The Millbrook Power (Gas Fired Power Station) Order

6.2 Environmental Statement Appendices – Volume N Appendix 15.1 EMF Report

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15.1 - EMF Report

MILLBROOK POWER PLANT

INFRASTRUCTURE EMF ASSESSMENT

SEPTEMBER 2017

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INFRASTRUCTURE EMF ASSESSMENT

Millbrook Power Ltd.

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ABBREVIATIONS AND SYNONYMS

A	ampere, measure of electrical current, or ‘load’
ac	alternating current
EIA	Environmental Impact Assessment
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”
OPGW	The type of overhead line conductor used here for the earth wire
NRPB	UK National Radiological Protection Board
WSP	Formerly Parsons Brinckerhoff Ltd
μT	microtesla, a measure of magnetic field strength
V/m	volts per metre, a measure of electric field strength
Rubus	The type of overhead line conductor used here for the phases

1 INTRODUCTION

1.1 OVERVIEW

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

1.1.2 Millbrook Power Ltd is promoting a new thermal gas fired peaking power generation plant on the site of a disused clay pit at Millbrook in Bedfordshire, England. The Project provisionally includes the following electrical infrastructure, based on a double tee-in connection:

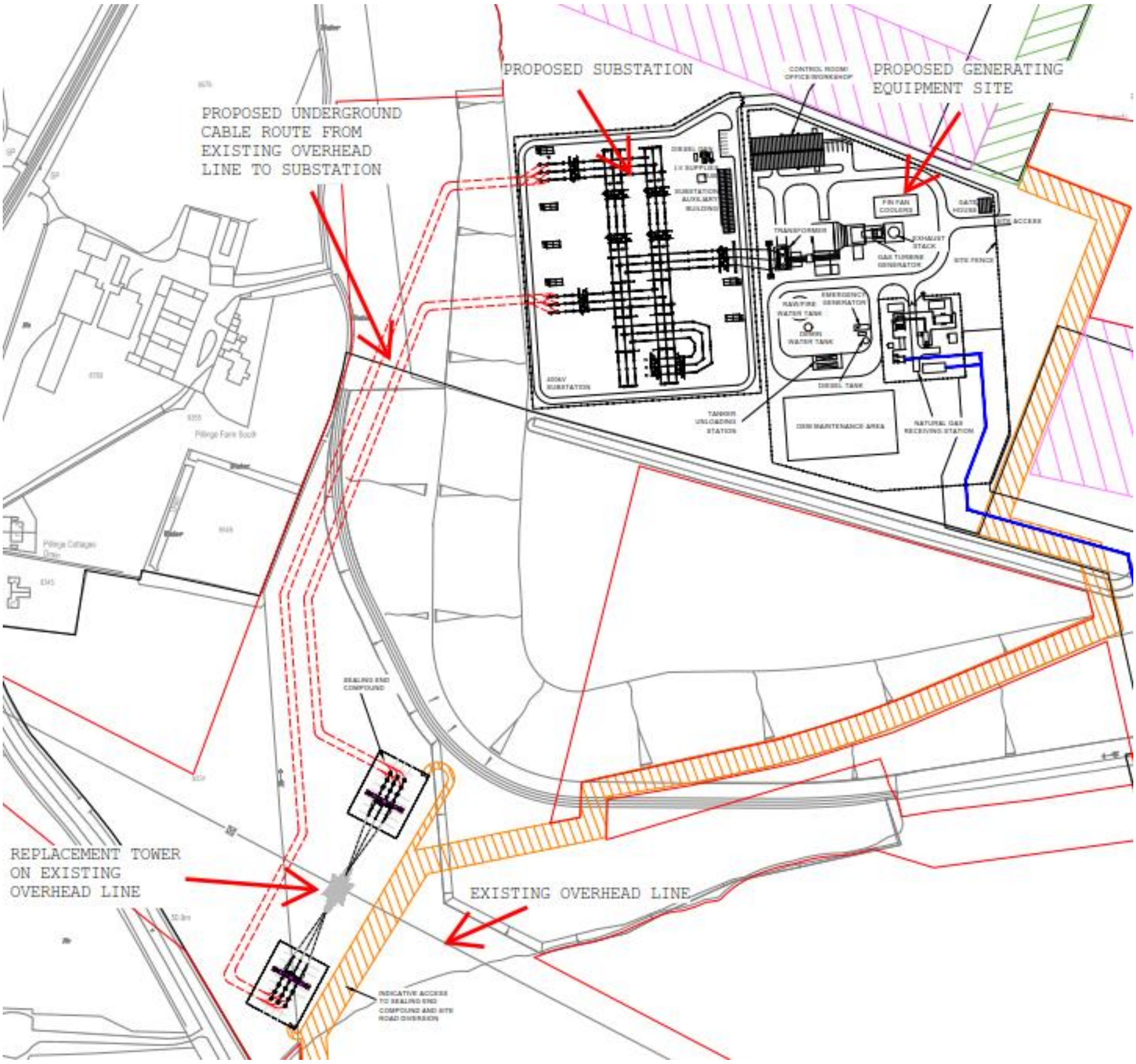
- 400 kV switching substation (the Substation) to be built adjacent to the proposed Generating Equipment Site,
- Two three phase underground cable connections from the Substation to cable sealing ends beside the neighbouring existing double circuit 400 kV overhead line.

1.1.3 Figure 1 shows the proposed location of the Substation beside the proposed Generating Equipment Site and the underground cable connections to the cable sealing ends beside the existing overhead line.

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

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

Figure 1 Proposed location of the Generating Equipment Site, the Substation and underground cable circuits



2 ELECTRIC AND MAGNETIC FIELD EFFECTS

2.1 INTRODUCTION TO EMFS

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.

2.1.2 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".

2.1.3 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.

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.

2.1.5 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.

2.2 EMF EXPOSURE GUIDELINES

2.2.1 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 the UK's Health Protection Agency, the World Health Organisation, and the UK Government. A summary of the 1998 ICNIRP guidelines for general public exposure is provided below in Table 2-1.

Table 2-1 EMF - Summary of the 1998 ICNIRP exposure UK guidelines

Basic Restriction			
1	Basic Restriction • mA/m^2 Induced current density in central nervous system	2mA/m^2 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

2.2.2 Item 1 in Table 2-1 indicates the ICNIRP ‘Basic Restriction’ which the EU recommend as the maximum current density to be induced in the central nervous system of an individual [ref 6] .

2.2.3 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 2-1 which indicates field strength types that are measurable practically and the values considered to correspond to the ‘Basic Restriction’.

2.2.4 Item 3 in Table 2-1, 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 3] 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 2-1 are generally considered more relevant to overhead lines than the ‘Reference Level field strengths’ of item 3.

2.2.5 The UK has implemented the EU recommendation [ref 6], 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 4]. It is the policy of National Grid to ensure that all new assets comply with public exposure guidelines unless there are exceptional circumstances.

3 APPRAISAL METHODOLOGY

3.1 GENERAL

3.1.1 The appraisal methodology has been based upon the industry Code of Practice on Compliance [ref 4] 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 Substation, which does not include air-cored reactors, is inherently compliant.

3.1.2 In this present assessment, electric and magnetic field strengths due to the existing 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.

3.1.3 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.

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

3.1.5 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.

3.2 ELECTRIC FIELDS

3.2.1 The electric field due to the Substation is inherently compliant with the public exposure limits as discussed in section 3.1. Electric fields diminish within the vicinity of earthed objects and structures. The proposed Substation would be surrounded by an earthed metal fence and consequently the electric field outside of this fence due to the substation equipment it encloses would certainly comply with ICNIRP exposure guidelines for the public.

3.2.2 There are no external electric fields associated with underground cables as explained in the BICC Electric Cables Handbook [ref 5]. 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.

3.3 MAGNETIC FIELDS

3.3.1 Some equipment within the Substation would produce magnetic fields, but these fields tend to diminish rapidly with increasing distance from the equipment. Magnetic fields outside the Substation due to these items of equipment are inherently compliant with public exposure limits, as discussed in section 3.1.

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

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

3.4 BASELINE CONDITIONS

3.4.1 An existing 400 kV overhead line, specifically the 400 kV Grendon to Sundon route ZA overhead line, passes near to the proposed Substation and so field strengths due to this, L2[3] tower transmission line, have been calculated to compare with those associated with the Project. Detailed overhead line parameters are tabulated in Appendix A.

3.4.2 The pre fault continuous current rating of the existing overhead line is 2440 A.

3.4.3 Table 3-1 presents the calculated maximum field strengths due to the existing 400 kV overhead line. These are based upon the surveyed minimum ground clearance (9.12 metres) for the 400 kV conductors in the affected spans. 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 overhead line comply with the basic restriction levels.

Table 3-1 EMF - Calculated maximum field strengths due to the existing 400kV overhead line

	Maximum Field Strength at 1m above ground due to existing 400kV/400kV 2440A/2440A L2 overhead line with 9.12m ground clearance	Public Exposure Basic Restriction
Electric Field	6,226 V/m	9,000 V/m
Magnetic Field	42.3 µT	360 µT

3.5 IMPACT APPRAISAL

3.5.1 The fields due to the Substation are inherently compliant.

3.5.2 The impact appraisal has included evaluation of the maximum field strengths due to the 400 kV underground cable tee-in connections from the cable sealing ends beside the existing overhead line to the Substation.

3.5.3 For the purposes of this appraisal, the calculations have assumed that the current flowing in each phase, in the two circuits forming the tee-in connection, is the pre fault continuous current rating of the existing nearby overhead line, i.e. 2440 A. This assumption provides a ‘worst case’ assessment since, for all normal operations, the current, and thus the magnetic field strengths, would not exceed these values. This is in line with the UK voluntary Code of Practice [ref 4] which requires consideration of intact system conditions.

3.5.4 The currents in the two underground cable circuits forming the tee-in connection have been assumed to flow in the same direction. This is the worst case and leads to the greatest field strengths.

[3] L2 is the name of the particular design of overhead line tower being used for the connection.

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

3.5.6 Calculated maximum field strengths are tabulated in Table 3-2.

3.5.7 Since the proposed underground cable from the sealing ends beside the existing overhead line to the Substation does not produce an external electric field, the expected maximum electric field strength in this corridor will be due to the existing overhead line that passes near the Substation.

3.5.8 The prospective maximum magnetic field strength due to the proposed underground cable circuits to the Substation is greater than that due to the existing 400 kV line. However, the prospective magnetic field strength due to proposed underground cables is calculated to remain below the public exposure basic restriction levels.

3.5.9 Since the existing overhead line and proposed underground cables have been found to be individually compliant, the cable sealing end compound is automatically compliant in accordance with Energy Networks Association (ENA) guidance.

Table 3-2 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 2440 A L2 overhead line with 9.12 m ground clearance	6,226 V/m	42.3 µT
Maximum Field Strength at 1m above ground due to underground cable circuit from the existing 400 kV overhead line into the Substation 400 kV 2440 A (Assumed typical cable lay)	-	133 µT

3.6 MITIGATION / BEST PRACTICE

3.6.1 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 4]. As the proposed development complies with the current public exposure guidelines, EN-5 [ref 7] states that "*no further mitigation should be necessary*".

3.7 SUMMARY

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

3.7.2 The change in the electric and magnetic field strengths due to the establishment of the Substation would constitute a ‘Minor’ effect.

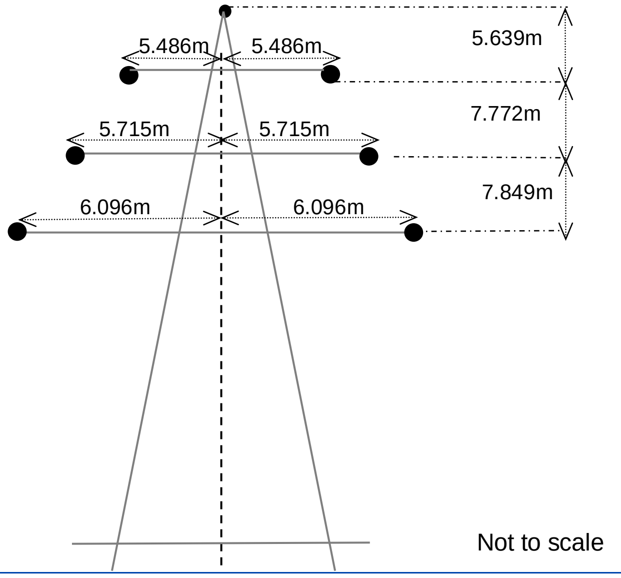
4 REFERENCES

- 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 - 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. 4 - Power Lines: Demonstrating compliance with EMF public exposure guidelines. A Voluntary Code of Practice. Department of Energy & Climate Change March 2012.
- Ref. 5 - Electric Cables Handbook, 3rd Edition. BICC Cables, Blackwell Science Ltd, October 1997. Chapter 2 section Electromagnetic Fields.
- Ref.6 - 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.7 – National Policy Statement for Electricity Networks Infrastructure (EN-5), Department of Energy and Climate Control, July 2011.

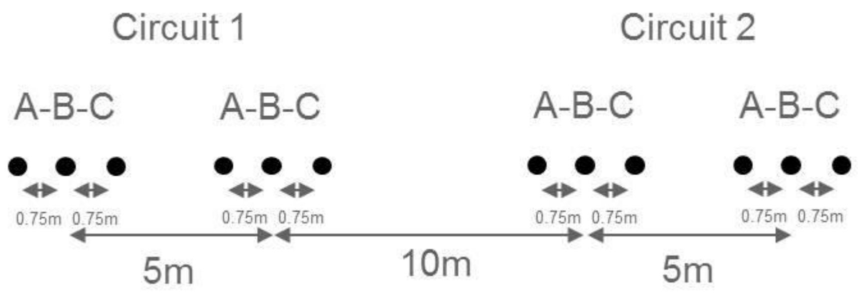
Appendix A

CALCULATION PARAMETERS

Overhead line calculation parameters for the existing Grendon to Sundon circuit and assumed for the proposed circuit from the proposed Substation to the existing overhead line.

PARAMETER	**VALUE**
Number of Phases/Frequency	3 Phases at 50Hz
No. of circuits on overhead line	2
Nominal Voltage	400kV
Conductor	500mm^2 AAAC Rubus, 2 per phase (twin bundle 0.4m bundle separation).
Conductor Diameter	0.0315m
Transposition	Transposed (existing) R B Y Y B R
Maximum Continuous Current Capacity (per phase per circuit)	2440A pre fault continuous rating
Earth Wire Conductor	EARTHWIRE OPGW (160MM2 KEZIAH EQUIVALENT)
Earth Wire Conductor Diameter	0.0206m
Tower Construction	L2 Double Circuit
Tower Dimensions & Conductor Centres	
Minimum Ground Clearance	9.12m (existing)

Assumed calculation parameters for the underground cable tee-in connection from the cable sealing ends beside the existing overhead line to the Substation.

ROUTE	PROPOSED CIRCUIT FROM BESIDE THE EXISTING OVERHEAD LINE TO THE SUBSTATION
Number Phases/Frequency	3 Phases at 50Hz
Nominal Voltage	400kV
Conductor	2500 mm^2
Conductor Diameter	0.0635m
Maximum Continuous Current Capacity (per phase per circuit)	2440A corresponding to 1690MVA
Conductor Centres	
Burial Depth	1.1m