



Visual Impact Provision: Peak District National Park (East)

Electric and Magnetic Fields Report

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July 2019

Document Control			
Document Properties			
Organisation		National Grid	
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Approved by			
Title		Visual Impact Provision: Peak District National Park (East) - Electric and Magnetic Fields Report	
Document Reference			
Version History			
Date	Version	Status	Description/Changes
November 2018	1	Draft	
May 2019	2	Draft	Updated assessment for new design data

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INTRODUCTION

1.1 The applicant and an overview of the Peak District National Park (East) VIP Project

- 1.1 National Grid is seeking to underground a section of the existing 4VO overhead line (OHL) (hereafter referred to as the 'Peak East Project') within the Peak District National Park.
- 1.2 The undergrounding of the Peak East Project includes the following main elements:
 - Removal of one existing sealing-end compound (SEC) and installation of one new SEC including permanent access, required to connect the new underground cables to the remaining existing OHL;
 - Installation of one new span of overhead line to connect the existing OHL to the new SEC, and replacement of the conductors of a further two spans of the existing OHL;
 - Installation of approximately 2km of 400kV underground cable; and
 - Permanent removal of the existing OHL subsection including 7 pylons and approximately 2km of OHL.
- 1.3 This stakeholder-driven Project forms part of the wider VIP project. The VIP Project will make use of a £500m allocation by Ofgem to carry out work to help reduce the impact of existing transmission lines in English and Welsh Areas of Outstanding Natural Beauty (AONBs) and National Parks.
- 1.4 National Grid has prepared a series of plans and reports to explain its proposals to build the Project. Applications have been submitted under the Town and Country Planning Act 1990 and the Electricity Act 1989.

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 construction, operation and decommissioning of the Project.
- 1.2.2 National Grid has a very clear policy on EMFs, as set out in its Public Position Statement (Ref. 1) which states “...*In all our operations, as a minimum we comply with EMF regulations, guidelines or practices in force in the countries and different jurisdictions in which we operate.*” and this policy would be applied to this Project. As is explained in more detail in section 2 below, compliance with the relevant guidelines and practices in force in the UK ensures that there should be no significant health or environmental effects of EMFs. Therefore, it was proposed in the Scoping Report (Ref. 2) that the assessment of EMFs be scoped out of the Environmental Statement (ES), which in accordance with the relevant Environmental Impact Assessment Regulations (Ref. 3) 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 and the Planning Inspectorate have previously accepted, for various recent nationally significant infrastructure proposals submitted by National Grid, that the required EMF information be provided in a separate report. National

Grid is therefore following the same procedure for this project. 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 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 Electric fields depend on the operating voltage of the equipment producing them 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 This Project comprises underground cables and cable sealing-end compounds, at a voltage of 400kV. These are each 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.
- 1.3.6 Electric and magnetic fields 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 or 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 section 2.9 below). The potential impact of both direct and indirect effects has been assessed using the guidance provided in National Policy Statement (NPS) EN-5 (Ref.4) and the codes of practice (discussed in Section 2 below).
- 1.3.7 Electric and magnetic fields at much higher frequencies 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 much lower frequencies and are sometimes referred to as "non-ionising" radiation.

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, restated in October 2009 and incorporated in NPS EN-5 (Ref. 4), 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.5) agreed between industry and Government.
- 2.1.2 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. 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.
- 2.1.3 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) (Ref.6) in line with the terms of the 1999 European Union (EU) Recommendation (Ref.7) on public exposure to EMFs. In a Written Ministerial Statement in October 2009 (Ref. 8.; 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, 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. The Government also made clear in the Written Ministerial Statement that no other precautionary measures are appropriate for high-voltage infrastructure.
- 2.1.4 These two policies, compliance with exposure limits plus, for overhead lines, optimum phasing, are the only ones applying to high-voltage infrastructure. NPS EN-1 (Ref. 9) does not contain any provisions specific to EMFs. NPS EN-5 (Ref. 4) documents these policies and they are explained fully below.

2.2 National Policy Statement EN-5

As summarised above, Government has set out clear policies on control of EMF exposures in general. NPS EN-5 (Ref.4) 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 1. NPS EN-5 is drafted in the specific context of applications for development consent for nationally significant infrastructure projects, principally for overhead lines, which are determined by the

Planning Inspectorate, but the principles apply to all developments producing EMFs, including the present Project.

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

Paragraph	Requirement	Compliance Assessment
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 (Ref. 5), 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.	The Project 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.6), as demonstrated in this report.
2.10.10	Before granting consent to an overhead line application, the IPC should satisfy itself that the proposal is in accordance with the ICNIRP (1998) guidelines	All assets associated with the Project are 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. 10) 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.	The overhead lines involved in this project all have transposed phasing and therefore comply with the Code of Practice.
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.	This decision tree has been replicated at Figure 1 and forms the basis for the assessment of EMFs from the Project.

Paragraph	Requirement	Compliance Assessment
2.10.15	<p>The applicant should have considered the following factors:</p> <ul style="list-style-type: none"> - Height, position, insulation and protection (electrical or mechanical as appropriate) measures subject to ensuring compliance with the Electricity Safety, Quality and Continuity Regulations 2002 	<p>The realigned spans of overhead line that form part of this Project have been designed to comply with the statutory requirements of the Electricity Safety, Quality and Continuity Regulations 2002 (Ref. 11). 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.</p>
	<ul style="list-style-type: none"> - 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; 	<p>The overhead lines involved in this project all have transposed phasing and therefore comply with the Code of Practice.</p>
	<ul style="list-style-type: none"> - Any new advice emerging from the Department of Health relating to Government policy for EMF exposure guidelines. 	<p>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.</p>
	<ul style="list-style-type: none"> - 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. 	<p>This report shows that the Project would be compliant with the current public exposure guidelines of ICNIRP 1998 using the principles in the Codes of Practice on Compliance.</p>

- 2.2.1 As summarised above, Government has set out clear policies on control of EMF exposures in general. NPS EN-5 (Ref.4) 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.”

- 2.2.2 A simplified route map for dealing with EMFs from overhead lines is provided in NPS EN-5 and is reproduced in Figure 1. Other than the parts that relate specifically to overhead lines, this route map also applies to this project.

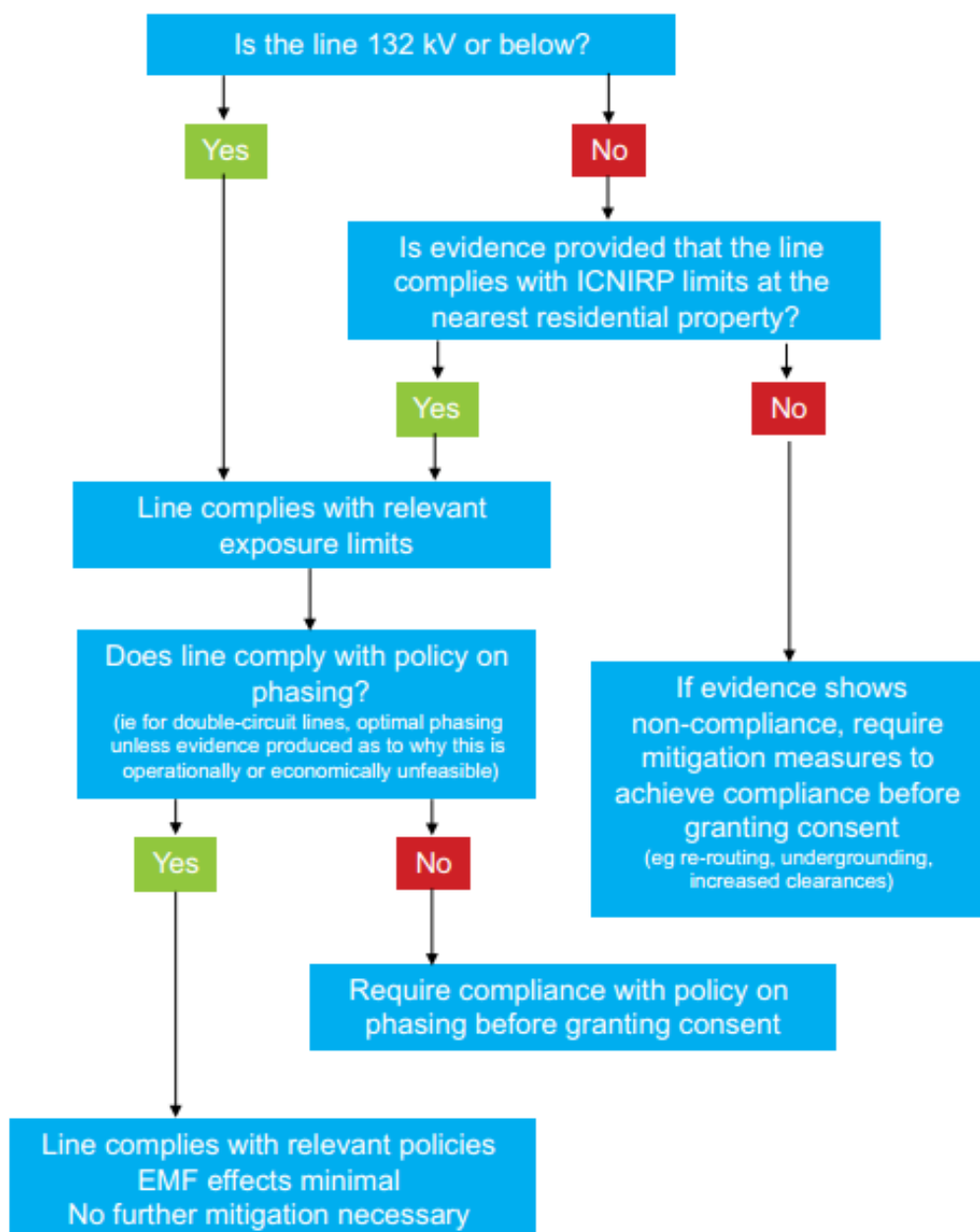


Figure 1 : Simplified Route Map for Dealing with EMFs. Reproduced from NPS EN-5 (page 23)

2.2.3 All relevant legislation, policies and guidance, including those contained within NPS EN-1 (Ref. 9) and EN-5 (Ref.4) have been reviewed and applied to this EMF assessment of the Project. 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 then 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.6). The Government subsequently adopted this recommendation, saying that limits for public exposures should be applied in the terms of the 1999 EU Recommendation (Ref. 7). This Government policy was

subsequently set out more formally in the Written Ministerial Statement (Ref. 8) and incorporated into NPS EN-5 (Ref. 4). Table 2 below summarises the relevant values for power frequencies.

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 (Ref.12). 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.4) 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.5) published by the then Department of Energy and Climate Change (DECC). It is the electricity industry's policy to comply with Government guidelines on EMFs, and this Code of Practice forms an integral part of this policy.
- 2.3.4 The ICNIRP guidelines (Ref.6) 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.7) uses the same basic restriction value as ICNIRP (Ref.6).
- 2.3.5 However, the basic restriction cannot be assessed directly, since *in-vivo* measurements of current density are not practical. 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 5kV/m, and the reference level for magnetic fields is 100μT. The 1999 EU Recommendation (Ref.7) uses the same reference level values as ICNIRP (Ref.6).
- 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.5) 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.5) 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 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 (Ref.5), 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.13) (CEFW Regulations), which implement a 2013 EU Directive (Ref.14). For power frequencies, these are based on a more recent ICNIRP publication, ICNIRP 2010 (Ref.15) rather than the ICNIRP 1998 (Ref.6) 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 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 Project in order to comply (the CEFW Regulations impose certain general duties on all employers which would apply regardless of the Project).
- 2.4.4 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 cable sealing end compound perimeter fences, higher field 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.

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.6), in the terms of the 1999 EU Recommendation (Ref.7). In 2010, ICNIRP published new exposure guidelines (Ref. 15) 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. 5):

“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. National Grid’s assessment is that the Project 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, National Grid would have a duty to bring the whole

transmission system, including the Project, into compliance with whatever new regime was introduced.

2.6 Scientific Evidence

- 2.6.1 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 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 WHO, and the relevant official scientific advisory committee for the EU, until recently the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR).
- 2.6.3 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 then NRPB published new "Advice on Limiting Exposure to Electromagnetic Fields (0-300GHz)" (Ref.12) and accompanied it with a "Review of the Scientific Evidence for Limiting Exposure to Electromagnetic Fields (0-300GHz)" (Ref.16). 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 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)¹.*

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.17). 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.18), 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

¹ A reference to the previous NRPB review of the science by its Advisory Group on Non-Ionising Radiation

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. 19). 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 μ T. 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.

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.17) and reiterated in 2007 (Ref.18), 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 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 transmission equipment is a policy of “optimum phasing”, which applies only to high-voltage overhead power lines. “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.8) in response to a recommendation from the Stakeholder Advisory Group on ELF EMFs (SAGE) in its First Interim Assessment (Ref.20). The details are given in a second Code of Practice, ‘Optimum Phasing of High Voltage Double-Circuit Power Lines’ (Ref.10).
- 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.10) 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.20).
- 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 for overhead lines (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. Government has not considered it appropriate to adopt any specific precautionary policies applying to high-voltage underground cables.
- 2.7.5 Government have specifically rejected the introduction of “corridors” around power lines (and, by implication, underground cables) on EMF grounds, stating of this option in the Written Ministerial Statement (Ref.8):
- “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 such restrictions, 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) on constructing new power lines (and, by implication, underground cables) 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 Therefore, no additional measures or precautions are necessary or appropriate beyond the exposure limits.

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 is already built in to the public exposure limits. No additional protective measures are required.

2.9 Microshocks

- 2.9.1 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.
- 2.9.2 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.
- 2.9.3 In a 2005 Information Sheet (Ref.21), 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.”*
- 2.9.4 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.6) 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 (Ref.5) 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.”

- 2.9.5 A separate Code of Practice on Microshocks, developed jointly by Industry and the then DECC, has been adopted (Ref 22). This follows the principles for managing microshocks quoted above, but contains more details on the practical measures which can be taken.
- 2.9.6 As the net effect of this project is to remove 2km of overhead line, the project is much more likely to reduce any microshock issues than to introduce them. The project includes a single realigned span of overhead line at the eastern end, to connect the new SEC to the retained overhead line. Microshocks are unlikely from this span, but 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 (Ref.22).

2.10 Active Implantable Medical Devices

- 2.10.1 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.
- 2.10.2 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.7) 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.
- 2.10.3 Specifically, the Active Implantable Medical Devices Directive (90/385/EEC) (Ref. 23) 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 ...”*
- 2.10.4 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.
- 2.10.5 The Project would be capable of producing 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:

- 1) 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) 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: the circuits are unlikely to 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.

2.10.6 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 assets 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.

2.10.7 This is confirmed in NPS EN-5 (Ref.4), 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.”

2.11 Farming, Flora and Fauna

2.11.1 The NPS for Electricity Networks Infrastructure (EN-5) (Ref.4) 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 Summary of Policy and Legislation

2.12.1 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; for overhead lines, the policy on optimum phasing, as set out in the Code of Practice on Optimum Phasing; but no other policies.

2.12.2 NPS EN-5 (Ref.4) explicitly applies these policies to applications for development consent for new nationally significant electricity connections, but the principles apply to all applications that produce EMFs, such as the Project. If a proposed underground cable, cable sealing-end compound, etc., complies with these, there are no grounds in relation to EMFs not to grant consent.

3 ELECTROMAGNETIC COMPATIBILITY

3.1.1 Electromagnetic compatibility (EMC) is controlled by EU Directive 2014/30/EU (Ref.24) (the EMC Directive) which replaced Directive 2004/108/EC (Ref.25) on 20 April 2016. These Directives are enacted in UK law by Regulations. The current Regulations are the 2016 Regulations (Ref. 26).

3.1.2 The requirements of the EMC Directive 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 specific provisions in the EMC Directive relating to “fixed installations”.
- 3.1.4 Article 6 of the 2014 Directive (Ref. 24) requires conformity with Annex 1, Part 2 of that Directive, which in turn 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 proposed 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 (Ref.27), along with other equipment specific standards such as BS EN60437 (Ref.28) for the insulators on the pylons. Thus, National Grid’s Transmission System applies good engineering practices and meets the essential requirements detailed in Annex 1 of the EMC Directive.
- 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 (Ref.29), 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. 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 Annex A.
- 3.1.7 The subsequent EMC Directive, 2004/108/EC (Ref.25), and the current EMC Directive 2014/30/EU (Ref.24), 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 EMC Directive.
- 3.1.8 The Project would contain electrical equipment 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 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 EMC Directive 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 following appropriate on-site testing, the Project would present no issues with TV or radio interference under normal operating conditions.

3.2 Effects on magnetic compasses

- 3.2.1 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.
- 3.2.2 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 cables proposed for use in the Project and no DC fields could be produced.
- 3.2.3 The magnetic fields produced by this Project would be 50Hz fields. These oscillate far 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 Project.
- 3.2.4 Therefore, the Project would have no significant effect on magnetic compasses.

4 ASSESSMENT METHODOLOGY

- 4.1.1 The assessment considers the EMFs produced from the electricity assets associated with the Project. Each asset is assessed including the cumulative impacts on existing assets.

4.2 Study Area

- 4.2.1 The EMFs produced by the electrical assets of the Project would have a given magnitude at a given distance from the asset. Therefore, the Study Area of the assessment includes all areas around the assets where the EMFs could potentially be significant, such that the assessment is asset-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 Field Levels

- 4.3.1 The magnetic field produced by a current in an individual conductor falls 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 quite 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 quite 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 presented here follow the provisions

specified in the Code of Practice on Compliance (Ref.5) and were performed using specialised computer software that has been validated against direct measurement (Ref.30).

- 4.3.3 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 sealing-end compound are usually those produced by the overhead lines entering the sealing-end compound. The fields produced by equipment within the sealing-end compound 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 report 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 (Ref.5) specifies that the maximum fields an overhead line is capable of producing should be calculated for certain specified conditions. The same provisions apply, where relevant, to assessing the magnetic fields from underground cables. The relevant provisions are:
- 1) electric fields: for nominal voltage;
 - 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);
 - 3) for overhead lines, for both electric and magnetic fields: for design minimum clearance;
 - 4) taking account of the basic geometry for the design of the underground cable in question, taking account of the basic pylon geometry for the design of overhead line in question, but ignoring minor variations in conductor spacing at bends and variations in conductor spacing at angle pylons; and
 - 5) for 1m above ground level, of the unperturbed field, 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 Therefore, the calculations for the Project were performed using worst-case conditions. The circuits are unlikely to operate at this maximum rating routinely, resulting in lower typical magnetic fields on a day to day basis.
- 4.3.7 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.5). 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.5) specifies that it is acceptable to demonstrate compliance by reference to the unperturbed fields.

- 4.3.8 As an alternative to calculations, the Code of Practice on Compliance (Ref.5) 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 (which for this purpose includes sealing-end compounds) 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)

- 4.3.9 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) 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), 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.

4.5 Assessment of Effects

- 4.5.1 The 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.5). Conversely, as specified in NPS EN-5 (Ref.4), if the Project complies with the exposure limits and with the policies on phasing (Ref.10) and microshocks (Ref.22), EMF effects would be assessed as not significant and no mitigation would be necessary.

5 BASELINE ENVIRONMENT

- 5.1.1 The Project would be located within a mixture of primarily rural and semirural areas, which accommodate existing electrical assets. 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 $50\mu\text{T}$ 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 $0.01 - 0.2\mu\text{T}$ with an average of approximately $0.05\mu\text{T}$, normally arising from currents in the low voltage distribution circuits that supply electricity to homes. The highest magnetic fields to which most people are exposed arise close to domestic appliances that incorporate motors and transformers. For example, close to the surface, fields can be $2000\mu\text{T}$ for electric razors and hair dryers, $800\mu\text{T}$ for vacuum cleaners, and $50\mu\text{T}$ for washing machines. The electric field in most homes is in the range $1-20\text{V/m}$, rising to a few hundred V/m close to appliances (Ref.31).
- 5.1.4 The project replaces a stretch of existing 400kV overhead line. Other overhead lines at various voltages are present in the general area, all of which produce EMFs. The fields produced by the specific lines in any location 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 a range of overhead lines carry are shown in Figure 2 and Figure 3. The 400kV line represents the existing line; typical overhead lines carried on smaller lattice pylons are represented by a 132kV design; and wood-pole distribution lines are represented by a 33kV design.

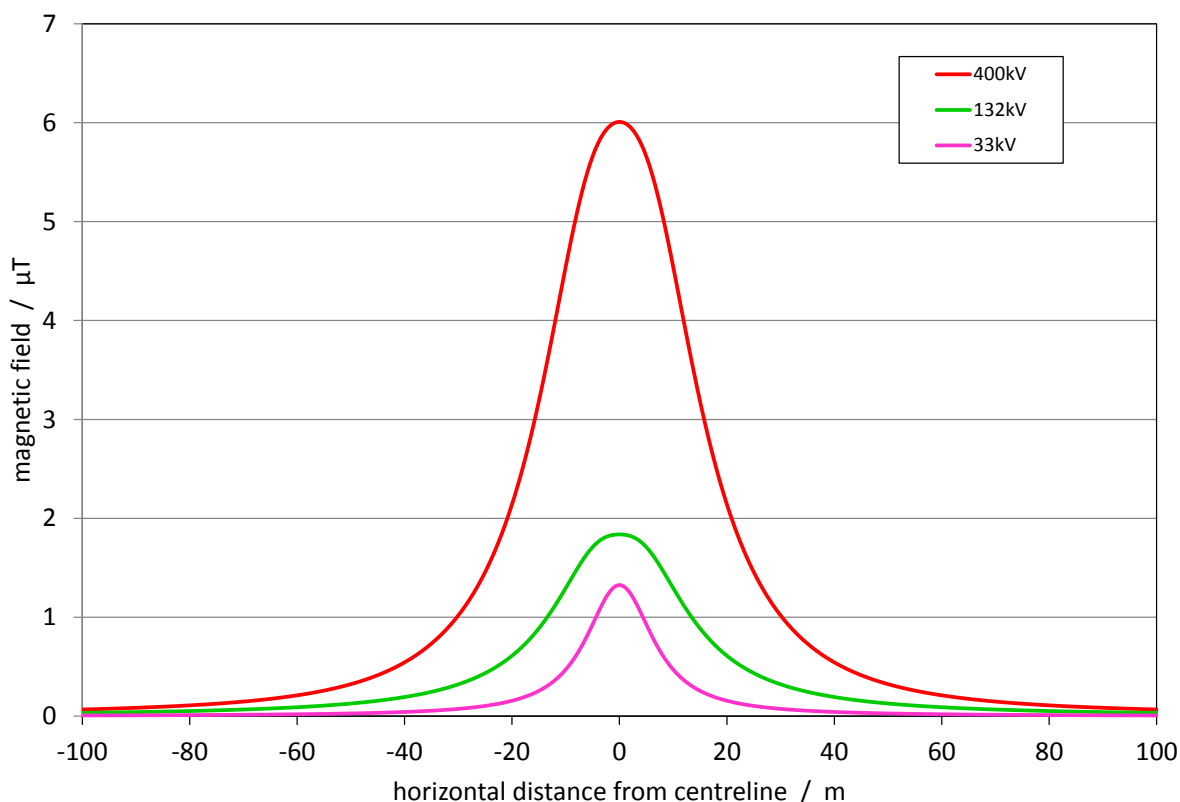


Figure 2: Typical magnetic fields from existing overhead lines

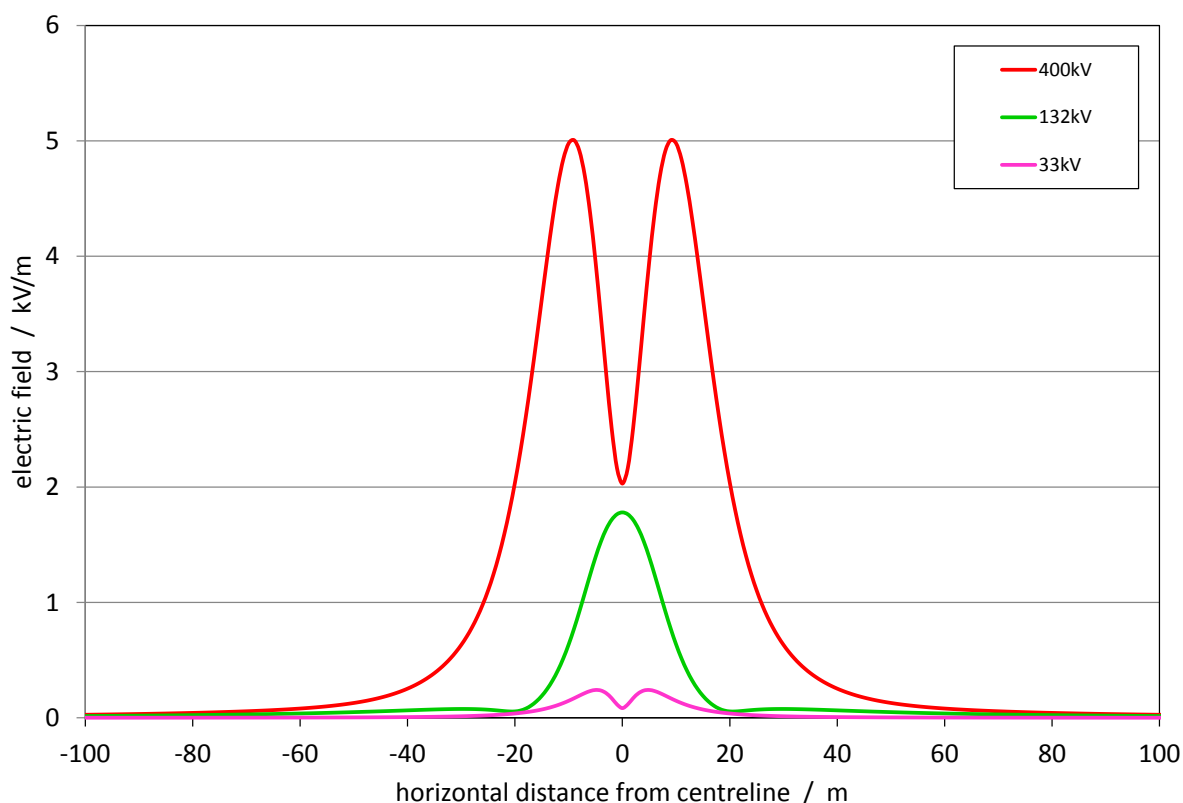


Figure 3 : Typical electric fields from existing overhead lines

6 PREDICTION AND ASSESSMENT OF THE SIGNIFICANCE OF THE POTENTIAL EFFECTS

6.1 Construction Effects

- 6.1.1 During construction and prior to energisation, transmission equipment would not produce any significant EMFs. Therefore, construction effects are not considered further.

6.2 Operational Effects – cable sealing-end compound

- 6.2.1 As explained above, cable sealing-end compounds are treated, according to the Code of Practice on Compliance (Ref.5), as inherently compliant with the exposure limits. The highest fields around them are usually from any overhead lines entering them and not from equipment within the sealing-end compound itself.

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

- 6.3.2 The proposed underground cable consists of two circuits, each with three conductors representing the 3 phases of each circuit. The intended spacing of these conductors

will be 0.55m. The minimum depth of the conductors below ground is intended to be 0.825m. The phasing of the conductors in the two circuits will be transposed.

- 6.3.3 The calculations are performed for a rating of 1432MVA, equivalent to 2067A. The exact rating is subject to fine-tuning as the project reaches its final design, but as will be seen below, the margin of compliance is such that the conclusion that the cable is compliant is not affected by any minor changes to the rating.
- 6.3.4 This is the rating for each circuit operating on its own. When both circuits are operating, a lower rating applies, because of the limitation of the total heat generated by both circuits combined within the Woodhead Tunnel. For simplicity, this effect is ignored in the calculations presented here (the magnetic field is calculated for both circuits simultaneously operating at 1432MVA), meaning that the assessment presented here is unnecessarily onerous.
- 6.3.5 As a consequence of their design, underground cables do not produce an external electric field. Cables would be enclosed in a metal sheath (a protective metal layer within the cable) which would shield the electric field. Therefore electric fields are not considered further for this type of equipment.
- 6.3.6 Magnetic fields produced by direct buried cables fall quickly with distance as you move away and the highest magnetic fields are observed directly above the cables.
- 6.3.7 The resulting fields are shown in Figure 4.

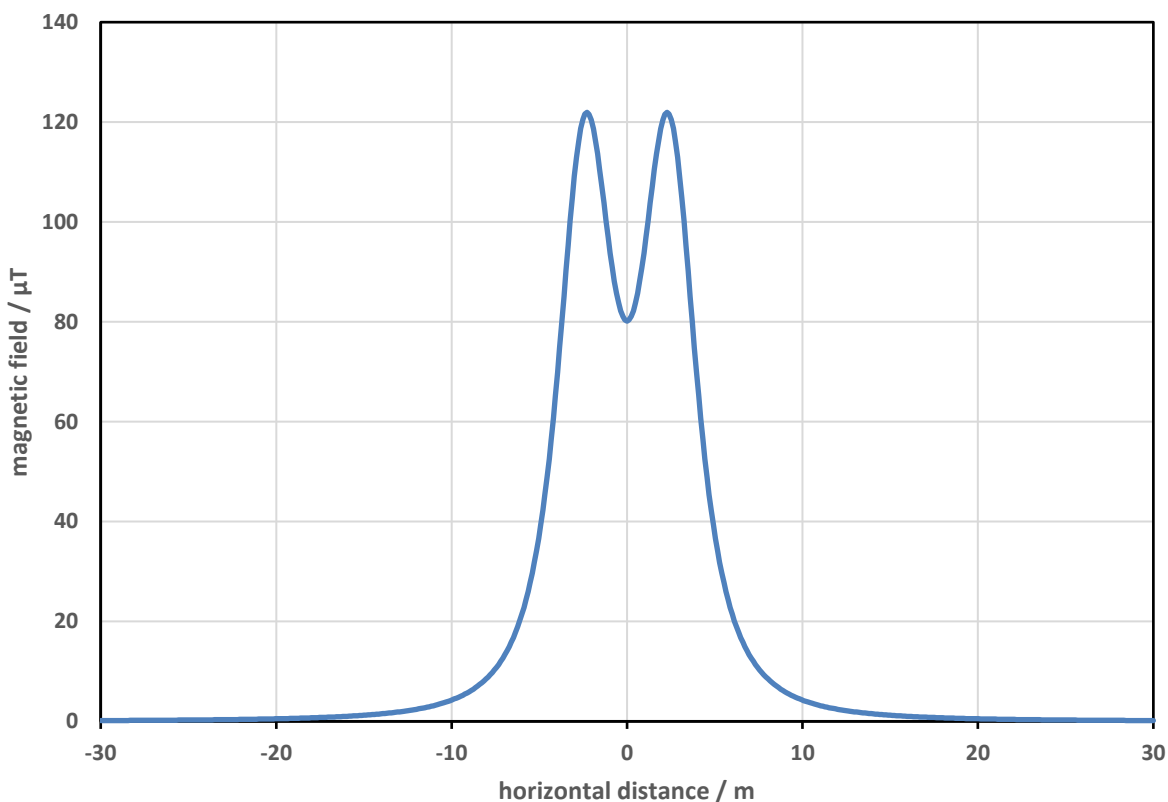


Figure 4 : Maximum magnetic field from 400kV underground cable for minimum depth

- 6.3.8 The calculations presented in Figure 4 are for the purposes of assessing compliance with the exposure limits, and therefore have been performed for the maximum field the cable would be capable of producing, i.e. specifically for the rating. As extra

information not required for assessing compliance, calculations have also been performed for what is a typical load for National Grid circuits, 500A per circuit. The field for this typical condition is presented in Figure 5.

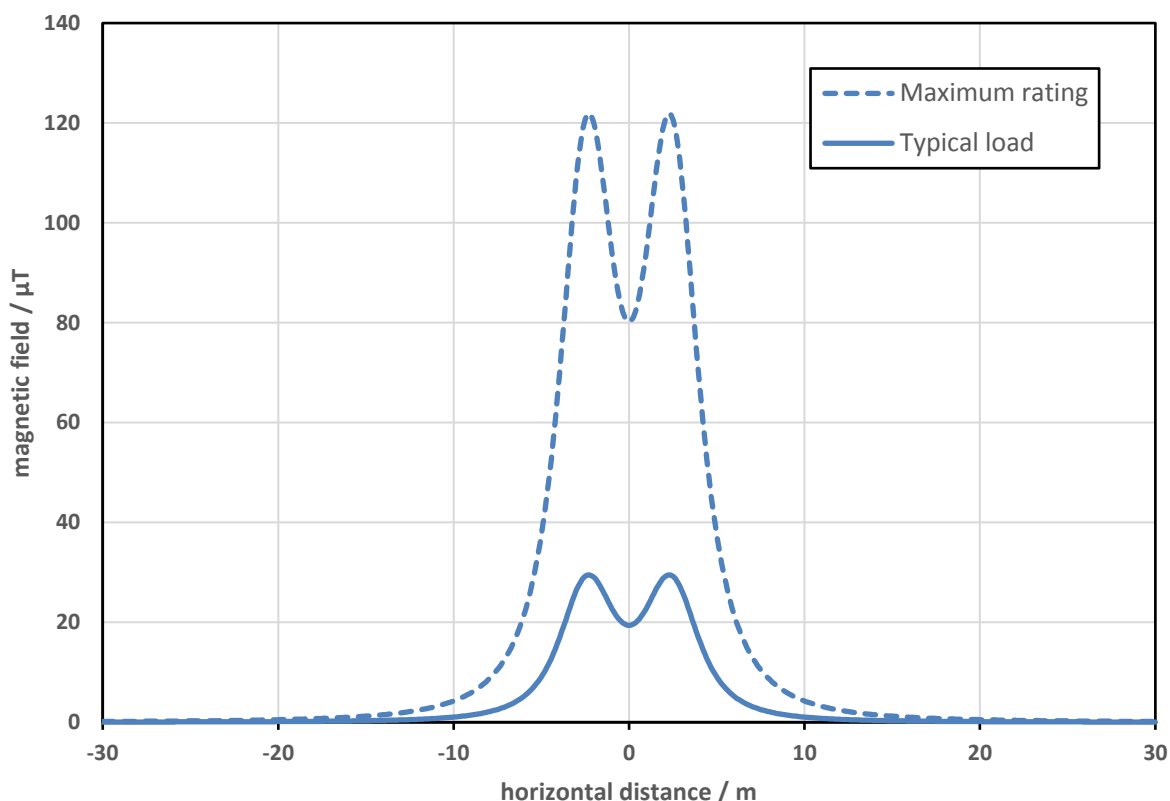


Figure 5: Typical magnetic field from underground cable

6.3.9 All calculations were performed in accordance with the conditions set out in the Code of Practice on Compliance (Ref. 5).

Compliance of underground cables with exposure limits

6.3.10 The maximum magnetic field from the cable is 121.9μT when assessed according to the provisions of the Code of Practice. This is below the relevant exposure limit of 360μT and therefore the cable is compliant. This calculation is a worst-case and under typical loading conditions the typical maximum magnetic field would be around 29.5 μT .

6.4 Operational Effects – overhead line

Predicted field from proposed short new sections of overhead line

6.4.1 In relation to overhead lines, the main effect of this Project is to remove approximately 2km of existing overhead line. However, at the eastern end of the proposed new underground cable, there is one new span of overhead line to connect the replacement terminal pylon to the new sealing end compound, and the next two spans of the existing overhead lines will have their conductors changed to a different type.

- 6.4.2 These new sections of overhead line will be continuous with the existing overhead line, which is of a design known as L6. According to the provisions of the Code of Practice, these new sections should therefore be assessed based on the basic pylon geometry of the L6 design.
- 6.4.3 For the two spans of existing overhead line that will have their conductors changed, the minimum clearance above ground is approximately 13m. At the location of this minimum clearance (and hence highest field), the maximum magnetic field, calculated for the rating (2000MVA), would be 31.8 μ T, which is essentially unaffected by the change in conductors. The maximum electric field at this clearance reduces from 4.2kV/m to 3.9kV/m as a result of the change in conductors.
- 6.4.4 For the new span of overhead line connecting the terminal pylon to the sealing end compound, the minimum clearance is approximately 10m. At this clearance, the magnetic field, calculated for the rating (2000MVA), would be 47.1 μ T. The electric field at this clearance would be 6.2kV/m.
- 6.4.5 The maximum magnetic field is therefore 47.1 μ T, which is less than the limit for the general public of 360 μ T. The maximum electric field is 6.2kV/m, which is less than the limit for the general public of 9kV/m. Therefore, the proposed new sections of overhead line will be compliant with the relevant exposure limits.
- 6.4.6 In normal operation, both the magnetic and electric fields will be less than these maximum values, because the load carried will be less than the maximum, and the clearance of the overhead lines greater than the minimum.

Compliance with Policy on Phasing

- 6.4.7 The new span of 400kV overhead line, and the two spans having their conductors changed, will inherently have the same phasing as the existing overhead line that they continue, which is transposed phasing, meaning that it they are optimally phased as set out in the Code of Practice on Optimum Phasing (Ref.10).

6.5 Decommissioning Effects

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

7 MITIGATION

- 7.1.1 No mitigation measures are necessary as the Project 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.4). If these requirements are met NPS EN-5 states that “*no further mitigation should be necessary.*”

8 RESIDUAL EFFECTS

- 8.1.1 The Project has been demonstrated to comply with the current public exposure guidelines and the policy on phasing as detailed in NPS EN-5 (Ref.4). If these requirements are met NPS EN-5 states that “*EMF effects are minimal.*”

9 CUMULATIVE EFFECTS

- 9.1.1 The electric and magnetic fields from the proposed underground cable and other components of the Project can combine with the EMFs already present in the

development area from other sources such as appliances, domestic and industrial wiring etc. However, the largest sources of fields are 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 electrical asset would affect the direction of the fields from each asset 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 Project and any interactions with other developments which produce lower EMFs would not be significant.

- 9.1.2 It is National Grid's and the electricity industry's policy to ensure that all electrical assets comply with Government exposure limits and policies. As all of the proposed developments will comply with these exposure limits, the cumulative impacts would not be significant.

10 CONCLUSIONS

- 10.1.1 Government, acting on the advice of authoritative scientific bodies, has put in place appropriate measures to protect the public from EMFs. The core measure comprises compliance with the relevant exposure limits. This policy is incorporated in NPS EN-5 (Ref.4).
- 10.1.2 The assets associated with the Project would be fully compliant with the Government policy. Specifically, all the EMFs produced would be below the relevant exposure limits. Therefore, there would be no significant EMF effects resulting from the Project.

11 ANNEX A: CERTIFICATE OF EMC COMPLIANCE

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: 
Rob St John James
EMC Technical Manager

Approved: 
Ian Kenney
EMC Quality Manager

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Issue Date: 17th March 2005

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