

Llandyfaelog Substation EMF Assessment



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1. Introduction

- 1.1.1 This report provides an assessment of the electric and magnetic fields (EMFs) associated with the proposed Llandyfaelog 400kV substation. This report comprises of a desktop analysis, undertaken in accordance with Government Policy and is based upon site specific design information.
- 1.1.2 National Grid has a very clear policy on EMFs, as set out in its Public Position Statement¹ which states “...*In all our operations, as a minimum we comply with EMF regulations, guidelines or practices in force in the countries and different jurisdictions in which we operate.*” and this policy would be applied to this proposed substation consisting of the new substation and modified overhead line. As is explained in more detail in Section 2 below, compliance with the relevant guidelines and practices in force in the UK ensures that there should be no significant health or environmental effects of EMFs.
- 1.1.3 The proposed 400 kV substation will be an Air Insulated Switchgear (AIS) design, with eight Super Grid Transformers (SGTs). The substation will connect to the existing overhead line network through the modification of an existing span.
- 1.1.4 All equipment that generates, distributes or uses electricity produces EMFs. The UK power frequency is 50 Hz, which is therefore the principal frequency of the EMFs produced which are also known as Extremely Low Frequency (ELF) EMFs.

Electric fields

- 1.1.5 Electric fields depend on the operating voltage of the equipment producing them and are measured in volts per metre, symbol V/m. The operating voltage of most equipment is a relatively constant value. Electric fields are shielded by most common building materials, trees and fences, and diminish rapidly with distance from the source.
- 1.1.6 As a consequence of their design, some types of equipment do not produce an external electric field. This applies to underground cables which are enclosed in a metal sheath (a protective metal layer within the cable).

Magnetic fields

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

¹ National Grid's Public Position Statement on Electric and Magnetic Fields
<https://www.nationalgrid.com/electricity-transmission/document/137286/download>

2. EMF policy and exposure limits

2.1 Overview of policy

- 2.1.1 Whilst there are no statutory regulations in the UK that limit the exposure of the general public to power-frequency EMFs, responsibility for implementing appropriate measures for the protection of the public lies with the UK Government. Government has a clear policy, documented in National Policy Statement (NPS) EN-5², on the exposure limits and other policies they expect to see applied. This Government policy explicitly applies in England and Wales. Practical details of how the policy is to be implemented are contained in a Code of Practice on Compliance³ agreed between industry and Government.
- 2.1.2 The UK Government acts on the scientific advice from the UK Health Security Agency (UKHSA), which has responsibility for advising on non-ionising radiation protection, including power-frequency EMFs. UKHSA exercise radiological protection functions across the whole of the UK. The National Radiological Protection Board (NRPB) had this responsibility until becoming part of the Health Protection Agency (HPA) on 1 April 2005, which in turn was replaced by Public Health England (PHE) on 1 April 2013, which in turn was replaced by UKHSA on 1 April 2021. This report refers to UKHSA, PHE, NRPB or HPA according to the name of the organisation at the time each statement was issued.
- 2.1.3 In 2004, following a recommendation by the NRPB, the UK Government adopted exposure guidelines for the public published in 1998 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP)⁴ in line with the terms of the 1999 European Union (EU) Recommendation⁵ on public exposure to EMFs.
- 2.1.4 In a Written Ministerial Statement in October 2009⁶, (references to the Written Ministerial Statement encompass both the Statement itself and the detailed Response that the Statement introduced) the Government restated this policy of compliance with exposure limits and, acting on the recommendations of a stakeholder process, added a single precautionary measure in relation to high voltage infrastructure; a policy of “optimum phasing” of some overhead lines. “Optimum phasing” is an engineering measure that can be incorporated in the design of some overhead lines and which reduces the EMFs they produce. The Government also made clear in the Written Ministerial Statement that no other precautionary measures are appropriate for high voltage infrastructure.
- 2.1.5 The question of whether health concerns related to electricity infrastructure justifies planning constraints is one that has been addressed at a national level. Thus, the Written

² Department of Energy Security and Net Zero. National Policy Statement for Electricity Network Infrastructure (EN-5). London, 2024.

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

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.

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.

⁶ 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

Ministerial Statement of 16 October 2009⁶, made by The Minister of State, Department of Health on behalf of herself and the Minister of State for the Department of Energy and Climate Change (now Department of Energy Security and Net Zero) and the Parliamentary Under-Secretary of State for the Communities and Local Government, introduced a comprehensive statement of Government policy. This policy has been reiterated in NPS EN-5 and applies to all electricity infrastructure, including applications made under the Town and Country Planning Act.

- 2.1.6 NPS EN-5² gives clear guidance on the EMF requirements of all electricity infrastructure projects stating:

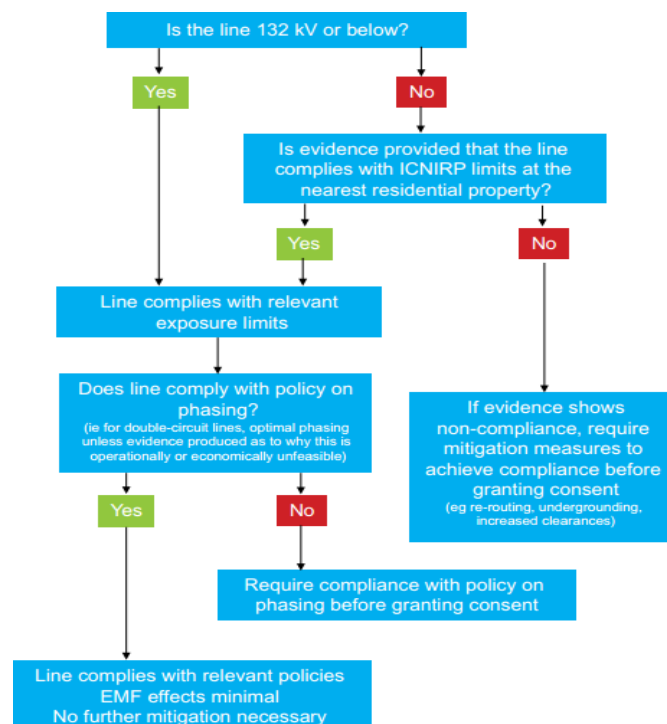
‘Before granting consent to an overhead line application, the Secretary of State should be satisfied that the proposal is in accordance with the guidelines, considering the evidence provided by the applicant and any other relevant evidence.’ (paragraph 2.11.10)

AND

‘Where the applicant cannot demonstrate that the line will be compliant with the Electricity Safety, Quality and Continuity Regulations 2002, 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 Secretary of State should not grant consent.’ (paragraph 2.11.12)

- 2.1.7 A simplified route map for dealing with EMFs is provided in NPS EN-5² and is reproduced in Figure 2.1.

Figure 2.1 : Simplified Route Map for Dealing with EMFs



2.2 Public exposure limits

- 2.2.1 The ICNIRP guidelines⁴ are explained, together with details of how to apply them, in the Department of Energy and Climate Change (DECC) Code of Practice ‘Power Lines: Demonstrating compliance with EMF public exposure guidelines – a voluntary Code of Practice’³. National Grid has ensured that it complies with Government policy on EMFs, and this Code of Practice forms an integral part of demonstrating that compliance. The assessment included in this report has been undertaken in line with the principles of this Code of Practice³.
- 2.2.2 The ICNIRP public exposure limits⁴ which apply in the UK are documented in Table 2.1

Table 2.1: Recommended Public Exposure Limits Values for Power Frequencies

Public Exposure Levels	Electric Fields	Magnetic Fields
Basic restriction (induced current density in central nervous system)	2 mA/m ²	
Field corresponding to the basic restriction	9000 V/m	360 µT

- 2.2.3 There has been extensive research in an attempt to establish whether or not long term exposure to fields at lower levels than the ICNIRP guidelines⁴ might be a cause of ill health in humans; this research has been extensively reviewed by bodies such as PHE (formerly NRPB)⁷ and the World Health Organisation (WHO)⁸. There is some evidence to suggest that high magnetic fields may be associated with an increased risk of one particular disease, childhood leukaemia. However, the weight of scientific evidence is against electric and magnetic fields causing ill health in humans at levels below the ICNIRP guideline limits⁴. The Government has addressed this uncertainty by adopting precautionary measures, set out in the Code of Practice - Optimum Phasing of high voltage double-circuit Power Lines⁹.
- 2.2.4 All relevant legislation, policies and guidance, including those contained within EN-5² have been reviewed and applied to the EMF assessment of this proposed substation.

2.3 Planning policy

- 2.3.1 The question of whether health concerns related to electricity infrastructure justifies planning constraints is one that has been addressed at a national level. Thus, the Written Ministerial Statement of 16 October 2009⁶, made by The Minister of State, Department of Health on behalf of himself and the Minister of State for the Department of Energy and Climate Change (now Department for Energy Security and Net Zero) and the Parliamentary Under-Secretary of State for the Communities and Local Government, introduced a comprehensive statement of Government policy.

⁷National Radiological Protection Board (NRPB) (2004). Review of the scientific evidence for limiting exposure to electromagnetic fields (0-300 GHz). Doc NRPB, 15(3), 1-215

⁸World Health Organisation (2007) Environmental Health Criteria Monograph No 238 on Extremely Low Frequency Fields

⁹ Department of Energy and Climate Change. Optimum Phasing of high voltage double-circuit Power Lines. A voluntary Code of Practice. London, 2012

- 2.3.2 The policy, in essence, is that new electrical infrastructure, and new developments near existing electrical infrastructure, must comply with the relevant exposure limits put in place for the protection of the public, and there is one further policy relating to the design of high-voltage overhead power lines, which is not applicable in this case. Beyond this, there are no other measures or mitigation required.
- 2.3.3 Details of what the policies mean in practice and what evidence is considered acceptable to demonstrate compliance is contained in two Codes of Practice^{3,9}. The Code of Practice on Compliance states:
- “The Electricity Industry agrees that whenever evidence is required of compliance with EMF exposure limits, it will provide evidence according to this Code of Practice. Government agrees that such evidence will be regarded as sufficient to demonstrate compliance.”* (page 2)
- 2.3.4 Thus, a local authority, faced with a planning application for a site including a substation, would be fully entitled to ask for evidence, as specified in the Code of Practice, of compliance³ with the relevant exposure limits. This report constitutes such evidence, ensuring that the health issues relating to that substation are appropriately addressed, and further restrictions on the development on health grounds, or refusal of permission on these grounds, are not appropriate.

3. Assessment Methodology

3.1 Assessment of effects

- 3.1.1 The proposed substation 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 ‘Power Lines: Demonstrating compliance with EMF public exposure guidelines – a voluntary Code of Practice³.
- 3.1.2 The UK Government’s adopted guidelines are those of ICNIRP 1998 for 50 Hz EMFs, which are produced by the electricity transmission system. These guidelines equate to a public exposure limit for uniform electric and magnetic field exposure of 9.0 kV/m and 360 μ T respectively. They apply particularly to areas where people spend significant periods of time, mainly residential properties and schools. They do not apply directly to areas where people pass infrequently such as Public Rights of Way/ pathways. However, compliance with the policy has been assessed irrespective of land use and time of exposure.

3.2 Surveys undertaken

- 3.2.1 EMFs have been assessed as per the conditions set out in the Code of Practice and compared with UK Government exposure guideline levels. This assessment is a desk-based exercise using electric and magnetic field calculation software EFC400 from Narda.
- 3.2.2 The Code of Practice states that calculations should be performed at the maximum continuous rating of the conductors, nominal voltage, 50 Hz only and at 1m above ground, which has been used for this assessment. Calculations were performed using worst case conditions including minimum conductor clearances. The circuits are unlikely to operate at

this maximum rating routinely, therefore resulting in lower typical electric and magnetic fields on a day-to-day basis.

4. Assessment of compliance with exposure limits

4.1 400 kV Substation

4.1.1 As agreed with Government under the Code of Practice³, the Energy Networks Association maintains a list of types of equipment where the design is such that it is inherently not capable of exceeding the ICNIRP exposure guidelines⁴, i.e. a list of equipment that is therefore always compliant with the guidelines, and where a detailed case-by-case demonstration of compliance is not required.

4.1.2 Substations at any voltage without reactive equipment are deemed compliant with the exposure limits. In practical terms, this means that even substations operating at the highest operating voltages and currents are not capable of producing electric and magnetic fields in excess of 9000 V/m and 360 μ T in publicly accessible areas, because of their design. Most equipment contained within substations produce very localised EMFs which reduce extremely quickly with distance, so at the perimeter fence the levels are low. Air-cored reactors are a particular type of equipment which is capable of exceeding the EMF exposure limits at the substation boundary, which is why these required further assessment. This equipment is not being installed at the proposed substation. Evidence for the demonstration of compliance with exposure guidelines is maintained at <https://www.emfs.info/exposure-limits-and-policy/compliance-with-public-limits>.

4.1.3 The assessment of compliance states:

“Substations not containing air-cored reactors

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

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

...

Smaller, lower-voltage substations: indoors

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

4.1.4 As described above, the dominant EMFs produced by a substation, outside its boundary fence, are from the overhead lines entering and exiting the site, rather than the substation equipment itself.

4.1.5 The proposed substation has the provision to have reactive equipment installed. National Grid technical specifications ensure that any such equipment is designed to ensure that maximum magnetic field levels from reactive equipment at the public boundary remain below the established public exposure limits.

4.1.6 The dominant source of EMFs entering and exiting the substation site is assessed below.

4.2 400 kV Overhead line

4.2.1 A section of 400 kV overhead line is required to be modified in order to connect the substation to the existing electricity transmission system.

4.2.2 The existing line is optimally phased, as per the conditions set out in the Code of Practice on Optimum Phasing⁹, and circuit phasing will not be modified as a result of these works, so no further assessment against this policy is necessary.

4.2.3 Energised high voltage overhead transmission lines are a source of both electric and magnetic fields. The electric field generated by an overhead line is mainly dependent on the voltage of the line and remains more or less constant once the overhead line is operational. The magnetic field will vary depending on the current flowing in the conductors. The EMFs produced by an overhead line will be highest directly under the line and will rapidly decrease at increasing distance from the line. The overhead line design will also influence the EMFs produced and a worst-case design is considered in this assessment.

4.2.4 Calculations of the EMFs from a worst-case for the modified section of the 400 kV overhead line created using Narda EFC400 software are provided.

400 kV overhead line EMF assessment

4.2.5 The existing overhead line will be modified to allow the new substation to connect to the existing transmission system via downloads and an overhead line cross under span. The modified overhead line section is a double circuit, steel lattice design which has been modified to allow connection to the substation from both circuits.

4.2.6 The minimum design clearance to ground for the modified section has been used in this assessment.

4.2.7 Calculations were performed at the worst-case pre-fault continuous rating of the conductor type and nominal voltage (400 kV) for 1m above ground. The highest calculated EMFs produced by the overhead line using the worst-case conditions are shown in Table 4.2. All calculations were performed in accordance with the conditions set out in the code of practice³.

Table 4.2: Calculated Maximum worst-case EMFs from the modified 400 kV Overhead Line

Horizontal distance from centre of overhead line	Maximum Electric Field at Nominal Voltage (V/m)	Maximum Magnetic Field at Pre-Fault Continuous Loading (μT)
Directly under overhead line circuit	8542*	110.6**

* the public exposure limit for electric fields is 9000 V/m

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

4.3 Assessment summary

- 4.3.1 The maximum magnetic fields at the boundary of the proposed substation is dominated by the overhead line that connects the site to the electricity transmission system.
- 4.3.2 The worst-case for the modified overhead line has been assessed and the maximum EMFs under those conditions are 8542 V/m and 110.6 μ T. These are below the relevant exposure limits.
- 4.3.3 The assessment presented above, demonstrates that the maximum fields produced by the proposed substation, including the associated overhead line, would be compliant with the relevant exposure limits in Table 2.1.

5. Conclusions

- 5.1.1 The Government, acting on the advice of authoritative scientific bodies, has put in place appropriate measures to protect the public from EMFs. These measures are set out in a Written Ministerial Statement, National Policy statement EN-5², and two Codes of Practice^{3,9}.
- 5.1.2 The proposed 400 kV substation is fully compliant with the Government policy on EMFs. Specifically, all the fields produced would be below the relevant exposure limits. Therefore, there will be no significant EMF effects resulting from this proposed substation and no mitigation is required.
- 5.1.3 The predominant source of exposure is the 400 kV overhead line connecting the substation to the electricity transmission system. The EMFs from the overhead line have been demonstrated as complying with the relevant exposure limits (Section 4.2).