Monk Fryston Substation the existing 4YS 400kVMonk Fryston to Eggboroughoverhead line, which currently connects to the existing substation, would be reconfigured to connect to the proposed Monk Fryston Substation.

1.1.5 Further detail about the Project is provided in **Chapter 3: Description of the Project (Volume 5, Document 5.2.3).**

1.2 Purpose of this report

1.2.1 This report provides an assessment and conclusions of the likely significant health and environmental effects of electric and magnetic fields (EMFs) associated with the construction, operation, maintenance and decommissioning of the Project. A description of the Project is provided in Section 1.1.

1.2.2 National Grid has a very clear policy on EMFs, as set out in its Public Position Statement[2] which states *"…In all our operations, as a minimum we comply with EMF regulations,*

[2] National Grid's Public Position Statement on Electric and Magnetic Fields. See Appendix A

guidelines or practices in force in the countries and different jurisdictions in which we operate.". In the UK, there are no statutory regulations, but the guidelines and practices are set out in National Policy Statement EN-5 (NPS EN-5)[3], and these requirements are further explained in Section 2. These policies would be applied to the Project. As is explained in more detail in section 1.3.8 below, compliance with the relevant guidelines and practices in force in the UK ensures that there are no significant health or environmental effects from EMFs relating to the Project. It was proposed in the Scoping Report[4] that the assessment of EMFs be scoped out of the Environmental Statement (ES), which in accordance with the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017[5] is required to describe the "likely significant effects of the development". It was instead proposed that comprehensive information about EMFs be provided in a separate report to be submitted alongside the ES.

1.2.3 The Secretary of State agreed with this approach and the Scoping Opinion[6] states in Section 4.11 Health and Wellbeing, Ref 15.6.10:

"Chapter 17 of the Scoping Report sets out aspects proposed to be scoped out of the ES, which include EMF. On the basis that the Proposed Development will comply, as a minimum, with relevant EMF guidelines in all of its operations and will include a separate document with comprehensive information as described in section 17.4 of the Scoping Report to demonstrate that the Proposed Development will not give rise to likely significant effects in respect of EMF, the Inspectorate agrees that this matter can be scoped out of the ES."

1.2.4 This report constitutes the separate document covering EMFs, submitted alongside the ES.

1.3 Introduction to EMFs

1.3.1 Electric and magnetic fields and the electromagnetic forces they represent are an essential part of the physical world. Their sources are the charged fundamental particles of matter (principally electrons and protons). EMFs occur naturally within the body in association with nerve and muscle activity allowing these functions to take place. Humans also experience the natural static magnetic field of the Earth (to which a magnetic compass responds) and natural static electric fields in the atmosphere.

1.3.2 Electric and magnetic fields occur in the natural world, and people have been exposed to them for the whole of human evolution. The advent of modern technology and the wider use of electricity and electrical devices have inevitably introduced changes to the naturally

[3] Department of Energy and Climate Change. National Policy Statement for Electricity Network Infrastructure (EN-5). London: The Stationary Office, 2011

[4] National Grid, March 2021, Environmental Impact Assessment Scoping Report: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN020024/EN020024-000008-YGRN%20Scoping%20Report.pdf

[5] The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (Online). Available from: https://www.legislation.gov.uk/uksi/2017/572/regulation/31/made (Accessed 14 October 2021).

[6] PLANNING INSPECTORATE (2021) Scoping Opinion: Proposed Yorkshire Green Energy Enablement (GREEN) Project: Case Reference EN020024. Available from: EN020024-000048-YGRN - Scoping Opinion.pdf (planninginspectorate.gov.uk) [Accessed June 2022].

occurring EMF patterns. Energised high voltage power-transmission equipment, along with all other uses of electricity, are a source of EMFs.

1.3.3 The UK power system mainly uses alternating current (AC) so the fields that are produced are likewise alternating. The EMFs have the same frequency as the voltages and currents that produce them, which is 50 hertz (Hz) in the UK. The fields are described as power-frequency or extremely-low-frequency (ELF) EMFs and exist in addition to the Earth's steady natural fields.

1.3.4 Electric fields depend on the operating voltage of the equipment producing them and are measured in volts per metre (V/m.) The operating voltage of most 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.

1.3.5 Magnetic fields are measured in microteslas (μT), and depend on the electrical currents flowing, which vary according to the electrical power requirements at any given time. They are not significantly shielded by most common building materials or trees but do diminish rapidly with distance from the source.

1.3.6 The Project comprises overhead lines, underground cables, substations, and cable sealing end compounds at voltages of 400kV and 275kV. These are all assessed in detail in this report, but it can be noted here that above-ground equipment produces both electric and magnetic fields, but underground cables produce only a magnetic field, as the electric field is confined within the cable by the metallic sheath of the cable.

1.3.7 Electric and magnetic fields at 50Hz can cause induced currents to occur in the body, which can interfere with nerves; however this only occurs in very high EMFs, orders of magnitude higher than electricity transmission equipment can produce. There are Government adopted exposure guidelines[3] [11] (discussed in Section 2.3), which are set to protect against these known or direct effects of EMF exposure, ensuring there is no interaction with nerves. This report documents the Projects compliance with those exposure limits. There are also 'indirect' effects that can occur as a result of exposure to EMFs and which are not explicitly covered by the exposure guidelines. Examples of indirect effects are interference with active implantable medical devices (AIMDs), and microshocks, small discharges sometimes experienced when touching a metal object in an electric field (discussed in Sections 2.10 and 2.11). The potential impact of both direct and indirect effects has been assessed using the guidance provided in National Policy Statement (NPS) EN-5[3] and the codes of practice, Power Lines: Demonstrating compliance with EMF public exposure guidelines[7] and Optimum Phasing of high voltage double-circuit Power Lines[8] (discussed in Section 2).

1.3.8 Electric and magnetic fields at much higher frequencies, typically hundreds of thousands time higher than those generated by the electricity transmission system can be generated by other devices, e.g. radio, television transmissions and microwaves. These higher frequencies interact with objects and people in a rather different way to power frequencies, for example by heating of the body, so in scientific terms these are a different phenomenon, and it is important to make the distinction. Overhead lines produce EMFs at frequencies many thousands of times lower than radio and television

[7] Department of Energy and Climate Change. Power Lines: Demonstrating compliance with EMF public exposure guidelines. A voluntary Code of Practice. London, 2012.

[8] Department of Energy and Climate Change. Optimum Phasing of high voltage double-circuit Power Lines. A voluntary Code of Practice. London, 2012.

frequencies and are sometimes referred to as "non-ionising" radiation, meaning they do not contain enough energy to disrupt atoms and molecules within the human body.

2. Policy and Legislation

2.1 Overview of policy

2.1.1 Whilst there are no statutory regulations in the UK that limit the exposure of the general public to power-frequency EMFs, responsibility for implementing appropriate measures for the protection of the public lies with the UK Government, which has a clear policy, incorporated into NPS EN-5[3], on the exposure limits and other policies they expect to see applied. Practical details of how the policy is implemented are contained in a Code of Practice on Compliance[7] agreed between industry and UK Government.

2.1.2 UK Government in turn acts on the scientific advice from Public Health England (PHE), that has responsibility for advising on non-ionising radiation protection, including power-frequency EMFs. The National Radiological Protection Board (NRPB) had this responsibility until becoming part of the Health Protection Agency (HPA) on 1 April 2005, which in turn was replaced by PHE on 1 April 2013. Public Health England officially became the UK Health Security Agency (UKHSE) in October 2021. This report refers to UKHSE, PHE, NRPB or HPA according to the name of the organisation at the time each statement was issued.

2.1.3 In 2004, following a recommendation by the then NRPB, the UK Government adopted exposure guidelines for the public published in 1998 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP)[9] in line with the terms of the 1999 European Union (EU) Recommendation[10] on public exposure to EMFs. In a Written Ministerial Statement in October 2009[11]; references to the Written Ministerial Statement encompass both the Statement itself and the detailed Response that the Statement introduced the UK Government restated this policy of compliance with exposure limits and, acting on the recommendations of a stakeholder process, added, in relation to high voltage infrastructure, a single precautionary measure, a policy of optimum phasing of some overhead lines. “Optimum phasing” is an engineering measure that can be incorporated in the design of some overhead lines, and which reduces the EMFs they produce, and is considered in detail in Section 6.2. The UK Government also made clear in the Written Ministerial Statement that no other precautionary measures are appropriate for high voltage infrastructure.

[9] International Commission on Non Ionising Radiation Protection. Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields. Health Physics, 1998, 74 (4), p.494.

[10] European Council. 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, 1999.

[11] Department of Health. Government response to the stakeholder advisory group on extremely low frequency electric and magnetic fields (ELF EMFs) (SAGE) recommendations. 2009. (Online) Available from http://webarchive.nationalarchives.gov.uk/20130107105354/http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_107124

2.1.4 These two policies, compliance with exposure limits plus optimum phasing, are the only policies applying to high voltage infrastructure. NPS EN-1 [12] does not contain any provisions specific to EMFs. NPS EN-5[3] documents these policies and they are explained fully below.

2.2 National Policy Statement EN-5

2.2.1 As summarised above, UK Government has set out clear policies on control of EMF exposures in general. NPS EN-5[3] gives clear guidance on the EMF requirements of all electricity infrastructure projects. The relevant paragraphs and how they have been addressed are summarised in **Table 2.1**.

Table 2.1 – Summary of NPS EN-5 requirements relevant to EMF

Paragraph	Requirement	Section of this report	Compliance assessment
Para 2.10.9	Before granting consent to an overhead line application, the Infrastructure Planning Commission (IPC) (replaced in 2012 by the Planning Inspectorate), should satisfy itself that the proposal is in accordance with the "Power Lines: Demonstrating compliance with EMF public exposure guidelines – a voluntary Code of Practice" published in February 2011[7], considering the evidence provided by the applicant and any other relevant evidence. It may also need to take expert advice from the Department of Health.	6	The Scheme has been designed and assessed in line with the Code of Practice- Power Lines: Demonstrating compliance with EMF public exposure guidelines. All the EMFs produced would comply with the Government-adopted ICNIRP 1998 guidelines[9], as demonstrated in this report.
Para 2.10.10	There is no direct statutory provision in the planning system relating to protection from EMFs and the construction of new overhead power lines near residential or other occupied buildings. However, the Electricity Safety, Quality and Continuity Regulations 2002[13] set out the minimum height, position, insulation, and protection	6	The overhead lines and all other electrical transmission infrastructure capable of producing EMFs associated with the Scheme are demonstrated in this report to comply with the Government-adopted ICNIRP 1998 guidelines.

[12] Department of Energy and Climate Change. Overarching National Policy Statement (NPS) for Energy (EN-1). London: The Stationary Office, 2011

[13] The Electricity Safety, Quality and Continuity Regulations 2002. Statutory Instrument No. 2665 2002.HSE

Paragraph	Requirement	Section of this report	Compliance assessment
	specifications at which conductors can be strung between towers to ensure safe clearance of objects. The effect of these requirements should be that power lines at or below 132kV will comply with the ICNIRP 1998 basic restrictions, although the IPC should be satisfied that this is the case on the basis of the evidence produced as specified in the Code of Practice.		
Para 2.10.11	The Government has developed with industry a voluntary Code of Practice, "Optimum Phasing of high voltage double-circuit Power Lines – A Voluntary Code of Practice", published in February 2011[8] that defines the circumstances where industry can and will optimally phase lines with a voltage of 132kV and above. Applicant should demonstrate compliance with this.	6.2	The overhead lines and diversions have been designed in compliance with the policy on optimum phasing as specified in the Code of Practice on Optimum Phasing, as demonstrated in this report.
Para 2.10.14	The diagram at the end of Section 2.10 shows a basic decision tree for dealing with EMFs from overhead power lines to which the IPC can refer.	2.2 in Figure 2.1	This decision tree has been replicated in Figure 2.1 and forms the basis for the assessment of EMFs from the Scheme.
Para 2.10.15	The applicant should have considered the following factors: Height, position, insulation and protection (electrical or mechanical as appropriate) measures subject to ensuring compliance with the Electricity Safety, Quality and Continuity Regulations 2002	2.13 and 6.2	The proposed overhead lines and associated diversions have been designed to comply with the statutory requirements of the Electricity Safety, Quality and Continuity Regulations 2002[13]. EMF requirements can, for some designs of overhead line, result in conductor clearances to ground (one of the requirements of these regulations) being increased but never reduced compared to the requirements of the Electricity Safety, Quality and Continuity Regulations 2002. The minimum conductor clearance information provided

Paragraph	Requirement	Section of this report	Compliance assessment
			in this report demonstrates this compliance.
	That optimal phasing of high voltage overhead power lines is introduced wherever possible and practicable in accordance with the Code of Practice to minimise effects of EMFs.	6.2	The overhead line has been designed in line with the policy on optimum phasing as specified in the Code of Practice on Optimum Phasing.
	Any new advice emerging from the Department of Health relating to Government policy for EMF exposure guidelines.	2.5	This has been considered in this chapter, and all current advice has been used for the assessment. The assessment has been carried out against the current Government-recommended EMF exposure guidelines and policies.
	Where it can be shown that the line will comply with the current public exposure guidelines and the policy on phasing, no further mitigation should be necessary.	6	This report shows that the Scheme would be compliant with the current public exposure guidelines of ICNIRP 1998 and the policy on phasing using the principles in the Codes of Practice on Compliance and Optimum Phasing.

2.2.2 As summarised above, Government has set out clear policies on control of EMF exposures in general. NPS EN-5[3] gives clear guidance on the EMF requirements of all electricity infrastructure projects stating:

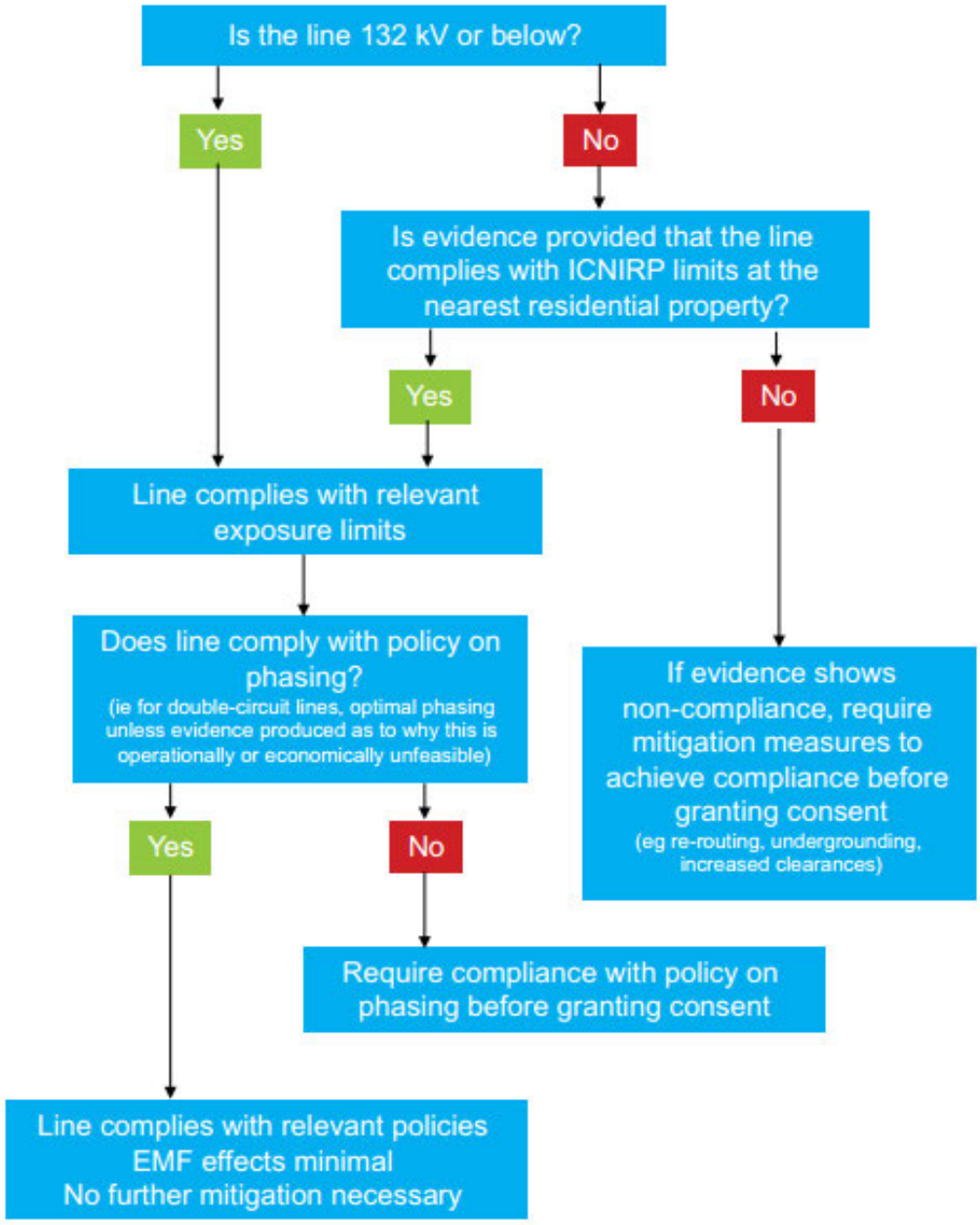
"2.10.9… Before granting consent to an overhead line application, the IPC should satisfy itself that the proposal is in accordance with the guidelines, considering the evidence provided by the applicant and any other relevant evidence."

And

"2.10.11… Where the applicant cannot demonstrate that the line will be compliant … with the exposure guidelines as specified in the Code of Practice on compliance, and with the policy on phasing as specified in the Code of Practice on optimal phasing then the IPC should not grant consent."

2.2.3 A simplified route map for dealing with EMFs is provided in NPS EN-5 and is reproduced in Figure 2.1 - Simplified Route Map for Dealing with EMFs. Reproduced from NPS EN-5 (page 23).

Figure 2.1 - Simplified Route Map for Dealing with EMFs. Reproduced from NPS EN-5 (page 23)



2.2.4 All relevant legislation, policies and guidance, including those contained within NPS EN-1[12] and EN-5[3] have been reviewed and applied to this EMF assessment of the Project. These policies, guidance and legislation are explained and documented in Sections 2.3 to 2.13 including, for openness and transparency, a commentary of the science on which these have been based.

2.3 Summary of Relevant Policy and Legislation

2.3.1 The EMF policies applying to high-voltage electricity equipment comprise compliance with the exposure guidelines, as set out in the Code of Practice on Compliance; the policy on optimum phasing, as set out in the Code of Practice on Optimum Phasing; and the policy on indirect effects expressed in the Code of Practice on Microshocks.

2.3.2 NPS EN-5[3] explicitly applies these policies to applications for consent for new electricity connections such as the Project. If a proposed overhead line or, where relevant, underground cable, substation etc. complies with these, there are no grounds in relation to EMFs not to grant consent.

2.4 Public Exposure Limits

2.4.1 In March 2004 the then NRPB provided new advice to Government on public exposure limits, replacing previous advice from 1993, and recommending the adoption in the UK of guidelines published in 1998 by the ICNIRP[9]. The Government subsequently adopted this recommendation, saying that limits for public exposures should be applied in the terms of the 1999 EU Recommendation[10]. This Government policy was subsequently set out more formally in the Written Ministerial Statement[11] and incorporated into NPS EN-5[3]. **Table 2.2** below summarises the relevant values for power frequencies.

Table 2.2 – Exposure limits for power-frequency EMFs

Public exposure limits	Electric fields	Magnetic fields
Basic restriction (induced current density in central nervous system)	2mA/m^2	
Reference level (external unperturbed field)	5kV/m	100µT
Field corresponding to the basic restriction (external unperturbed field)	9kV/m	360µT

2.4.2 In recommending these levels, the NRPB considered the evidence for all suggested effects of EMFs. They concluded that the evidence for effects on the nervous system of currents induced by the EMFs was sufficient to justify setting exposure limits, and this is the basis of their quantitative recommendations[14]. They concluded that the evidence for effects at lower fields, for example the evidence relating to childhood leukaemia, was not sufficient to justify setting exposure limits, but was sufficient to justify recommending that Government consider possible precautionary measures. Precautionary measures are considered in more detail below.

2.4.3 The EMF guidelines are documented in NPS EN-5[3] and practical details of their application are given in the Code of Practice 'Power Lines: Demonstrating compliance

[14] National Radiological Protection Board. Advice on limiting exposure to electromagnetic fields (0-300 GHz). Doc NRPB, 2004, 15(2), p.1

with EMF public exposure guidelines – a voluntary Code of Practice'[7] published by the then Department of Energy and Climate Change (DECC). It is the electricity industry's policy to comply with Government guidelines on EMF, and this Code of Practice forms an integral part of this policy.

2.4.4 The ICNIRP guidelines[9] are set so as to limit the currents induced in the body by external exposure to EMFs to below the threshold for those currents having any effects. These induced currents can be expressed as a current density that is the quantity on which the guidelines are based. Specifically, the ICNIRP guidelines recommend that the general public are not exposed to levels of EMFs able to cause a current density of more than 2mA/m^2 within the human central nervous system, as shown in **Table 2.2.** This value of the induced current density is described as the "basic restriction". The 1999 EU Recommendation[10] uses the same basic restriction value as ICNIRP[9].

2.4.5 However, the basic restriction cannot be assessed directly, as measurements of current density within a live human body are not practical, it would require a probe being inserted deep within the body. Instead, the external fields required to produce this current density within the body are calculated by numerical dosimetry. This is a computerised model of the human body, including the various organs and tissue and is used to calculate the induced current inside the body when exposed to external EMFs. This allows internal induced currents to be calculated accurately without the need for medical procedures in live humans. Those calculations are normally performed for uniform fields which assume a constant field value of exposure across the body, which is the most onerous exposure condition; However, the field from overhead lines and cables reduce quickly with distance from the source, so exposure is not uniform and varies across the body. Non-uniform exposure results in lower induced currents in the body, as the total exposure is lower.

2.4.6 Therefore, the ICNIRP guidelines also contain values of the external fields called "reference levels". For the public, the reference level for electric fields is 5kV/m, and the reference level for magnetic fields is 100μT. The 1999 EU Recommendation[10] uses the same reference level values as ICNIRP[9].

2.4.7 In the ICNIRP guidelines and the EU Recommendation, the limit compliance is required to be achieved against is the basic restriction. The reference levels are not limits but are guides to when detailed investigation of compliance with the actual limit, the basic restriction, is required. If the reference level is not exceeded, the basic restriction cannot be exceeded, and no further investigation is needed. If the reference level is exceeded, the basic restriction may or may not be exceeded.

2.4.8 The Code of Practice on Compliance[7] endorses this approach and gives the values of field corresponding to the basic restriction, stating:

"The 1998 ICNIRP exposure guidelines specify a basic restriction for the public which is that the induced current density in the central nervous system should not exceed 2mA m^{-2}. The Health Protection Agency specify that this induced current density equates to uniform unperturbed fields of 360μT for magnetic fields and 9.0kV m^{-1} for electric fields. Where the field is not uniform, more detailed investigation is needed. Accordingly, these are the field levels with which overhead power lines (which produce essentially uniform fields near ground level) shall comply where necessary. For other equipment, such as underground cables, which produce non-uniform fields, the equivalent figures will never be lower but may be higher and will need establishing on a case-by-case basis in accordance with the procedures specified by HPA. Further explanation of basic restrictions, reference levels etc is given by the Health Protection Agency."

2.4.9 The Code of Practice on Compliance[7] also specifies the land uses where exposure is deemed to be for a significant period of time and consequently where the public guidelines apply. These land uses are, broadly, residential uses and schools[15].

2.4.10 Therefore, if the EMFs produced by an item of equipment are lower than 9kV/m and 360µT, the fields corresponding to the ICNIRP basic restriction, the equipment is compliant with the ICNIRP guidelines and with PHE recommendations and Government policy. If the fields are greater than these values, the equipment is still compliant with Government policy if the land use falls outside the residential and other uses specified in the Code of Practice[7], and it may also still be compliant if the fields are non-uniform. This report has assumed that the EMFs produced by the electrical infrastructure associate with the Project are uniform for compliance purposes, although this is a worst-case approach.

2.5 Occupational Exposure Limits

2.5.1 Occupational exposures to EMFs in England, Wales and Scotland are controlled by the Control of Electromagnetic Fields at Work Regulations 2016[16] (CEMFWR Regulations), which implement a 2013 EU Directive[17]. For power frequencies, these are based on a more recent ICNIRP publication, ICNIRP 2010[18] rather than the ICNIRP 1998[9] that is the basis for the public exposure limits.

2.5.2 The CEMFWR Regulations are based on limiting the same underlying physical quantity, the current induced in the body by external exposure to EMFs, as for public exposure, but the quantity is expressed in a different way, as the induced field rather than the induced current density, and different values are given for the head and for the rest of the body. This makes direct comparison between the occupational and public limits difficult, but the occupational limits are always higher than the public limits, typically by factors of two or more. Therefore, where the fields are compliant with the public limits, any occupational activities would also be compliant with the relevant occupational limits.

2.5.3 Employers have a duty of care to their employees. Employers discharge that duty of care in relation to EMFs primarily by complying with the relevant exposure limits. As noted above, occupational exposure limits are higher than the public exposure limits which the Project would be compliant with in all areas accessible to the public and to employees of third parties. Therefore, all exposures from the Project would be compliant with the occupational exposure limits and employers need take no additional action specific to the

[15] Land uses defined in Code of practice on compliance states, 'This would embrace use classes variously described as "dwellinghouses", "houses", "houses in multiple occupation" and "residential institutions". It should sensibly be taken more broadly as also embracing other residential properties which may not fall within a particular use class e.g. flats or hostels. A less clear cut case exists for extending it to schools but given the health concern is very much orientated towards childhood sickness it would seem prudent to behave in a precautionary manner and include non-residential uses such as schools, crèches and day nurseries'

[16] Statutory Instrument, 2016 No. 588, Health and Safety, The Control of Electromagnetic Fields at Work Regulations 2016

[17] Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (20th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) and repealing Directive 2004/40/EC

[18] International Commission on Non Ionising Radiation Protection. ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (1 Hz-100 kHz), Health Physics. 2010, 99(6): p.818

Project in order to comply (the CEMFWR Regulations impose certain general duties on all employers which would apply regardless of the Project).

2.5.4 In some areas of the Project, accessible only to National Grid staff and to contractors of National Grid but not to the public or to employees of third parties, e.g., inside substation perimeter fences, higher fields could be found that exceed the public exposure limits. National Grid has its own procedures for ensuring that staff do not exceed the occupational exposure limits in these areas[19].

2.6 Potential Future Changes to Exposure Limits

2.6.1 As discussed, current Government policy for public exposure is based on the limits from the 1998 ICNIRP Guidelines[9], in the terms of the 1999 EU Recommendation[10]. In 2010, ICNIRP published new exposure guidelines[18] for the range of frequencies including power frequencies. These new guidelines do not apply in the UK for public exposure unless and until Government decides to adopt them. This is clear in the Code of Practice on Compliance[7]:

"Current Government policy on electric and magnetic fields (EMFs) is that power lines should comply with the 1998 ICNIRP Guidelines on exposure to EMFs in the terms of the 1999 EU Recommendation, and this Code of Practice implements this policy. As and when either ICNIRP issue new Guidelines or the EU revise the Recommendation, it will be for Government to consider those changes and to decide whether to adopt them or not. If Government policy changes, this Code of Practice will also be changed accordingly, but until that happens, the present policy as reflected in this Code of Practice remains in force." (page 2)

2.6.2 In fact, ICNIRP's intention in its new guidelines does not appear to be to make the guidelines either more or less onerous. It takes account of the most recent scientific developments but, having done so, the key scientific effects used as the basis for the guideline levels are essentially unchanged and the safety margins applied are broadly unchanged. The detailed values derived as basic restrictions and reference levels have changed, but this is principally a consequence of a different method of derivation, without representing any change in scientific thinking about the appropriate level of protection. National Grid's assessment is that the Project would in fact be compliant with those guidelines were they ever to be introduced.

2.6.3 More generally, if in the future there were other changes to the exposure limits or other policies in relation to EMFs, National Grid would have a duty to bring the whole transmission system, including the Project, into compliance with whatever new regime was introduced.

2.7 Pregnant women and other potentially sensitive subgroups

2.7.1 The scientific basis as given by the NRPB (now UKHSE) in their recommendation to Government for setting the public exposure limits lower than the occupational limits is not that the public in general need greater protection; it is that the public contains certain potentially sensitive subgroups, where EMF effects may occur at lower levels than in the

[19] National Grid Control of Electromagnetic Field at Work Regulations 2016 Risk Assessment. [redacted] (assessed June 2022)

population at large. One of those subgroups is pregnant women and the developing embryo (others include people with epilepsy or taking certain drugs).

Therefore, the potential extra sensitivity of pregnant women is already built into the public exposure limits. No additional protective measures are required.

2.8 Scientific Evidence

2.8.1 As well as these established effects, over the past 30 years it has been suggested that exposure to power-frequency magnetic or electric fields of the magnitude encountered close to electricity transmission and distribution equipment could be linked with various health problems, ranging from headaches to Alzheimer's disease and cancer. The most persistent of these suggestions relates to childhood leukaemia. A number of epidemiological studies have suggested a statistical association between the incidence of childhood leukaemia and the proximity of homes to power transmission and distribution equipment or the power-frequency magnetic-field strengths found within homes. However, no causal link has been established between cancer (or any other disease) and magnetic or electric fields. No mechanism by which these fields could cause or promote the disease has been established.

2.8.2 The question of possible adverse health effects of environmental power-frequency fields has been thoroughly reviewed in recent years by a number of national and international bodies. The principal bodies that currently have authoritative relevance in the UK are the PHE (formerly the HPA, formerly the NRPB), the International Agency for Research on Cancer (IARC), the WHO, and the relevant official scientific advisory committee for the EU, until recently the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR).

2.8.3 When assessing the scientific evidence on EMFs, it is essential to consider all the evidence and to perform an overall assessment of the evidence, weighting each strand of evidence and each individual study as appropriate to its strengths and weaknesses. No single study can ever be conclusive (in either direction). Such reviews have been performed by the authoritative expert bodies, and it is those bodies that provide the most reliable conclusions, and on whose conclusions Government policy is based. The following are summaries of the conclusions of these relevant authoritative review bodies.

The National Radiological Protection Board/The Health Protection Agency/Public Health England

2.8.4 In 2004 the then NRPB published new “Advice on Limiting Exposure to Electromagnetic Fields (0-300GHz)” [14] and accompanied it with a “Review of the Scientific Evidence for Limiting Exposure to Electromagnetic Fields (0-300GHz)” [20]. The former summarises epidemiological evidence as follows (page 15):

54 “In the view of NRPB, the epidemiological evidence that time-weighted average exposure to power frequency magnetic fields above 0.4μT is associated with a small absolute raised risk of leukaemia in children is, at present, an observation for which there is no sound scientific explanation. There is no clear evidence of a carcinogenic effect of ELF EMFs in adults and no plausible biological explanation of the association that can be

[20] National Radiological Protection Board. Review of the scientific evidence for limiting exposure to electromagnetic fields (0-300 GHz). Doc NRPB, 2004, 15(3), p.1

obtained from experiments with animals or from cellular and molecular studies. Alternative explanations for this epidemiological association are possible: for example, potential bias in the selection of control children with whom leukaemia cases were in some studies and chance variations resulting from small numbers of individuals affected. Thus any judgements developed on the assumption that the association is causal would be subject to a very high level of uncertainty.

55 "Studies of occupational exposure to ELF EMFs do not provide strong evidence of associations with neurodegenerative diseases…..

56 "Studies of suicide and depressive illness have given inconsistent results in relation to ELF EMF exposure, and evidence for a link with cardiovascular disease is weak.

57 "The overall evidence from studies of maternal exposure to ELF EMFs in the workplace does not indicate an association with adverse pregnancy outcomes, while studies of maternal exposure in the home are difficult to interpret.

58 "Results from studies of male fertility and of birth outcome and childhood cancer in relation to parental occupational exposure to ELF EMFs have been inconsistent and unconvincing.

59 "All these conclusions are consistent with those of AGNIR (2001)[21].

60 "NRPB concludes that the results of epidemiological studies, taken individually or as collectively reviewed by expert groups, cannot currently be used as a basis for restrictions on exposure to EMFs."

International Agency for Research on Cancer (IARC)

2.8.5 The IARC is an agency of the WHO. The IARC's Unit of Carcinogen Identification and Evaluation has, since 1972, periodically published Monographs that assess the evidence as to whether various agents are carcinogenic and classify the agents accordingly. In June 2001, a Working Group met to consider static and ELF EMFs[22]. Power-frequency magnetic fields were classified as "*possibly carcinogenic*", on the basis of "limited" evidence from humans concerning childhood leukaemia, "*inadequate*" evidence from humans concerning all other cancer types, and "*inadequate*" evidence from animals. Power-frequency electric fields were judged "*not classifiable*" on the basis of "*inadequate*" evidence from both humans and animals. These classifications are consistent with the conclusions reached by the NRPB.

World Health Organization

2.8.6 The WHO published an Environmental Health Criteria Monograph in 2007 on ELF EMFs[23], produced by a Task Group that met in 2005. This concluded, in part:

"Chronic effects

[21] A reference to the previous NRPB review of the science by its Advisory Group on Non-Ionising Radiation

[22] Working Group on the Evaluation of Carcinogenic Risks to Humans. Non-ionizing radiation, Part 1: Static and extremely low-frequency (ELF) electric and magnetic fields. (Monographs on the Evaluation of Carcinogenic Risks to Humans, 80). Lyon, IARC, 2002

[23] World Health Organisation, Environmental Health Criteria Monograph No 238 on Extremely Low Frequency Fields, 2007. (Online) Available from [redacted]

Scientific evidence suggesting that everyday, chronic low-intensity (above 0.3-0.4μT) power-frequency magnetic field exposure poses a health risk is based on epidemiological studies demonstrating a consistent pattern of increased risk for childhood leukaemia. Uncertainties in the hazard assessment include the role that control selection bias and exposure misclassification might have on the observed relationship between magnetic fields and childhood leukaemia. In addition, virtually all of the laboratory evidence and the mechanistic evidence fail to support a relationship between low-level ELF magnetic fields and changes in biological function or disease status. Thus, on balance, the evidence is not strong enough to be considered causal, but sufficiently strong to remain a concern.

A number of other diseases have been investigated for possible association with ELF magnetic field exposure. These include cancers in both children and adults, depression, suicide, reproductive dysfunction, developmental disorders, immunological modifications and neurological disease.

The scientific evidence supporting a linkage between ELF magnetic fields and any of these diseases is much weaker than for childhood leukaemia and in some cases (for example, for cardiovascular disease or breast cancer) the evidence is sufficient to give confidence that magnetic fields do not cause the disease."

Scientific Committee on Emerging and Newly Identified Health Risks

2.8.7 The Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) was, until 2016, the EU's designated source of expert scientific advice on EMFs (along with other issues). In March 2015 SCENIHR published its most recent report on EMFs, "Potential Health Effects of Exposure to EMF"[24]. The section of the abstract concerned with power-frequency fields states:

"Overall, existing studies do not provide convincing evidence for a causal relationship between ELF MF exposure and self-reported symptoms.

The new epidemiological studies are consistent with earlier findings of an increased risk of childhood leukaemia with estimated daily average exposures above 0.3 to 0.4 μT. As stated in the previous Opinions, no mechanisms have been identified and no support is existing from experimental studies that could explain these findings, which, together with shortcomings of the epidemiological studies prevent a causal interpretation.

Studies investigating possible effects of ELF exposure on the power spectra of the waking EEG are too heterogeneous with regard to applied fields, duration of exposure, and number of considered leads, and statistical methods to draw a sound conclusion. The same is true for behavioural outcomes and cortical excitability.

Epidemiological studies do not provide convincing evidence of an increased risk of neurodegenerative diseases, including dementia, related to power frequency MF exposure. Furthermore, they show no evidence for adverse pregnancy outcomes in relation to ELF MF. The studies concerning childhood health outcomes in relation to maternal residential ELF MF exposure during pregnancy involve some methodological issues that need to be addressed. They suggest implausible effects and need to be replicated independently before they can be used for risk assessment.

[24] Scientific Committee on Emerging and Newly Identified Health Risks SCENIHR (2015), Potential Health Effects of Exposure to EMF, [redacted]

Recent results do not show an effect of the ELF fields on the reproductive function in humans."

Conclusions from review of Scientific evidence

2.8.8 There is some scientific evidence suggesting that electric or, particularly, magnetic fields may have health effects at levels below the current UK exposure guidelines. The authoritative classification is that of the WHO, in 2001 and reiterated in 2007, that power-frequency magnetic fields are "*possibly*" a cause of cancer, specifically just of childhood leukaemia, with the evidence relating to any other health effect "*much weaker*". The scientific evidence in these various reviews has been used to formulate the EMF precautionary policies that the Project has applied.

2.9 Precautionary Policies

2.9.1 The Government has addressed the uncertainty in the scientific evidence by adopting specified precautionary measures relating to various sources of EMFs.

2.9.2 The only specific precautionary measure that relates to high-voltage power lines or any other high-voltage transmission equipment is the policy of "optimum phasing". "Phasing" is the order in which the conductors of the two circuits of double-circuit overhead lines are connected relative to each other, and certain phasing arrangements produce lower magnetic fields than others. This policy was introduced in the Written Ministerial Statement of 2009[11] in response to a recommendation from the Stakeholder Advisory Group on ELF EMFs (SAGE) in its First Interim Assessment[25]. The details are given in a second Code of Practice, 'Optimum Phasing of High Voltage Double-Circuit Power Lines' [8].

2.9.3 "Optimum phasing" is the phasing that produces the lowest magnetic fields moving away, perpendicular from the overhead line, taking account of the likely current flows in the line. **Paragraph 2.10.11** of NPS EN-5 mentions the February 2011 publication "Optimum Phasing of high voltage double-circuit Power Lines – A Voluntary Code of Practice". This has now been replaced by a March 2012 edition with the same name and substantive content. The Code of Practice on Optimum Phasing[8] states that new overhead power lines should have optimum phasing where reasonable. It explains that it will normally be possible to achieve optimum phasing simply by choosing how to order the connections at the end of the overhead line, but that if achieving optimum phasing would either require an extra structure or would conflict with the requirements for power system stability, this would normally be "unreasonable" and is not required. The Code of Practice states that where necessary, "unreasonable" will be interpreted in terms of the cost-benefit analysis presented in the SAGE First Interim Assessment[25].

2.9.4 All the relevant scientific evidence on EMFs was considered fully in the process of establishing the exposure guidelines that apply in the UK. Those exposure guidelines together with the policy on optimum phasing (and other precautionary policies that relate only to low-voltage equipment) are considered by PHE and the Government to be the appropriate response to that evidence.

[25] Stakeholder Advisory Group on ELF EMF. SAGE First Interim Assessment. 2007. (Online) Available from

2.9.5 Government have specifically rejected the introduction of “corridors” around power lines on EMF grounds, stating of this option in the Written Ministerial Statement[11]:

“The Government therefore considers this additional option to be disproportionate in the light of the evidence base on the potential health risks arising from exposure to ELF/EMF and has no plans to take forward this action.”

2.9.6 Having established that it is not Government policy to have restrictions on homes and schools near power lines, the Statement goes on to say **(paragraph 38**):

“It is central Government’s responsibility (rather than individual local authorities) to determine what national measures are necessary to protect public health.”

2.9.7 This makes it clear that Government has not introduced any restrictions (beyond those that may be created by the EMF exposure limits and the safety clearance distances) on constructing new power lines close to existing properties on grounds of safety or health risks, and neither is it appropriate for individual local authorities to do so.

2.9.8 In relation to undergrounding, the NPS EN-5[3] states:

“*2.10.12 Undergrounding of a line would reduce the level of EMFs experienced, but high magnetic field levels may still occur immediately above the cable. It is not the Government’s policy that power lines should be undergrounded solely for the purpose of reducing exposure to EMFs. Although there may be circumstances where the costs of undergrounding are justified for a particular development, this is unlikely to be on the basis of EMF exposure alone, for which there are likely to be more cost-efficient mitigation measures.”*

2.9.9 Therefore, the UK has a carefully thought-out set of policies for managing EMFs, which includes both numerical exposure guidelines to protect against established, acute effects of EMFs, and precautionary policies to provide appropriate protection against the possibility of chronic effects of EMFs at lower levels, including, specifically, the possibility of a risk for childhood leukaemia. These policies are incorporated into the DCO decision-making process in NPS EN-5[3] which are applied to the Project.

2.10 Microshocks

2.10.1 Under high-voltage overhead lines, conducting objects may become electrically charged if they are isolated from earth. If this charged object is then touched by a person at a different electrical potential, charge is transferred between the person and the object. When the person is very close to the object but before touching it, the voltage difference between the person and the object can be sufficient to cause the air in the gap to break down, and a small spark discharge occurs. This can be perceived by the person and is known as a microshock.

2.10.2 The size of a microshock depends on the size of the electric field, the sizes of the objects concerned, how well grounded or insulated they are, meteorological conditions, and the sensitivity of the skin. All of these factors determine the severity of the perception which can range from barely perceptible through to annoyance and in some rare circumstances even pain. Microshocks are similar to the static shocks that can occur by, for example, walking across a nylon carpet in dry weather. Microshocks have no known long-term

health effects and any sensation is normally confined to the momentary spark discharge as contact is made or broken.

2.10.3 In a 2005 Information Sheet[26], HPA (now UKHSE) state:

"… on the basis of the available evidence, the direct effects of microshocks on the body are not considered capable of producing lasting harm. The response to some extent will depend on the sensitivity of the individual. Although the possibility of microshocks cannot be ruled out, in field strengths up to about 5kV m^{-1} they are unlikely to be painful to the majority of people."

2.10.4 Microshocks are indirect effects and as such are not directly covered by the quantitative exposure limit values that protect against direct effects of electric fields. The ICNIRP guidelines [9] do have a cautionary reference level of 5kV/m but limiting exposure to 5kV/m is not considered the most appropriate way of dealing with microshocks. Reducing electric fields by changes to the design is possible, but will usually result in taller pylons, increasing the visual impact of the overhead line. As there is no threshold of electric field for preventing microshocks, the benefit of reducing the field to 5kV/m may be marginal. Rather than introducing an arbitrary limit the Code of Practice on Compliance [7] states:

"…..there is a suite of measures that may be called upon in particular situations, including provision of information, earthing, and screening, alongside limiting the field which should be used to reduce the risk to the public of indirect effects. In some situations, there may be no reasonable way of eliminating indirect effects, for instance where erecting screening would obstruct the intended use of the land."

2.10.5 A separate Code of Practice on Microshocks, developed jointly by Industry and the then DECC, has been adopted [27]. This follows the principles for managing microshocks quoted above but contains more details on the practical measures which can be taken.

2.10.6 The proposed overhead line has been designed to comply with the government exposure limit values for electric fields, ensuring 9kV/m is not exceeded, and in accordance with the Code of Practice on Microshocks, as demonstrated in **Section 6.2.** It is very difficult to eliminate microshocks completely when an electric field is present, which is recognised in the Code of Practice. National Grid will ensure that if microshocks are reported these will be investigated and mitigated where appropriate, following the provisions of the Code of Practice on Microshocks[27].

2.11 Active Implantable Medical Devices

2.11.1 Electric and magnetic fields can affect Active Implantable Medical Devices (AIMDs), such as pacemakers, insulin pumps and Implanted Cardiac Defibrillators (ICDs), if the external field strength exceeds the immunity of the device. EMFs can induce voltages in the body which, if high enough, can potentially exceed the immunity of the device and temporarily affect its operation.

[26] Health Protection Agency. Application of ICNIRP Exposure Guidelines for 50 Hz Power Frequency Fields. 2005. (Online) Available from: [redacted]

[27] Department of Energy and Climate Change. Power lines: Control of microshocks and other indirect effects of public exposure to electric fields. A voluntary Code of Practice. London, 2013.

2.11.2 All modern AIMDs are expected to be immune from interference from electric and magnetic EMFs up to the reference levels for public exposure of the 1999 EU Recommendation[10] where the AIMD has been implanted and programmed in a standard manner. The reference levels at 50Hz are 100μT for magnetic fields and 5kV/m for electric fields. However, many AIMDs will have considerably higher immunity to external EMFs than the minimum requirements.

2.11.3 Specifically, the Active Implantable Medical Devices Directive (90/385/EEC)[28] includes the following provision:

"Devices must be designed and manufactured in such a way as to remove or minimize as far as possible: … risks connected with reasonably foreseeable environmental conditions such as magnetic fields, external electrical influences …"

2.11.4 Neither National Grid nor the Medicines and Healthcare products Regulatory Agency (MHRA) are aware of any instance of a patient with a modern, correctly fitted AIMD experiencing any interference from the electricity transmission system.

2.11.5 The Project would be capable of producing electric and magnetic fields which, while still compliant with the public exposure limits, are in excess of the reference levels for public exposure. Therefore, in theory, some interference of EMFs with AIMDs could possibly occur. However, some existing National Grid overhead lines and underground cables are likewise theoretically capable of producing fields that exceed the public reference levels, and as noted above neither the MHRA or National Grid are aware of any instance of electricity transmission infrastructure interfering with a correctly fitted modern AIMD such as a pacemaker or ICD. The risk of any interference occurring is not significant in practice for the following reasons:

2.11.6 While manufacturers have to ensure that AIMDs are immune up to the reference levels for public exposure, many modern AIMDs will be immune to EMFs considerably in excess of these levels; and

2.11.7 The maximum EMFs from an overhead line or underground cable as calculated for assessing compliance with the exposure limits represent a worst-case scenario, chosen to demonstrate that exceeding the exposure guidelines is not possible. However, typically, the overhead line or underground cable would produce EMFs lower than these levels for two reasons: transmission circuits, including those on this Project do not operate at the maximum rating routinely, and a typical current on a day-to-day basis would be around 50% or less of this; and for overhead lines typically the conductors would be higher than the minimum design clearance used for assessing compliance, reducing the EMFs at ground level, with the minimum clearance found only in a limited area towards the middle of certain spans.

2.11.8 Thus, there is considerable confidence in saying that, based on the absence of reported incidents and on the typical EMF exposures that would occur on a daily basis, transmission overhead lines, cables and substations do not appear to interfere with AMIDs in practice. The risk of any interference occurring is assessed as being negligible and does not constitute a significant effect.

2.11.9 This is supported in NPS EN-5[3], at **Section 2.10.7**, which states that:

[28] Council Directive 90/385/EEC of 20 June 1990 on the approximation of the laws of the Member States relating to active implantable medical devices. Brussels, 1990.

"The Department of Health's Medicines and Healthcare Products Regulatory Agency (MHRA) does not consider that transmission line EMFs constitute a significant hazard to the operation of pacemakers."

2.12 Farming, Flora and Fauna

2.12.1 The NPS for Electricity Networks Infrastructure (EN-5)[3] in Part 2, **Section 2.10.8** states:

"There is little evidence that exposure of crops, farm animals or natural ecosystems to transmission line EMFs has any agriculturally significant consequences."

2.12.2 Given this lack of evidence, EMFs from the Project will not have a significant effect on farming, flora and fauna.

2.13 The Electricity Safety, Quality and Continuity Regulations 2002

2.13.1 NPS EN-5 (paragraph 2.10.10) refers to the Electricity Safety, Quality and Continuity Regulations 2002[13] which set out the minimum height, position, insulation and protection specifications at which conductors can be strung between pylons to ensure safe clearance of objects. Regulation 17(2) and Schedule 2 require the clearances set out in **Table 2.3**

Table 2.3 – The Electricity Safety, Quality and Continuity Regulations 2002 – minimum height above ground of overhead lines

Nominal voltages	Over roads (m)	Other locations (m)
Exceeding 66kV but not exceeding 132kV	6.7	6.7
Exceeding 132kV but not exceeding 275kV	7	7
Exceeding 275kV but not exceeding 400kV	7.3	7.3

2.13.2 The minimum conductor clearance information for the Project is provided in **Section 6.2** which demonstrates compliance with these requirements.

3. Electromagnetic Compatibility

3.1.1 Electromagnetic compatibility (EMC) is controlled by EU Directive 2014/30/EU[29](the EMC Directive) which replaced Directive 2004/108/EC[30] on 20 April 2016. These Directives are enacted in UK law by Regulations. The current Regulations are the Electromagnetic compatibility Regulations, 2016[31], which are based on the 2014 Directive.

3.1.2 The requirements of the Electromagnetic Compatibility Regulations 2016 are that the electromagnetic disturbance that an apparatus generates should not exceed a level allowing radio and telecommunication equipment and other apparatus to operate as intended; and that the apparatus itself has an adequate level of intrinsic immunity to electromagnetic disturbance to enable it to operate as intended.

3.1.3 Permanent, fixed infrastructure of the type owned and operated by National Grid is covered by Regulation 37 in the Electromagnetic Compatibility Regulations 2016 relating to "fixed installations". Although not a requirement of the 2016 Regulations, the requirements have also been applied to temporary overhead lines, as will be required for the Project.

3.1.4 Regulation 37, paragraph 4 of the Electromagnetic Compatibility Regulations 2016 enacts Article 6 of the 2014 Directive which requires that "*A fixed installation shall be installed applying good engineering practices*…." in order to avoid EMC problems.

3.1.5 The main potential source of interference from transmission systems such as the Project arises from radio frequency (RF) emissions caused by corona discharge from overhead lines and substations (underground cables do not in general produce any significant radio-frequency emissions). Corona discharge results from the high voltages on the surface of conductors particularly in wet conditions where water droplets can concentrate the electric field; it is recognisable by the characteristic crackling sound. RF emissions and corona levels are limited by designing to National Grid's technical specifications which include BS5049-3[32], along with other equipment specific standards such as BS EN60437[33] for the insulators on the pylons. Thus, National Grid's Transmission System applies good engineering practices and meets the essential requirements detailed in the Electromagnetic Compatibility Regulations 2016, Regulation 37.

[29] Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility.

[30] Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC.

[31] The Electromagnetic Compatibility Regulations 2016. Statutory Instrument 2016 No. 1091.

[32] British Standards Institution. EN BS 5049-3: Radio interference characteristics of overhead power lines and high voltage equipment: Part 3- Code of practice for minimising the generation of radio frequency noise. London: BSI, 1994

[33] British Standards Institution. BS EN 60437:1998 Radio interference test on high voltage insulators. London: BSI, 1998.

3.1.6 This was initially documented and certified under the provisions of the EMC Directive then in force, the 1989 Directive 89/336/EEC[34], by creating a Technical Construction File (TCF) for the National Grid transmission system. The TCF is based on a combination of extensive on-site testing (overhead lines and substations) and examination of National Grid's technical specifications, policies and standards to ensure that RF noise and corona are adequately addressed. The on-site surveys showed that there were no significant emission problems to address; and equipment technical specifications and policies ensured equipment was designed in accordance with British Standards to limit RF noise and corona discharge. Using the rationale of the TCF it was determined that the National Grid system meets the essential requirements of the EMC Directive. A Certificate of Conformity was issued by Hursley EMC Services (the Competent Body) and is provided at **Appendix B of this document.**

3.1.7 The subsequent EMC Directive, 2004/108/EC[30], and the current EMC Directive 2014/30/EU [30], no longer use the terminology of a TCF and Certification. However, the essential requirements of the Directives have not changed, and the content of the TCF remains a valid method of documenting compliance with the Electromagnetic Compatibility Regulations 2016[32].

3.1.8 The Project would contain electrical infrastructure that is the same as or similar to that tested by on-site measurements documented in the TCF and would also be designed to the same technical specifications.

3.1.9 Occasionally, radio interference is reported from equipment on the National Grid transmission system. The most likely cause of such interference is equipment that has been damaged or degraded while in operation. This sort of occurrence is normally addressed during routine maintenance. Interference reports are extremely rare but where interference is reported it will be investigated and remedial action will be taken to mitigate interference where it is appropriate to do so.

3.1.10 Given that the provisions of the current Electromagnetic Compatibility Regulations 2016 are met through using good engineering practice and applying the relevant technical standards, and that the EMC performance of this system has been certificated as compliant by a Competent Body, as defined by Schedule 5 of the Electromagnetic Compatibility Regulations 2016 (renamed Conformity Assessment bodies), following appropriate on-site testing, the Project would present no issues with TV or radio interference under normal operating conditions.

[34] Council Directive 89/336/EEC of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility

4. Requirements for demonstrating compliance with the EMF policy

4.1.1 The assessment considers the EMFs produced from the electricity infrastructure associated with the Project.

4.2 Study Area

4.2.1 The EMFs produced by the electrical infrastructure, including overhead lines, underground cables and substations of the Project would have a given size at a given distance from the infrastructure. Therefore, the Study Area of the assessment includes all areas around the infrastructure where the EMFs could potentially be significant, such that the assessment is infrastructure-specific rather than location-specific. Therefore, any changes in alignment that could occur within the Limits of Deviation proposed for the Project would not alter the assessments presented here. This ensures that the equipment would be compliant with exposure guidelines irrespective of the Project's exact location within the Limits of Deviation.

4.3 Predicted EMF Levels

4.3.1 The magnetic field produced by a current in an individual conductor reduces with distance from the conductor. Where there is more than one current forming part of one or more electrical circuits, there is also partial cancellation between the magnetic fields produced by the individual currents, and that cancellation generally becomes more complete as the distance increases. Overall, the magnetic field is highest at the point of closest approach to the conductors and falls rapidly with distance. Similarly, there is partial cancellation between the electric fields produced by the voltages on individual conductors, and the electric field is usually highest at the point of closest approach to the conductors and falls rapidly with distance.

4.3.2 For sources of field with a simple, defined geometry, such as overhead lines or underground cables, calculations are the best way of assessing fields and are acceptably accurate. The calculations of fields for the Project, presented in Section 6 follow the provisions specified in the Code of Practice on Compliance[7] and were performed using specialised computer software that has been validated against direct measurement of EMFs from overhead lines and cables[35].

4.3.3 By contrast, due to the complex physical arrangement of substations and the electrical equipment associated with these, the EMFs produced are not readily calculable. However, the highest field levels at and outside the perimeter of a substation are usually those produced by the overhead lines entering the substation. The fields produced by

[35] J. Swanson, Magnetic fields from transmission lines: Comparison of calculations and measurements, IEE Proceedings.-Generator Transmission Distribution, 1995, 142 (5), p481.

equipment within the substation are generally smaller and decrease with distance more quickly than fields generated by overhead lines.

4.3.4 Since field strengths are constantly varying, they are usually described by reference to an averaging calculation known as the "root mean square" or RMS. Future mention of power-frequency field strengths in this chapter refer to the RMS amplitude of the power-frequency modulation of the total field, which is the conventional scientific way of expressing these quantities.

4.3.5 To assess compliance with exposure limits, the Code of Practice on Compliance[7] specifies that the maximum fields the overhead line is capable of producing should be calculated using the following conditions:

- electric fields: for nominal voltage and design minimum clearance;
- magnetic fields: for the highest rating that can be applied continuously in an intact system (i.e. including ratings which apply only in cold weather, but not including short-term ratings or ratings which apply only for the duration of a fault elsewhere in the electricity system) and design minimum clearance; and
- electric and magnetic fields: for 1m above ground level, of the unperturbed field, taking account of the correct wire type and bundle size, taking account of the basic pylon geometry for the design of overhead line in question, but ignoring variations in conductor spacing at angle pylons etc, of the 50Hz component ignoring harmonics, ignoring zero-sequence currents and voltages and currents induced in the ground or earth wire, and using the infinite-straight-line approximation.

4.3.6 The same provisions apply, where relevant, to assessing the fields from underground cables.

4.3.7 Therefore, the calculations for the Project were performed using worst-case conditions including minimum conductor clearances for overhead lines. The circuits are unlikely to operate at this maximum rating routinely, resulting in lower typical magnetic fields on a day-to-day basis.

4.3.8 Electric fields (but not magnetic fields) are readily perturbed by conducting objects, including, for example, buildings, fences and trees. The fields calculated here are unperturbed fields, as specified by the Code of Practice on Compliance[7]. These give a valid indication of the size of any electric-field related phenomena over the area concerned, but the local value, close to a source of perturbation, would vary. In practice, perturbations within or to the sides of buildings and other fixed objects usually act so as to reduce, not increase, the electric field. Fields inside any buildings are generally reduced. However, the Code of Practice[7] specifies that it is acceptable to demonstrate compliance by reference to the unperturbed fields.

4.3.9 As an alternative to calculations, the Code of Practice on Compliance[7] specifies that there are certain classes of equipment which inherently produce fields below the guideline levels, and can be assumed to comply without producing case-by-case specific assessments of the field. Substations are one such type of equipment:

"*The Energy Networks Association will maintain a publicly-available list on its website of types of equipment where the design is such that it is not capable of exceeding the ICNIRP exposure guidelines, with evidence as to why this is the case. Such types of equipment are likely to include:*

- *overhead power lines at voltages up to and including 132kV*
- *underground cables at voltages up to and including 132kV*
- *substations at and beyond the publicly accessible perimeter*

Compliance with exposure guidelines for such equipment will be assumed unless evidence is brought to the contrary in specific cases." (page 4)

4.3.10 The Energy Networks Association's publicly available list can be found on the National Grid EMF website[36]. This confirms that substations (that do not contain a static var compensator) and sealing end compounds, such as those proposed by the Project, are within the class of equipment which are regarded as inherently compliant without the need for case-by-case specific assessments.

4.4 Combining fields from different sources

4.4.1 When more than one source of EMFs are present, such as two different overhead lines or an overhead line and an underground cable, the field from each source is calculated separately, and it is then necessary to combine the two individual fields to obtain the resulting field.

4.4.2 Because of the physical properties of EMFs, specifically that they are what is known as "vectors" not "scalars", (i.e. direction as well as magnitude is relevant), EMFs from two different sources do not simply add together. The addition of EMFs from different sources is complex, but has the general effect that, when the field from one source is larger than the other, the larger field dominates, with the smaller field making only a small difference to the resulting field.

4.5 Significance Evaluation

4.5.1 The Project is assessed as having a significant effect if non-compliance with the EMF exposure limits was demonstrated, using the principles set out in the Code of Practice on Compliance[7]. Conversely, as specified in Section 2.10.15 of NPS EN-5[3], if the Project complies with the exposure limits and with the policies on phasing[8] and microshocks[27], EMF effects would be assessed as not significant and no mitigation would be necessary. Compliance with these policies is documented in Section 6.

[36] EMFs.info, Statement of compliance with public exposure limits Available at: [redacted] [Assessed June 2022]

5. Baseline Environment

5.1.1 The Project would be located within a mixture of primarily rural and semi-rural areas, which accommodate existing electrical infrastructure, mainly overhead lines. All equipment that generates, distributes or uses electricity produces EMFs. The UK power frequency is 50Hz which is the principal frequency of the EMFs produced.

5.1.2 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 roughly 50µT in the UK. This field may be distorted locally by ferrous minerals or by steelwork such as in buildings. At the Earth's surface there is also a natural electric field, created by electric charges high up in the ionosphere, of about 100V/m in fine weather.

5.1.3 As detailed earlier in this report, the Earth's natural fields are static, and the power system produces alternating fields. In homes in the UK that are not close to 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 – 0.2µT with an average of approximately 0.05µT, 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 arise close to domestic appliances that incorporate motors and transformers. For example, close to the surface, fields can be 2000µT for electric razors and hair dryers, 800µT for vacuum cleaners, and 50µT for washing machines. The electric field in most homes is in the range 1-20V/m, rising to a few hundred V/m close to appliances[37].

5.1.4 There are currently existing National Grid 400kV and 275kV overhead lines in the geographical area in which the Project is located. Some of these existing overhead lines connect the Project to the transmission network. Currently, an existing 400kV 'YR' route overhead line is located at the north end of the Project. There is also the existing 275kV XCP route running southwards from the proposed Overton substation. A 2.35km section of this overhead line and six pylons between Skelton and Moor Monkton will be removed as part of the Project. There are also wood-pole distribution lines in the area. The fields produced by these specific lines depend on the loads carried and will be different for different lines and at different times but would all be within the exposure limits. Magnetic and electric fields for typical loads that overhead lines such as these carry are shown in **Figure 5.1 and 5.2** below. Wood-pole distribution lines are represented by a 33kV design, but 11kV distribution lines may also be present producing similar EMFs. Typically, the magnetic fields produced by 400kV and 275kV overhead lines are similar, as demonstrated in **Figure 5.1.**

5.1.5 Overhead lines rarely operate at 100% of the current load they are designed to carry. That extra capacity to be provided by the Project is required to increase boundary transfer capability and to be SQSS compliant. Typical current loads or the average current the overhead line would be carrying on a typical day throughout the year, are significantly lower. Due to typical current load being lower than the designed current load typical day

[37] J. Swanson & D.C. Renew, Power-frequency fields and people, Engineering Science and Education Journal, 1994, p 71

magnetic fields are significantly lower than those provided for compliance purposes in Section 6.

Figure 5.1: Typical magnetic fields from existing overhead lines

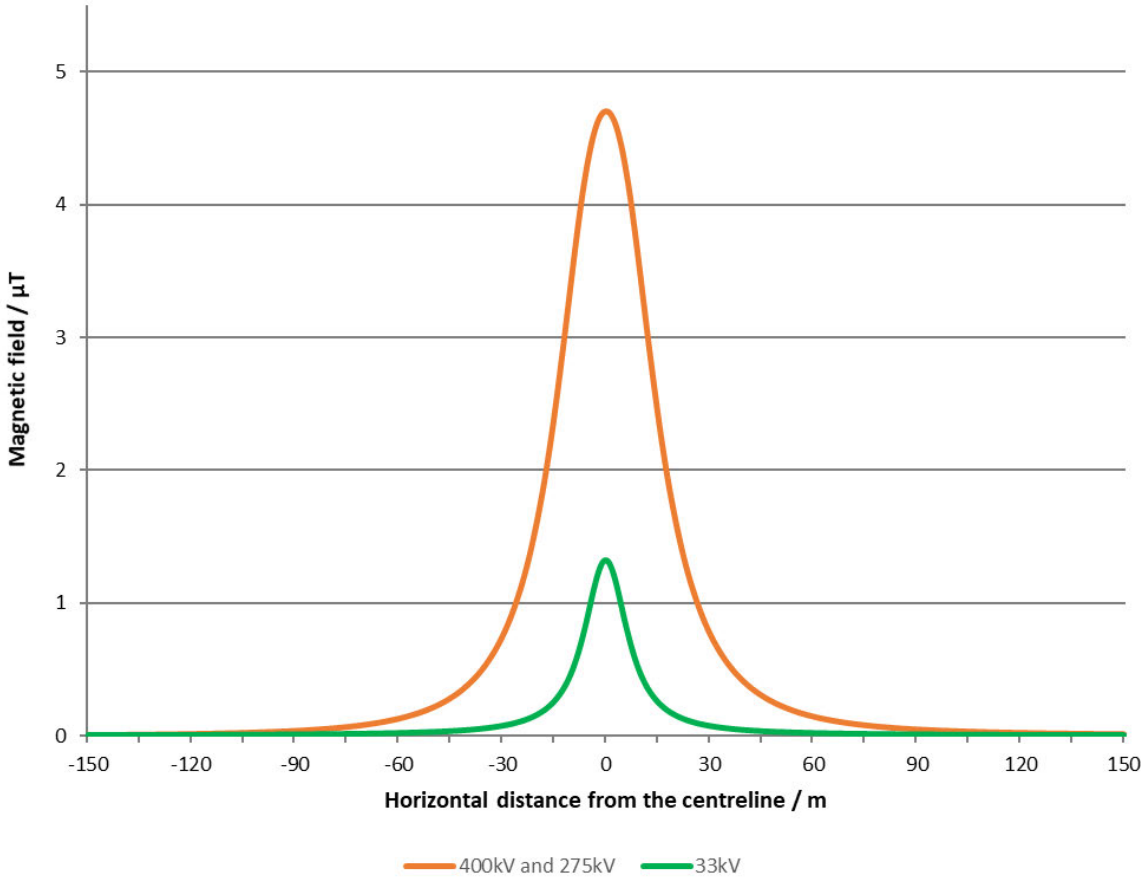
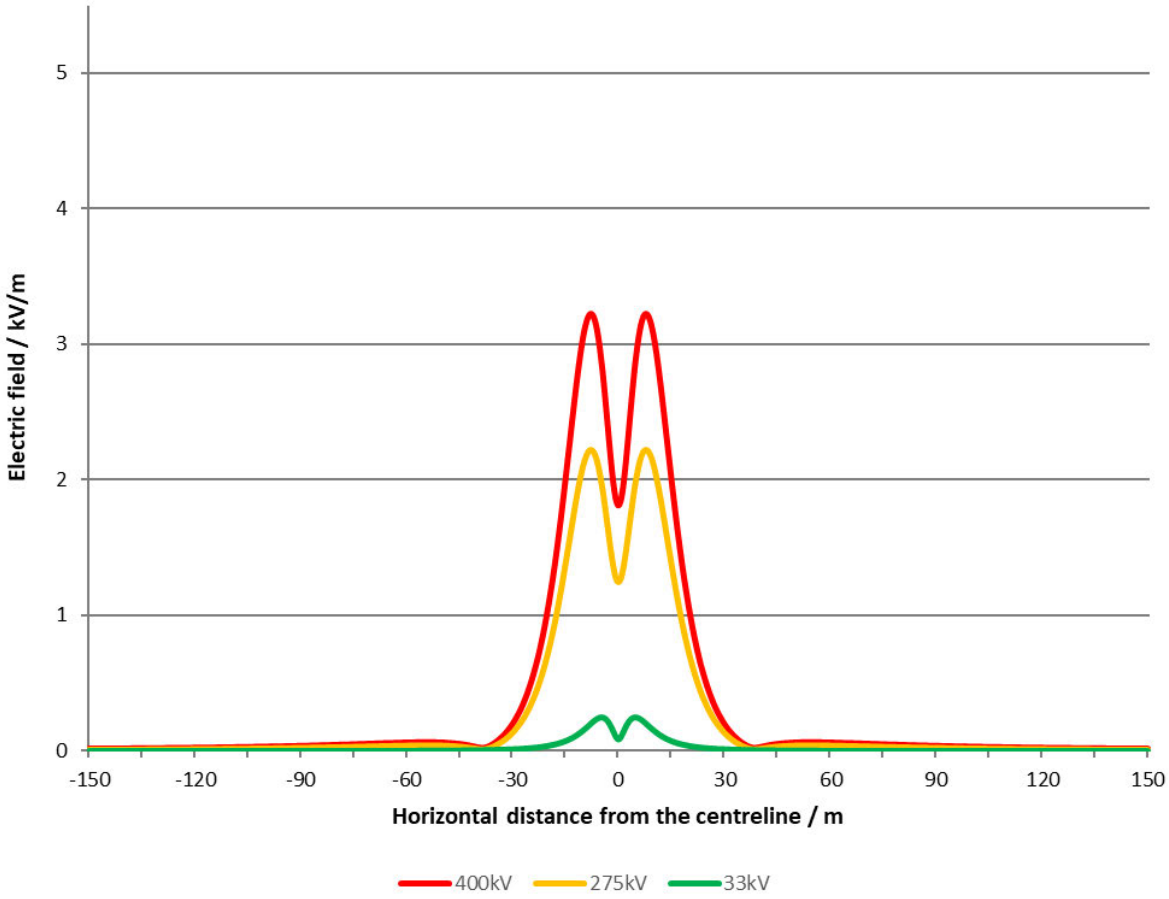


Figure 5.2: Typical electric fields from existing overhead lines



6. Demonstrating compliance with the EMF requirements of NPS EN-5

6.1 Construction Effects

6.1.1 During construction and prior to energisation, the new transmission equipment would not produce any EMFs as no voltage is applied or current flowing in the equipment. Therefore, construction effects are not considered further.

6.2 Operational Effects – Overhead lines

6.2.1 Three new overhead line routes are proposed as part of this Project, along with re-conducting of an existing overhead line route. The temporary diversion overhead line designs do not significantly differ from those noted in **paragraph 6.2.2** and are covered by the calculations in this section. The overall overhead line design will influence the EMFs produced and therefore each of the proposed pylon designs for each route has been assessed separately for compliance against the EMF requirements of NPS EN-5.

Overhead lines – Compliance with exposure limits

New 400kV overhead line – YN route

6.2.2 The proposed new double-circuit 400kV overhead line would be constructed using an L12 pylon design, with Twin Rubus conductor bundles. All spans would have a minimum conductor design clearance to ground of 7.7m, although in many cases this would be higher.

6.2.3 Calculations for the 400kV overhead line were performed at the pre-fault continuous rating of the Twin Rubus conductor bundle which is 1260MVA and nominal voltage (400kV) at 1m above ground.

New 275kV overhead line – SP route

6.2.4 The proposed new double-circuit 275kV overhead line would be constructed using new L8(C) pylons, with single Araucaria conductors. All spans would have a minimum conductor design clearance to ground of 7.0m, although in many cases this would be higher.

6.2.5 Calculations for the 275kV overhead line were performed at the pre-fault continuous rating of the single araucaria conductor which is 590MVA and nominal voltage (275kV) at 1m above ground.

New 275kV overhead line– XC route

6.2.6 The proposed new double-circuit 275kV overhead line would be constructed using new L8(C) pylons and connect to the existing XCP route (renamed XC Route). This would be

strung with twin Leipzig conductors and all spans would have a minimum conductor design clearance to ground of 7.0m, although in many cases this would be higher.

6.2.7 Calculations for the 275kV overhead line were performed at the pre-fault continuous rating of the twin Leipzig conductor which is 1260MVA and nominal voltage (275kV) at 1m above ground.

Reconductoring existing 275kV overhead line – XC route

6.2.8 The existing 275kV XC overhead line route between Poppleton and Monk Fryston substations currently has a single Araucaria conductor. As part of the proposed works, this route would be reconductored with twin Leipzig conductors, to match the new XC route rating. The impact of this change in conductor type has been assessed. All spans would have a minimum conductor design clearance to ground of 7.0m, although in many cases this would be higher. The route is constructed predominately of L3(c) and L66 pylons.

6.2.9 Calculations were performed at the pre-fault continuous rating of the twin Leipzig conductor which is 1260MVA and nominal voltage (275kV) at 1m above ground.

Figure 6.1: Maximum magnetic fields from proposed and reconducted overhead lines

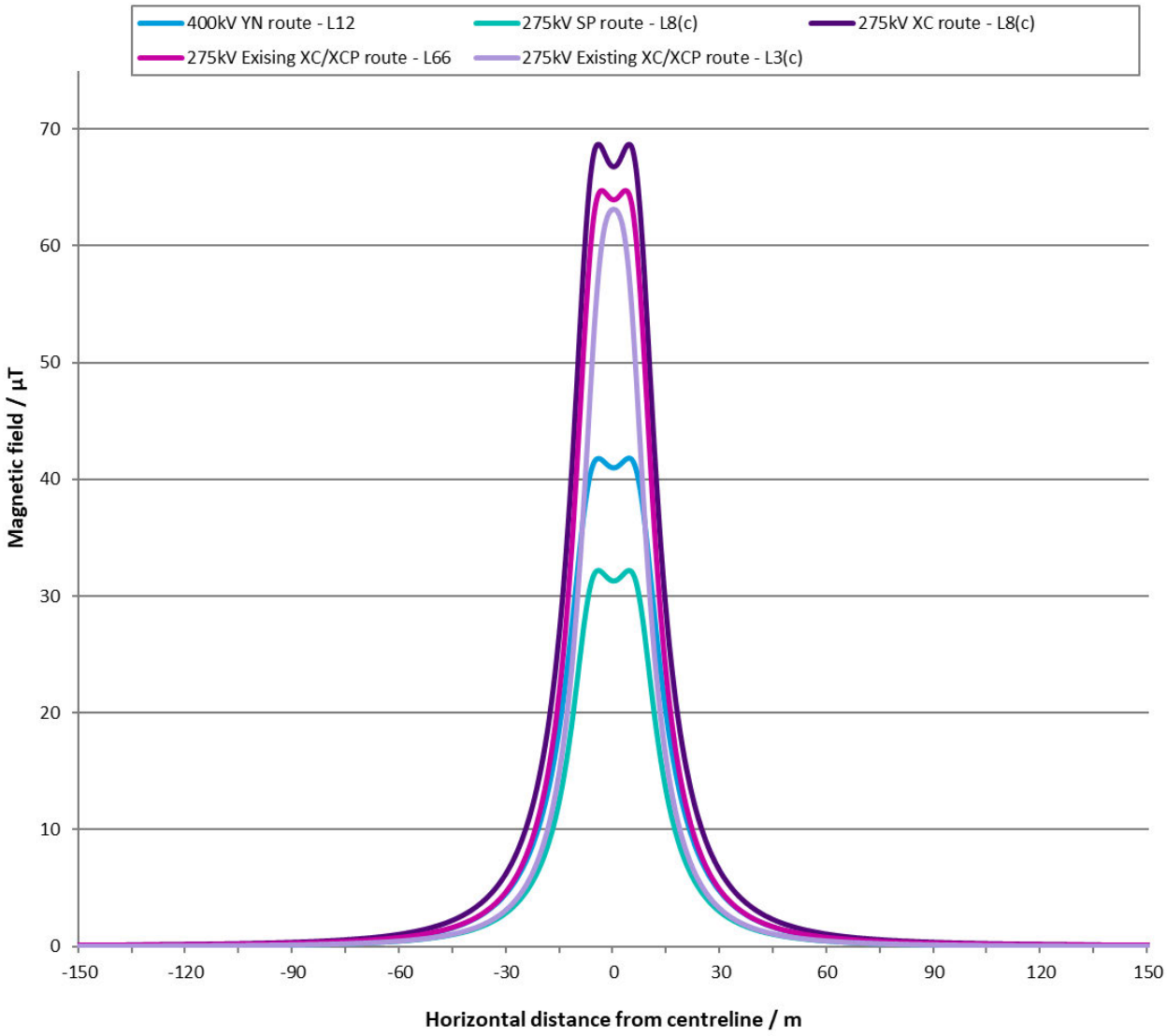
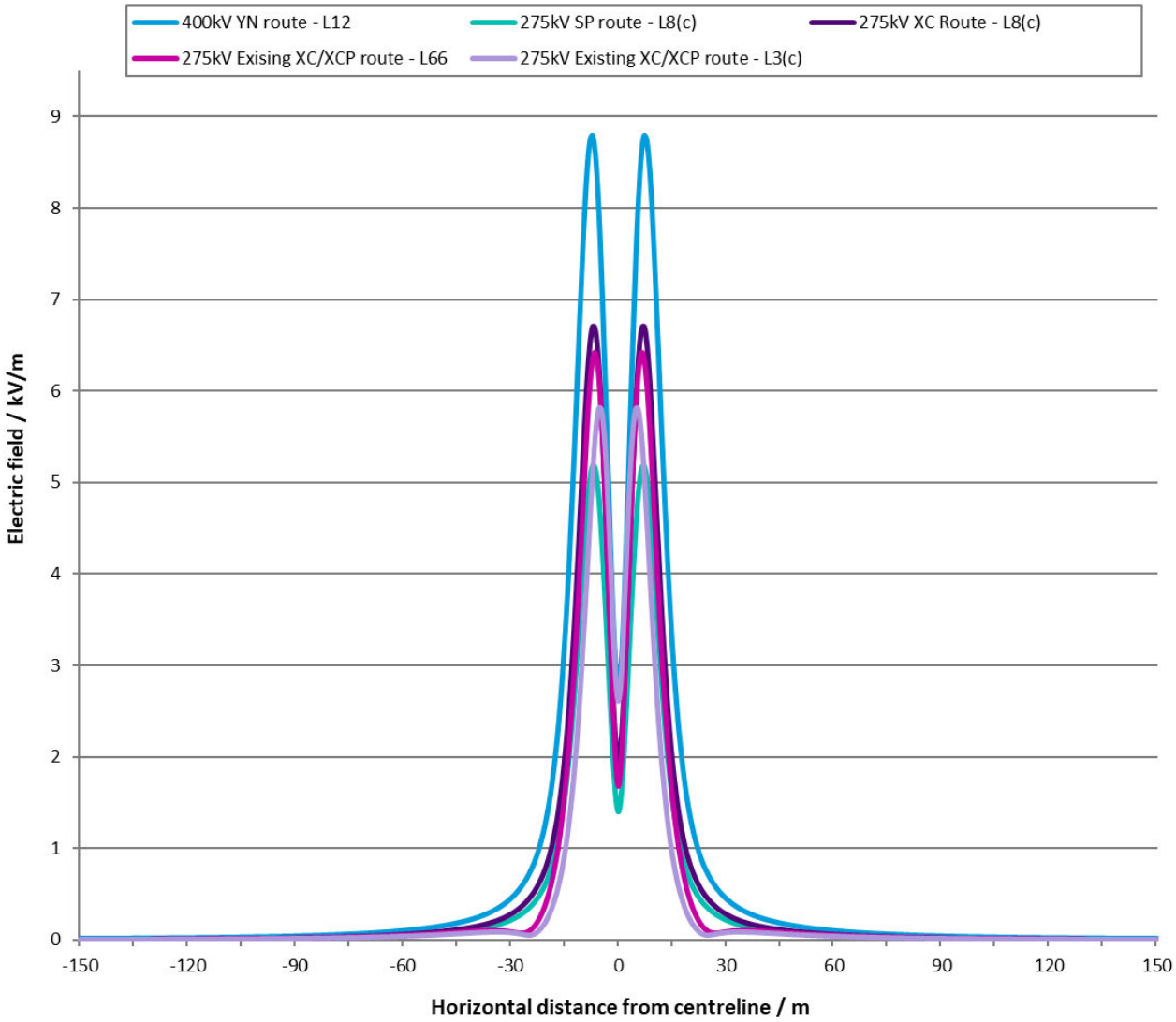


Figure 6.2: Maximum electric fields from proposed and reconductored overhead lines



6.2.10 The results presented in **Figures 6.1 and 6.2** above are the maximum magnetic and electric fields the overhead lines would be capable of producing (i.e. the rating level) as specified in the Code of Practice on Compliance[7]. Under normal conditions, the overhead lines would carry lower loads and therefore produce lower magnetic fields. Typical clearances above ground would also be higher than the minimum clearances assumed for the previous calculations which would reduce both the electric and magnetic fields.

6.2.11 The maximum fields from the various overhead lines are summarised in **Table 6.1 below**.

Table 6.1: Summary of calculated fields for proposed and reconductored overhead lines

Route	Pylon Type	Conductor Bundle	Maximum Electric Field at Nominal Voltage (kV/m)	Maximum Magnetic Field at Pre-Fault Continuous Loading (μT)
New proposed overhead line				
400kV YN route	L12	Twin Rubus	8.80*	41.9**
275kV XC route	L8(c)	Twin Leipzig	6.71*	68.7**
275kV SP route	L8(c)	Single Araucaria	5.20*	32.2**
Existing reconducted overhead line				
275kV XC/XCP route	L3(c)	Twin Leipzig	5.83*	63.2**
	L66	Twin Leipzig	6.42*	64.7**

* the public exposure limit for electric fields is 9.0kV/m

**the public exposure limit for magnetic fields is 360.0μT

Compliance with Policy on Phasing

6.2.12 The new 400kV and 275 kV overhead lines have been designed with transposed phasing meaning that they are optimally phased as set out in the Code of Practice on Optimum Phasing[8]. On all three routes, the two circuits are arranged to produce the greatest degree of cancellation between the magnetic fields produced by the two circuits and hence the lowest resultant magnetic field to the sides of the line.

6.2.13 The existing XC/XCP route is currently optimally phased, and this phasing will remain the same after the works, also complying with the requirements in the Code of Practice[8].

Overhead Lines – Assessment

6.2.14 The maximum calculated magnetic field from the proposed 400kV overhead lines, calculated according to the Code of Practice on Compliance, is 41.9μT. The maximum calculated electric field is 8.80kV/m. The calculated fields under the proposed 275kV SP and XC routes varied, depending on pylon design and conductor, but the maximum for all designs was 68.7μT for magnetic fields and 6.71kV/m for electric fields. Changing the conductors from single to twin Leipzig conductors on the existing XC route resulted in a maximum magnetic and electric fields field of 64.7μT and 6.42kV/m respectively. The exposure limits for the general public are 360μT and 9kV/m. Therefore, the maximum EMFs produced by the proposed overhead lines and reconductoring works would be less than the relevant public exposure limits. Thus, the proposed overhead lines would meet the relevant exposure limits, the ICNIRP general public guidelines [9] in the terms of the EU Recommendation [10]. They would also comply with the Government policy on phasing,

and there are no other restrictions on grounds of EMFs, health or safety applying to power lines.

6.2.15 The assessment presented above shows that the maximum value of the fields produced by the proposed overhead lines would be compliant with the relevant exposure limits in **Table 2.1**, even directly under the overhead line. There is no minimum lateral distance from the overhead line required in order to achieve compliance. Therefore, assessment of compliance is not dependent on: the exact routing of the overhead line; the exact location of the nearest existing residential property to the overhead line; the nearest proposed property already granted planning permission; or the nearest property that might in future be granted planning permission, because the field from the overhead line is compliant everywhere, not just compliant outside a specified distance.

6.3 Operational Effects – underground cables

Electric fields

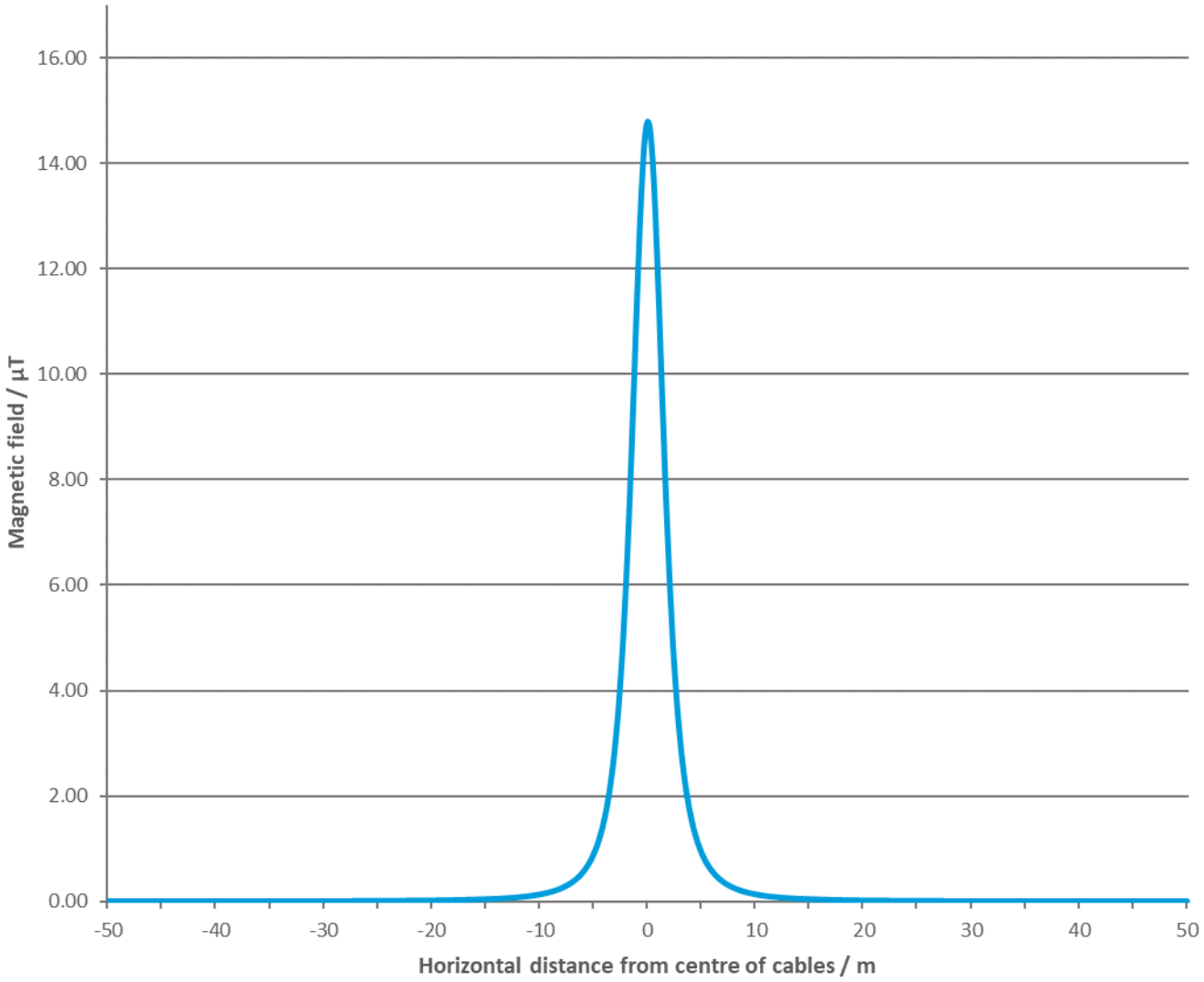
6.3.1 Underground cables produce no external electric field because of the metallic sheath.

Magnetic fields – 400kV underground cable – Shipton Tee

6.3.2 The short section of 400kV underground cable would be installed to allow the new overhead line to connect to the existing YR overhead line route via cable sealing end compounds. The 400kV cables consists of one circuit, with two cables per phase, totalling six cables. These cables will be installed in a flat formation in two groups of three cables. The groups will be separated by 1.1m (group centre to centre) with each conductor in the group separated by 200mm. The minimum burial depth of the cables is 1.0m. The maximum rating of the 400kV cable circuit is 1260MVA.

6.3.3 **Figure 6.3** below presents the maximum magnetic fields for the design, calculated for the rating of the cables and representing the maximum field capable of being produced.

Figure 6.3: Maximum magnetic fields from proposed 400kV underground cables

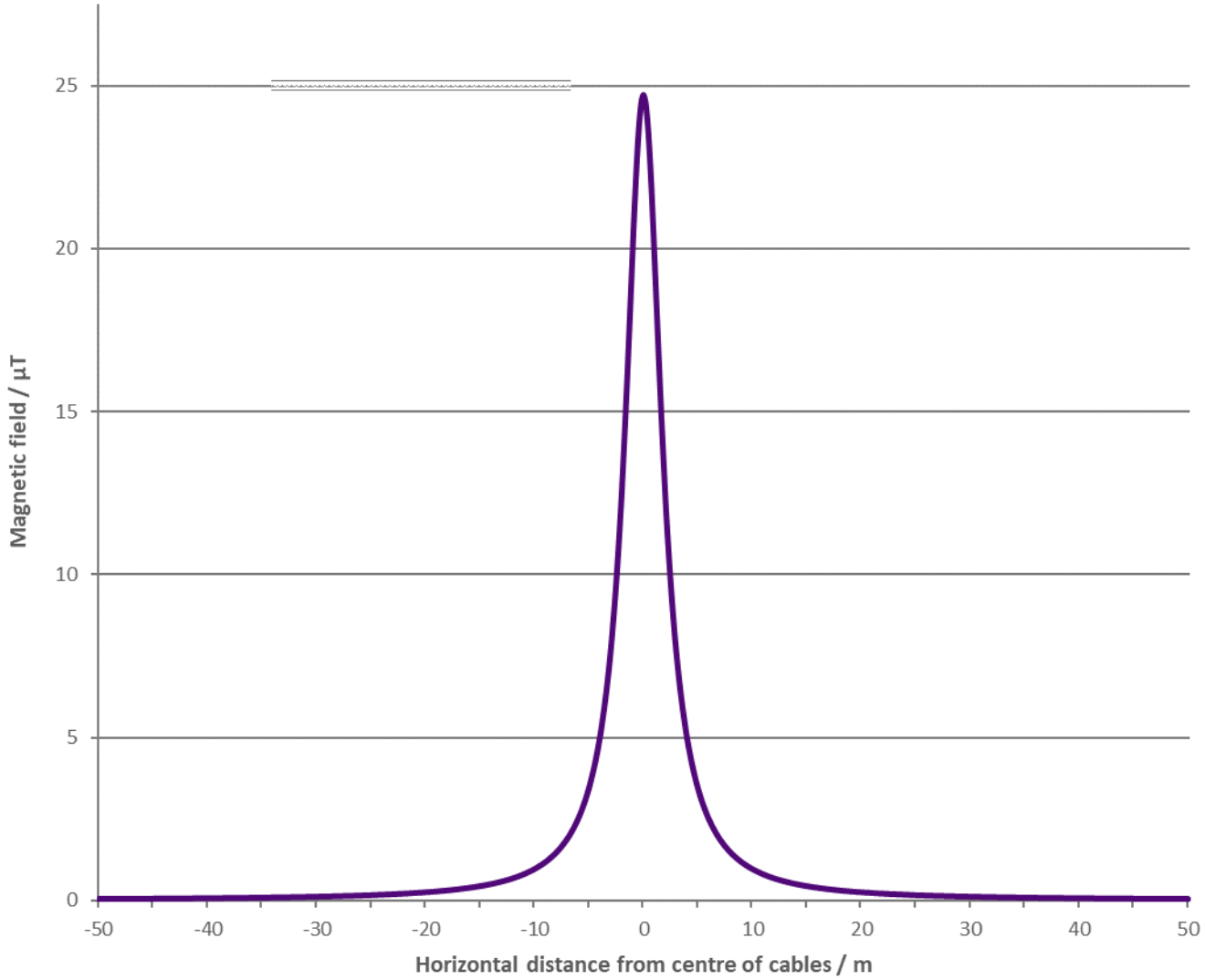


Magnetic fields – 275kV underground cable southwest of Tadcaster

6.3.4 The short section of 275kV underground cable would be installed 3km southwest of Tadcaster to manage power flows on the existing XC route. The 275kV cables will be one circuit, consisting of three cables (one cable per phase) arranged in a flat formation. The separation distance of the individual conductors would be 200mm, with a minimum burial depth of 1.0m. The maximum rating of these cables are 685MVA.

6.3.5 **Figure 6.4** below presents the maximum magnetic fields for the design of the 275kV underground cable southwest of Tadcaster, calculated for the rating of the cables and representing the maximum field capable of being produced.

Figure 6.4: Maximum magnetic fields from proposed 275kV underground cables



Magnetic fields – crossing of overhead line and cable circuits

6.3.6 In Section B: Northwest of York Area, the new 400kV overhead line would connect to the existing YR line via a small section of cable that runs underneath the existing YR overhead line and connects to the northern most circuit via a CSEC (see **Figure 3.2, Volume 5, Document 5.4.3**). The magnetic fields from the proposed 400kV cables and overhead line have been assessed above. Where the overhead and underground circuits cross, the field at that point would be a combination of the fields from the two sources separately. The maximum magnetic field from the proposed 400kV overhead lines was calculated as 41.9µT and 14.8µT from the 400kV underground cables. The worst case would be if these two fields simply added together, in which case the resultant would be 56.7µT. However, because of the way magnetic fields add vectorially, as explained in **Section 4.4**, a more realistic resultant field would be 44.4 µT.

6.3.7 The same would apply to the 275kV cable and overhead line crossing. The maximum magnetic field from the proposed 275kV overhead lines was calculated as 68.7µT and

24.7µT from the 275kV underground cable. The worst case would be if these two fields simply added together, in which case the resultant would be 93.4µT, however a more realistic resultant field would be 73.0µT.

Compliance of underground cables with exposure limits

6.3.8 The maximum magnetic fields from the underground cables and cumulative impacts with the overhead lines are summarised in **Table 6.1**.

Table 6.1: Summary of calculated fields from proposed underground cables and cumulative impacts

	Maximum magnetic field from cables	Cumulative maximum magnetic field from cables and overhead lines
400kV underground cables	41.9 µT*	56.7 µT*
275kV underground cables	68.7 µT*	93.4 µT*

*the public exposure limit for magnetic fields is 360.0µT

6.3.9 The maximum magnetic fields, calculated according to the Code of Practice on Compliance, are 93.4µT directly under the 275kV overhead line where the cables cross directly underneath. The magnetic fields where the 400kV cables and overhead line cross are lower and a maximum of 56.7µT. Both of these occur only over a limited area and are likely an overestimate of the worst-case exposures. All these are less than the exposure limit for the general public of 360µT, confirming that the underground cables would be compliant with the exposure limits.

6.4 Operational Effects – Overton and Monk Fryston substations and cable sealing end compounds

6.4.1 Paragraph 4.3.10 of this report sets out and explains the types of equipment that are inherently compliant with the ICNIRP exposure guidelines[9].

6.4.2 Substations at any voltage without reactive equipment and cable sealing end compounds (CSECs) are deemed compliant with the exposure limits. In practical terms, this means that even substations and CSECs operating at the highest operating voltages and currents are not capable of producing electric and magnetic fields in excess of 9kV/m and 360µT, because of their design. Most equipment contained within substations produce very localised EMFs which reduce extremely quickly with distance, so at the perimeter fence the levels are low. Air-cored reactors are a particular type of equipment which is capable of exceeding the EMF exposure limits at the substation boundary, which is why these required further assessment. This equipment is not being installed at the proposed substations. Evidence for the demonstration of compliance with exposure guidelines is maintained at [redacted]

6.4.3 The assessment of compliance states:

“Substations not containing air-cored reactors

Fields from substations are usually measured rather than calculated. Calculations are not usually feasible because of the complex geometry of the current paths within a substation.

The electricity industry has performed extensive measurements round existing substations at all voltages from the highest - 400 kV - to the lowest - 11 kV. Fields fall with distance, so the highest fields are found at the closest approach, at the perimeter fence or wall. Based on these measurements:

…

Smaller, lower-voltage substations: indoors

Modern designs of substation are such that, even when placed indoors, the largest fields are produced by the cables entering and leaving them.”

6.4.4 As described above, the dominant EMFs produced by a substation, outside its boundary fence, are from the overhead lines entering and exiting the site, rather than the substation equipment itself. This is the same for CSEC, where the dominant sources are the overhead line and cable entering and exiting the compound.

6.4.5 The dominate source of EMFs entering and exiting the substations and CSEC have been assessed as compliant with the requirement sin NPS EN-5.

6.4.6 Therefore, both Overton and Monk Fryston substations, and the four proposed CSECs (two at Shipton and two at Tadcaster) proposed are inherently compliant with the public exposure limits.

6.5 Decommissioning Effects

6.5.1 When the equipment is de-energised and decommissioned, at the end of its life, no EMFs would be produced. Therefore, this is not considered further.

7. Conclusions

7.1.1 UK 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 to high voltage power lines. This policy is incorporated in NPS EN-5 [3].

7.1.2 The Project would be fully compliant with the UK Government policies on EMFs. Specifically, all the EMFs produced as a result of the Project would be below the relevant exposure limits, and the proposed overhead lines would comply with the policy on optimum phasing. If these requirements are met NPS EN-5 states that “EMF effects are minimal” and there would be no significant EMF effects resulting from the Project. This report demonstrates compliance with these requirements and as a result no further measures are necessary to mitigate any significant effects of EMFs.

8. Abbreviations and Glossary

Table 8.1 – List of Abbreviations

Abbreviations	Full Term
AC	Alternating Current
AIMDs	Active Implantable Medical Devices
AGNIR	Advisory Group on Non-Ionising Radiation
BS	British Standard
CCC	Climate Change Committee
CEMFWR	Control of Electromagnetic Fields at Work Regulations
CSEC	Cable Sealing End Compound
DECC	Department of Energy and Climate Change
EC	European Commission
EEG	Electroencephalogram
EIA	Environmental Impact Assessment
ELF	Extremely Low Frequency
EMC	Electromagnetic Compatibility
EMFs	Electric and Magnetic Fields
EN-1	Overarching National Policy Statement for Energy
EN-5	National Policy Statement for Electricity Networks Infrastructure
ES	Environmental Statement
EU	European Union
HPA	Health Protection Agency (Centre for Radiation)
Hz	Hertz
IARC	International Agency for Research on Cancer
ICDs	Implanted Cardiac Defibrillators
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IPC	Infrastructure Planning Commission (replaced by the Planning Inspectorate)

kV	Kilovolt
kV/m	kilovolts per metre
m	metre/million
MHRA	Medicines and Healthcare products Regulatory Agency
MF	Magnetic Field
MVA	Mega Volt Ampere. This is a Standard Unit of Power and is used to describe physical capabilities of electrical equipment
NPS	National Policy Statement
NRPB	National Radiological Protection Board
PHE	Public Health England
PINS	Planning Inspectorate
RF	Radio Frequency
RMS	Root Mean Square
SAGE	Stakeholder Advisory Group on ELF EMFs
SCENIHR	Scientific Committee on Emerging and Newly Identified Health Risks
SGT	Super Grid Transformer
SQSS	Security and Quality of Supply Standard
TCF	Technical Construction File
TV	Television
UK	United Kingdom
UKHSE	United Kingdom Heath Security Agency
WHO	World Health Organisation

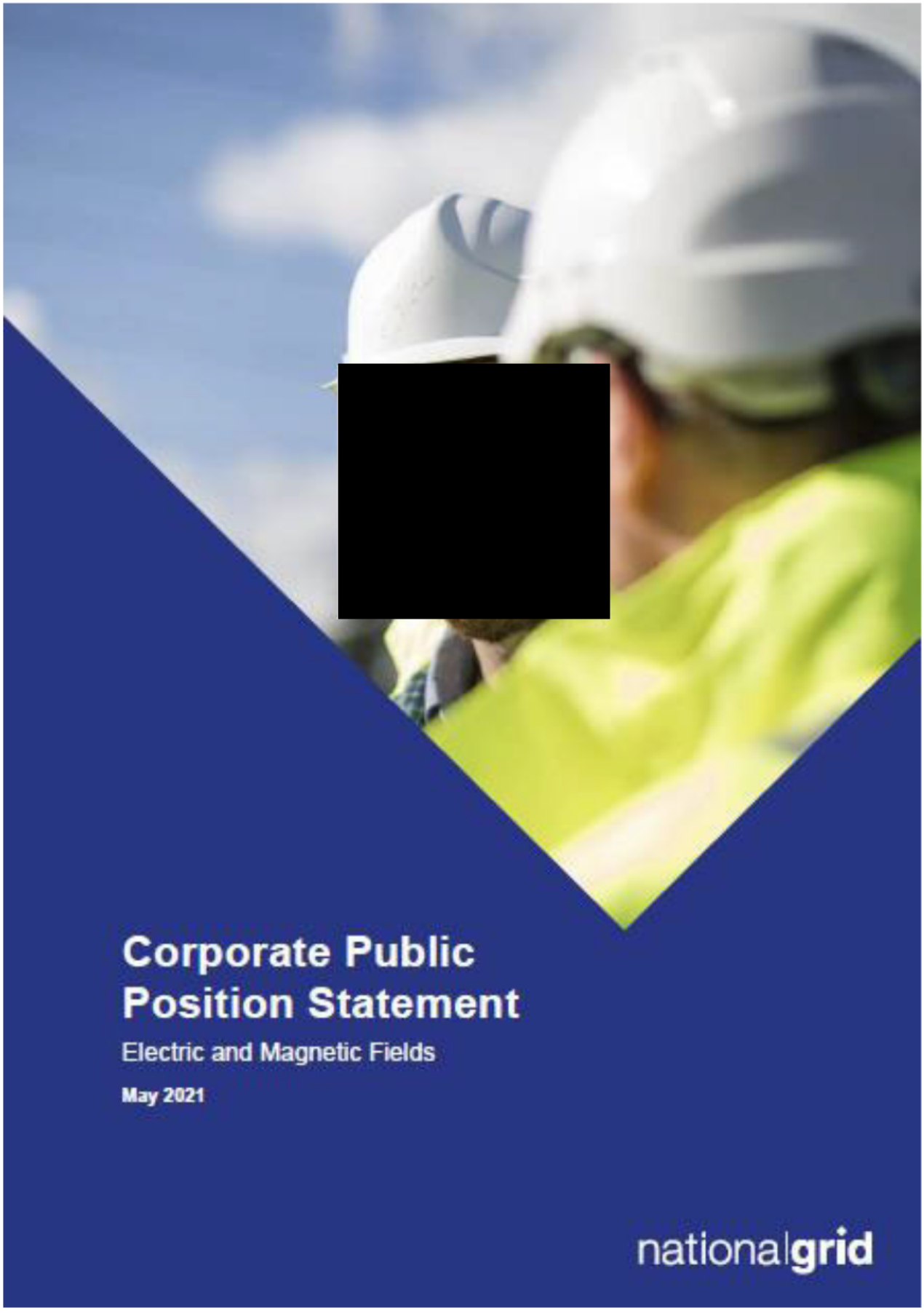
Table 8.2 – Glossary

Term	Definition
2TW/YR 400kV overhead line	Existing 400kV overhead line running between Norton Substation and Osbaldwick Substation.
Baseline	The situation prevailing before the Project is commenced (the current baseline), and also to the situation that would projected in the future without the Project (the projected future baseline).
Cable Sealing End Compound (CSEC)	Electrical infrastructure used as the transition point between overhead lines and underground cables. A compound on the ground acts as the principal transition point.
Circuit	A set of wires along which current flows and returns. It is necessary to have a complete circuit for current to flow. In AC transmission circuits, each consists of three phases.
Corona Discharge	Is an electrical discharge caused by the ionization of a fluid, such as air surrounding a conductor carrying a high voltage. It represents a local region where the air has undergone electrical breakdown and become conductive, allowing charge to continuously leak off the conductor into the air.
Conductor	A material that allows electricity to flow through it. This are the wires or cables that for overhead lines and underground cables.
Current	The flow of electricity. A voltage will always try to drive a current. The size current that is driven depends on the resistance of the circuit
Development Consent Order (DCO)	The consents for a Nationally Significant Infrastructure Project required under the Planning Act 2008.
Direct effects	Direct effects are those that result directly from the Project.
Extremely Low Frequency	Defined as the range of frequencies from 30 to 300 Hz and therefore including the power frequencies of 50 or 60 Hz.
Electricity transmission system	The electricity transmission system is made up largely of 400kV, 275kV and 132kV assets connecting separately owned generators and interconnectors with the demand for electricity fed directly from the transmission system, and distribution systems. The ‘transmission’ classification applies to assets at 132kV or above in Scotland or offshore. In England and Wales, it relates to assets at 275kV and above. The electricity transmission system is designed to make sure there is sufficient transmission capacity to ensure that the system can be operated in an economic and efficient way by the ESO, ensuring power can be moved from where it is generated to demand centres across Britain. This planning and development of the electricity transmission system is governed by the Security and Quality of Supply Standard

	(SQSS) which ensure that the network is developed and operated securely and is resilient to any foreseeable network faults and disruption.
Electric and magnetic fields (EMF)	Electric fields are created by differences in voltage: the higher the voltage, the stronger the resultant field. Magnetic fields are created when electric current flows: the greater the current, the stronger the magnetic field. An electric field will exist even when there is no current flowing. If current does flow, the strength of the magnetic field will vary with power consumption but the electric field strength will be constant.
Environmental Impact Assessment (EIA)	An EIA is a tool for systematically examining and assessing the impacts and effects of a development on the environment. The objective of the EIA is to identify any likely significant effects which may arise from the Project on the environment and identify measures to prevent, reduce or offset any adverse effects.
Environmental Statement (ES)	The outcome of the EIA process is reported within a document called an ES.
Impacts	For the purposes of the EIA and this Environmental Statement the term ‘impacts’ is used to describe the changes that arise as a result of the Project (e.g. changes in drainage pattern because of the hole in the ground).
Kilovolts (kV)	Kilovolt (kV) is equal to 1,000 volts.
Microshock	Small discharges sometimes experienced when touching a metal object in an electric field, similar to touching a filing cabinet or doorknob after walking across a nylon carpet
Microtesla	1/1,000,000 of a tesla. A unit of magnetic field more commonly used than the tesla because it is more convenient. Symbol µT
Nominal Voltage	A value assigned to a circuit or system to designate its voltage class conveniently e.g., 400kV, 275kV, rather than its operating voltage
Numerical Dosimetry	Calculation and assessment of the induced current by the human body. Computerized models of the human body, including the varying tissue cconductivities are used to calculated the induced current inside the body when exposures to external EMFs.
Optimum Phasing	A design feature of double-circuit overhead lines that reduces the electric and magnetic fields at perpendicular distances from the ooverhead line.
Overhead line	Conductor (wire) carrying electric current, strung from pylon to pylon.
Phasing	The way in which the two circuits of a power line are wired relative to each other, which affects the magnetic field produced
Pylon	Overhead line structure used to carry overhead electrical conductors, insulators and fittings.

Reconductoring	The replacement of old conductors (wires), insulators, earthwires, etc on an existing overhead line and may also require pylon steelwork and foundations to be strengthened or replaced.
Root Mean Square	A measure used for AC quantities which allows them to be expressed as a single number. For practical purposes in the electricity industry, it is just a constant fraction of the amplitude: rms = 0.71 x amplitude, amplitude = 1.41 x rms. (The factor 1.41 is the square root of 2.) Rms is used because an alternating current usually has the same effect as a direct current when its rms values is the same as the direct current.
Scoping Opinion	A Scoping Opinion is requested from the Planning Inspectorate on behalf of the SoS, to inform the requirements of EIA process and ultimately the ES which will be submitted as part of the application for development consent. Through the scoping process the views of the statutory consultees and other relevant organisations on the proposed scope of the EIA are sought.
Security and Quality of Supply Standard (SQSS)	The SQSS sets out a coordinated set of criteria and methodologies that the Transmission Licences shall use in the planning and operation of the national electricity transmission system.
Substation	Electrical equipment in an electric power system through which electrical energy is passed for transmission, transformation, distribution or switching.
Underground Cable	An insulated conductor carrying electric current designed for underground installation.
XC/XCP 275kV overhead line	Existing 275kV overhead line running between Monk Fryston and Poppleton.
XD/PHG 275kV Tadcaster Tee to Knaresborough overhead line	Existing 275kV overhead line running between Tadcaster Tee and Knaresborough.
Yorkshire Green Energy Enablement (GREEN) Project (the Project)	The Project is required to reinforce the north to south boundary flow by 2027 enabling National Grid to meet future system demands which include several Green Energy customer connections such as Eastern Link (wind/hydro), Continental Interconnector (wind) and Hornsea P4 Windfarm (wind) and the Atlantic Super Connection (interconnector).

Appendix A: National Grid's Public Position Statement on Electric and Magnetic Fields



Contents

Electric and Magnetic Fields

Objective

Electric and Magnetic Fields (EMFs) can be generated from a wide variety of sources, including distribution and transmission power lines and wireless infrastructure. National Grid recognises that there is scientific debate about whether certain adverse health effects may be linked to EMFs. As a consequence, there is public concern around the subject.

We take the responsible management of EMFs very seriously. This public position statement sets the framework within which National Grid will manage EMFs. We will:

- Continually assess the scientific evidence in this area;
- Determine any implications for the way in which we conduct our business; and
- Explain to society what the science is telling us.

The President of Electricity Transmission is responsible for ensuring that this public position statement reflects and is compliant with current legislation and is kept up to date with new or changing legislation.

Scope

This public position statement applies to National Grid and its Subsidiary Companies. For Associate Companies, National Grid will seek to promote the adoption of statements and practices consistent with those set out in this document.

This statement covers:

- EMFs that arise from transmission and distribution power lines and associated equipment; and
- Radio-frequency EMFs that arise from wireless infrastructure, including from third-party assets.

Framework

Electric and Magnetic Fields can arise from many sources including household appliances, electrical distribution and transmission facilities and equipment, mobile telephones, and radio-transmission devices. Research is ongoing to improve our understanding of the effects of EMFs. The balance of evidence remains against both power-frequency and radio-frequency EMFs causing ill health. However, National Grid recognises that the World Health Organization has classified power-frequency EMFs as "possibly" carcinogenic. This scientific position is reflected in the views of the regulatory bodies in the countries in which we operate.

We also recognise that scientific developments on EMFs do not depend on international boundaries. This public position statement establishes the common threads applicable across all our operations.

This public position statement has seven central principles:

1. We recognise that the societies in which we operate hold a variety of views on EMFs. In view of the scientific position and the fact that EMFs are of concern to some, we take the matter very seriously.
2. In all our operations, as a minimum, we comply with legal requirements, including relevant EMF regulations. We also aim to follow industry guidelines or best practice in the countries and different jurisdictions in which we operate. Where other companies (such as telecommunications operators) use our assets, we require them to do the same.
3. We support the view of regulators and governments that the EMF issue warrants consideration for a precautionary approach. We look to them to decide on any measures that may be necessary, as they can evaluate the science and weigh-up costs and benefits on behalf of society as a whole.
4. To mitigate the amenity impact of new overhead transmission lines, we always endeavour to route them:
   - along formal Rights of Way in countries where they exist; or
   - away from existing buildings where they do not.

   In order to ensure safety clearances and to help us maintain our network, we do not encourage housing development immediately beneath our lines. We will work with planning bodies to promote the sustainable use of land under our lines. These steps will usually result in EMF exposures being lower than would otherwise be the case.
5. We recognise that scientific understanding of any effects of EMFs is improving. We review all relevant scientific developments in this area from across the world and assess any implications for the way in which we operate.
6. We support high-quality research into EMFs and make the results available for scientific review.
7. We communicate in an open manner with those who have an interest in EMF matters, and make available information that will help society's understanding of EMFs. We will participate openly and constructively in debate on precautionary approaches appropriate to the EMF issue.

In support of this public position statement, each Subsidiary Company will ensure that:

- A plan is put in place to ensure all relevant elements of this public position statement are implemented.
- All regulatory and legal requirements are met for both new and existing lines and infrastructure.
- All legal non-compliances or suspected non-compliances are investigated, and if appropriate. prompt corrective actions taken. Associate Companies will be encouraged to put similar arrangements in place.

Related Corporate Policies and Other Documents

- Framework for Responsible Business.
- Environment policy.
- Safety and Occupational Health policy.
- Terms of Reference of the Safety, Environment and Health Committee.

Key Contacts

This public position statement is written and maintained by the President of Electricity Transmission, to whom questions regarding its content and application should be addressed.

The lead expert for this public position statement and the first point of contact is Dr Hayley Tripp, EMF Specialist, Electricity Transmission.

Monitoring and Compliance

The President of Electricity Transmission is responsible for ensuring that this public position statement is effectively communicated throughout its lifecycle.

The President of Electricity Transmission will ensure that compliance with this public position statement is reviewed periodically. Any changes needed to ensure its effectiveness will be drawn to the attention of the Board's Safety, Environment and Health Committee and to the Board itself.

Each Subsidiary Company will ensure that it has the necessary arrangements in place to monitor and report compliance against this public position statement periodically. Each Associate Company will be encouraged to put in place similar arrangements to enable compliance to be reported periodically.

In line with good corporate governance practices, we will review this public position statement periodically.

The Corporate Environmental Audit Programme will be used from time-to-time to determine the level of compliance with all, or aspects of, this public position statement.

Definitions

Associate Company: A company whose equity share capital is 20% or more, but not more than 50%, beneficially owned by a National Grid company or companies.

Subsidiary Company: A company that is a subsidiary of National Grid provided that a National Grid company holds or controls a majority of the voting rights in it or the right to appoint or remove a majority of its directors.

Review Cycle

This Public Position Statement came into effect in 2003.

It was last reviewed in April 2021.

The next review will take place no later than April 2023.

National Grid plc
National Grid House,
Warwick Technology Park,
Gallows Hill, Warwick.
CV34 6DA United Kingdom
Registered in England and Wales
No. 4031152

nationalgrid

Appendix B: Certificate of Conformity of National Grid Transmission System with EMC requirements

Technical Certificate 05R110 issued by
Hursley EMC Services Ltd

Appointed by the Secretary of State for Trade and Industry as a UK EMC Competent Body

HURSLEY EMC SERVICES

TECHNICAL CERTIFICATE

PRODUCT TITLE: NGT Electricity Transmission Network

MANUFACTURED BY: National Grid Transco (NGT) plc
Manufacturers Address: NGT House, Warwick Technology Park, Gallows Hill, Warwick CV34 6DA UK

Applicants Name: Mr Jon Carlton, of NGT plc.

Product Description: The NGT Electricity Transmission Network (consisting of some 14,000 Km of high voltage supply lines) is the high voltage electricity transmission system in England and Wales.

Technical Statement: The Technical Construction File (TCF), "NGT Electricity Transmission Network" (dated 2005), describes the general construction, conformity procedures and EMC test rationale for the Electricity Network. This Technical Construction File, in so far as is technically viable, is based on testing to international standards, specifically EN50121-2:2000 and CISPR 18 for emissions. These standards were used as the most suitable guide for the emissions testing in lieu of any other practical or harmonized product related standards. Given the size of the equipment, testing was performed in-situ at several representative sites and is therefore an approximation to the standards. The results of the tests applied and described in the test reports along with the EMC detail supplied in the TCF indicate that the product complies with the standards.
Taking into consideration the technical rationale provided in the TCF and the results of the site measurement reports, Hursley EMC Services is satisfied the TCF does demonstrate compliance with the essential protection requirement of EC Directive 89/336. NGT operates a certified ISO 9001 quality management system covering both the operation and installation procedures for the Electricity Network. Due to its size and nature along with quality procedures used for installations the NGT Electricity Transmission Network would seem inherently immune to normal EMC phenomena.
This route to compliance with respect to the provisions of EC Directive 89/336 is in accordance with section 42(c) of the UK Statutory Instrument 1992 No 2372 (The Electromagnetic Compatibility Regulations). This application and certificate applies only to the NGT Electricity Transmission Network for the UK as described in the Technical Construction File.

COMPETENT BODY CONFORMITY STATEMENT

Hursley EMC Services Ltd. certifies that the National Grid Transco plc TCF demonstrates that the NGT Electricity Transmission Network conforms to the protection requirements of European Council Directive 89/336 and its amendments. This directive is on the approximation laws of the Member States relating to electromagnetic compatibility.

Signed: [redacted] **Approved:** [redacted]

Rob St John James
EMC Technical Manager

Ian Kenney
EMC Quality Manager

Hursley EMC Services Ltd
Unit 16, Brickfield Lane, Eastleigh
Hampshire, SO53 4DP, UK

[redacted]

Issue Date: 17th March 2005

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