SP MANWEB

The North Wales Wind Farms Connection Project

Environmental Statement Chapter 14 - Electric and Magnetic Fields

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The North Wales Wind Farms Connection Project

Environmental Statement

Chapter 14 Electric and Magnetic Fields

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DCO Document Reference	Appendix	Document
6.27	14.1	Electro Magnetic Field Study 2014

Reference is also made to the following documents:

DCO Document Reference	Document
5.1	Consultation Report (March 2015)

14 ELECTRIC AND MAGNETIC FIELDS

14.1 Introduction

14.1.1 This chapter assesses the potential effects of electric and magnetic fields (EMFs) associated with the construction, operation and decommissioning of the proposed development.

14.1.2 This chapter describes the methods used to assess the environmental effects, the baseline conditions which currently exist and the potential direct and indirect effects of the development arising from EMFs. The assessment explains why no mitigation measures are required to prevent, reduce, or offset the effects and the residual effects. The chapter also includes a cumulative assessment.

14.1.3 EMFs are produced both naturally and as a result of human activity. The earth has both a magnetic field (produced by currents deep inside the molten core of the planet) and an electric field (produced by electrical activity in the atmosphere, such as thunderstorms).

14.1.4 Electric fields are produced by voltage. Voltage is the pressure behind the flow of electricity. It can be likened to the pressure of water in a hose. Electricity in UK homes is at a voltage of 230 volts (V), but outside homes it is distributed at higher voltages, from 11,000 volts (usually written 11kV) up to 400,000 volts (400kV). Generally, the higher the voltage, the higher the electric field. Electric fields are measured in volts per metre (V/m).

14.1.5 Magnetic fields are produced by current, which is the flow of electricity. Current, which is measured in amperes or amps, can be likened to the flow of water in a hose when the nozzle is open. Generally, the higher the current, the higher the magnetic field. Magnetic fields are measured in microteslas (μT).

14.2 Legislation and Policy Background

14.2.1 The UK Government sets guidelines for exposure to EMFs in the UK on advice from Public Health England. In March 2004 the UK adopted the 1998 guidelines published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and this policy was reaffirmed by a Written Ministerial Statement in October 2009. These guidelines also form the basis of a 1999 European Union Recommendation on public exposure and a Directive on occupational exposure.

14.2.2 Whilst there are no statutory regulations in the UK that limit the exposure of people to power frequency electric or magnetic fields, it is the policy of SP Manweb and the UK electricity industry to follow these independent exposure guidelines. In 2010, ICNIRP produced new guidelines. However, these do not automatically take effect in the UK and UK policy remains based on 1998 ICNIRP until the Government decides otherwise.

14.2.3 National Policy Statements (NPSs) are produced by the UK Government and include the Government's policy for the development of nationally significant infrastructure. There are 6 NPSs for energy infrastructure and two are of relevance for the Proposed Development; Overarching National Policy Statement for Energy (EN-1) and National Policy Statement for Electricity Networks Infrastructure (EN-5).

14.2.4 Table 14.1 below sets out sections of NPS (EN-1)[1] (reference table 14.1) that are relevant to this assessment.

Table 14.1 Compliance with NPS (EN-1) Requirements

NPS EN-1 Section	Covered in ES Section
Para 4.13.2 Where the proposed project has an effect on human beings, the ES should assess these effects for each element of the project, identifying any adverse health impacts, and identifying measures to avoid, reduce or compensate for these impacts as appropriate.	Health effects associated with EMFs are assessed in Section 14.7. The residual effects are reported in Section 14.10

14.2.5 The UK Government incorporated in NPS (EN-5)[2] (reference table 14.1) the exposure limits and other policies they expect to see applied. NPS (EN-5) gives clear guidance on the EMF requirements of all electricity infrastructure projects.

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

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

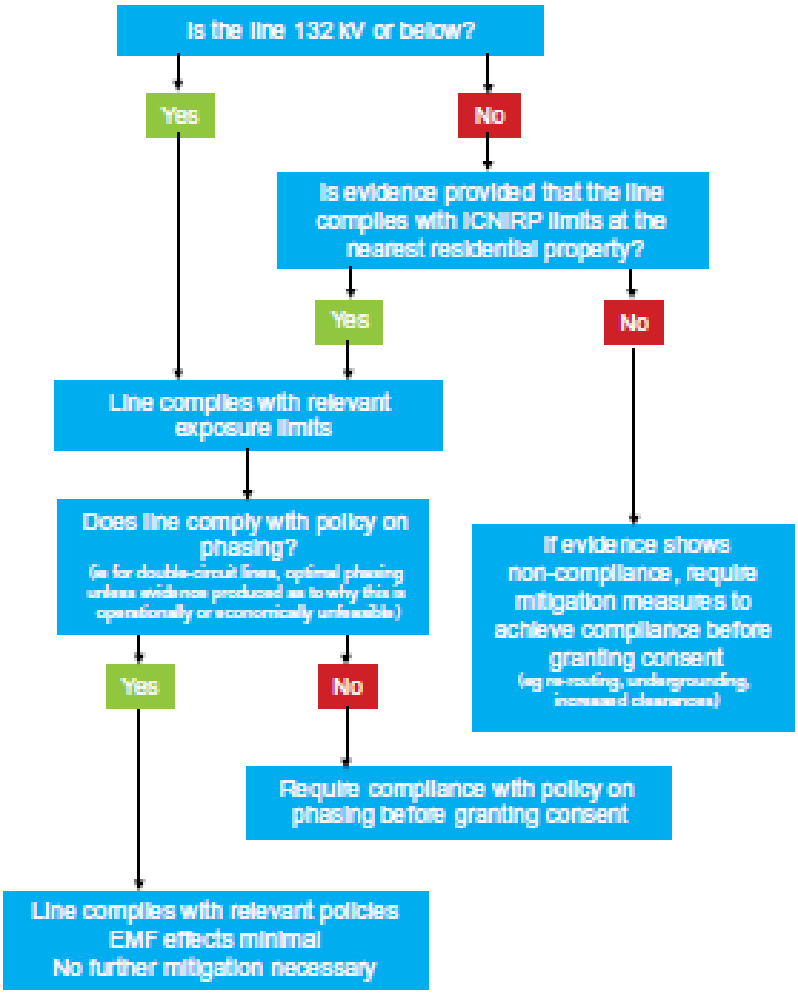
14.2.6 Table 14.2 sets out the sections of NPS (EN-5) that are relevant to this assessment.

Table 14.2 Compliance with NPS (EN-5) Requirements

NPS EN-5 Section	Covered in ES Section
Para 2.10.9 The IPC 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.	Section 14.4 sets out how the Proposed Development has been designed and assessed in accordance with the Code of Practice. The 2011 Code of Practice has now been replaced with a 2012 edition.
Para 2.10.10 The IPC should satisfy itself that the proposal is in accordance with the ICNIRP (1998) guidelines	Section 14.7 explains that all of the EMFs produced comply with the UK Government adopted ICNIRP 1998 guidelines and relevant policies.
Para 2.10.11 The Government has developed with industry a voluntary Code of Practice, "Optimum Phasing of high voltage double-circuit Power Lines – A Voluntary Code of Practice", published in February 2011 that defines the circumstances where industry can and will optimally phase lines with a voltage of 132 kV and above. Applicant should demonstrate compliance with this.	The Proposed Development is one single electrical circuit and phasing is not relevant for these types of overhead lines.
Para 2.10.14 The diagram at the end of section 2.10 shows a basic decision tree for dealing with EMFs from overhead power lines to which the IPC can refer.	Section 14.2 Replicates the decision tree and forms the basis for the assessment. The decision tree shows that 132 kV overhead lines comply with the exposure limits and no further evidence is required.
Para 2.10.15 The applicant should have considered the following factors:	See below

Table 14.2 Compliance with NPS (EN-5) Requirements	
NPS EN-5 Section	**Covered in ES Section**
- Height, position, insulation and protection (electrical or mechanical as appropriate) measures subject to ensuring compliance with the Electricity Safety, Quality and Continuity Regulations 2002	Sections 14.4 and 14.5 explains that the Proposed Development has been designed to comply with the Electricity Safety, Quality and Continuity Regulations 2002. The minimum conductor clearance is provided in Section 14.5
- 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;	The Proposed Development is one single electrical circuit and phasing is not relevant for these types of overhead lines
- Any new advice emerging from the Department of Health relating to Government policy for EMF exposure guidelines.	Section 14.2 explains the policy and legislation that has been used for this assessment. Section 14.3 sets out the consultation undertaken with the relevant UK Government Agencies responsible for health and radiation. Section 14.4 explains that the assessment has been carried out against the current UK 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.	Section 14.7 shows that the Proposed Development has been shown to be compliant with the current public exposure guidelines of ICNIRP 1998. The Proposed Development is one single electrical circuit and phasing is not relevant for these types of overhead lines

14.2.7 NPS (EN-5) provides a simplified route map for dealing with EMFs at voltages of 132 kV and below that comply with the relevant exposure limits. It is shown below.



14.2.8 NPS (EN-5) does not require evidence to be provided for 132 kV or below overhead lines as they are deemed to comply with relevant exposure limits. The Proposed Development includes a single-circuit overhead line and therefore optimal phasing is not relevant. SP Manweb has carried out calculations on the potential levels of EMFs to provide evidence to show that the line complies with the ICNIRP limits.

14.2.9 Practical details of how the UK Government policy on EMFs is to be implemented are contained in a Code of Practice[3] (the Code) agreed between the electricity industry and the UK Government. 'Power Lines: Demonstrating compliance with EMF public exposure guidelines a voluntary Code of Practice, March 2012. This document was developed following publication of the UK Government response to the Stakeholder Advisory Group on extremely low frequency electric and magnetic fields (ELF EMFs)(SAGE) First Interim Assessment: Power Lines and Property, Wiring in Homes and Electrical

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

Equipment in Homes, published in June 2007. It sets out what will be regarded as suitable evidence of compliance with these exposure guidelines as far as the electricity system is concerned.

14.2.10 The Code sets out when specific evidence of compliance is required. For overhead lines at voltages up to and including 132 kV (kilovolts) compliance with exposure guidelines are assumed unless evidence is brought to the contrary in specific cases. The EMF.info website maintains a publicly-available list 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[4].

14.2.11 SP Manweb acknowledges that concerns have been raised during consultation on the Proposed Development in relation to EMFs. Consultation responses from government agencies have also requested calculations on EMF levels for the overhead line. As such, SP Manweb will be carrying out an assessment of the EMF levels to provide evidence that the Proposed Development complies with the exposure guidelines.

14.2.12 A second Code of Practice exists ('Optimum Phasing of high voltage double-circuit Power Lines – A Voluntary Code of Practice", published in March 2012)[5]. The document replaces the February 2011 document referenced in NPS (EN-5). It is relevant only for double-circuit overhead lines and as the Proposed Development includes a single-circuit overhead line, it is not considered relevant and as such not addressed in this assessment.

14.3 Consultation

14.3.1 SP Manweb prepared a Scoping Report (January 2014) as part of the scoping phase of the environmental impact assessment (EIA). The document set out the proposed approach to the EIA for the Proposed Development including the assessment methods for the EIA topics.

14.3.2 Since 2012, SP Manweb has carried out three stages of consultation on the Project with certain statutory bodies, PILs and the local community. The first two stages of pre-application consultation were 'non-statutory' iterative consultation used to help refine the Proposed Development from route corridor options, to a preferred route corridor, to a proposed route alignment.

14.3.3 In 2014, SP Manweb carried out statutory consultation on the Proposed Development under sections 42, 47 and 48 of the Act. This consultation was carried out on the Project's proposed route alignment(s), including two route options near to the village of Henllan. The consultation started on 20 March 2014 and ran until 28 June 2014.

14.3.4 The Consultation Report (DCO Document Ref 5.1) sets out in more detail the three stages of consultation and reports on public comments received during the three stages on a variety of themes including EMFs.

[4] http://www.emfs.info/sources/overhead/specific/132-kv/

5 Department of Energy and Climate Change. Optimum Phasing of high voltage double-circuit Power Line. A Voluntary Code of Practice, London, 2012.

14.3.5 No comments relevant to EMFs were received from consultee bodies during Stage 1 (non-statutory) consultation. For Stage 2 (non-statutory) consultation NHS Wales and Public Health England provided representations on EMFs. For Stage 3 NHS Wales, Public Health England and Denbighshire County Council all provided representations on EMFs. Table 14.3 provides a summary of the main Scoping, non-statutory and statutory consultation representations received in relation to EMFs and SP Manweb's response.

Table 14.3 Summary of Main EMF Scoping, Non-statutory and Statutory Consultation Representations

Organisation	Representation	SP Manweb Response
Planning Inspectorate (Scoping Opinion)	No receptors have been identified in this section of the Scoping Report. These should be clearly identified in the ES and potential impacts assessed.	Section 14.4.11 identifies the receptors for the assessment.
Public Health England	PHE's view is that the assessments undertaken to inform the ES should be proportionate to the potential impacts of the project. Where a promoter determines that it is not necessary to undertake detailed assessment(s) (e.g. undertakes qualitative rather than quantitative assessments), if the rationale for this is fully explained and justified within the application documents, then PHE considers this to be an acceptable approach.	SP Manweb has carried out a full assessment of the impacts of EMFs.
	Provided a framework for considering the health impact associated with the proposed development, including the direct and indirect effects of the electric and magnetic fields.	Section 14.4 shows that the assessment has been carried out with reference to the relevant guidelines and Section 14.7 shows that the Proposed Development is within the ICNIRP exposure limits.

Organisation	Representation	SP Manweb Response
Public Health England	PHE notes that SP Manweb intends to calculate the electric and magnetic fields from the equipment using the conditions set out in the DECC Code of Practice 'Power Lines: Demonstrating Compliance with Public Exposure Guidelines'.....PHE will comment further when these calculations become available.	Section 14.4 sets out the approach to the calculations in line with the Code of Practice. Table 14.4contains the calculations. The Proposed Development complies with the Code of Practice and the EMF levels for the overhead line are below the ICNIRP exposure limits.
	PHE notes the intention to design the equipment such that the electric and magnetic fields comply with the ICNIRP exposure guidelines for the general public, which is consistent with Government policy.	Section 14.4.12 sets out how the 132 kV Overhead Line will be designed such that it complies with the ICNIRP exposure limits.
NHS Wales	Provided generic considerations to be addressed when preparing an ES.	Considerations are the same as those provided by Public Health England. Section 14.4 shows that the assessment has been carried out with reference to the relevant guidelines and Section 14.7 shows that the Proposed Development is within the ICNIRP exposure limits.

Organisation	Representation	SP Manweb Response
NHS Wales	The Health Board notes that SP Manweb intends to calculate the electric and magnetic fields from the equipment using the conditions set out in the DECC Code of Practice 'Power Lines: Demonstrating Compliance with Public Exposure Guidelines'.....PHE will comment further when these calculations become available.	Section 14.4 sets out the approach to the calculations in line with the Code of Practice. Table 14.4 contains the calculations. The Proposed Development complies with the Code of Practice and the EMF levels for the overhead line are below the ICNIRP exposure limits.
Denbighshire County Council	The EMF issue needs to be highlighted and they should clearly state that they are using a precautionary approach to the matter.	SP Manweb have carried out a full assessment of the potential effects of EMFs. Section 14.7 explains that the Proposed Development is within the ICNIRP exposure limits.
	All properties which are in close proximity to the route alignment should be clearly identified and the Council would request information is clearly presented in the ES with respect to the level of risk to public health from EMF. The assessment should have regard to the proximity of overhead lines to garden areas as well as residential properties.	Section 14.4 explains the background to EMFs and the research that has been carried out into the health effects. Section 14.7 explains the levels of EMFs for the Proposed Development. Section 14.7 explains that the maximum EMF calculations are within the exposure limits and as such no minimum lateral distance from the 132 kV Overhead Line is required in order to achieve compliance.

Organisation	Representation	SP Manweb Response
Llangernyw Community Council	Is concerned about the positioning of pylons and electric cables above ground.....it will have an effect on people's and children's health – particularly as it is close to houses and schools (magnetic effects in the air)	Section 14.4 explains the background to EMFs and the research that has been carried out into the health effects. Section 14.7 explains that the Proposed Development is within the ICNIRP exposure limits
Henllan Community Council	Henllan Community Council require independent consultation / investigation to be carried out on the affects the cables have on health. The power-lines will be within 600 metres of the community recreation area.	Section 14.4 explains the methodology for the EMF calculations. The Proposed Development does not follow the route alignment closest to Henllan and as such is now over 1.5km away from the community recreation area.

14.4 Methodology

Exposure Limits

14.4.1 Exposure to the general public in the UK should comply with the ICNIRP 1998 exposure limits in the terms of the 1999 EU Recommendation. The ICNIRP provides reference recommended exposure levels for the general public as follows:

- Basic restriction (induced current density in central nervous system) 2mA/m^2 for electric fields and magnetic fields;
- Reference level (external unperturbed field)
    - 5,000V/m (5kV/m) for electric fields; and
    - 100 microteslas (μT) for magnetic fields
- **Field corresponding to the basic restriction**
    - **9,000V/m (9kV/m) for electric fields**
    - **360μT for magnetic fields**

14.4.2 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. This is described as the “basis restriction”.

14.4.3 The ICNIRP guidelines also contain values of the external fields. For the public, the reference level for electric fields is 5kV/m, and 100 μT for magnetic fields. The reference levels are not limits but are guides to when detailed investigation of compliance with the actual limit, the basis restriction, is required.

14.4.4 The permitted levels of exposure (basis restriction) are somewhat higher, 360 microteslas and 9000 volts per metre. These are the fields levels with which overhead power lines shall comply where necessary.

14.4.5 These guidelines are designed to ensure that EMFs do not interfere with nerves, but were set after examining all the evidence, including the evidence on cancer. The occupational limits are five times higher, therefore, where the fields are compliant with the public guidelines, any occupational activities will also be compliant with the relevant guidelines.

14.4.6 It is the policy of SP Manweb and the electricity industry to follow these independent exposure guidelines. The Code of Practice, adopted jointly by industry and UK Government, sets out all the practical details needed to apply the exposure limits. All exposures in homes already comply with the ICNIRP guidelines. The electricity industry designs all new equipment to comply with the UK Government guidelines as set out in the Code of Practice.

14.4.7 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 by the World Health Organisation 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 UK Government has addressed this uncertainty by adopting precautionary measure relating to various sources of EMFs.

14.4.8 The only specific precautionary measure relating to overhead lines is optimal phasing. As described above, the Proposed Development is a single-circuit overhead line and as such optimal phasing cannot be applied to this project as it relates to double-circuit overhead lines only.

14.4.9 The balance of scientific evidence over several decades of research has not proven a causal link between EMFs and cancer or any other disease. Public Health England provides advice to the UK Government on standards of protection for exposure to non-ionizing radiation, including EMFs arising from overhead lines. Public Health England keeps under review emerging scientific research and/or studies that may link EMF exposure with various health problems and provides advice to the Department of Health on the possible need for introducing further precautionary measures.

14.4.10 The Department of Health does not consider that overhead line EMFs constitute a significant hazard to the operation of pacemakers. There is little evidence that exposure of crops, farm animals or natural ecosystems to overhead line EMFs has any agriculturally significant consequences.

14.4.11 The UK Government have specifically rejected the introduction of "corridors" around overhead lines on EMF grounds and consider this option to be disproportionate in the light of the evidence base on the potential health risks.

Study Area

14.4.12 The Study Area for the EIA is asset rather than location-specific and includes consideration of any changes in the Final Route Alignment that could occur within the Limits of Deviation for the Proposed Development. The assessment looks at the levels of EMFs produced by the 132 kV Overhead Line (the asset) rather the levels at specific locations along the route of the Proposed Development. The Study Area includes all areas where the EMFs could potentially extend from the electrical assets of the Proposed Development. The assessment considers the EMFs produced from the 132 kV Overhead Line only as this is considered the only aspect of the Proposed Development that has the potential to produce EMFs.

14.4.13 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. This produces a bell-shaped curve when shown on a diagram.

14.4.14 For the purposes of this EIA, and to relate the measurements to the ICNIRP guidelines, sensitive receptors are deemed to be the general public. This includes local residents, workers businesses, tourists, walkers and all other people living, working and travelling through the area.

14.4.15 The assessment is not dependent on the exact routeing of the overhead line and therefore the exact location of properties (either existing or with planning permission) is not required. The assessment will show that the overhead line is compliant everywhere not just outside a specific distance.

Overhead Line Design

14.4.16 The 132 kV Overhead Line design is based on the double wood pole design (also known as the Heavy Duty Wood Pole). Further detail on the design is given in Chapter 2 'Description of the Proposed Development' of this ES. The Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR) impose requirements regarding the installation and use of electrical networks and equipment owned or operated by distributers such as SP Manweb. For 132 kV overhead lines the minimum height above ground is required to by 6.7m. ESQCR also require any part of a 132 kV Overhead Line which is not connected with earth to be supported or surrounded by insulation, insulted that it is protected or adequately protected to prevent danger. The height, position, insulation and protection (electrical or mechanical) of the proposed design are described to show compliance with ESQCR.

Calculations

14.4.17 Calculations are the best way of assessing the impact of EMFs for overhead lines and underground cables, which have a simple defined field geometry. For this assessment the calculations follow the code of Practice for Compliance and are based on the methodology described in Chapter 8 of the EPRI Red Book (EPRI, 1982). Appendix 14.1 Electro Magnetic Field Study, Motts 2014 explains in detail the approach to calculations (DCO Document Ref 6.27).

14.4.18 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.

14.4.19 Government policy is that the ICNIRP guidelines for the general public will be observed in areas where the land use is such that exposure might be for a significant period of time. Therefore, it is not appropriate to assess compliance for extreme, rare, or unlikely situations. Accordingly, for the purposes of compliance with Government policy, field levels will be assessed:

- For electric fields: for nominal voltage and, for overhead lines, design minimum clearance (excluding reduced clearances that occur only during exceptional ice loading);

- For 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, for overhead lines, design minimum clearance;

- For both electric and magnetic fields: for 1 m above ground level on a plain, level surface;

- For both electric and magnetic fields: for the 50 Hz field only, ignoring harmonics.

14.4.20 This assessment will provide a calculation of the maximum fields (i.e. directly under the line). If this maximum value is less than the ICNIRP guideline levels, it may be assumed that all fields and exposures from that source will be compliant. If this maximum value exceeds the ICNIRP guideline levels, then it is also necessary to provide a calculation of the field at the location of the closest property at which the public exposure guidelines apply.

14.4.21 The analysed span was modelled on plain ground based on 13.0m poles with 2.5m burial depth (10.5m height above ground) which represents the lowest possible height, and therefore worst case, for the following span length. The analysed span is 120m long which, considering the geometry and thermal characteristics of the conductors represents the worst case condition (6.7m ground clearance from OPGW conductor at mid span, limited by the Electricity Safety, Quality & Continuity Regulations 1992[6]).

14.4.22 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 the Code of Practice. Equally, as specified in NPS (EN-5), if the Proposed Development complies with the exposure limits, EMF effects are assessed not significant and no mitigation is necessary.

14.5 Baseline Context

Baseline Environment

14.5.1 The Proposed Development is located within a rural area which accommodates existing electrical assets. All equipment that generates, distributes or uses electricity produces EMFs. The UK power frequency is 50 Hz which is the principal frequency of the EMFs produced.

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

[6] Electricity Safety, Quality & Continuity Regulations, 1992

14.5.3 As detailed earlier in this 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 – 0.2 μT with an average of approximately 0.05 μT, normally arising from currents in the low-voltage distribution circuits that supply electricity to homes. The highest magnetic fields to which most people are exposed arise close to domestic appliances that incorporate motors and transformers. For example, close to the surface, fields can be 2000 μT for electric razors and hair dryers, 800 μT for vacuum cleaners, and 50 μT for TVs and washing machines. The electric field in most homes is in the range 1-20 V/m, rising to a few hundred V/m close to appliances.

Overhead Line Design

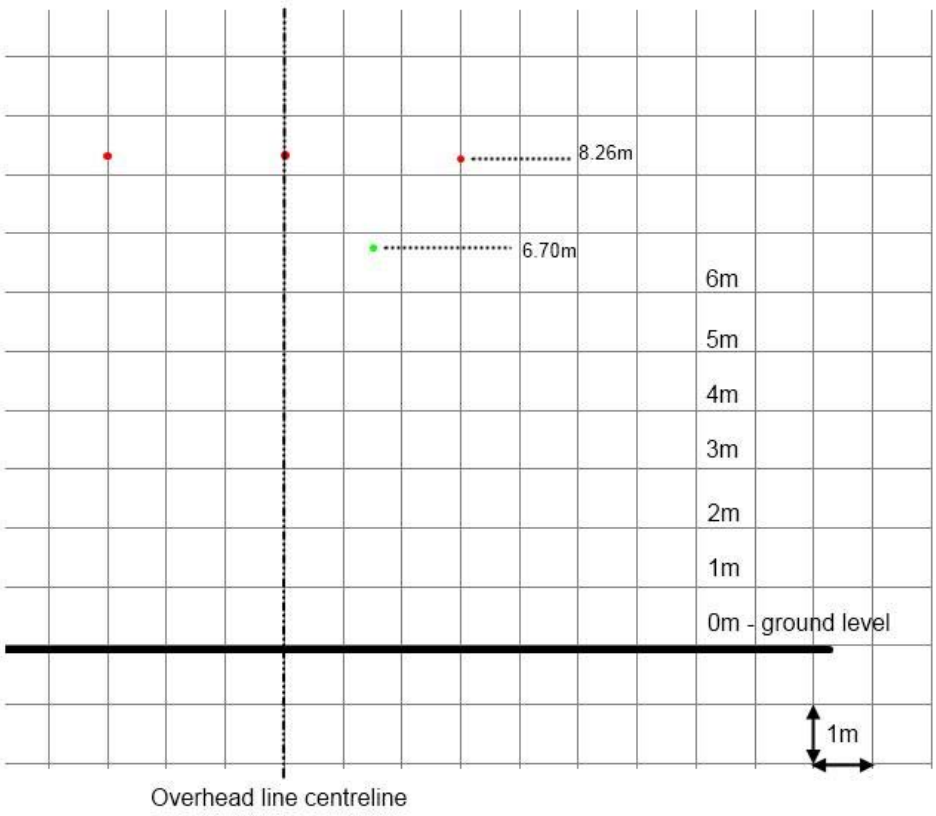
14.5.4 The overhead line design will influence the EMFs produced due to the capacity of a design and the height of the structure from the ground. As described in Chapter 2 'Description of the Proposed Development' a double wood pole design is proposed for the 132 kV Overhead Line.

14.5.5 The calculations were based on a 300sq.mm 'UPAS AAAC' conductor and an 'AACSR-ACS 190-48 2C KEZIAH' earth wire. The insulator used was a 125kN tension insulator set. Further information on the overhead line design, conductor, earth wire and insulator can be found in Appendix 14.1 (DCO Document Ref 6.27).

14.5.6 For the purposes of the calculations a worse case condition is assessed, i.e. the shortest pole with the longest span (creating the minimum ground clearance of 6.7m). The analysed span was modelled on plain ground based on 13.0m poles with 2.5m burial depth (10.5m height of pole above ground). The analysed span is 120m long which, considering the geometry and thermal characteristics of the conductors represents the worst case condition (6.7m ground clearance from the earth wire at mid span).

14.5.7 The calculations of the fields is based on the wires at their maximum sag (i.e. lowest position) and considered a maximum voltage of 145kV and rated phase current of 770Amp. These parameters represent a worse case condition and therefore reflect the maximum fields that will be generated by this type of wood pole design. The position of conductors at mid span (60m from each support, where ground clearance is at its minimum is shown in Figure 14.1. Information on the conductors and the insulator drawings are included in Appendix 14.1. The 132 kV Overhead Line has insulators on each double wood pole structure and the earth wire also contains a fibre optic cable that allows remote protection of the line.

Figure 14.1 Position of wires (red) and earth wire (green) used for EMF calculations.



14.6 Embedded Mitigation

14.6.1 As described in Chapter 4 'EIA Methodology' mitigation has been considered as an integral part of the overall design strategy of the 132 kV Overhead Line, not just 'add-on' measures to ameliorate significant environmental effects. The choice of the overhead line design is one such decision, with a wood pole being used instead of the more typical steel lattice tower design. From an EMF perspective, the use of a steel tower would allow a larger capacity of electricity to flow along the circuit and therefore increase the level of EMFs.

14.7 Assessment of Effects

Construction Effects

14.7.1 During construction and prior to energising, electrical equipment will not be transmitting electricity and therefore will not produce any EMFs; therefore this is not considered further.

Operational Effects

14.7.2 132 kV overhead lines are specified in the Code of Practice (Ref. 14.3) as a type of equipment that is inherently compliant with Government exposure limits due to the design. However, SP Manweb acknowledges that concerns have been raised during consultation on the Proposed Development in relation to EMFs. Consultation responses from government agencies have also requested calculations on EMF levels for the 132 kV Overhead Line. As such, SP Manweb has carried out the assessment of the EMF levels to provide evidence that the Proposed Development complies with the ICNIRP exposure guidelines.

14.7.3 As described above, the 132 kV Overhead Line design influences the EMFs produced and the calculations performed for this assessment are based on the proposed double wood pole design. Section 14.5.5 sets out the basis for which the calculations were performed. The new single circuit 132 kV Overhead Line would be constructed using a double wood pole design, 300sqmm UPAS conductors and a KEZIAH earth wire.

14.7.4 Calculations were performed at the pre-fault rating of the UPAS conductor which is 770Amps and a nominal voltage of 145kV at 1m above ground. The highest calculated EMFs produced by the 132 kV Overhead Line using the worst case conditions are shown in Table 14.4. All calculations were performed in accordance with the conditions set out in the Code of Practice.

Table 14.4 Calculated Maximum EMFs from 132 kV Overhead Line Double Wood Pole Design

Overhead Line	Maximum Electric Field at Nominal Voltage (kV/m)	Maximum Magnetic Field at Pre-Fault Continuous Loading (μT)
Double Wood Pole Design	1.589*	15.36**

Note:

*the public exposure limit for electric fields is 9.00kV/m

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

14.7.5 The EMFs produced by the 132 kV Overhead Line decrease rapidly with distance from the overhead line. Figures 14.2 and 14.3 show the calculated magnetic and electric fields from the proposed 132 kV Overhead Line. The two figures show that the calculated fields are highest very close to the 132 kV Overhead Line and fall rapidly as the distance increases. At 10m the electric field is below 1kV/m and the magnetic field is below 6 μT. Appendix 14.1 contains all the calculated values used to produce the figures.

Figure 14.2 Calculated Electric Field RMS Values on 100m Cross-Section at Mid-Span

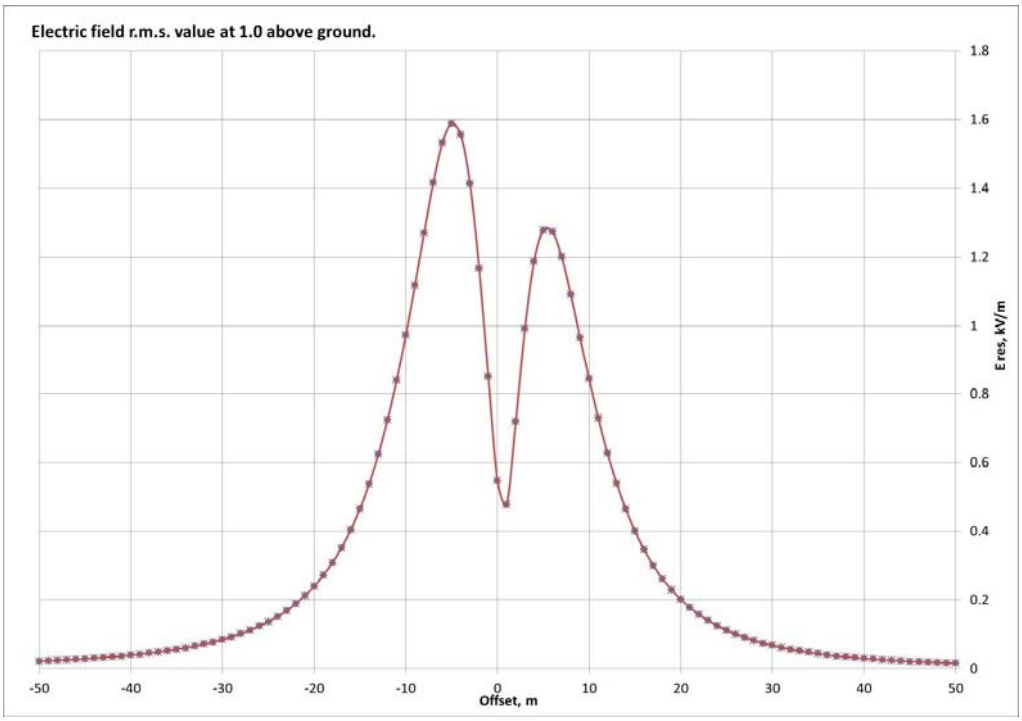
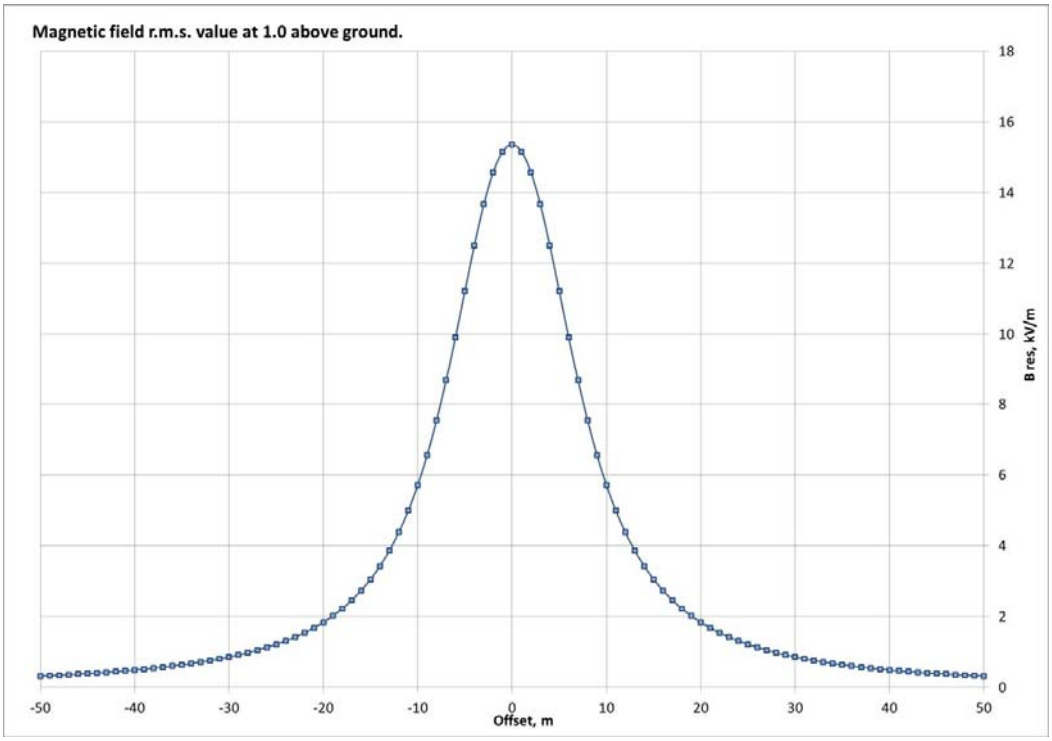


Figure 14.3 Calculated Magnetic Field RMS Values on 100m Cross-Section at Mid Span



14.7.6 The maximum EMFs produced by the proposed 132 kV overhead line would be less than the relevant public exposure limits of 9kV/m and 360 μT and therefore meets the relevant exposure guidelines, the ICNIRP general public guidelines in terms of the EU Recommendation. As the Proposed Development meets the exposure guidelines the effects are **not significant**.

14.7.7 There is no minimum lateral distance from the 132 kV Overhead Line required in order to achieve compliance. As such compliance is not dependent on the exact route of the 132 kV Overhead Line, the exact location of the nearest property (either existing or with planning permission granted) because the field from the 132 kV Overhead Line is compliant everywhere not just compliant outside a specific distance. This also means that if the 132 kV Overhead Line were to move within the Limits of Deviation set out earlier in this document no increases in the levels would occur and the effect would remain **not significant**.

Decommissioning Effects

14.7.8 When the 132 kV Overhead Line equipment is de-energised and decommissioned no EMFs would be produced. Therefore this is not considered further.

14.8 Specific Mitigation Measures

14.8.1 No mitigation is required as the Proposed Development complies with the current public exposure guidelines as detailed in NPS (EN-5). If these requirements are met NPS (EN-5) states that "no further mitigation should be necessary."

14.9 Cumulative Effects

Stage 1 Cumulative Assessment

14.9.1 The Wider Scheme elements are described in Chapter 3 of this ES. The elements associated with the Wider Scheme will also produce EMFs.

Underground Cables

14.9.2 132 kV underground cables can produce high magnetic fields directly above them than an overhead line would produce at ground level, because the physical distance from the underground cable is smaller. The field falls more rapidly with distance to the sides, and they produce no external electric field.

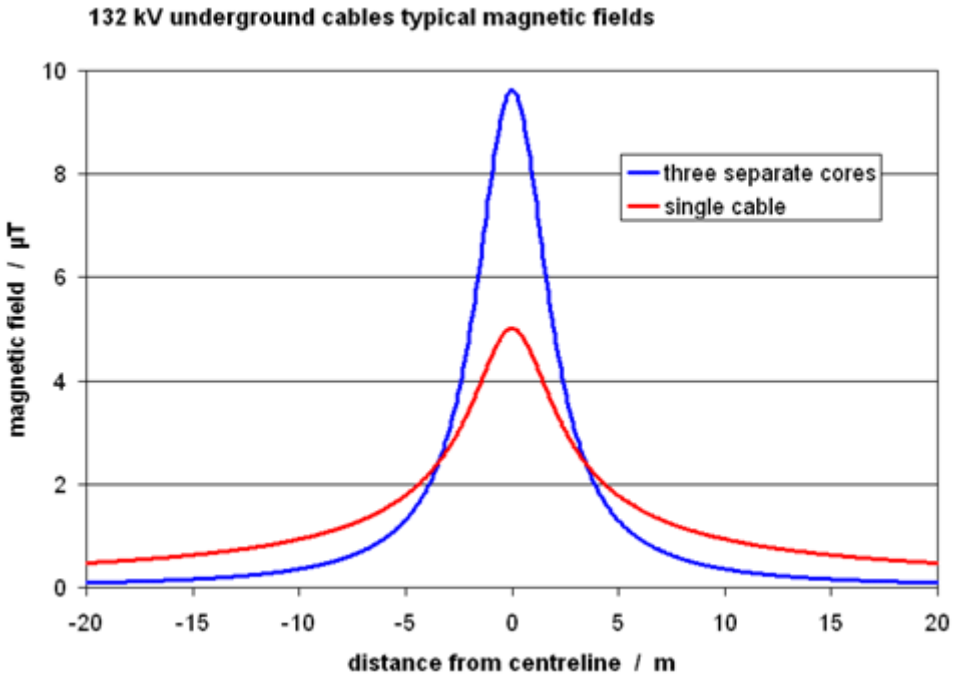
14.9.3 Two main types of cable are used at 132 kV:

- separate cores: the three conductors for the three phases are laid separately but close together in the ground, typically 1m deep; and,
- single cable: the three cores are twisted round each other in a single outer sheath.

14.9.4 With a single cable, because the cores are so close together and twisted, the fields they produce directly are very small. Instead, the field comes from any net current in the sheath. This cannot be predicted accurately.

14.9.5 Figure 14.4 shows typical fields for these two types of cable.

Figure 14.4 Typical Magnetic Fields for 132 kV Underground Cables[7]



14.9.6 Underground cables do not produce any external electric fields. Table 14.5 gives some actual magnetic field values for the same conditions with fields calculated at 1m above ground.

Table 14.5 Field Values for 132 kV underground cables

				Magnetic field in µT at distance from centreline			
				0m	5m	10m	20m
132 kV	Separate cores (flat formation)	0.3m spacing 1m depth	typical	9.62	1.31	0.36	0.09
	Single cable	1m depth	typical	5.01	1.78	0.94	0.47

[7] Source – http://www.emfs.info/sources/overhead/specific/132-kv/

Substations

14.9.7 Distribution electricity substations, such as the proposed Clocaenog Collector substation and the existing grid substation at St Asaph, generally produce up to 2 μT close to their perimeter fence and often no electric field at all. The fields fall rapidly with distance, and within 1-2m from a typical substation, the fields associated with it are usually indistinguishable from other fields present. The proposed Clocaenog Collector substation and the existing St Asaph grid substation will comply with current UK Government guidelines at all times and will be significantly within the current guidelines for permitted public exposure levels.

Lower voltage overhead electricity lines

14.9.8 Lower voltage electricity lines will need to be undergrounded or diverted to make way for the Proposed Development. Typical fields for these electricity lines vary from 7μT for the magnetic field and 700v/m for the electric field under the line to 0.01-0.05μT for the magnetic field and 10-20v/m for the electric field 25m either side of the line. The existing lower voltage overhead electricity lines will comply with current UK Government guidelines at all times and will be significantly within the current guidelines for permitted public exposure levels.

Wind Farms

14.9.9 Magnetic field levels in the vicinity of wind turbines are typically lower than those levels produced by household electrical devices. The main sources of EMFs associated with a wind farm are the 33kV underground cables that are installed to connect turbines with the wind farm substation.

14.9.10 It is anticipated that the underground cables for the Clocaenog Forest and Brenig Wind Farms will be in proximity to the Proposed Development. The Clocaenog Forest Wind Farm substation is located adjacent to the Collector Substation and will have underground cables connecting into it and to the nearby turbines. The Brenig Forest Wind Farm underground cables will run underneath the Proposed Development and head west to the Brenig Wind Farm substation. The cables for Derwydd Bach Wind Farm and Nant Bach Wind Farm exit the Collector Substation in the east and head south to their respective wind farm substation in the opposite direction to the Proposed Development. As they will not be located close to the Proposed Development they are not considered to result in any cumulative effects and are not considered further here.

14.9.11 RWE, as part of the Clocaenog Forest Wind Farm DCO application, produced a Health Impact Report[8] which detailed the likely magnetic fields for the 33kV underground cables proposed for the development. It is anticipated that the underground cables at Brenig Wind Farm will be a similar arrangement.

[8] RWE npower renewables. Clocaenog Forest Wind Farm Health Impact Report, October 2013

Table 14.6 Field Values for 33kV Underground Cables

				Magnetic field in μT at distance from centreline			
				0m	5m	10m	20m
33kV	3 cables (trefoil arrangement)	0.9m depth	typical	0.98	0.05	0.007	0.0008

14.9.12 The 33kV cables installed at Clocaenog Forest and Brenig Wind Farms, based on the nominal data presented will comply with current UK Government guidelines at all times and will be significantly within the current guidelines for permitted public exposure levels.

Assessment of Proposed Development with Wider Scheme and Proposed Wind Farms

14.9.13 All electrical assets owned and operated by SP Manweb are checked to ensure compliance with UK Government exposure limits and polices. All new equipment, both SP Manweb owned and constructed by the various wind farms, will also be required to comply with the same limits and policies. As the Proposed Development, the Wider Scheme and the wind farms will comply with these exposure limits, the impacts are assessed as **not significant**.

Stage 2 Cumulative Assessment

Single Wind Turbines

14.9.14 Magnetic field levels in the vicinity of wind turbines are typically lower than those levels produced by household electrical devices. As the turbines are singular they will only require lower voltage cable connections into the distribution network. These developments are not considered to result in any cumulative effect.

14.9.15 SP Manweb considers that all of the other major development proposals identified in Chapter 3 of this ES will 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**.

Assessment of Cumulative Effects

14.9.16 SP Manweb ensures that all electrical assets comply with the UK Government exposure limits and policies. As all of the developments defined above will comply with these exposure limits, the cumulative impacts will **not be significant**.

14.10 Summary of Residual Effects

14.10.1 The Proposed Development has been demonstrated to comply with the current public exposure guidelines as detailed in NPS (EN-5). If these requirements are met NPS (EN-5) states that "EMF effects are minimal."

14.10.2 The UK Government, acting on advice of the relevant scientific bodies, has put in place appropriate measures to protect the public from EMFs. These measures comprise compliance with the relevant exposure limits and are incorporated into NPS (EN-5).

14.10.3 The Proposed Development would be fully compliant with the UK Government policy, specifically all the fields produced would be below the relevant exposure limits. Therefore there would be **no significant EMF effects** resulting from this Proposed Development.

14.10.4 The Proposed Development, Wider Scheme and other developments identified as part of the cumulative assessment all comply with current exposure limits. Therefore there would be no significant EMF effects resulting from the Proposed Development in combination with the Wider Scheme, wind farms and other developments identified as part of the cumulative assessment.

14.10.5 NPS (EN-5) states "The balance of scientific evidence over several decades of research has not proven a causal link between EMFs and cancer or any other disease." However SP Manweb recognises that EMFs generate public concern and has carried out detailed calculations to prove the EMF levels for the Proposed Development comply with UK Government policy.