The Abergelli Power Gas Fired Generating Station Order

6.2 Environmental Statement Appendices - Volume M EMF Report

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The Infrastructure Planning
(Applications: Prescribed Forms and Procedure) Regulations 2009

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Appendix 15.1

Infrastructure EMF Assessment

Drax Group Plc

ABERGELLI POWER PLANT

Infrastructure EMF Assessment

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PUBLIC

Drax Group Plc

ABERGELLI POWER PLANT

Infrastructure EMF Assessment

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QUALITY CONTROL

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1 ABBREVIATIONS AND SYNONYMS

A	ampere, measure of electrical current, or ‘load’
ac	alternating current
ACSR	Aluminium conductor steel-reinforced – a type of conductor
dc	Direct current
ELF	extremely low frequency
EMF	electromagnetic fields
Hz	hertz, measure of frequency
ICNIRP	International Commission on Non-Ionizing Radiation Protection
kV	kilovolt = 1,000 volts, measure of electrical “pressure”
NRPB	UK National Radiological Protection Board
SCGT	Simple Cycle Gas Turbine
WSP	Formerly Parsons Brinckerhoff Ltd
μT	microtesla, a measure of magnetic field strength
V/m	volts per metre, a measure of electric field strength
Zebra Lynx	Types of ACSR overhead line conductor used here on the 4YW 400 kV line from Swansea to Clifynydd

2 INTRODUCTION

2.1 OVERVIEW

2.1.1. This document is the Electrical Infrastructure Electric and Magnetic Fields (EMF) Assessment for the Abergelli Power Project (hereafter referred to as 'the Project'). It has been prepared by WSP on behalf of Abergelli Power Ltd.

2.1.2. Abergelli Power Ltd is promoting a new Open Cycle Gas Turbine (OCGT) peaking power generating station on rural land at Abergelli Farm, Felindre, near Swansea, Wales. The Project provisionally includes the following electrical infrastructure, based on a single circuit turn-in connection:

- 400 kV transformer compound to be built adjacent to the proposed Generating Equipment Site
- One three phase, 400 kV underground cable connection from the transformer compound to a gas-insulated switchgear (GIS) bay at National Grid's Swansea North Substation.

2.1.3. Figure 1 shows the proposed location of the transformer compound to be built adjacent to the proposed Generating Equipment Site and the proposed single underground cable radial connection to Swansea North Substation.

2.1.4. This report presents an assessment of the changes in EMFs that would result from the development of the new 400 kV electrical infrastructure.

2.1.5. It is anticipated that some of the information included within this report will be used within the 'Other Effects' Chapter of the Environmental Statement.

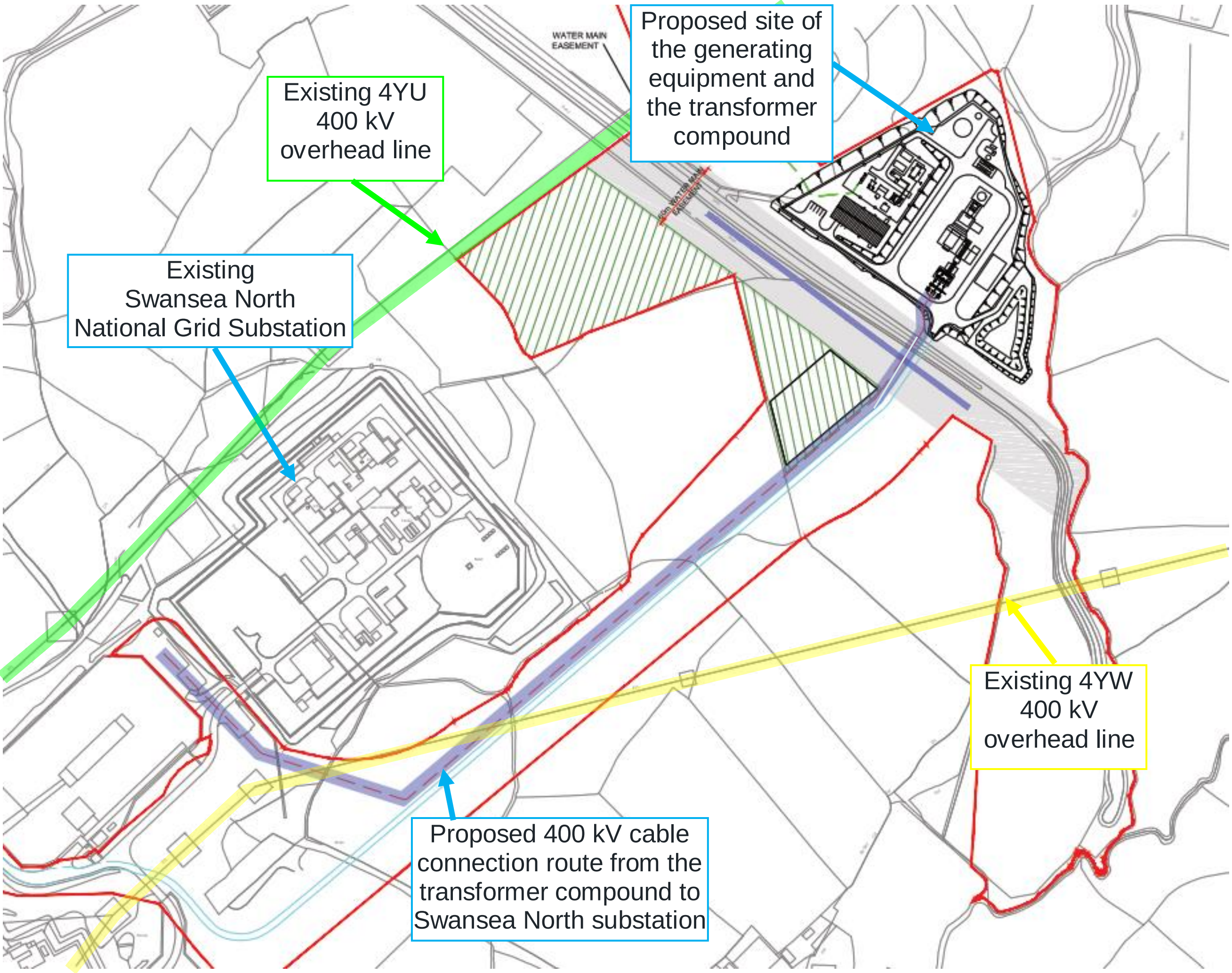

Figure 1 – Proposed location of the Generating Equipment Site, the Transformer Compound and underground cable circuit

3 ELECTRIC AND MAGNETIC FIELD EFFECTS

3.1 INTRODUCTION TO ELECTROMAGNETIC FIELDS

3.1.1. Electromagnetic Fields (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.

3.1.2. Electric-field strengths are measured in volts per metre (V/m) or kilovolts per metre (kV/m). One kilovolt per metre is one thousand volts per metre. The atmospheric electric field at ground level is normally between 10 – 130 V/m in fine weather and may rise to many thousands of volts per metre during thunderstorms. The Earth's electric field is referred to as static or "dc".

3.1.3. 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 chapter. Other units are sometimes quoted, for example milligauss, where 1 milligauss = 0.1 µT.

3.1.4. 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 current or "ac" fields.

3.1.5. All wiring, equipment, and other conductors connected to the electric power system are sources of ac EMFs with frequencies in the extremely low frequency (ELF) range. In the UK and Europe the fundamental power frequency is 50 Hertz (Hz). AC fields 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.

3.2 EMF EXPOSURE GUIDELINES

3.2.1. In the UK, there are presently no statutory regulations to limit the exposure of people to power-frequency electric or magnetic fields. However, in 2004 the National Radiological Protection Board (NRPB) provided advice to Government [ref 1], recommending the adoption in the UK of guidelines published in 1998 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [ref 2]. These guidelines are designed to set conservative exposure levels for the general public to 50 Hz electric and magnetic fields, and they are endorsed by Public Health England (formerly the Health Protection Agency, formerly NRPB), the World Health Organisation, and the UK Government. A summary of the 1998 ICNIRP guidelines for general public exposure is provided below in Table 1.

Table 1 – EMF – Summary of the 1998 ICNIRP exposure UK guidelines

Basic Restriction			
1	Basic Restriction mA/m2 Induced current density in central nervous system	2mA/m2 for general public	
Practical Exposure Measures			
		Electric Fields	**Magnetic Fields**
		Public Exposure	Public Exposure
2	Field strengths corresponding to the Basic Restriction	9,000 V/m	360 µT
3	Reference Level field strengths, below which no further action is necessary, and above which further investigation may be warranted	5,000 V/m	100 µT

3.2.2. Item 1 in Table 1 indicates the ICNIRP 'Basic Restriction' which the EU recommend as the maximum current density to be inducted in the central nervous system of an individual [ref 3] .

3.2.3. Current density, however, is a quantity that cannot realistically be measured in people, so Public Health England (formerly Health Protection Agency) also provided a second, more practical, guideline for EMF strengths as per item 2 in Table 1 which indicates field strength types that are measurable practically and the values considered to correspond to the 'Basic Restriction'.

3.2.4. Item 3 in Table 1, Reference Level field strengths, are yet more conservative values that would, under all normal circumstances, be expected to induce current densities significantly less than the 'Basic Restriction'. Research by Dimbylow [ref 4] indicates that, for overhead power lines, the field strengths quoted as corresponding to the 'Basic Restriction' (item 2) act as good, if slightly conservative, equivalents to the 1998 ICNIRP Basic Restriction for the general public, and for this reason the 'Basic Restriction' figures in item 2 of Table 1 are generally considered more relevant to overhead lines than the 'Reference Level field strengths' of item 3.

3.2.5. The UK has implemented the EU recommendation [ref 3], and has stated that compliance with the general public exposure limits is considered to be required at locations where the public may spend significant time, for example residential buildings, as defined in the UK Voluntary Code of Practice [ref 5]. It is the policy of National Grid to ensure that all new assets comply with public exposure guidelines unless there are exceptional circumstances.

4 APPRAISAL METHODOLOGY

4.1 GENERAL

4.1.1. The appraisal methodology has been based upon the industry Code of Practice on Compliance [ref 5] which specifies that compliance should be specifically demonstrated for 400 kV underground cables. Conversely, it recognises that some equipment is inherently compliant with exposure guidelines and appropriate evidence is maintained on the Energy Networks Association (ENA) website[1,2]. The evidence hosted on the ENA website demonstrates that the transformer compound, which does not include air-cored reactors, is inherently compliant.

4.1.2. In this present assessment, electric and magnetic field strengths due to the existing nearby overhead line and proposed underground cable were calculated using standard equations based on fundamental properties. All electric and magnetic fields were calculated based upon guidance outlined in the aforementioned Code of Practice. Accordingly, the calculations of EMF are always referenced to a height of 1 m above ground level.

4.1.3. Mention of field strengths later in this document will mean the root-mean-square amplitude of the power-frequency modulation of the total field, which is the conventional way of expressing these quantities.

4.1.4. The acceptability of the prospective field strengths was judged by comparing the results of the calculations with the appropriate ICNIRP guidelines.

4.1.5. High-voltage transmission lines can create, or channel, electromagnetic emissions over a wide range of frequencies, however, this report only considers 50 Hz electromagnetic fields.

4.2 ELECTRIC FIELDS

4.2.1. The electric field due to the transformer compound is inherently compliant with the public exposure limits as discussed in section 4.1. Electric fields diminish within the vicinity of earthed objects and structures. The proposed transformer compound would be surrounded by an earthed metal fence and consequently the electric field outside of this fence would certainly comply with ICNIRP exposure guidelines for the public.

4.2.2. There are no external electric fields associated with underground cables as explained in the BICC Electric Cables Handbook [ref 6]. Electric fields associated with underground cable are contained by the sheath of the cable itself. The public would thus not be exposed to electric fields from the proposed underground cables.

4.3 MAGNETIC FIELDS

4.3.1. Some equipment within the transformer compound would produce magnetic fields, but these fields tend to diminish rapidly with increasing distance from the equipment. Magnetic fields outside the transformer compound due to these items of equipment are inherently compliant with public exposure limits, as discussed in section 4.1.

4.3.2. There will be a magnetic field due to the underground cable from the cable sealing ends beside the existing overhead line to the proposed transformer compound.

4.4 BASELINE CONDITIONS

4.4.1. The existing 400 kV 4YW overhead line from Swansea to Clifynydd passes close to the route of the cable between the proposed transformer compound and the point of connection at Swansea North substation. The field strengths due to this L6 tower transmission line have been calculated to compare with those associated with the Project. Detailed overhead line parameters are tabulated in Appendix A.

4.4.2. The pre-fault continuous current rating of the existing 400 kV 4YW overhead line is 3180 MVA corresponding to 4590 Amps.

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[1] http://www.energynetworks.org/electricity/she/emfs.html
[2] http://www.emfs.info/Related+Issues/limits/UK/compliance

4.4.3. Table 2 presents the calculated maximum field strengths due to the existing 400 kV 4YW overhead line. These are based upon the surveyed minimum ground clearance (9.4 metres) for the 400 kV conductors in the nearby spans (spans between towers 252-253 and 253-254). The field strengths corresponding to the ICNIRP public exposure basic restriction are also included in the table. It may be seen that the maximum field strengths due to the existing 400 kV 4YW overhead line comply with the basic restriction levels.

Table 2 – EMF – Calculated maximum field strengths due to the existing nearby 400 kV 4YW overhead line

	Maximum Field Strength at 1m above ground due to existing 400 kV/400 kV 4590 A/4590 A L6 overhead line with 9.4m ground clearance	Public Exposure Basic Restriction
Electric Field	7,731 V/m	9,000 V/m
Magnetic Field	82.3 µT	360 µT

4.5 IMPACT APPRAISAL

4.5.1. The fields due to the transformer compound are inherently compliant.

4.5.2. The impact appraisal has included evaluation of the maximum field strengths due to the 400 kV underground cable connection from the transformer compound to National Grid's Swansea North substation.

4.5.3. For the purposes of this appraisal, the calculations have assumed that the current flowing in each phase of the proposed underground cable is 477 Amps. This assumption corresponds to operating at a minimum voltage of 380 kV (95% x 400 kV) and the maximum export from the generator which is to be rated at 314 MVA.

4.5.4. Detailed parameters including the assumed cable laying arrangement are provided in Appendix A.

4.5.5. Calculated maximum field strengths are tabulated in Table 3.

4.5.6. Since the proposed underground cable from the transformer compound to National Grid's Swansea North Substation does not produce an external electric field, the expected maximum electric field strength above the cable will be due to the existing nearby 400 kV 4YW overhead line.

4.5.7. The prospective maximum magnetic field strength due to the proposed underground cable circuit from the transformer compound to National Grid's Swansea North Substation is below the public exposure basic restriction level and is significantly less than that due to the existing 400 kV 4YW line.

4.5.8. There is potential for the magnetic field due to the proposed underground cable circuit from the transformer compound to National Grid's Swansea North substation to add to that of the existing 4YW overhead line because the proposed cable route passes underneath the existing overhead line. These magnetic fields are vectors which vary in magnitude and direction because they come from different sources. The theoretical maximum sum of the fields is calculated by adding the field magnitudes arithmetically corresponding to both fields being totally aligned. The average of the combined fields, corresponding to the fields being at right angles, would be less and calculated as the root sum of the squares of the field magnitudes. Based on the magnetic field values given in Table 3, the maximum sum of the fields is 85.4 µT (82.3 + 3.1) and is below the public exposure basic restriction level.

Table 3 – EMF – Calculated maximum field strengths

	Electric Field at 1m above ground	Magnetic Field at 1m above ground
Fields strengths corresponding to 1998 ICNIRP Basic restrictions for Public Exposure	9,000 V/m	360 µT
Baseline Maximum Field Strength at 1 m above ground due to existing 400 kV 4YW 4590 A / 4590 A L6 overhead line with 9.4 m ground clearance	7,731 V/m	82.3 µT
Maximum Field Strength at 1m above ground due to underground cable circuit from the transformer compound to National Grid's Swansea North substation 400 kV 477 A (Assumed typical cable lay)	-	3.1 µT

4.6 MITIGATION / BEST PRACTICE

4.6.1. Since the calculated prospective maximum electric and magnetic field strengths expected due to the underground cable connection fall within the ICNIRP EMF exposure guidelines, the development designs would be considered to follow best practice for electricity transmission installations as defined in the UK Voluntary Code of Practice [ref 5]. As the proposed development complies with the current public exposure guidelines, EN-5 [ref 7] states that "no further mitigation should be necessary".

4.7 SUMMARY

4.7.1. Although the maximum magnetic field strengths due to the proposed underground cable connection is greater than that due to the existing overhead line running nearby the proposed cable route, it is within nationally and internationally accepted guidelines.

4.7.2. The change in the electric and magnetic field strengths due to the establishment of the transformer compound would constitute a 'Minor' effect.

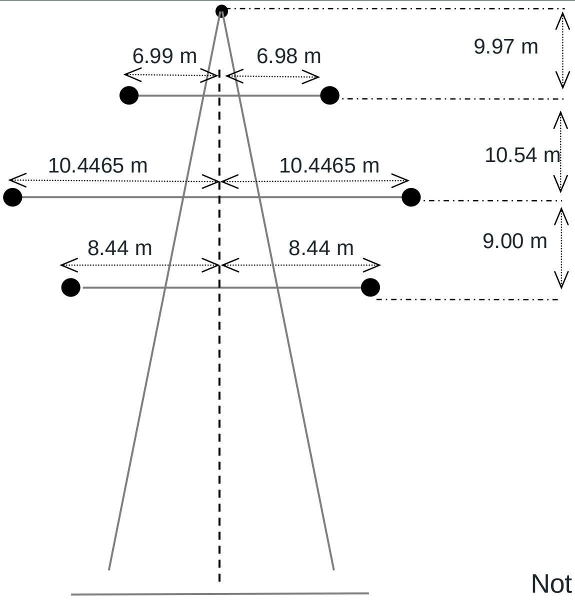
5 REFERENCES

- Ref. 1 - NRPB advice to Government: "Advice on Limiting Exposure to Electromagnetic Fields (0-300 GHz)" Documents of the NRPB Volume 15 No 2 2004.
- Ref. 2 - ICNIRP guidance: "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)". Health Physics April 1998, Volume 74, Number 4:494-522.
- Ref. 3 - COUNCIL RECOMMENDATION of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz), Official Journal of the European Communities, 1999/519/EC.
- Ref. 4 - Development of the female voxel phantom, NAOMI, and its application to calculations of induced current densities and electric fields from applied low frequency magnetic and electric fields. Dimbylow P. Phys Med Biol. 2005 Mar 21;50(6):1047-70. Epub 2005 Feb 23.
- Ref. 5 - Power Lines: Demonstrating compliance with EMF public exposure guidelines. A Voluntary Code of Practice. Department of Energy & Climate Change March 2012.
- Ref. 6 - Electric Cables Handbook, 3rd Edition. BICC Cables, Blackwell Science Ltd, October 1997. Chapter 2 section Electromagnetic Fields.
- Ref. 7 – National Policy Statement for Electricity Networks Infrastructure (EN-5), Department of Energy and Climate Control, July 2011.

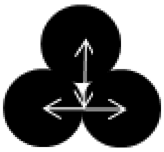
Appendix A

CALCULATION PARAMETERS

Overhead line calculation parameters for the existing 400 kV 4YW overhead line from Swansea to Clifynydd that passes close to the proposed route of the new cable from the transformer compound to the point of connection at National Grid's Swansea North substation.

PARAMETER	VALUE
Type	Overhead line
Line Identifier	4YW (Swansea to Clifynydd)
Number of Phases/Frequency	3 Phases at 50Hz
No. of circuits on overhead line	2
Nominal Voltage	400 kV
Conductor	400 mm^2 ACSR Zebra 4 per phase (quad bundle 0.305 m bundle separation)
Conductor Diameter	0.02862m
Transposition	Transposed (existing) R B Y Y B R
Maximum Continuous Current Capacity (per phase per circuit)	4590 Amps corresponding to 3180 MVA pre fault continuous rating
Earth Wire Conductor	175 mm^2 ACSR Lynx
Earth Wire Conductor Diameter	0.01953 m
Tower Construction	L6 Double Circuit
Tower Dimensions & Conductor Centres	 Not to scale
Minimum Ground Clearance	9.4 m (corresponding to span 4YW253-254)

Assumed calculation parameters for the proposed new cable from the transformer compound to the point of connection at National Grid's Swansea North substation.

PARAMETER	VALUE
Type	Cable circuit From the transformer compound to National Grid's Swansea North substation
Number Phases/Frequency	3 Phases at 50 Hz
Nominal Voltage	400 kV
Conductor	630 mm^2 Aluminium
Conductor Diameter	0.0303 m
Cable Outside Diameter	124 mm (assuming 630 mm^2 and corrugated Al Sheath)
Maximum Continuous Current Capacity (per phase per circuit)	477 Amps corresponding to 314 MVA at 380 kV assuming minimum voltage
Conductor Centres	 Trefoil arrangement Horizontal distance = outside diameter = 124 mm Vertical distance = (√3/2) x outside diameter = 107.387 mm
Burial Depth	1.1 m

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