DOCUMENT 5.7

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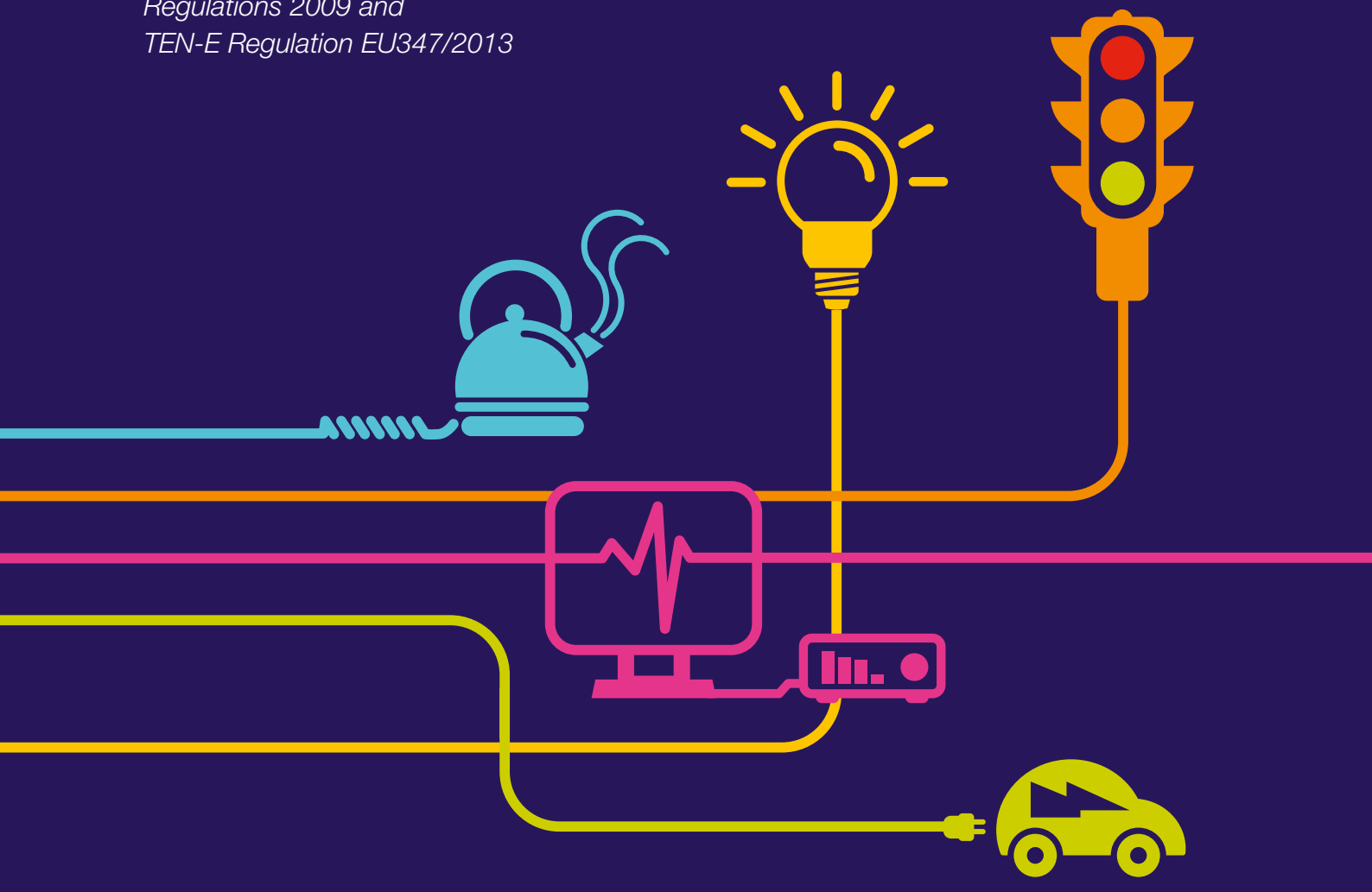
Electric and Magnetic Fields Report

National Grid (Richborough Connection Project) Order

Regulation 5(2)(q) of the
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 and
TEN-E Regulation EU347/2013



Application Ref: EN020017

January 2016

nationalgrid

Richborough Connection Project

Volume 5

5.7 Electric and Magnetic Field Report

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Final

January 2016

Document Control	
Document Properties	
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Title	**Electric and Magnetic Fields Report**
Document Reference	**5.7**

Version History

Date	Version	Status	Description/Changes
04/01/16	1	Final	1st Issue

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1 INTRODUCTION

1.1 The applicant and an overview of the Richborough Connection project

1.1.1 At National Grid, our job is to connect people to the energy they use, whether to heat and light homes, or to keep factories and offices running. As old power stations close new sources of energy need to be connected to our network, so that electricity continues to be available at the flick of a switch.

1.1.2 One of these new sources of energy is a proposed high-voltage electricity link between Belgium and Richborough near Sandwich in Kent, known as the Nemo Link®. In order to transport the energy from the Nemo Link around the country, National Grid need to connect it to the high-voltage electricity network.

1.1.3 There is no high-voltage electricity network in the Richborough area, so National Grid will need to build a new connection to join the Nemo Link from Richborough to their existing network approximately 20km away, near Canterbury. This new infrastructure project is known as the Richborough Connection project.

1.1.4 The proposed development consists of the following principle activities:

- A new 400,000 volts (400kV) overhead line between Richborough and Canterbury North 400kV Substations (to be known as the PC route). This would be approximately 20km long and would be built using 45 standard lattice pylons and 15 low height lattice pylons (60 pylons in total).
- A permanent diversion of an existing lower voltage (132kV) overhead line, known as the PY route, owned by UK Power Networks.
- Three temporary diversions of another existing lower voltage (132kV) overhead line, known as the PX route, owned by UK Power Networks..
- The removal of 20.6km (79 pylons) of the existing lower voltage (132kV) PX route overhead line
- Other works, for example, temporary access roads to reach pylon construction and demolition areas, bridge structures, highway works, construction compounds, protective scaffold structures, pylon work sites and ancillary works.

1.1.5 National Grid has prepared a series of plans and reports to explain our proposals to build a new 400kV overhead line between the existing 400kV substation at Canterbury and the proposed Richborough 400kV Substation. Our application has been submitted under the Planning Act 2008 (known as a Development Consent Order application) and the TEN-E Regulations (European Legislation) which has been submitted to the Planning Inspectorate for their review.

1.2 Background to the 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 proposed development. A description of the proposed development is provided in **Section 1.1**.

1.2.2 National Grid has a very clear policy on EMFs, as set out in its Public Position statement (Ref. 1.1) which states *"…as a minimum comply with EMF regulations, guidelines and practices in force in which we operate*" and will be the case for the Project. It was, therefore, proposed that the assessment of EMFs was scoped out of the ES, which in accordance with the 2009 EIA Regulations, is required to describe the "*likely significant effects of the development*".

1.2.3 The Secretary of State agreed with this approach and the Scoping Opinion states:

"3.13 The Secretary of State acknowledges the applicants' intention to meet these requirements and welcomes the consideration given in Paragraph 4.4.5 to the requirements of NPS EN-5. This will include the provision in a separate document (submitted alongside the ES) of comprehensive information on EMFs, such as evaluations of the EMFs that will be produced as well as relevant scientific evidence."

1.2.4 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 happen. 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.

1.2.5 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. These 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) alternating EMFs, and exist in addition to the Earth's steady natural fields.

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

1.2.7 Magnetic fields are measured in μT (microtesla) 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.

1.2.8 Electric and magnetic fields at 50Hz can cause induced currents to occur in the body and, if high enough can interfere with nerves. There are Government adopted exposure guidelines (discussed in **Paragraphs 1.3.8 to 1.3.16**), which are set to protect against these known or direct effects of EMF exposure. There are also

1.1 National Grid's Public Position Statement on Electric and Magnetic Fields http://www.emfs.info/wp-content/uploads/2014/09/EMF-PPS-2014.pdf

'indirect' effects that can occur as a result of exposure to EMFs 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 1.3.38 to 1.3.50**). The potential impact of both direct and indirect effects has been assessed using the guidance provided in National Policy Statement (NPS) EN-5 (Ref. 1.2) and the codes of practice (discussed in **Section 1.3**).

1.2.9 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, 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.

1.3 Policy and Legislation

1.3.1 Whilst there are no statutory regulations in the UK that limit the exposure of people to power-frequency EMF, responsibility for implementing appropriate measures for the protection of the public lies with the UK Government, that has a clear policy, restated in October 2009 and incorporated in NPS EN-5 (Ref. 1.2), 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 Codes of Practice (Ref. 1.3) agreed between industry and Government.

1.3.2 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 it became part of the Health Protection Agency (HPA) on 1 April 2005, until it was replaced by PHE on 1 April 2013. This Report refers to either NRPB or HPA according to the name at the time each statement was issued.

1.3.3 In 2004, following a recommendation by NRPB, the UK Government adopted exposure guidelines for the public published in 1998 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) (Ref. 1.4) in line with the terms of the 1999 EU recommendation (Ref. 1.5) on public exposure to EMFs. In a Written Ministerial Statement in October 2009 (DH 2009; references to the Written Ministerial Statement encompass both the Statement itself and the detailed

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

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

1.4 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.

1.5 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.

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 relating to high voltage infrastructure, a policy of optimum phasing of some overhead lines. The Government also made clear that no other precautionary measures are appropriate for high voltage infrastructure.

1.3.4 These two policies, compliance with exposure limits plus optimum phasing, are the only ones applying to high voltage infrastructure. NPS EN-5 (Ref. 1.2) documents these policies and they are explained fully below.

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. 1.2) gives clear guidance on the EMF requirements of all electricity infrastructure projects. The relevant sections and how they have been addressed are summarised in **Table 1.1** below.

Table 1.1 Summary of NPS EN-5 Requirements Relevant to EMF

Para	Requirement	Section	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 (PINS), 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, 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.	**3**	The proposed development has been designed and assessed in line with this code of practice. All of the EMFs produced comply with the Government adopted ICNIRP 1998 guidelines and relevant policies.
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	**3**	The overhead line and all other assets associated with the proposed development have been demonstrated to comply with the Government adopted ICNIRP 1998 guidelines.

Para	Requirement	Section	Compliance Assessment
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 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.	**3.2.7**	The overhead line has been designed in compliance with the Policy on Optimum phasing.
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.	**1.3.6 at Figure 1.1**	This decision tree has been replicated at Figure 1.1 and forms the basis for the assessment of EMFs from the proposed development.
2.10.15	The applicant should have considered the following factors:	See below.	See below.
	- Height, position, insulation and protection (electrical or mechanical as appropriate) measures subject to ensuring compliance with the Electricity Safety, Quality and Continuity Regulations 2002	**1.3.52**	The proposed overhead line has been designed to comply with the statutory requirements of the Electricity Safety, Quality and Continuity Regulations 2002. EMF requirements can result in conductor clearances to ground (one of the requirements of these regulations) being increased but always in compliances with the Electricity Safety, Quality and Continuity Regulations 2002. The minimum conductor clearance information provided in **Section 1.3.52** demonstrates this compliance.

Para	Requirement	Section	Compliance Assessment
	- 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;	**3.2.7**	The overhead line has been designed in line with the Policy on Optimum phasing.
	- Any new advice emerging from the Department of Health relating to Government policy for EMF exposure guidelines.	**1.3**	This has been considered in the policy and legislation section of the current report **Section 1.3** and all current advice has been used for the assessment. The assessment has been carried out against the current Government recommended EMF exposure guidelines and policies.
	- Where it can be shown that the line will comply with the current public exposure guidelines and the policy on phasing, no further mitigation should be necessary.	**4 and 7**	The proposed development has been shown to be compliant with current public exposure guidelines of ICNIRP 1998 and the policy on phasing using the principles in the DECC Codes of Practice.

1.3.5 As summarised above, Government has set out clear policies on control of EMF exposures in general. NPS EN-5 (Ref. 1.2) gives clear guidance on the EMF requirements of all electricity infrastructure projects stating:

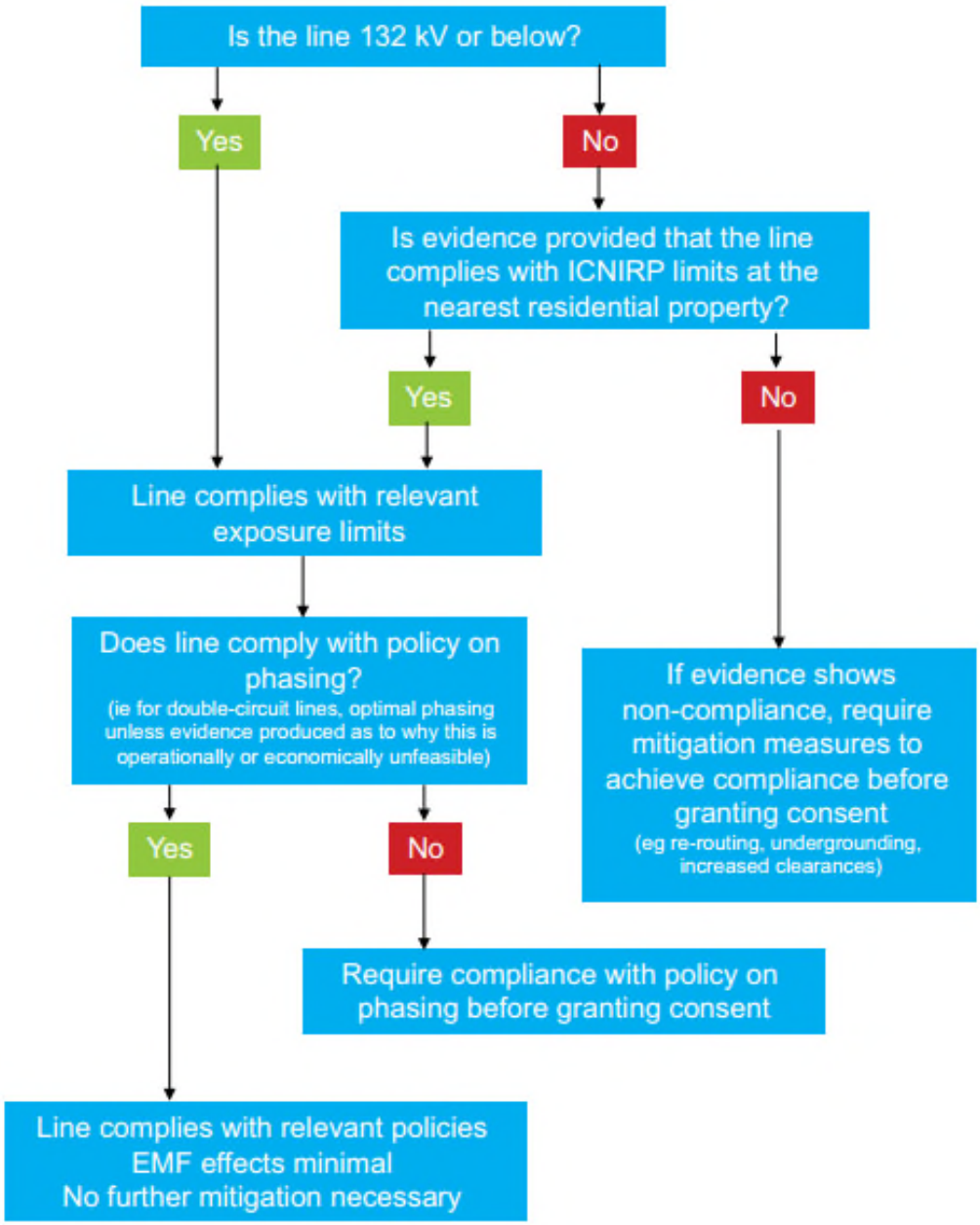
"2.10.9… Before granting consent to an overhead line application, the IPC should satisfy itself that the proposal is in accordance with the guidelines, considering the evidence provided by the applicant and any other relevant evidence."

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."

1.3.6 A simplified route map for dealing with EMFs is provided in NPS EN-5 and is reproduced in **Figure 1.1**.

Figure 1.1: Simplified Route Map for Dealing with EMFs Reproduced from NPS EN-5 (Pg. 23)



1.3.7 All relevant policies and guidance, such as those contained within NPS EN-1 (Ref. 1.6) and EN-5 (Ref. 1.2) have been reviewed and applied to this assessment of the

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

proposed development. 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.

Exposure Limits

1.3.8 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. 1.4). The Government subsequently adopted this recommendation, saying that limits for public exposures should be applied in the terms of the 1999 EU Recommendation (Ref. 1.5). **Table 1.2** summarises the recommended values for power frequencies.

Table 1.2 Recommended Values for Power Frequencies

Public Exposure Levels	**Electric Fields**	**Magnetic Fields**
Basic restriction (induced current density in central nervous system)	$2mA/m^2$	
Reference level (external unperturbed field)	5,000V/m	100µT
Field corresponding to the basic restriction	9,000V/m	360µT

1.3.9 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. 1.7). 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.

1.3.10 The EMF guidelines are documented in NPS EN-5 (Ref. 1.2) and practical details of their application are explained in the Code of Practice, 'Power Lines: Demonstrating compliance with EMF public exposure guidelines – a voluntary Code of Practice' (Ref. 1.3) published by the Department of Energy and Climate Change (DECC). It

1.7 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

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.

1.3.11 The ICNIRP guidelines (Ref. 1.4) are set to limit external exposure to EMFs causing currents to be induced in the body over a threshold. These induced currents can be expressed as a current density and are what the guidelines are based. The ICNIRP guidelines recommend that the general public are not exposed to levels of EMFs able to cause a current density of more than 2mA/m^2 within the human central nervous system, as shown in **Table 1.2** above. This recommendation is described as the "basic restriction". The external fields that have to be applied to the body to cause this current density have to be calculated by numerical dosimetry, since *in-vivo* measurements of current density are not practical.

1.3.12 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. 1.5) uses the same values as ICNIRP (Ref. 1.4).

1.3.13 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.

1.3.14 The Code of Practice on compliance (Ref. 1.3) 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."

1.3.15 The Code of Practice (Ref. 1.3) also specifies the land uses where exposure is deemed to be for potentially a significant period of time and therefore where the public guidelines apply. These land uses are, broadly, residential uses and schools.

1.3.16 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, it is compliant with the ICNIRP guidelines and hence 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. 1.3) and it may still be compliant if the fields are non-uniform.

Occupational Exposure

1.3.17 The ICNIRP occupational guidelines are higher than the public guidelines, by, broadly, a factor of five. Therefore, where the fields are compliant with the public guidelines, any occupational activities will also be compliant with the relevant guidelines.

1.3.18 The occupational guidelines do not yet have a clear paper trail of implementation in the UK in the way that the public exposure guidelines do. It is anticipated that occupational limits (based on ICNIRP 2010 (Ref. 1.8) rather than ICNIRP 1998 (Ref. 1.4), see below) will acquire legal force through an 2013 EU Directive (Ref. 1.9), which will be transposed into UK domestic legislation in due course by Regulation. The present situation is that the occupational limits have effect through the Health and Safety Executive's endorsement of them.

1.3.19 Employers have a duty of care to their employees. Employers discharge that duty of care in relation to EMFs by complying with the relevant exposure limits. Occupational exposure guidelines are higher than the public exposure guidelines which the proposed development will be compliant with. Therefore all exposures from the proposed development will be compliant with the occupational exposure limits and an employer need take no additional action in order to comply.

Future Changes

1.3.20 As discussed, current Government policy is based on the limits from the 1998 ICNIRP Guidelines (Ref. 1.4), in the terms of the 1999 EU Recommendation (Ref. 1.5). In 2010, ICNIRP published new exposure guidelines (Ref. 1.8) for the range of frequencies including power frequencies. These new guidelines do not apply in the UK unless and until Government decide to adopt them. This is clear in the Code of Practice on Compliance (Ref. 1.3):

"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."

1.3.21 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

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

1.9 European Parliament. 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. Brussels, 2013.

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 proposed development would in fact be compliant with those guidelines were they ever to be introduced.

Precautionary Measures

1.3.22 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 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.

1.3.23 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 have authoritative relevance in the UK are the PHE (formerly the HPA), the International Agency for Research on Cancer (IARC), WHO, the official scientific advisory committee for the EU the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), and the standards-setting body the ICNIRP.

1.3.24 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).

1.3.25 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

1.3.26 In 2004 the then NRPB published new "Advice on Limiting Exposure to Electromagnetic Fields (0-300GHz)" (Ref. 1.10) and accompanied it with a "Review of the Scientific Evidence for Limiting Exposure to Electromagnetic Fields (0-300GHz)" (Ref. 1.10). The former summarises epidemiological evidence as follows (p15):

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

1.3.27 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. 1.11). 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.

1.11 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

World Health Organization

1.3.28 WHO published an Environmental Health Criteria Monograph in 2007 on ELF EMFs (Ref. 1.12), produced by a Task Group that met in 2005. This concluded, in part:

"Chronic effects

Scientific evidence suggesting that every day, 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

1.3.29 Scientific Committee on Emerging and Newly Identified Health Risks is the European Union's Scientific Committee on Emerging and Newly Identified Health Risks. In March 2015 SCENIHR published its most recent report on EMFs, "Potential Health Effects of Exposure to EMF" (Ref. 1.13). 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

1.12 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.

1.13 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

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

1.3.30 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. 1.11) and reiterated in 2007 (Ref. 1.12), that power-frequency magnetic fields are "possibly" a cause of cancer, specifically just of childhood leukaemia, with the evidence relating to any other health effect "much weaker". The Government has addressed this uncertainty by adopting precautionary measures relating to various sources of EMFs.

1.3.31 The only specific precautionary measure that relates to high voltage power lines or any other high voltage transmission equipment is a policy of "optimum phasing". "Phasing" is the order in which the conductors of the two circuits 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 in response to a recommendation from the Stakeholder Advisory Group on ELF EMFs (SAGE) in its First Interim Assessment (Ref. 1.14). The details are given in a second Code of Practice, 'Optimum Phasing of high voltage double-circuit Power Lines' (Ref. 1.15).

1.3.32 "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**

1.14 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

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

2.10.11 of 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. The Code of Practice (Ref. 1.15) states that new 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 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. 1.14).

1.3.33 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 the PHE and Government to be the appropriate response to that evidence.

1.3.34 Government have specifically rejected the introduction of "corridors" around power lines on EMF grounds, stating of this option (Ref. 1.16):

"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."

1.3.35 Having thus 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."

1.3.36 This makes it clear that Government has not introduced any restrictions 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.

1.3.37 Therefore, no additional measures or precautions are necessary or appropriate beyond the exposure guidelines and the policy on optimal phasing.

Microshocks

1.3.38 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,

1.16 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

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.

1.3.39 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.

1.3.40 In a 2005 Information Sheet (Ref. 1.17), 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."

1.3.41 Microshocks are indirect effects and as such are not directly covered by quantitative limits that protect against direct effects of electric fields. The ICNIRP guidelines (Ref. 1.4) 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 are 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. 1.3) 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."

1.3.42 A separate code of practice on microshocks, developed jointly by Industry and DECC, has been adopted (Ref. 1.18). This follows the principles for managing microshocks quoted above, but contains more details on the practical measures which can be taken.

1.17 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

1.18 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.

1.3.43 The proposed overhead line has been designed to comply with the government exposure limits for electric fields, ensuring 9kV/m is not exceeded, and in accordance with the Code of Practice as demonstrated in **Sections 3.2.5 and 3.2.6**. Some areas under the proposed overhead line will have electric fields which could potentially cause microshocks to occur if the correct set of circumstances exists. 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 (Ref. 1.18).

Active Implantable Medical Devices

1.3.44 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 exceed the immunity of the device and temporarily affect its operation.

1.3.45 All modern AIMDs are required to be immune from interference from magnetic EMFs up to the ICNIRP General Public Reference Levels of 1999/519/EC (Ref. 1.5) where the AIMD has been implanted and programmed in a standard manner. The ICNIRP General Public 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.

1.3.46 Specifically, the Active Implantable Medical Devices Directive (90/385/EEC) (Ref. 1.19) 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 …"

1.3.47 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.

1.3.48 The proposed overhead line is capable of producing electric and magnetic fields in excess of the ICNIRP General Public Reference Levels (Ref. 1.4), but which remain lower than the public exposure guideline limit. In theory, therefore, 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 neither the MHRA or National Grid are aware of any instance of electricity transmission infrastructure interfering with a correctly fitted modern AMID such as a pacemaker or ICD. The risk of any interference occurring is not significant in practice for the following reasons:

1.19 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.

- manufacturers have to ensure that AIMDs are immune up to the General Public Reference Level, however many modern AIMDs will be immune to EMFs considerably in excess of these levels; and

- 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. Typically, however, the overhead line will 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; and typically the conductors of an overhead line will be higher than the minimum design clearance used for assessing compliance, therefore reducing the EMFs, with the minimum clearance found only in a limited area towards the middle of certain spans.

1.3.49 Thus, there is considerable confidence in saying that, based on the absence of reported incidents and the typical EMF exposures that will 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.

1.3.50 This is confirmed in NPS EN-5 (July 2011) (Ref. 1.2), 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."

Farming, Flora and Fauna

1.3.51 The NPS for Electricity Networks Infrastructure (EN-5) (July 2011) (Ref. 1.2) 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."*

The Electricity, Safety, Quality and Continuity Regulations 2002

1.3.52 The regulations quoted by **Paragraph 2.10.10** of NPS EN-5 contain specific details in both the body of the Regulations and in one of Schedules. Regulation 17(2) and Schedule 2 of The Electricity Safety, Quality and Continuity Regulations 2002 require:-

Table 1.3 The Electricity Safety, Quality and Continuity Regulations 2002 – Minimum Height above Ground of Overhead Lines

Nominal Voltages	Over Roads	Other Locations
Exceeding 66,000 volts but not exceeding 132,000 volts	6.7 metres	6.7 metres
Exceeding 132,000 volts but not exceeding 275,000 volts	7 metres	7 metres
Exceeding 275,000 volts but not exceeding 400,000 volts	7.3 metres	7.3 metres

1.3.53 The Project complies with these requirements, and the minimum conductor clearance information is provided in **Section 3.2.4** which demonstrates this compliance.

Summary of Policy

1.3.54 The EMF policies applying to high voltage electricity equipment comprise compliance with the exposure guidelines; the policy on optimum phasing, the policy on indirect effects expressed in the code of practice; but no other policies.

1.3.55 National Policy Statement EN-5 (July 2011) (Ref. 1.2) explicitly applies these policies to applications for consent for new overhead lines. If a proposed overhead line complies with the relevant exposure guidelines and the policy on optimum phasing, there are no grounds in relation to EMFs not to grant consent.

1.4 Electromagnetic Compatibility

1.4.1 In 2009 the European Council Directive on electromagnetic compatibility, 89/336/EEC (Ref. 1.20) and its amendments, was enacted into UK law. The main objective of the EMC Directive is to guarantee the free movement of electrical and electronic appliances and to create an acceptable electromagnetic environment within the European Union.

1.4.2 Fixed apparatus and large networks of the type owned and operated by National Grid are also included in the EMC Directive. The requirements of the EMC Directive are that the electromagnetic disturbance that the apparatus generates should not exceed a level allowing radio and telecommunication equipment and

1.20 Council Directive 89/336/EEC of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility, Brussels, 1989.

other apparatus to operate as intended; and the apparatus has an adequate level of intrinsic immunity to electromagnetic disturbance to enable it to operate as intended.

1.4.3 The main source of interference from transmission systems arises from radio frequency (RF) emissions caused by corona discharge. 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. 1.21), along with other equipment specific standards such as BS EN60437 (Ref. 1.22) for the insulators on the pylons.

1.4.4 National Grid's Transmission System has met the essential requirements detailed in Article 4 of the EMC Directive. This was achieved by creating a Technical Construction File (TCF) as per Article 10.2 of the EMC Directive (Ref. 1.20). 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 radio 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 and is provided at **Volume 5, Document 5.4.5A**.

1.4.5 A significant portion of the TCF is establishment of good engineering practices to ensure that RF, corona and therefore EMC issues are adequately considered in the design and installation specifications. National Grid's technical specifications ensure that all equipment prone to RF emissions is designed and tested so these remain within acceptable levels as set out in BS5049-3 (Ref. 1.21). The proposed overhead line will contain electrical equipment that is the same as those tested by on-site measurements documented in the TCF, and will also be designed to the same technical specifications.

1.4.6 Given that the EMC performance of this system has been certificated as compliant with Directive 89/336/EEC (Ref. 1.20) by a Competent Body following appropriate onsite testing, the proposed development will therefore present no issues with TV or radio interference under normal operating conditions.

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

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

2 METHOD

2.1 Study Area

2.1.1 The study area of the assessment includes all areas where the EMFs could potentially extend from the electrical assets of the proposed development. This is asset rather than location-specific and also includes consideration of any changes in alignment that could occur within the Limits of Deviation proposed for the development. This ensures that the equipment will be compliant with exposure guidelines irrespective of the proposed development's exact location within the Limits of Deviation.

2.1.2 The assessment considers the EMFs produced from the electricity assets associated with the proposed development. Each asset is assessed including the cumulative impacts on existing assets.

2.2 Predicted Field Levels

2.2.1 The magnetic field produced by the currents in an electrical circuit falls with distance from the circuit. 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.

2.2.2 For sources of field with a simple, defined geometry, such as overhead lines, 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. 1.3) and were performed using specialised computer software that has been validated against direct measurement (Ref. 2.23).

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

2.2.4 To assess compliance with exposure limits, the Code of Practice on Compliance (Ref. 1.3) specifies that the maximum fields the line is capable of producing should be calculated using the following conditions:

- electric fields: for nominal voltage and design minimum clearance;
- magnetic fields: for the highest rating that can be applied continuously in an intact system (i.e. including ratings which apply only in cold weather, but not including short-term ratings or ratings which apply only for the duration of a fault elsewhere in the electricity system) and design minimum clearance; and
- electric and magnetic fields: for 1m above ground level, of the unperturbed field, taking account of the correct wire type and bundle size, taking account of

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

the basic pylon geometry for the design of overhead line in question, but ignore variations in wire spacing at angle pylons etc, of the 50Hz component ignoring harmonics, ignoring zero-sequence currents and voltages and currents induced in the ground or earth wire, and using the infinite-straight-line approximation.

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

2.2.6 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 (Ref. 1.3). 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. 1.3) specifies that it is acceptable to demonstrate compliance by reference to the unperturbed fields.

2.3 Assessment of Effects

2.3.1 The proposed development would be assessed as having a significant effect if non-compliance with the EMF exposure limits was demonstrated, using the principles set out in Codes of Practice (Ref. 1.3). Conversely, as specified in NPS EN-5 (Ref. 1.2), if the proposed development complies with the exposure limits and with the policy on phasing (Ref. 1.15), EMF effects are assessed as not significant and no mitigation is necessary.

2.4 Baseline Environment

2.4.1 The proposed development is located within a mixture of rural, urban and industrial areas, all of 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.

2.4.2 Electric and magnetic fields s both occur naturally. The Earth's magnetic field, which is caused mainly by currents circulating in the outer layer of the Earth's core, is roughly 50μT in the UK. This field may be distorted locally by ferrous minerals or by steelwork such as in buildings. At the Earth's surface there is also a natural electric field, created by electric charges high up in the ionosphere, of about 100V/m in fine weather.

2.4.3 As detailed earlier in the chapter, the earth’s natural fields are static, and the power system produces alternating fields. In homes in the UK that are not close to high-voltage overhead lines or underground cables, the average “background” power-frequency magnetic field (the field existing over the whole volume of the house) ranges typically from 0.01 – 0.2μT with an average of approximately 0.05μT, normally arising from currents in the low voltage distribution circuits that supply electricity to homes (Ref. 2.24). The highest magnetic fields to which most people are exposed arise close to domestic appliances that incorporate motors and transformers. For example, close to the surface, fields can be 2000μT for electric

razors and hair dryers, 800μT for vacuum cleaners, and 50μT for some TVs and washing machines. The electric field in most homes is in the range 1-20V/m, rising to a few hundred V/m close to appliances (Ref. 2.24).

2.4.4 Along much of the route corridor of the proposed development there are, currently, existing 132kV overhead lines which produce EMFs; these are assessed in **Table 3.2**.

3 PREDICTION AND ASSESSMENT OF THE SIGNIFICANCE OF THE POTENTIAL EFFECTS

3.1 Construction Effects

3.1.1 During construction and prior to energisation, transmission equipment will not produce any significant EMFs; therefore this is not considered further.

3.2 Operational Effects

Overhead Lines – Compliance with Exposure Limits

3.2.1 132kV overhead lines are specified in the Code of Practice (Ref. 1.3) 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.energynetworks.org/electricity/she/emfs.html

3.2.2 However, calculations of the EMFs from 132kV overhead lines are provided for completeness.

3.2.3 The overhead line design will influence the EMFs produced and therefore each of the proposed pylon designs has been assessed separately.

3.2.4 The new double circuit 400kV overhead line would be constructed using a combination of standard lattice and low height lattice pylons. Standard lattice pylons will be constructed for the sections A, B and C of the route; section D of the route will be constructed using low height lattice pylons. Twin Sorbus conductor bundles will be used for the proposed 400kV overhead line. All spans would have a minimum conductor design clearance to ground of 8.1m although in many cases this will be higher. The existing double circuit 132kV overhead lines are constructed using lattice pylons strung with single Lynx conductor with a minimum conductor design clearance of 6.7m.

3.2.5 Calculations for the 400kV overhead line were performed at the pre-fault continuous rating of the Twin Sorbus conductor bundle which is 2295 Amps and nominal voltage (400kV) at 1m above ground. The highest calculated EMFs produced by the overhead line using the worst case conditions are shown in **Tables 3.1 and 3.2**. All calculations were performed in accordance with the conditions set out in the codes of practice.

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

Table 3.1 Calculated Maximum EMFs from 400kV Overhead Line Designs

Pylon Type	**Conductor Bundle**	**Maximum Electric Field at Nominal Voltage (kV/m)**	**Maximum Magnetic Field at Pre-Fault Continuous Loading (μT)**
Standard Lattice Pylon	Twin Sorbus	7.93*	48.89**
Low Height Lattice Pylon	Twin Sorbus	7.25*	50.27**

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

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

Table 3.2 Calculated Maximum EMFs from 132kV Overhead Line Designs

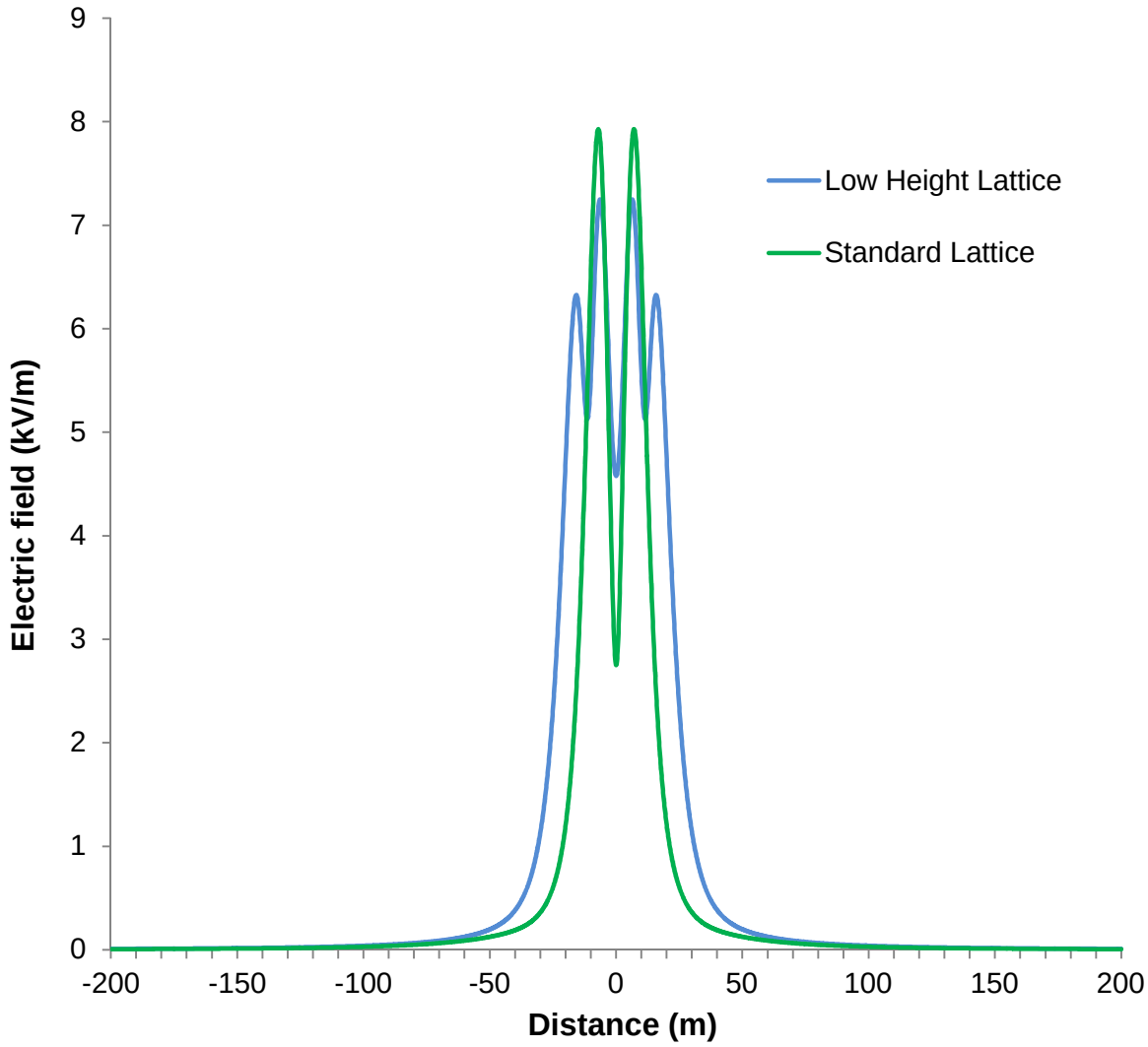
Pylon Type with Twin Redwood Conductor Bundle	**Maximum Electric Field at Nominal Voltage (kV/m)**	**Maximum Magnetic Field at Pre-Fault Continuous Loading (μT)**
Steel Lattice Pylon	1.62*	8.36**

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

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

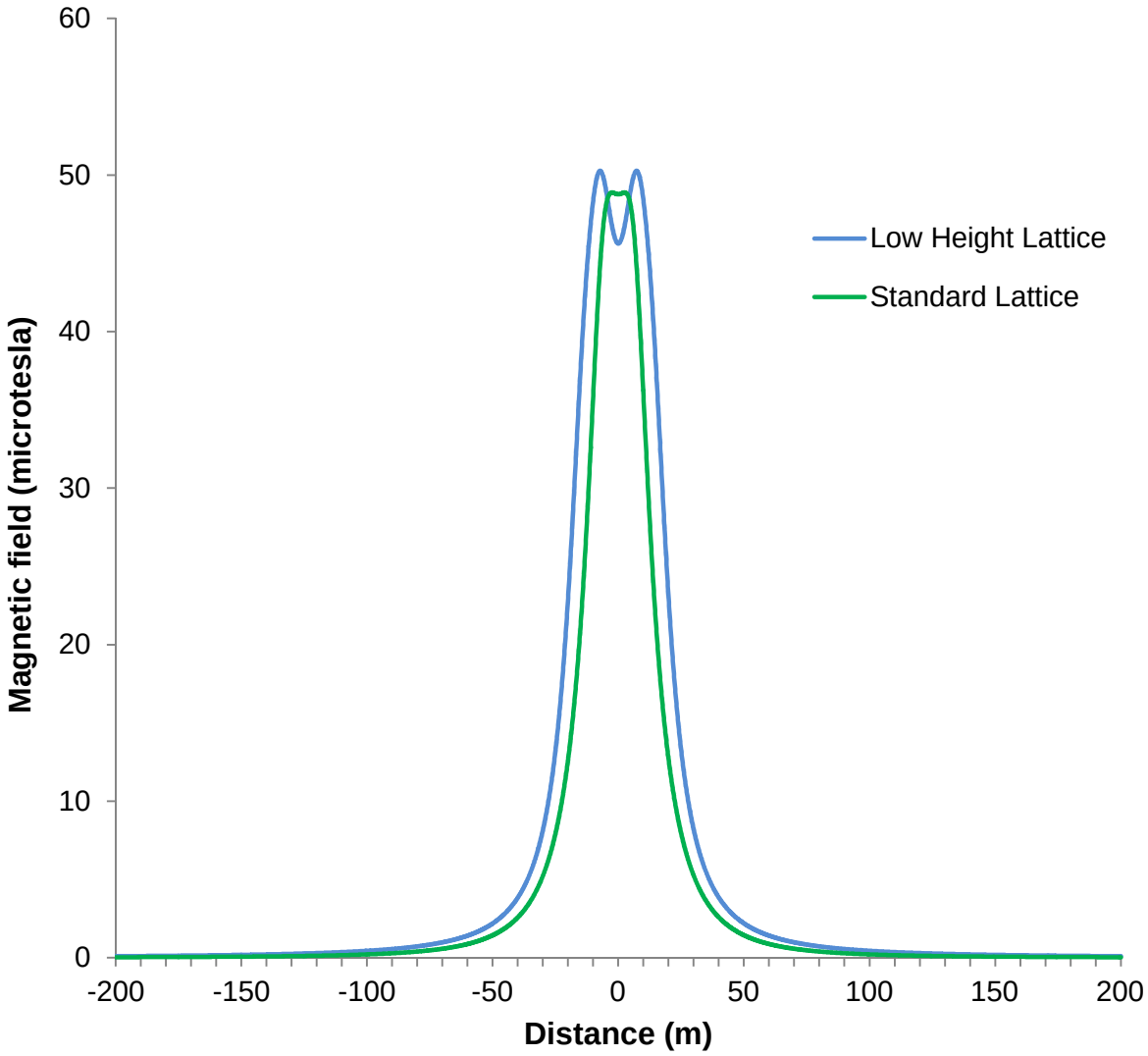
3.2.6 The EMFs produced by the overhead line decrease rapidly with distance from the overhead line (**Figures 3.1 and 3.2**).

Figure 3.1: Calculated Electric Field from Proposed 400kV Overhead Line Designs



All calculations were performed according to the principles in the Code of Practice.

Figure 3.2: Calculated Magnetic Field from Proposed 400kV Overhead Line Designs



Overhead Lines – Compliance with Policy on Phasing

3.2.7 The 400kV overhead line has been designed with transposed phasing meaning that it is optimally phased as per the Code of Practice (Ref. 1.15). The two circuits are arranged to produce the greatest degree of cancellation between the magnetic fields produced by the two circuits and hence the lowest resultant magnetic field to the sides of the line. This applies to both the standard lattice and to the low-height lattice sections.

Overhead Lines – Assessment

3.2.8 The maximum EMFs produced by the proposed overhead line would be less than the relevant public exposure limits. Thus, the proposed overhead line would meet the relevant exposure guidelines, the ICNIRP general public guidelines (Ref. 1.4) in the terms of the EU Recommendation (Ref. 1.5). It 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.

3.2.9 The assessment presented above shows that the maximum value of the fields produced by the proposed overhead lines would be compliant with the relevant exposure limits in **Table 1.2**, even directly under the overhead line. There is no minimum lateral distance from the overhead line required in order to achieve compliance. The assessment of compliance is therefore not dependent on: the exact routing of the overhead line; the exact location of the nearest existing residential property to the overhead line; the nearest proposed property already granted planning permission; or the nearest property that might in future be granted planning permission, because the field from the overhead line is compliant everywhere, not just compliant outside a specified distance.

3.2.10 However, although not required for assessing compliance, the graphs presented above can be used to estimate the maximum fields at any given distance from the line.

3.3 Decommissioning Effects

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

4 MITIGATION

4.1.1 No mitigation measures are necessary as the proposed development has been demonstrated to comply with the current public exposure guidelines as detailed in NPS EN-5 (Ref. 1.2). If these requirements are met NPS EN-5 (Ref. 1.2) states that "*no further mitigation should be necessary."*

5 RESIDUAL EFFECTS

5.1.1 The proposed development has been demonstrated to comply with the current public exposure guidelines as detailed in NPS EN-5 (Ref. 1.2). If these requirements are met NPS EN-5 states that "*EMF effects are minimal."*

6 CUMULATIVE EFFECTS

6.1.1 Both the transmission and distribution assets associated with the project have each been assessed for compliance against Government guideline limits documented in NPS EN-5 (Ref. 1.2).

6.1.2 Electric and magnetic fields 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 source 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 therefore 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.

6.1.3 However where the overhead lines cross over one another greater conductor clearances would be required to prevent flashovers. Therefore the worst case calculations presented in **Tables 3.1 and 3.2** would be reduced because the conductor clearances would be higher. Even considering the worst case situation of the maximum electric and magnetic fields from both the proposed 400 kV and existing 132 kV overhead lines, i.e. the highest EMFs encountered along the route, these combined fields would still be compliant with requirements of NPS EN-5 as set out in **Section 1.3.**

6.1.4 Therefore the cumulative impact of all of the components of the proposed development and any interactions with other developments which produce lower EMFs are not significant.

6.1.5 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 will not be significant.

7 CONCLUSIONS

7.1.1 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. 1.2).

7.1.2 The assets associated with the proposed development would be fully compliant with the Government policy. Specifically, all the fields produced would be below the relevant exposure limits, and the proposed overhead lines would comply with the policy on optimum phasing. Therefore there would be no significant EMF effects resulting from this proposed development.

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