

**Erskine to Devol Moor Project
Electric and Magnetic Fields Report
EIA Report Appendix 2.1**

National Grid
National Grid House
Warwick Technology Park
Gallows Hill
Warwick
CV34 6DA

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1 INTRODUCTION

1.1 The Applicant and an Overview of the Erskine to Devol Moor Project

- 1.1.1 Scottish Power Energy Networks (SPEN), owns and operates the high voltage electricity transmission system in central and southern Scotland.
- 1.1.2 The Erskine to Devol Moor Project ('the EDM Project') involves the construction of a new 17km 132kV single circuit wood pole (Trident) overhead line (OHL) between the existing Erskine and Devol Moor substations (referred to as 'the new OHL').
- 1.1.3 The EDM Project also involves removal of the existing 16.5km 132kV double circuit steel tower OHL (referred to as 'the existing OHL') between the existing Erskine and Devol Moor substations, following the commissioning of the new OHL.

1.2 Purpose of this Report

- 1.2.1 This report provides an assessment of the likely significant health and environmental effects of electric and magnetic fields (EMFs) associated with the operation of the new OHL, as described above. During construction and prior to energisation, the new OHL would not produce any discernible EMFs. Therefore, construction effects are not considered.

1.3 Introduction to EMFs

- 1.3.1 EMFs 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 EMFs 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 occurring EMF patterns. Energised high voltage power-transmission equipment, along with all other uses of electricity, is a source of EMFs. 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.
- 1.3.3 The Electric fields generated by powerlines are dependent on the voltage they operate at and are measured in volts per metre, symbol 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.
- 1.3.4 Magnetic fields are measured in microteslas, symbol 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.

- 1.3.5 EMFs at 50Hz can cause induced currents to occur in the body, which, if high enough, can interfere with nerves. There are Government-adopted exposure guidelines (discussed in Section 2 below), which are set to protect against these known "direct" effects of EMF exposure. 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 (discussed in paragraphs 2.10.1 to 2.11.1 below). The potential effect of both direct and indirect effects has been assessed using the guidance provided in the codes of practice (discussed in Section 2 below).

- 1.3.6 EMFs at much higher frequencies than those generated by the electricity transmission system can be generated by other devices, e.g. radio and 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 this distinction. Overhead lines produce EMFs at much lower frequencies than televisions, microwaves and other common electrical devices and are sometimes referred to as "non-ionising" radiation.

2 POLICY AND LEGISLATION

2.1 Overview of policy

- 2.1.1 In the absence of any specific Scottish Government guidelines, those set by the UK Government remain applicable for the new OHL.
- 2.1.2 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. Government has a clear policy, restated in October 2009 and incorporated in NPS EN-5 (Ref.1), on the exposure limits and other policies they expect to see applied. Practical details of how the policy is to be implemented are contained in a Code of Practice on Compliance (Ref.2) agreed between industry and Government.
- 2.1.3 The UK Government in turn acts on the scientific advice from Public Health England (PHE), which has responsibility for advising on non-ionising radiation protection, including power-frequency EMFs. PHE exercise radiological protection functions across the whole of the UK, including Scotland. 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. This report refers to PHE, NRPB or HPA according to the name of the organisation at the time each statement was issued.
- 2.1.4 In 2004, following a recommendation by the NRPB, the UK Government adopted exposure guidelines for the public published in 1998 by the International Commission on

¹ Department of Energy and Climate Change. National Policy Statement for Electricity Network Infrastructure (EN-5). London: The Stationary Office, 2011.

² Department of Energy and Climate Change. Power Lines: Demonstrating compliance with EMF public exposure guidelines. A voluntary Code of Practice. London, 2012.

Non-Ionizing Radiation Protection (ICNIRP) (Ref.3) in line with the terms of the 1999 European Union (EU) Recommendation (Ref.4) on public exposure to EMFs. In a Written Ministerial Statement in October 2009 (Ref.5); (references to the Written Ministerial Statement encompass both the Statement itself and the detailed Response that the Statement introduced) the Government restated this policy of compliance with exposure limits and, acting on the recommendations of a stakeholder process, added a single precautionary measure in relation to high voltage infrastructure; 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 5.1. The Government also made clear in the Written Ministerial Statement that no other precautionary measures are appropriate for high voltage infrastructure.

2.1.5 These two policies, compliance with exposure limits plus optimum phasing, are the only ones applying to high voltage infrastructure. NPS EN-1 (Ref.6) does not contain any provisions specific to EMFs. NPS EN-5 (Ref.1) documents these policies and they are explained fully below.

2.2 UK Government - National Policy Statement EN-5

As summarised above, the UK Government has set out clear policies on control of EMF exposures in general. NPS EN-5 (Ref.1) gives clear guidance on the EMF requirements of all electricity infrastructure projects. The relevant paragraphs are summarised in

Table 1: Summary of NPS EN-5 Requirements Relevant to EMF

Paragraph	Requirement	Section of this Report	Compliance Assessment
2.10.9	Before granting consent to an overhead line application, the determining body, 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 (Ref.2), 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.	5.2.12	The new OHL has been designed and assessed in line with this Code of Practice. All of the EMFs produced would comply with the Government adopted ICNIRP 1998 guidelines (Ref.3), as demonstrated in this report.

2.2.1 **Table 1**, with a reference to where they are covered in this Report, and a summary of the conclusion.

³ 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.

⁴ European Union 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.

⁵ 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

⁶ Department of Energy and Climate Change. Overarching policy statement for electricity (EN-1). London: The Stationary Office, 2011.

Paragraph	Requirement	Section of this Report	Compliance Assessment
2.10.10	Before granting consent to an overhead line application, the IPC should satisfy itself that the proposal is in accordance with the International Commission on Non-Ionizing Radiation Protection (ICNIRP) (1998) guidelines.	5.2.12	The new OHL is demonstrated in this report to comply with the Government adopted ICNIRP 1998 guidelines.
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 (Ref.7) 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.	5.2.11	The new OHL has 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.
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 determining authority can refer.	2.2 at Figure 1	This decision tree has been replicated at Figure 1 and forms the basis for the assessment of EMFs from the new OHL component of the EDM Project.

Paragraph	Requirement	Section of this Report	Compliance Assessment
2.10.15	The applicant should have considered the following factors:	2.12 and 5.2.3	The proposed new OHL has been designed to comply with the statutory requirements of the Electricity Safety, Quality and Continuity Regulations 2002. 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 in this report demonstrates this compliance.
	- Height, position, insulation and protection (electrical or mechanical as appropriate) measures subject to ensuring compliance with the Electricity Safety, Quality and Continuity Regulations 2002.		
	- 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.	5.2.11	The new OHL 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 the policy and legislation section of the current report, section 2, 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.

⁷ Department of Energy and Climate Change. Optimum Phasing of high voltage double-circuit Power Lines. A voluntary Code of Practice. London, 2012.

Paragraph	Requirement	Section of this Report	Compliance Assessment
	- Where it can be shown that the lines will comply with the current public exposure guidelines and the policy on phasing, no further mitigation should be necessary.	5	This report shows that the new OHL 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, the UK Government has set out clear policies on control of EMF exposures in general. NPS EN-5 (Ref.1) gives clear guidance on the EMF requirements of all electricity infrastructure projects.

2.2.3 A simplified route map for dealing with EMFs is provided in NPS EN-5 and is reproduced in **Figure 1 : Simplified Route Map for Dealing with EMFs)Figure 1.**

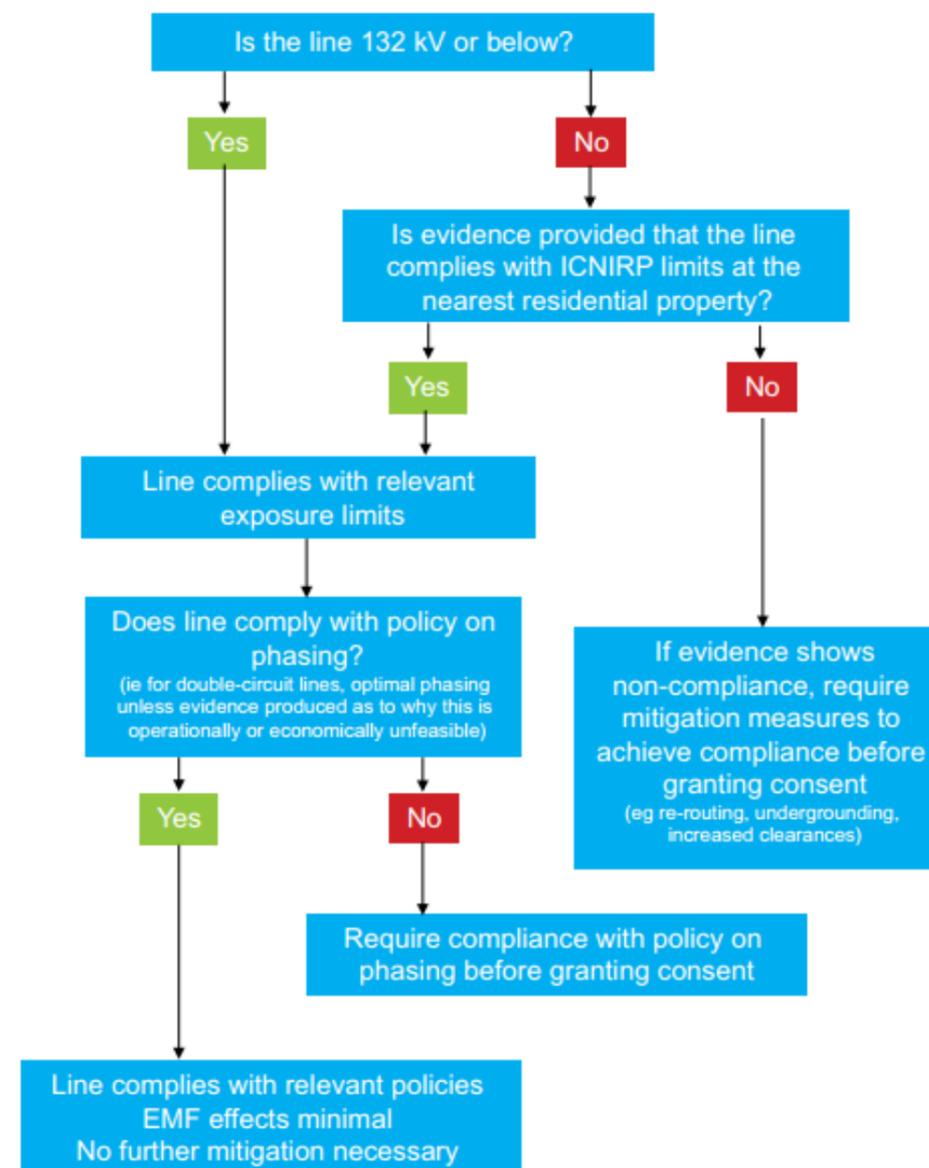


Figure 1 : Simplified Route Map for Dealing with EMFs

2.2.4 All relevant legislation, policies and guidance, including those contained within NPS EN-1 (Ref. 6) and EN-5 (Ref. 1) have been reviewed and applied to the EMF assessment of the new OHL. These policies, guidance and legislation are explained and documented below including, for openness and transparency, a commentary of the science on which these have been based.

2.3 Public Exposure Limits

2.3.1 In March 2004, the NRPB provided new advice to Government, replacing previous advice from 1993, and recommending the adoption in the UK of guidelines published in 1998 by the ICNIRP (Ref. 3). The Government subsequently adopted this recommendation, saying that limits for public exposures should be applied in the terms of the 1999 EU

Recommendation (Ref. 4). This Government policy was subsequently set out more formally in the Written Ministerial Statement (Ref. 5)

Table 2: Exposure Limits for Power Frequency EMFs

Public Exposure Levels	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

2.3.2 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 fields was sufficient to justify setting exposure limits, and this is the basis of their quantitative recommendations. 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 actions. Precautionary measures are considered in more detail below.

2.3.3 The EMF guidelines are documented in NPS EN-5 (Ref. 1) and practical details of their application are given in the Code of Practice ‘Power Lines: Demonstrating compliance with EMF public exposure guidelines – a voluntary Code of Practice’ (Ref. 2) published by the 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.

2.3.4 The ICNIRP guidelines (Ref. 3) 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 and this 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/m² within the human central nervous system, as shown in **Table 2**. This value of the induced current density is described as the “basic restriction”. The 1999 EU Recommendation (Ref. 4) uses the same basic restriction value as ICNIRP (Ref. 3).

2.3.5 However, the basic restriction cannot be assessed directly, since *in-vivo* measurements of current density are not practicable. Instead, the external fields that have to be applied

to the body to produce this current density are calculated by numerical dosimetry. Those calculations are normally performed for uniform fields, because this is the most onerous exposure condition; non-uniform fields produce lower induced currents.

2.3.6 Therefore, the ICNIRP guidelines also contain values of the external fields called “reference levels”. For the public, the reference level for electric fields is 5 kV/m, and the reference level for magnetic fields is 100 µT. The 1999 EU Recommendation (Ref.3) uses the same reference level values as ICNIRP (Ref.3).

2.3.7 In the ICNIRP guidelines and the EU Recommendation, the actual limit 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.

2.3.8 The Code of Practice on Compliance (Ref.2) 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.”

2.3.9 The Code of Practice on Compliance (Ref. 2) also specifies the land uses where exposure is deemed to be potentially for a significant period of time and consequently where the public guidelines apply. These land uses are, broadly, residential uses and schools.

2.3.10 Therefore, if the EMFs produced by an item of equipment are lower than 9 kV/m and 360 µT, 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 (Ref.2), and it may also still be compliant if the fields are non-uniform.

2.4 Occupational Exposure Limits

2.4.1 Occupational exposures to EMFs in England, Wales and Scotland are controlled by the Control of Electromagnetic Fields at Work Regulations 2016 (Ref.8) (CEFW Regulations), which implement a 2013 EU Directive (Ref.9). For power frequencies,

⁸ Statutory Instrument, 2016 No. 588, Health and Safety, The Control of Electromagnetic Fields at Work Regulations 2016

⁹ 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

these are based on a more recent ICNIRP publication, ICNIRP 2010 rather than the ICNIRP 1998 (Ref.3) that is the basis for the public exposure limits.

- 2.4.2 The CEFW 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.
- 2.4.3 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 new OHL component of the EDM Project would be compliant with in all areas accessible to the public and to employees of third parties. Therefore, all exposures from the new OHL would be compliant with the occupational exposure limits and employers need take no additional action specific to the new OHL in order to comply (the CEFW Regulations impose certain general duties on all employers which would apply regardless of the project).

2.5 Potential Future Changes to Exposure Limits

- 2.5.1 As discussed, current Government policy for public exposure is based on the limits from the 1998 ICNIRP Guidelines (Ref.3), in the terms of the 1999 EU Recommendation (Ref.4). In 2010, ICNIRP published new exposure guidelines 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 (Ref. 2):
- “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)
- 2.5.2 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.

SPEN’s assessment is that the new OHL would in fact be compliant with those guidelines were they ever to be introduced.

- 2.5.3 More generally, if in the future there were other changes to the exposure limits or other policies in relation to EMFs, SPEN would have a duty to bring the whole transmission system, including the new OHL component of the EDM Project, into compliance with whatever new regime was introduced.

2.6 Scientific Evidence

- 2.6.1 As well as these established effects discussed in section 2.3, over the past 30 years it has been suggested that exposure to power-frequency magnetic or electric fields of the magnitude encountered in the environment 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 in the homes. However, no causal link has been established between cancer (or any other disease) and magnetic or electric fields and indeed there is no established mechanism by which these fields could cause or promote the disease.
- 2.6.2 The question of possible health effects of environmental power-frequency fields has been thoroughly reviewed in recent years by a number of national and international bodies. The principal such 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 World Health Organisation (WHO), and the relevant official scientific advisory committee for the EU; which is currently the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR).
- 2.6.3 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***
- 2.6.4 In 2004 the NRPB published new ‘Advice on Limiting Exposure to Electromagnetic Fields (0-300GHz)’ (Ref. 10) and accompanied it with a ‘Review of the Scientific Evidence for Limiting Exposure to Electromagnetic Fields (0-300GHz)’ (Ref.10). The former summarises epidemiological evidence as follows (page 15):

¹⁰ 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

- 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 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).*
- 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)

- 2.6.5 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 (Ref. 11). 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

- 2.6.6 The WHO published an Environmental Health Criteria Monograph in 2007 on ELF EMFs (Ref.12), produced by a Task Group that met in 2005. This concluded, in part:

"Chronic effects

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

- 2.6.7 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' (Ref. 13). 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

¹¹ 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.

¹² World Health Organisation, Environmental Health Criteria Monograph No 238 on Extremely Low Frequency Fields, 2007. (Online) Available from http://www.who.int/peh-emf/publications/elf_ehc/en/index.html

¹³ Scientific Committee on Emerging and Newly Identified Health Risks SCENIHR (2015), Potential Health Effects of Exposure to EMF, http://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf

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.

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

Conclusions from Reviews of Science

- 2.6.8 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 (Ref. 12) and reiterated in 2007 (Ref. 13), 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”.

2.7 Precautionary Policies

- 2.7.1 The UK Government has addressed the uncertainty in the scientific evidence by adopting specified precautionary measures relating to various sources of EMFs.
- 2.7.2 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 (Ref.5) in response to a recommendation from the Stakeholder Advisory Group on ELF EMFs (SAGE) in its First Interim Assessment (Ref.14). The details are given in a second Code of Practice, ‘Optimum Phasing of High Voltage Double-Circuit Power Lines’ (Ref. **Error! Bookmark not defined.**).
- 2.7.3 “Optimum phasing” is the phasing that produces the lowest magnetic fields to the sides of the 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 (Ref. **Error! Bookmark not defined.**) 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 (Ref. 14).

- 2.7.4 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.

- 2.7.5 Government have specifically rejected the introduction of “corridors” around power lines on EMF grounds, stating of this option in the Written Ministerial Statement (Ref. 5):

“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.”

- 2.7.6 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.”

- 2.7.7 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.

- 2.7.8 In relation to undergrounding, the NPS EN-5 (Ref.1) 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.”

- 2.7.9 Therefore, no additional measures or precautions are necessary or appropriate beyond the exposure limits and the policy on optimum phasing.

2.8 Pregnant Women and other Potentially Sensitive Subgroups

- 2.8.1 The scientific basis as given by the NRPB (now PHE) 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 population at large. One of those subgroups is pregnant women and the developing embryo (others include people with epilepsy or taking certain drugs).

- 2.8.2 Therefore, the potential extra sensitivity of pregnant women and those considered more susceptible is already built in to the public exposure limits. No additional protective measures are required.

¹⁴ Stakeholder Advisory Group on ELF EMF. SAGE First Interim Assessment. 2007. (Online) Available from <http://www.emfs.info/NR/rdonlyres/39CDF32F-4E2E-AD30-A2B0006B8ED5/0/SAGEfirstinterimassessment.pdf>

2.9 Active Implantable Medical Devices

- 2.9.1 EMFs 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.
- 2.9.2 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 (Ref. 4) where the AIMD has been implanted and programmed in a standard manner. The reference levels at 50Hz are 100 μ T for magnetic fields and 5 kV/m for electric fields. However, many AIMDs will have considerably higher immunity to external EMFs than the minimum requirements.
- 2.9.3 Specifically, the Active Implantable Medical Devices Directive (90/385/EEC) (Ref. 15) 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 ...”*
- 2.9.4 The Medicines and Healthcare Products Regulatory Agency (MHRA) are not aware of any instance of a patient with a modern, correctly fitted AIMD experiencing any interference from the electricity transmission system.
- 2.9.5 Thus, there is considerable confidence in saying that, based on the absence of reported incidents and on the calculated EMF exposures being below the public reference levels, overhead power lines do not appear to interfere with AIMDs in practice. The risk of any interference occurring is assessed as being negligible and does not constitute a significant effect.
- 2.9.6 This is confirmed in NPS EN-5 (Ref. 1), at **Section 2.10.7**, which states that:
- “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.”*

2.10 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 (Ref.16), HPA (now PHE) 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 (Ref. 2) 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/poles, 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 (Ref. 2) 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 DECC, has been adopted (Ref. 17). 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 9 kV/m is not exceeded, and in accordance with the Code of Practice on Microshocks, as demonstrated in Section 5.1 below. The calculated electric fields for all overhead line designs will be below 5 kV/m reducing significantly the risk of microshocks occurring. SPEN 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 (Ref. 17).

¹⁵ 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.

¹⁶ Health Protection Agency. Application of ICNIRP Exposure Guidelines for 50 Hz Power Frequency Fields. 2005. (Online) Available from: http://www.hpa.org.uk/web/HPAweb&HPAwebStandard/HPAweb_C/1195733805036

¹⁷ 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 Farming, Flora and Fauna

2.11.1 No effects of EMFs on farming, flora and fauna are expected; the NPS for Electricity Networks Infrastructure (EN-5) (Ref.1) 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 The Electricity Safety, Quality and Continuity Regulations 2002

2.12.1 NPS EN-5 (Ref.6, paragraph 2.10.10) refers to the Electricity Safety, Quality and Continuity Regulations 2002 which set out the minimum height, position, insulation and protection specifications at which conductors can be strung between pylons/poles to ensure safe clearance of objects. Regulation 17(2) and Schedule 2 require the clearances set out in **Table 3**.

Table 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

2.12.2 The minimum conductor clearance information for the new OHL component of the EDM Project is provided in section 5.1 which demonstrates compliance with these requirements.

2.13 Summary of Policy and Legislation

2.13.1 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; but no other policies.

2.13.2 NPS EN-5 (Ref.1) explicitly applies these policies to applications for consent for new electricity connections such as the EDM 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.

2.14 Effects on Magnetic Compasses

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

2.14.2 This is a potential issue with direct current (DC) conductors or cables, which produce a static magnetic field that perturbs the geomagnetic field. However, there are no DC conductors proposed for use in the new OHL component of the EDM Project and no DC fields could be produced.

2.14.3 The magnetic fields produced by the new OHL would be 50Hz fields. These oscillate too quickly for a magnetic compass needle to be affected. Fluxgate magnetometers are capable of responding to 50Hz fields, but, when used as a compass, always have filtering to eliminate unwanted frequencies including 50Hz. They can cease working correctly if saturated by a high-enough field, but the field required are orders of magnitude higher than would be produced by the new OHL.

2.14.4 Therefore, the new OHL component of the EDM Project would have no significant effect on magnetic compasses.

3 ASSESSMENT METHODOLOGY

3.1.1 The assessment considers the EMFs produced from the new OHL proposed as part of the EDM Project.

3.2 Study Area

3.2.1 The EMFs produced by the new OHL forming part of the EDM Project would have a given magnitude at a given distance from the line. Therefore, the Study Area of the assessment includes all areas around the new OHL where the EMFs could potentially be significant, such that the assessment looks at the overhead line design rather than the specific location. Therefore, any changes in alignment that could occur within the 50m Infrastructure Location Allowance (ILA) proposed for the new OHL would not alter the assessments presented here. This ensures that the equipment would be compliant with exposure guidelines irrespective of the Project’s operational location within the ILA.

3.3 Predicted Field Levels

3.3.1 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 closest 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.

3.3.2 For sources of field with a simple, defined geometry, such as overhead lines or underground cables, calculations are the best way of assessing the fields and Government have advised these are acceptably accurate (Ref. 2). The calculations of fields presented here follow the provisions specified in the Code of Practice on

Compliance (Ref. 2) and were performed using specialised computer software that has been validated against direct measurement (Ref. 18).

3.3.3 By contrast, due to the complex physical arrangement of electrical equipment, the EMFs produced by an electrical substation or sealing-end compound 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 equipment within the substation are generally smaller and decrease with distance more quickly than fields generated by overhead lines.

3.3.4 Since field strengths are constantly varying, they are usually described by reference to an averaging calculation known as the “root mean square” or RMS. Subsequent references to 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.

3.3.5 To assess compliance with exposure limits, the Code of Practice on Compliance (Ref. 2) specifies that the maximum fields the overhead line is capable of producing should be calculated using the following conditions:

- 1) **electric fields:** for nominal voltage and design minimum clearance;
- 2) **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
- 3) **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 steel tower or wood pole geometry for the design of overhead line in question, but ignoring variations in conductor spacing at angle towers/poles 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.

3.3.6 Therefore, the calculations for the new OHL were performed using worst-case conditions including minimum conductor clearances for the overhead line. The circuit is unlikely to operate at this maximum rating routinely, resulting in lower typical magnetic fields on a day to day basis.

3.3.7 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 (Ref. 2). 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 much reduced. However, the Code of Practice (Ref. 2) specifies that it is acceptable to demonstrate compliance by reference to the unperturbed fields.

3.3.8 As an alternative to calculations, the Code of Practice on Compliance (Ref. 2) 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)

3.3.9 The Energy Networks Association’s publicly available list can be found on the National Grid EMF website (<http://www.emfs.info/compliance/public/>). This confirms that substations that do not contain a static var compensator, such as Erskine and Devol Moor substations, are within the class of equipment which are regarded as inherently compliant without the need for case-by-case specific assessments.

3.4 Combining Fields from Different Sources

3.4.1 When more than one source of EMFs is 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.

3.4.2 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), the magnitudes of the 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.

3.5 Assessment of Effects

3.5.1 The new OHL which forms part of the EDM Project would be 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 (Ref. 2). Conversely, as specified in NPS EN-5 (Ref.1), if the EDM Project complies with the exposure limits and with the policies on phasing (Ref.**Error! Bookmark not defined.**) and microshocks (Ref. 17), EMF effects would be assessed as not significant and no mitigation would be necessary.

4 BASELINE ENVIRONMENT

4.1.1 The existing OHL forming party of the EDM Project is located within a mixture of primarily rural and semirural areas, which accommodate existing steel overhead lines and substations.

¹⁸ J. Swanson, Magnetic fields from transmission lines: Comparison of calculations and measurements, IEE Proceedings.-Generator Transmission Distribution, 1995, 142 (5), p481.

- 4.1.2 EMFs 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 50 μT 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 100 V/m in fine weather.
- 4.1.3 As detailed above, the Earth's natural fields are static, and the power system produces alternating fields at 50 Hz frequency. 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 – 0.2 μT with an average of approximately 0.05 μT , normally arising from currents in the low voltage distribution circuits that supply electricity to homes. There is an existing overhead line in the area, which is a steel double circuit construction with an operating voltage of 132 kV. This would contribute to the overall background fields, if existing properties are within 50 m. Typical magnetic fields from different types of 132 kV overhead line are demonstrated in Figure 2 (taken from <http://www.emfs.info/sources/overhead/specific/132-kv/>).

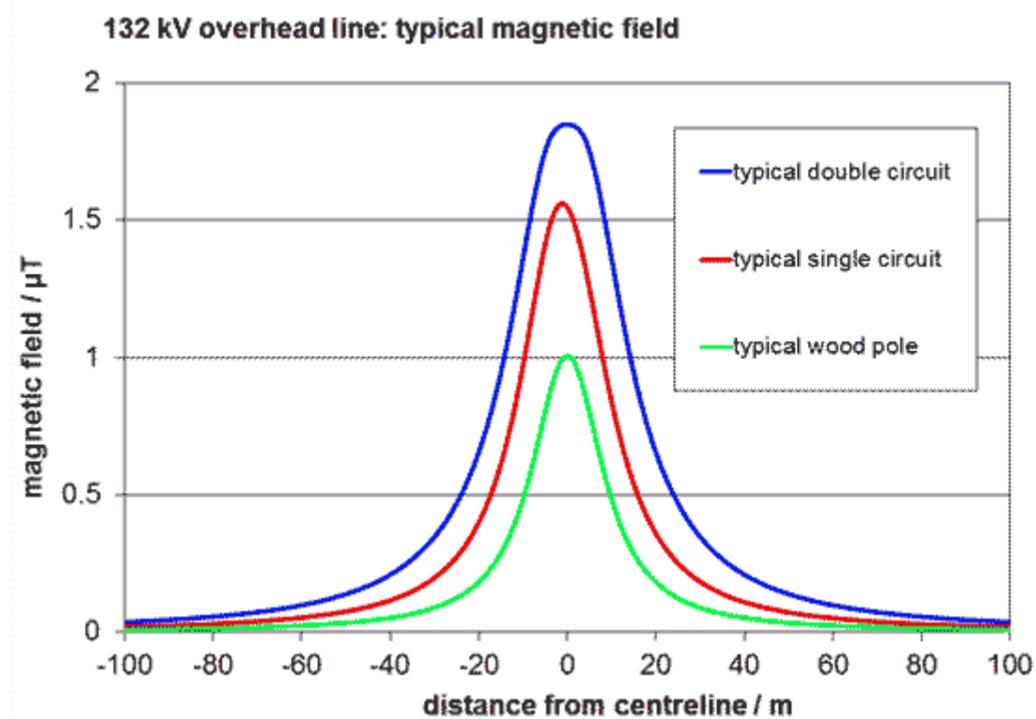


Figure 2: Typical magnetic fields from double circuit 132 kV steel tower OHLs as per the existing 132 kV EDM OHL (blue), single circuit steel tower 132 kV OHLs (red) and single circuit wood pole or Trident OHLs as proposed (green)

- 4.1.4 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 2000 μT for electric razors and hair dryers, 800 μT for vacuum cleaners, and

50 μT for washing machines. The electric field in most homes is in the range 1-20 V/m, rising to a few hundred V/m close to appliances.

5 ASSESSMENT OF THE SIGNIFICANCE OF THE POTENTIAL EFFECTS

5.1 Operational Effects – Overhead Lines

Predicted Field from Proposed New 132kV Trident Overhead Line

- 5.1.1 132kV overhead lines are specified in the Code of Practice (Ref. 1. **Error! Bookmark not defined.**) as a type of equipment that is inherently compliant with Government exposure limits due to the design. Evidence for demonstration of compliance with Government exposure guidelines for 132kV overhead lines is maintained at: <http://www.emfs.info/compliance/public/>
- 5.1.2 However, calculations of the EMFs from 132kV overhead lines are provided for completeness.
- 5.1.3 The new OHL that is proposed for the EDM Project is a single circuit "Trident" wood pole design with a conductor known as "Sycamore". All spans have a minimum conductor design clearance to ground of 6.7m, although in many cases this would be higher. Calculating the EMFs at minimum clearance would represent a worst-case assumption as higher clearances result in lower EMFs.
- 5.1.4 Calculations were performed at the pre-fault continuous rating of the circuit which is 179 MVA and nominal voltage (132 kV) at 1m above ground. The highest calculated EMFs produced by the overhead line using the worst-case conditions are shown in **Table 4**. All calculations were performed in accordance with the conditions set out in the codes of practice (Ref. 2). The EMFs produced by the overhead line decrease rapidly with distance as demonstrated in Figures 3 and 4.
- 5.1.5 The closest residential property to the proposed new OHL is 101m. At this distance the electric and magnetic fields have reduced to 0.002 kV/m and 0.06 μT respectively, which is below the average "background" EMFs for a UK home (Section 4.1.3).

5.1.6 The maximum fields from the proposed overhead line are summarised in **Table 4**.

Table 4: Summary of design and calculation parameters and calculated maximum fields for proposed new OHL

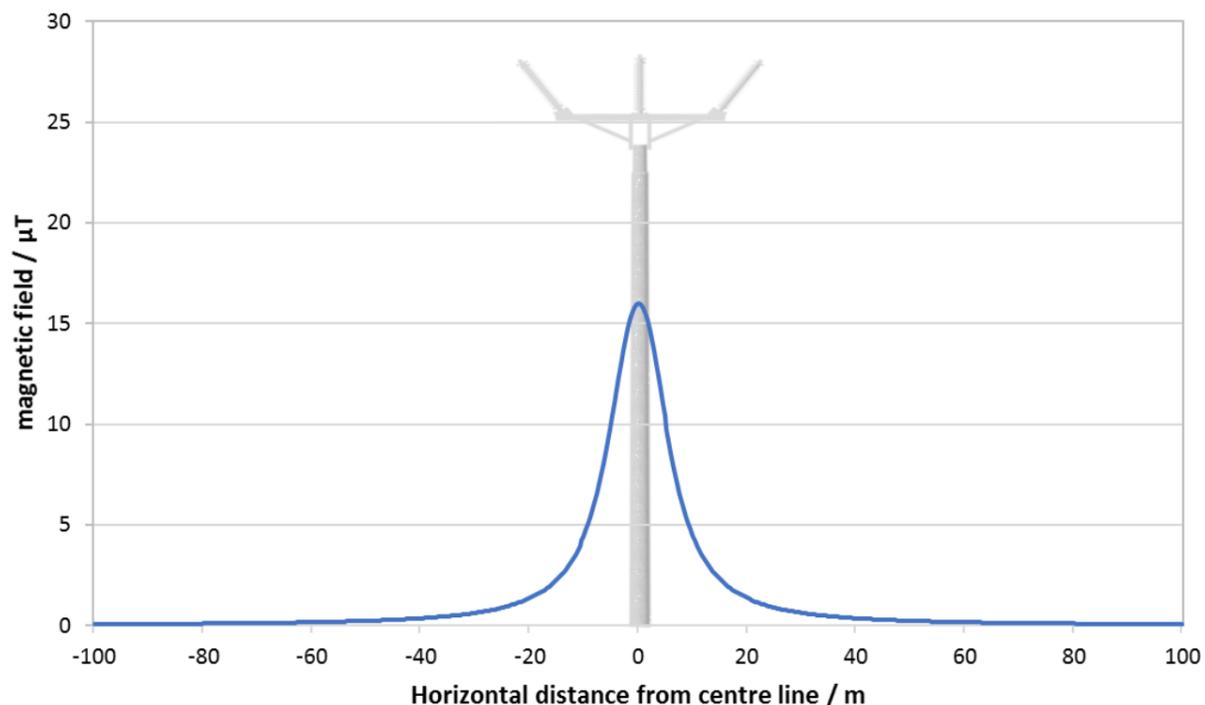


Figure 3: Maximum magnetic fields from the proposed "Trident" 132kV overhead line

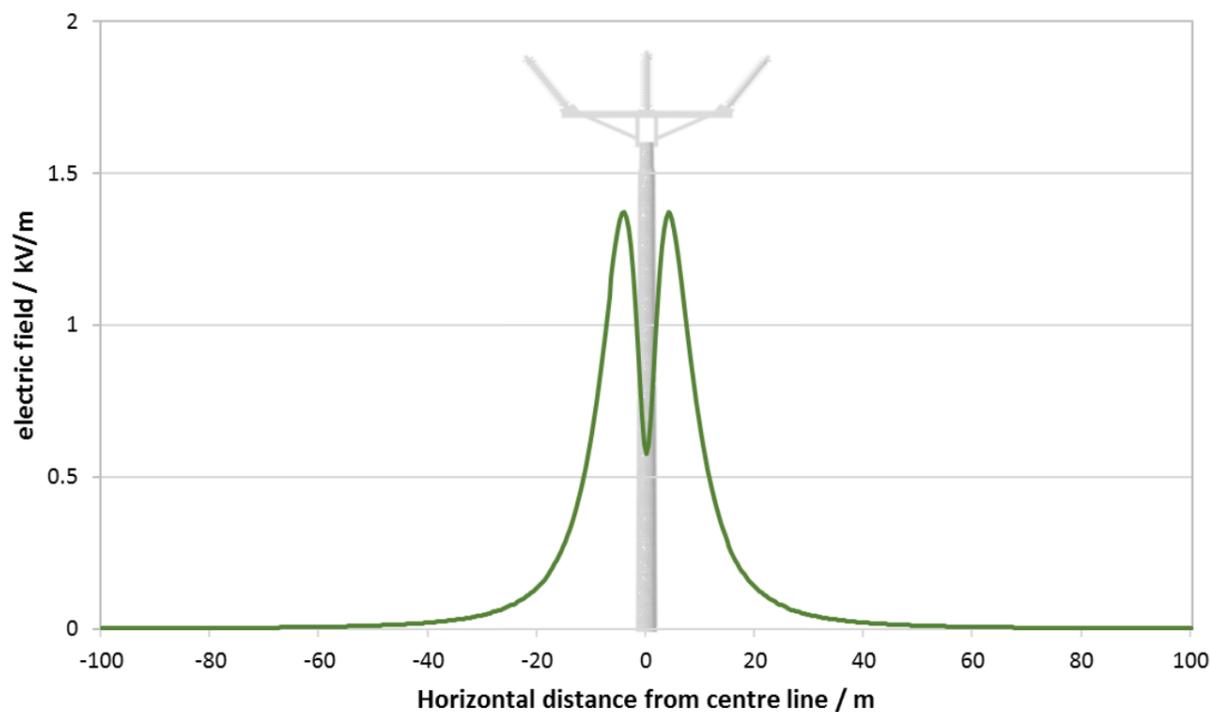


Figure 4: Maximum electric fields from the proposed "Trident" 132kV overhead line

Design and calculation parameters		
Poles and Conductor type	Trident 1x250mm ² AAAC 'Sycamore'	
Voltage	132kV	
Rating (per circuit)	179 MVA	
Phasing	Single Circuit	
Ground clearance of lowest conductors	6.7m	
Height above ground of calculation	1m	
	<i>Electric fields</i>	<i>Magnetic fields</i>
Exposure limits for public	9 kV/m	360 µT
Maximum fields produced by the proposed new OHL	1.37 kV/m	15.98 µT

Compliance with Policy on Phasing

5.1.7 The new OHL is a single circuit meaning that phasing relationship between two circuits is not applicable. Given this is the case, it is compliant with the policy on phasing set on in the Code of Practice on Optimum Phasing (Ref.[Error! Bookmark not defined.](#)).

Overhead Line – Assessment

5.1.8 The maximum calculated magnetic field from the new OHL of the EDM Project, calculated according to the Code of Practice on Compliance, is 15.98 µT. The maximum calculated electric field is 1.37 kV/m. Therefore, the maximum EMFs produced by the new OHL would be less than the public exposure limits of 360 µT and 9 kV/m, respectively. Thus, the new OHL would meet the relevant exposure limits stated in the ICNIRP general public guidelines (Ref. 3) in the terms of the EU Recommendation (Ref.4). 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. On this basis, the effects are **not** considered to be significant.

5.1.9 The assessment presented above shows that the maximum value of the fields produced by the proposed new OHL would be compliant with the relevant exposure limits in **Table 2**, even directly under the OHL. There is no minimum lateral distance from the OHL

required to achieve compliance. Therefore, assessment of compliance is not dependent on: the exact routing of the OHL; the exact location of the nearest existing residential property to the OHL; 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 OHL is compliant everywhere, not just compliant outside a specified distance.

- 5.1.10 However, although not required for assessing compliance, the graphs presented in Section 5.2 can be used to estimate the maximum fields at any given distance from the line.

6 MITIGATION

- 6.1.1 No mitigation measures are necessary as the new OHL has been demonstrated to comply with the current exposure limits for the general public and the policy on phasing as detailed in NPS EN-5 (Ref.1). If these requirements are met NPS EN-5 states that “*no further mitigation should be necessary.*”

7 RESIDUAL EFFECTS

- 7.1.1 The new OHL forming part of the EDM Project has been demonstrated to comply with the current public exposure guidelines and the policy on phasing as detailed in NPS EN-5 (Ref. 1). If these requirements are met NPS EN-5 states that “*EMF effects are minimal.*” On this basis, the effects are **not** considered to be significant.

8 CUMULATIVE EFFECTS

- 8.1.1 The EMFs from the proposed new OHL can combine with the EMFs already present from other sources, such as appliances, domestic and industrial wiring, etc. However, the largest source of EMFs is typically from electricity transmission and distribution infrastructure. The way in which fields from different sources combine with each other is complex. The relative power flows, voltage and the relative phasing of each powerline would affect the direction of the fields from each line and whether they add or subtract with one another. The cumulative field could increase or decrease depending on the specific conditions, but it would only be a slight effect either way. Therefore, the cumulative impact of all of the components of the EDM Project and any interactions with other developments which produce EMFs would not be significant.
- 8.1.2 The existing OHL will be decommissioned or ‘switched off’ before the new OHL is commissioned. Therefore, the existing OHL will not produce any EMFs when the new OHL is operational and will not have a cumulative effect.
- 8.1.3 Where the new OHL crosses existing 11 kV OHLs along the route, even if a worst-case assumption were taken i.e. that the fields would add directly, the cumulative fields would still be significantly below the Government exposure limits. The maximum electric and magnetic fields from 11 kV OHL are 0.22 kV/m and 9.5 µT (see <http://www.emfs.info/sources/overhead/specific/11-kv/>). If these were to combine with the maximum EMF from the new OHL, these would result in EMFs of 1.59 kV/m and 25.5 µT.
- 8.1.4 It is SPEN’s and the electricity industry’s policy to ensure that all powerlines comply with Government exposure limits and policies. As all of the components of the proposed

Project will comply with these exposure limits, the cumulative impacts would **not** be significant.

9 CONCLUSIONS

- 9.1.1 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 (Ref. 1).
- 9.1.2 The proposed new OHL forming part of the EDM project would be fully compliant with Government policy. Specifically, all the EMFs produced would be significantly below the relevant exposure limits, and the proposed new OHL would comply with the policy on optimum phasing. Therefore, there would be no significant EMF effects resulting from the new OHL and cumulatively with other developments.