AQUIND Limited

AQUIND INTERCONNECTOR

Environmental Statement – Volume 3 – Appendix 3.7 Onshore Electric and Magnetic Field Report

The Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 – Regulation 5(2)(a)

The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017

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APPENDIX 3.7 ONSHORE ELECTRIC AND MAGNETIC FIELD REPORT

1.1. INTRODUCTION

1.1.1.1. This Onshore Electric and Magnetic Field Report has been prepared on behalf of AQUIND Limited ('The Applicant') to support the application for a Development Consent Order ('DCO'). The application for the DCO is made in respect of the UK elements of AQUIND Interconnector Project which will operate between France and the UK.

1.1.1.2. The DCO Application for the UK elements covers the parts of the Project located onshore in the UK ('Onshore Components') and in the UK Marine area, defined as all of that part of the Project from the Mean High Water Spring ('MHWS') in the UK out to the limit of the UK/France EEZ boundary ('Marine Components'). Together the Onshore Components and the Marine Components comprise the 'Proposed Development', in respect of which the DCO Application is made.

1.1.1.3. This document provides an assessment of the electric and magnetic fields ('EMFs') due to the Proposed Development.

1.1.1.4. Calculations were performed for:

- the 400 kV High Voltage Alternating Current ('HVAC') Cables,
- the Onshore High Voltage Direct Current ('HVDC') Cables; and
- the Converter Station

1.2. BACKGROUND

1.2.1.1. EMFs, and the associated electromagnetic forces, are a fundamental part of the physical world. Their sources are electric charges (source of the electric field) and the movement of those charges (source of the magnetic field). Electromagnetic forces are partly responsible for the cohesion of material substances and they mediate all the processes of chemistry, including those of life itself. EMFs occur naturally within the body in association with nerve and muscle activity. People are also exposed to the natural magnetic field of the Earth (to which a magnetic compass responds) and natural electric fields in the atmosphere.

1.2.1.2. It has become common practice to report magnetic fields in units of microtesla ('µT') or nanotesla ('nT'). One nanotesla is one thousandth of a microtesla. Microtesla is used throughout this Appendix.

1.2.1.3. Electric-field strengths are measured in volts per metre (V/m) or kilovolts per metre (‘kV/m’). Atmospheric static or “DC” electric fields at ground level are normally between 10 – 130 V/m in fine weather and may rise to many thousands of volts per metre during thunderstorms.

1.2.1.4. The direction of the Earth’s magnetic field is normally constant, varying in size only slowly over time, and is referred to as a static or “DC” field. The Earth’s magnetic field is approximately 50 µT in the UK. Other fields that alternate in their intensity more frequently over time are referred to as alternating or “AC” fields.

1.2.1.5. All wiring, equipment, and other conductors connected to the electric power system are sources of EMFs. The fundamental power frequency of AC systems is 50 Hertz (‘Hz’) corresponding to the extremely low frequency (‘ELF’) range. DC equipment produces static fields which do not vary in time.

1.2.1.6. Fields due to electrical equipment add to (or modulate) the Earth's steady natural fields. The strength (or amplitude) of the electric-field modulation depends on the voltage of the transmission equipment. As the voltage level supplied to power conductors is regulated, the electric field remains more or less constant as long as the equipment is energised. Conversely, the strength of the magnetic-field modulation depends on the current (often referred to as the load) carried by the equipment, which varies according to the demand for power at any given time.

1.3. PUBLIC EXPOSURE LIMITS

1.3.1. EXPOSURE LIMITS FOR ALTERNATING (AC) FIELDS

Policy

1.3.1.1. In the UK, there are presently no statutory regulations to limit public exposure to power-frequency electric or magnetic fields, the limits to be considered apply as a matter of government policy.

1.3.1.2. In 2004 the National Radiological Protection Board (‘NRPB’) provided advice to Government (National Radiological Protection Board, 2004)], recommending the adoption in the UK of public exposure guidelines published in 1998 by the International Commission on Non-Ionizing Radiation Protection (‘ICNIRP’) (International Commission on Non-Ionizing Radiation Protection, 1998) in terms of the 1999 EU Recommendation (The Council of the European Union, 1999) when the time of exposure is significant.

1.3.1.3. The guidelines were designed to set conservative exposure levels for the general public to low frequency electric and magnetic fields. The guideline levels are endorsed by the UK’s Health Protection Agency (‘HPA’), the World Health Organisation (‘WHO’), and the UK Government.

1.3.1.4. In 2010, ICNIRP produced new guidelines which are less conservative; but these do not automatically take effect in the UK. The UK policy for public exposure remains in accordance with 1998 guidelines until Government decide otherwise.

Applicable Limits

1.3.1.5. ICNIRP define the "basic restriction" as the maximum current density which may be induced in the central nervous system of an individual "when the time of exposure is significant". The basic restriction for public exposure is 2 mA/m^2 which includes a factor of safety of 5 beyond what is allowed for occupational exposure.

1.3.1.6. Current density however, is a quantity that cannot realistically be measured in people, so ICNIRP also provide 'Reference Levels' of external fields which can be directly measured. Reference Levels are conservative values that would, under all normal circumstances, be expected to induce current densities significantly less than the basic restriction. These reference levels at 50 Hz are 5 kV/m for electric fields and 100 µT for magnetic fields.

1.3.1.7. The magnitude of external fields required to produce a current density equivalent to the basic restriction were calculated by HPA; it is these limits which apply in the UK.

1.3.1.8. **The absolute public exposure limit of external 50 Hz fields which apply in the UK are 9 kV/m for electric fields and 360 µT for magnetic fields. Limits apply where the time of exposure is significant.**

1.3.2. EXPOSURE LIMITS FOR STATIC (DC) FIELDS

Policy

1.3.2.1. UK Government's policy on exposure limits to static fields is based upon the 1999 EU Recommendation (The Council of the European Union, 1999) and NRPB's 2004 advice (National Radiological Protection Board, 2004) to implement the 1994 ICNIRP exposure guidelines for members of the public for static magnetic fields (International Commission on Non-Ionizing Radiation Protection, 1994) when the time of exposure is significant.

1.3.2.2. ICNIRP recommended in the 1994 guidelines that:

> "*continuous exposure of members of the general public should not exceed a magnetic flux density of 40 mT*", i.e. 40,000 µT.

1.3.2.3. Therefore, **the absolute public exposure limit of external static magnetic fields which apply in the UK is 40,000 µT, where the time of exposure is significant.**

1.3.2.4. Although the public exposure limit for static magnetic fields was increased by a factor of 10 to 400,000 µT in the 2009 ICNIRP publication, UK guideline limits remain at the lower value in accordance with the 1999 EU Recommendation.

1.3.2.5. The 1999 EU Recommendation does not set any limits for static electric fields. Instead, there is a statement:

> "*No E-field value is provided for frequencies <1Hz, which are effectively static electric fields. For most people the annoying perception of surface electric charges will not occur at field strengths less than 25 kV/m. Spark discharges causing stress or annoyance should be avoided*."

1.3.2.6. No limits for static electric fields are given in the NRPB's 2004 advice either, but it states:

> "*Where direct perception of static electric fields causes annoyance, or indirect effects of electrostatic discharge cause pain, it is important to reduce the possibility of occurrence of these effects. The threshold for perception of static electric fields is around 20 kV/m, and sensations become annoying above about 25 kV/m*."

1.3.2.7. The ICNIRP however suggest that static electric fields are perceptible at levels as low as 10 kV/m.

1.3.2.8. WSP suggest that the static electric fields are compared with the possible precaution**ary perceptible level of 10 kV/m.**

Demonstrating Compliance

1.3.2.9. A UK voluntary Code of Practice (Department of Energy & Climate Change , 2012) describes how compliance with the exposure limits may be demonstrated including details of acceptable calculations and the conditions that shall apply.

1.4. ASSESSMENT METHODOLOGY

1.4.1. METHODOLOGY

1.4.1.1. The appraisal methodology is in accordance with the industry Code of Practice on Compliance (Department of Energy & Climate Change , 2012) which specifies that compliance should be specifically demonstrated for cables above 132 kV and substations containing air-cored reactors.

1.4.1.2. Profiles of electric and magnetic field strengths were calculated using standard equations based on fundamental concepts.

1.4.1.3. The acceptability of the prospective field strengths was determined by comparing the results of the calculations with the appropriate exposure limits as detailed in the previous section.

1.4.1.4. The Proposed Development uses both HVAC and HVDC technologies, so both alternating and static electric and magnetic fields will be produced and are considered within this assessment.

1.4.1.5. Calculations were performed for:

- 400 kV HVAC cables,
- Onshore HVDC cables; and

- the Converter Station.

1.4.1.6. In accordance with the aforementioned Code of Practice, the field profiles are calculated at a height of 1 m above ground level.

1.4.1.7. For the HVAC and HVDC cable components, there will be no external electric fields due to earthed sheaths around each cable; they will only produce perceptible magnetic fields. The Converter Station will produce external electric fields, however the general public will be shielded due to the earthed fencing on the compound perimeter.

1.4.1.8. For exposure to the general public only magnetic fields were considered.

1.5. AQUIND CASE INPUT DATA

1.5.1.1. Details of the Cables and Converter Station Area are defined in the following sections. The key dimensions and ratings are used within the EMF calculations directly.

1.5.2. HVAC CABLES

1.5.2.1. The twin pole design of the Proposed Development requires 2 sets of 3-phase HVAC cables laid in trenches 5 m apart.

1.5.2.2. Conductor Properties:

- Conductor: 2500 mm^2 Copper;
- Conductor diameter: 140 mm; and
- Conductor rating: 1578 A @ 400 kV_{rms} = 1093.3 MVA (per circuit).

1.5.2.3. Standard trench burial conditions:

- Depth to top of the duct bank: 900 mm;
- Duct bank height: 400 mm;
- Duct diameter: 200 mm;
- Circuit spacing: 6000 mm; and
- Phase spacing: 300 mm.

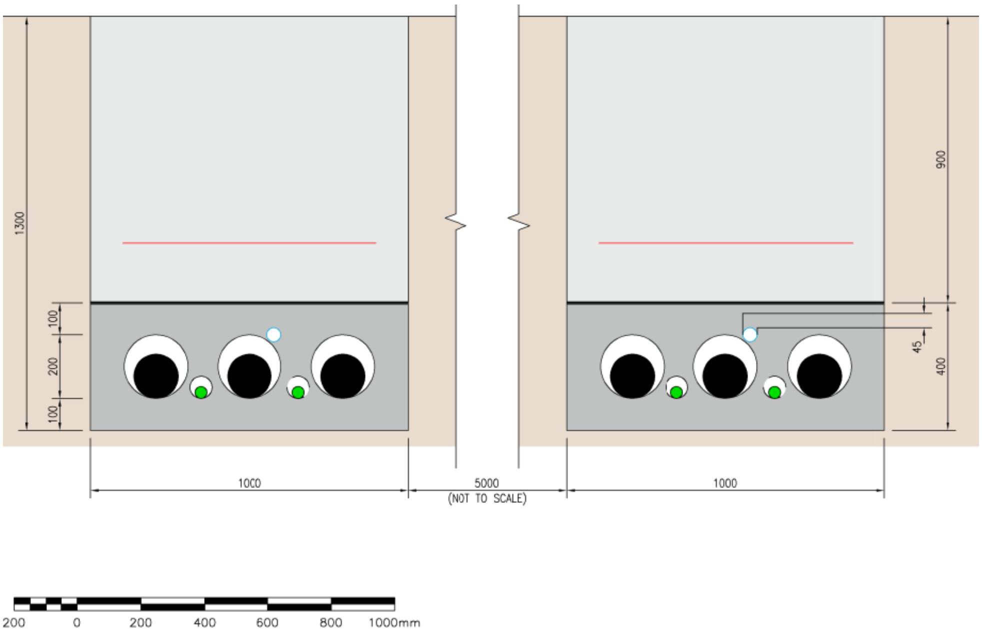

Plate 1 - HVAC Cable Trench Installation Assumption

1.5.3. HVDC CABLES

1.5.3.1. The twin pole design of the Proposed Development requires 2 pairs of HVDC cables laid in trenches 5 m apart.

Conductor Properties:

- Conductor: 2000 mm^2 Copper;
- Conductor diameter: 106 mm; and
- Conductor rating: 1562.5 A @ ± 320 kV$_{dc}$ = 1000 MW (per pole).

1.5.3.2. Standard trench burial conditions:

- Depth to top of the duct bank: 900 mm;
- Duct diameter: 200 mm;
- Circuit spacing: 5700 – 6000 mm; and
- Pole spacing: 300 mm.

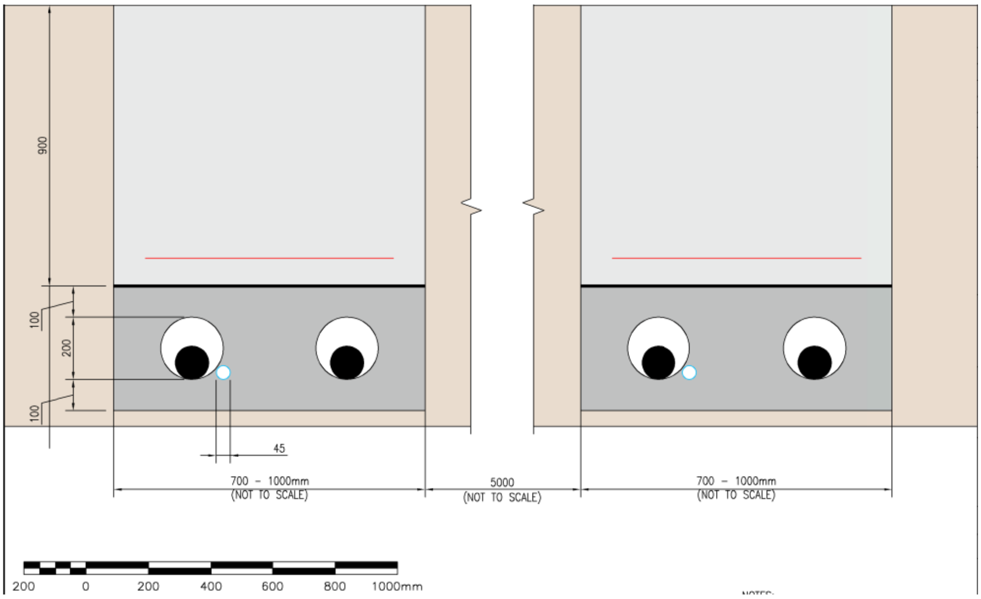

Plate 2 - HVDC Cable Installation Assumption

1.5.4. CONVERTER STATION HVAC AREA

1.5.4.1. The HVAC area within the Converter Station has been modelled as a single bus bar with a phase spacing of 5 m. The minimum bus height was 5.5 m in accordance with the minimum safety clearance stated in NG TS 2.01 (National Grid, 2017); but calculated at heights above this to show the effect of variation.

1.5.4.2. The electrical current loading applied to the busbars is assumed to be equal to the rating of each AC circuit, or 1578 Amps.

1.5.4.3. The Converter Station will require reactors within the compound which will contribute significantly to the overall field strength within the compound and at the perimeter.

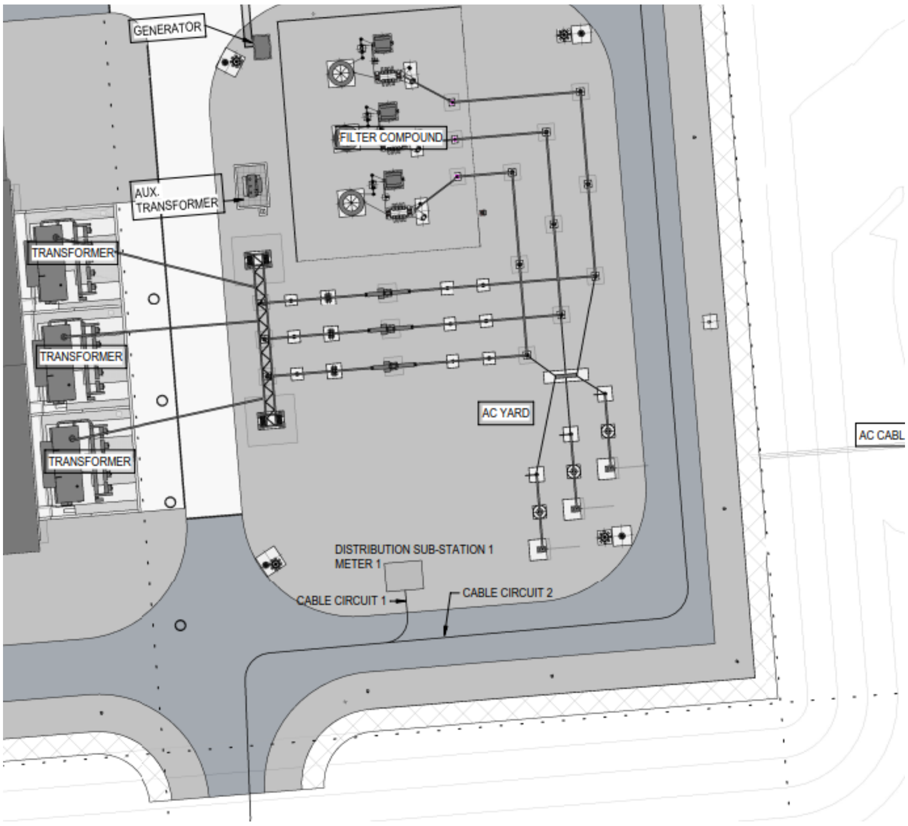

Plate 3 - Outdoor HVAC area of Converter Station

1.6. EMF ASSESSMENT RESULTS

1.6.1. CABLES

1.6.1.1. The peak magnetic field from the HVAC Cable is predicted to be 33 µT (50 Hz) at 1 m above ground, occurring directly above the outer phase cables. This corresponds to 9.1% of the public exposure limit for AC magnetic fields. As indicated in the figure below the magnetic field decreases rapidly with distance from the cables and is less that 1µT at 30 m distance.

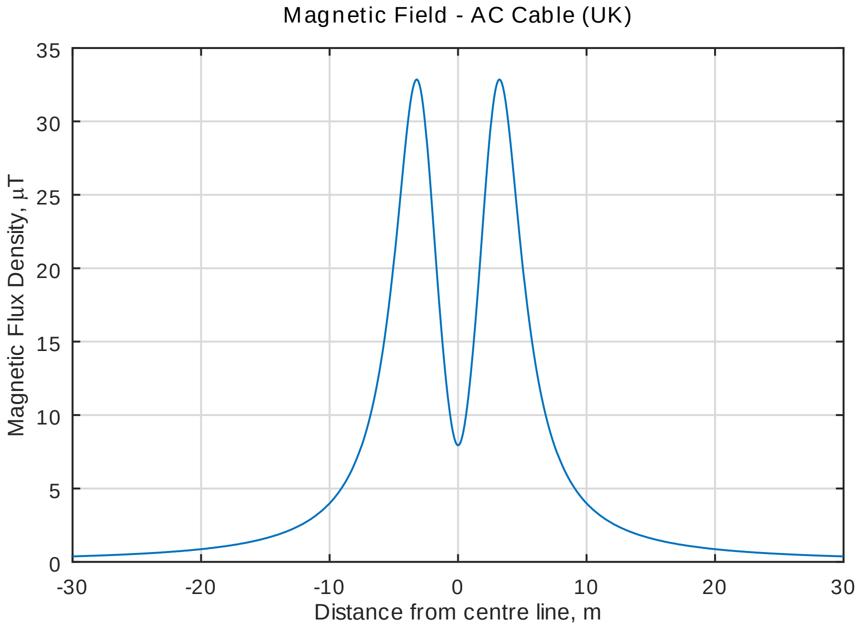

Plate 4 - Representation of Magnetic Field - HVAC Cable.

1.6.1.2. The peak magnetic flux density from the HVDC Cable is predicted 23 µT (DC) at 1 m above ground; this does not include the earth's geostatic field which varies with inclination, latitude, longitude and elevation; ranging between from 25 to 65 µT at the earth's surface. A field of 23 µT corresponds to 0.06 % of the public exposure limit for DC magnetic fields. As indicated in the figure below the magnetic field decreases rapidly with distance from the cable and is about 2 µT at 10 m from the cable.

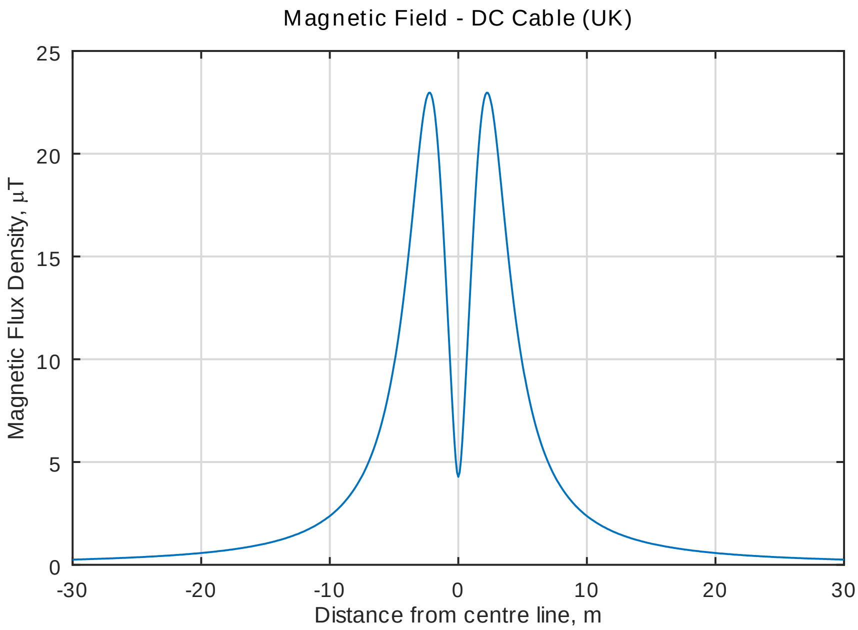

Plate 5 - Representation of Magnetic Field – HVDC Cable.

1.6.2. CONVERTER STATION

1.6.2.1. At the minimum 5.5 m bus height (safe working clearance), the peak electric field strength was 12.8 kV/m which occurs directly beneath the outer phases. This reduces to 9.7 kV/m at 6.5 m; 7.6 kV/m at 7.5 m and 6.1 kV/m at 8.5 m clearance.

1.6.2.2. Electric Field strength of this magnitude would not be seen by the general public due the grounding effect of the perimeter fencing. It may be advisable to maintain the bus bars at a height in excess of 6.5 m to restrict peak field to less than 10 kV/m which may reduce the burden within occupational risk assessments.

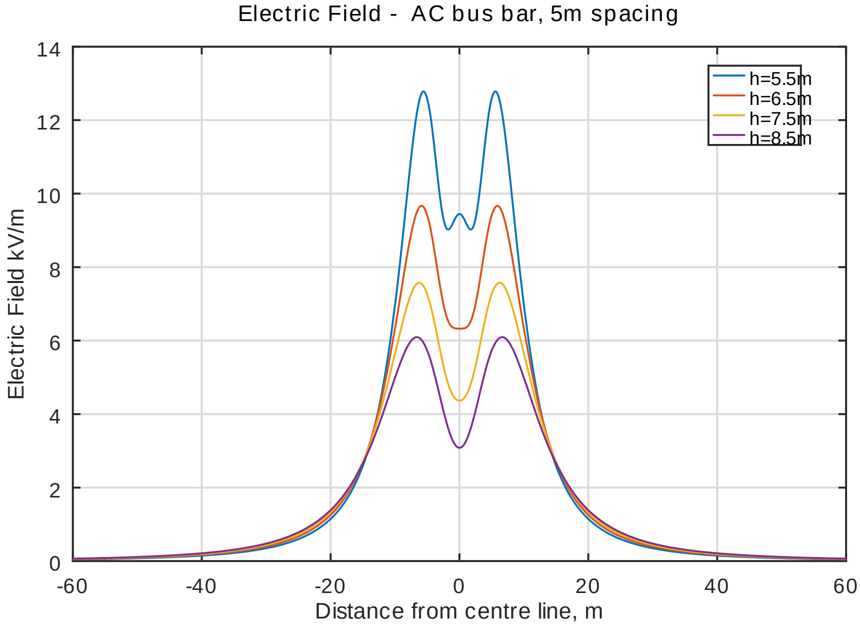

Plate 6 - Representation of Electric Feld – AC bus bar, 5 m spacing.

1.6.2.3. At the minimum 5.5 m bus height (safe working clearance), the peak AC magnetic flux density was 72 µT. This reduces to 56 µT at 6.5 m; 45 µT at 7.5 m and 36 µT at 8.5 m clearance. These values have been calculated directly beneath the busbars which is an inaccessible location for the public and such fields should not be assessed against public exposure limits.

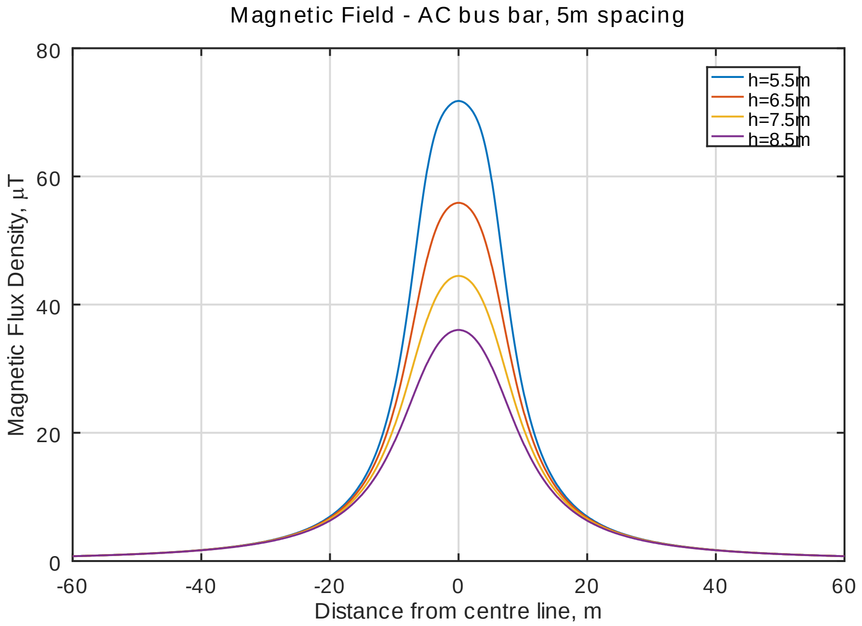

Plate 7 - Representation of Magnetic Field - AC bus bar, 5 m spacing

1.6.2.4. The closest point from the centre HVAC phase to the perimeter of the compound is around 23 m. At this distance it is feasible, though unlikely that public could be feasibly exposed. At this distance the maximum magnetic field strength from the HVAC bus is likely to be less than 5 µT.

1.6.2.5. However, the overall magenetic field from the Converter Station is likely to be dominated by the presence of HVAC air core reactors, whose stray magnetic fields can be significant. The actual magntitude of the source field will depend upon the dimensions and ratings of the reactors. The reactor design and locations are yet to be finalised therefore the field profile within the compound is uncertain.

1.6.2.6. As the magnetic field flux density from air core reactors is expected to reduce with the cube of distance; it is likely to well below typical background levels at the nearest dwelling (over 200 m) from the HVAC area. Detailed calculations will be required to be performed by the contractor which will confirm this statement and the exact magnitude of the field at the compound perimeter.

1.6.2.7. Provided that the field strengths at the compound perimeter are less than public exposure limits, then the Converter Station will comply with the exposure guidelines.

1.6.2.8. The field within the compound from air core reactors may present an occupational hazard and must be designed, located or screened appropriately to reduce or mitigate such risk to workers in accordance with legislation.

1.6.3. SUMMARY

1.6.3.1. Due to the earthed shielding of the HVAC Cables and HVDC Cables there will be no electric field present along the Onshore Cable Route.

1.6.3.2. The HVAC Cables are laid in agricultural land and the magnetic field strength is well below the guidelines and reduces rapidly with distance from the Cables.

1.6.3.3. The HVDC Cables are laid mainly along public highways and the magnetic field strength is well below the guidelines and reduces rapidly with distance from the Cables.

1.6.3.4. There will be no AC electric field outside of the Converter Station due to the earthed perimeter fence.

1.6.3.5. The Converter Station reactors must be designed and positioned to limit AC magnetic fields at the compound perimeter to levels below the guideline levels.

1.6.4. COMPLIANCE

1.6.4.1. The assessed components of the Proposed Development produce field strengths which are less than the public exposure limit in areas where the time of exposure to the general public is considered significant.

1.6.4.2. The HVAC and HVDC Cables are deemed to comply with public exposure guidelines for electric and magnetic fields.

1.6.4.3. At the time of writing the detailed and final design has not yet been performed for the Proposed Development. In the final design it shall be ensured that the Proposed Development complies with all guidelines and codes of practice applicable to the UK for the Converter Station and Onshore Cable Route.

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