Appendix I.4

High-Level Electromagnetic Field Assessment

PAGERPOWER
Urban & Renewables

High-Level Electromagnetic Field Assessment

Bodelwyddan Solar & Energy Storage Limited

Bodelwyddan

September 2025

ADMINISTRATION PAGE

Job Reference:	13525C
Author:	Jacob Cunningham
Telephone:	01787 319001
Email:	jacob@pagerpower.com

Reviewed By:	Hannah Lucey; Abdul Wadud
Email:	hannah@pagerpower.com; abdul@pagerpower.com

Issue	Date	Detail of Changes
1	June 2025	Initial issue
2	July 2025	Minor update
3	August 2025	Consideration of latest layout
4	September 2025	Minor update

Stour Valley Business Centre, Brundon Lane, Sudbury, CO10 7GB

T: +44 (0)1787 319001 E: info@pagerpower.com W: www.pagerpower.com

EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the potential electromagnetic fields generated by electrical equipment within a ground-mounted solar photovoltaic development with respect to safe levels for human exposure. The proposed development is located northwest of Bodelwyddan, Wales, UK, and will include underground power cables, transformers, photovoltaic (PV) inverters, substations, a Battery Energy Storage System (BESS) and other ancillary infrastructure.

Emissions

All electrical equipment emits electric and magnetic radiation. Power cables produce both electric and magnetic fields which can potentially affect human health. Radiation from underground cables is generally less than radiation from overhead powerlines because emissions from adjacent conductors within a cable tend to cancel each other out. When assessing the impacts of overhead power lines, it is important to consider the impact of both electric and magnetic fields. Underground cables generally cause a negligible electric field above ground but can cause a significant magnetic field which is dependent on the current in the conductors.

Standards in the UK

The UK Policy on public exposure limits to Electromagnetic Fields (EMF) radiation is designed to comply with the 1998 ICNIRP (International Commission on the Non-Ionizing Radiation Protection) guidelines in terms of the 1999 EU Recommendation. In 2010 ICNIRP produced new guidelines but these have not yet been incorporated into UK Policy. The public exposure limits in UK policy define reference levels for electric and magnetic fields. Where field levels exceed these reference levels in significantly occupied spaces, further investigation is warranted. Further information can be found in section 3 of the report.

Overall Conclusion

Maximum electromagnetic radiation levels from the proposed underground cables are predicted to exceed the ICNIRP reference levels. A 5m clearance distance would be recommended at which the maximum electromagnetic radiation levels will be reduced to below the ICNIRT reference levels, however, all dwellings and workplaces are located over 50m away, ensuring no significant impacts therefore a clearance distance is not required.

Radiation from the transformers and PV inverters will be even less significant due to protective enclosures and 'CE' marking (Conformité Européene, or European Conformity marking), and/or 'UKCA' marking (UK Conformity Assessed), ensuring compliance with electromagnetic disturbance standards.

Additionally, radiation from the substations and BESS will not be significant, as they will be located at least 50m from any surrounding dwellings and workspaces. For users of Public Rights of Way (PRoWs), any radiation effects are expected to be minimal due to their transient exposure.

33kV to 400kV Underground Cables

The maximum magnetic field produced by the proposed underground cables (33kV to 400kV) in double circuit configurations is predicted to be 192.34 micro-Tesla, which exceeds the 100 micro-Tesla public exposure reference level. This will only occur for the 400kV cable connections to the substation.

To mitigate this, a 5m clearance distance is recommended for these sections, as magnetic fields beyond this distance measure less than the reference level. The closest identified dwellings and workspaces to the cable route are located further than this at over 50m away, which is a safe distance, given that electromagnetic field strength decreases exponentially with distance.

For users of PRoWs, any radiation effects are expected to be minimal due to their transient exposure as these are not continually occupied, rather they are moving receptors, as opposed to residential dwellings and workplaces.

Therefore, no significant impacts associated with the proposed underground cables are predicted.

Transformers, and PV Inverters

Notable sources of radiation other than the cables will be the conversion units (transformers/PV inverters) positioned across the proposed development.

The electrical equipment associated with the transformers and PV inverters should be 'CE' marked (Conformité Européene, or European Conformity marking), and/or 'UKCA' marked (UK Conformity Assessed). CE and UKCA markings indicate that a product has been assessed by the manufacturer and determined to meet the safety, health, and environmental protection requirements of the European Union and the United Kingdom, respectively. CE marking requirements were adopted and extended indefinitely in Great Britain until the UK left the EU in 2020. From 1 January 2021, the UKCA mark started to replace the CE mark for goods sold within Great Britain, and the CE mark has continued to be required for goods sold in Northern Ireland. The CE marking should ensure that electrical and electronic equipment does not generate, or is not unintentionally affected by, electromagnetic disturbance.

The transformers and PV inverters are also predicted to produce fields at a lower level than that of underground cables because the equipment is typically housed in protective enclosures. Therefore, no significant impacts associated with the proposed conversion units are predicted.

Substations, BESS and Sub-distribution units

The proposed development will connect to Bodelwyddan Substation (an existing National Grid distribution substation). According to UK regulation, the substation conforms with the applicable exposure limitations for the general public, and the field from the equipment inside a substation does not extend far, if at all, outside the perimeter fence. Additionally, the proposed development will include connection to up to one substation (assumed to be 400kV) located within the proposed BESS Site. Electrical equipment associated with these substations are expected to be 'CE' or ‘UKCA’ marked and housed in protective enclosures and thus predicted to produce fields at a lower level than that of underground cables.

Additionally, the proposed 33kV Sub-distribution Switchroom is more than 190m from any identified dwelling and complies with public exposure limits, as electromagnetic fields from the equipment do not extend significantly beyond the perimeter fence.

The BESS and proposed substation contribute to the electromagnetic radiation produced by the proposed development and are situated within the BESS Site. The BESS Site is adjacent to Bodelwyddan Substation. The proposed BESS Site is situated more than 50m from any identified dwelling or workspace. As electromagnetic radiation levels reduce with increased distance, all nearby dwellings and workplaces are expected to be situated at a safe distance from the BESS and substation installations.

LIST OF CONTENTS

Administration Page 2
Executive Summary 3
Report Purpose 3
Emissions 3
Standards in the UK 3
Overall Conclusion 3
33kV to 400kV Underground Cables 4
Transformers, and PV Inverters 4
Substations, BESS and Sub-distribution units 4
List of Contents 6
List of Figures 7
List of Tables 8
About Pager Power 9
1 Introduction 10
1.1 Purpose of the Study 10
1.2 Proposed Development Site Areas 10
1.3 Assessed Infrastructure 12
1.4 Assessed Infrastructure Technical Information 13
2 Technical Background 15
2.1 Emissions 15
2.2 Electromagnetism 15
2.3 Health Concerns – Potential Effects 15
2.4 Radiation from Home Electrical Equipment 16
2.5 Radiation Reduction with Distance 16
3 Overview of electromagnetic fields 17
3.1 Overview 17
3.2 Exposure limits in the UK 17
3.3 Height Above Ground Used for Testing Compliance 18

3.4 Safe Levels – Summary 18

4 Technical Assessment 19

4.1 Field Levels – 400kV Underground Cables 19

4.2 Field Levels – 33kV Underground Cables 20

4.3 Recommended Minimum Clearance Distances 21

4.4 Radiation from Other Sources 23

4.5 Comparative Assessment 27

4.6 Cumulative Effects 27

5 Conclusions 28

5.1 33kV to 400kV Underground Cables 28

5.2 Transformers, and PV Inverters 28

5.3 Substations and BESS 28

LIST OF FIGURES

Figure 1 Proposed development site areas and cable route 11

Figure 2 Assessed infrastructure locations 12

Figure 3 Maximum magnetic fields associated with 400kV underground cables 19

Figure 4 Typical magnetic fields associated with 33 kV underground cable 20

Figure 5 Nearest building to the assessed cable route 22

Figure 6 Minimum distance between BESS and substation, and the nearest dwellings 24

Figure 7 Minimum distance between the proposed Sub-distribution Switchroom and the nearest dwellings 25

LIST OF TABLES

Table 1 Assessed infrastructure technical information 13

Table 2 Cable route technical information 14

Table 3 Typical emissions from home electrical equipment 16

Table 4 ICNIRP Exposure Limits 1998 18

Table 5 Maximum magnetic field levels for an underground 400kV cable 20

Table 6 Typical magnetic field levels for an underground 33 kV cable 21

Table 7 Recommended clearance distances for single circuit underground cables 21

Table 8 Recommended clearance distances for assessed trench configurations 22

ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 62 countries internationally.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems. Over the years, the company has expanded into numerous fields including:

- Renewable energy projects;
- Building developments;
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable, and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

1 INTRODUCTION

1.1 Purpose of the Study

Pager Power has been retained to assess the potential electromagnetic fields generated by electrical equipment within a ground-mounted solar photovoltaic development with respect to safe levels for human exposure. The proposed development is located northwest of Bodelwyddan, Wales, UK, and will include underground power cables, transformers, photovoltaic (PV) inverters, substations, a Battery Energy Storage System (BESS) and other ancillary infrastructure.

1.2 Proposed Development Site Areas

Figure 1 on the following page shows the site layout[1] for the proposed development. The infrastructure assessed in this report is detailed in the following sub-section, details of which have been obtained from the Solar and BESS Site Layout drawings, ref. 02 and 03 respectively.

[1] Source: Ref01_Site Location Plan (edited)

Figure 1 *Proposed development site areas and cable route*

1.3 Assessed Infrastructure

The known locations of assessed infrastructure are shown in Figure 2 below:

- Approximate proposed solar array footprint (dark blue polygons);
- All proposed underground cable routes (pink lines);
- PV inverters/transformers (circular icons);
- 33kV Sub-distribution switchroom (triangle icon);
- Substations (square icon);
- BESS (light blue areas).

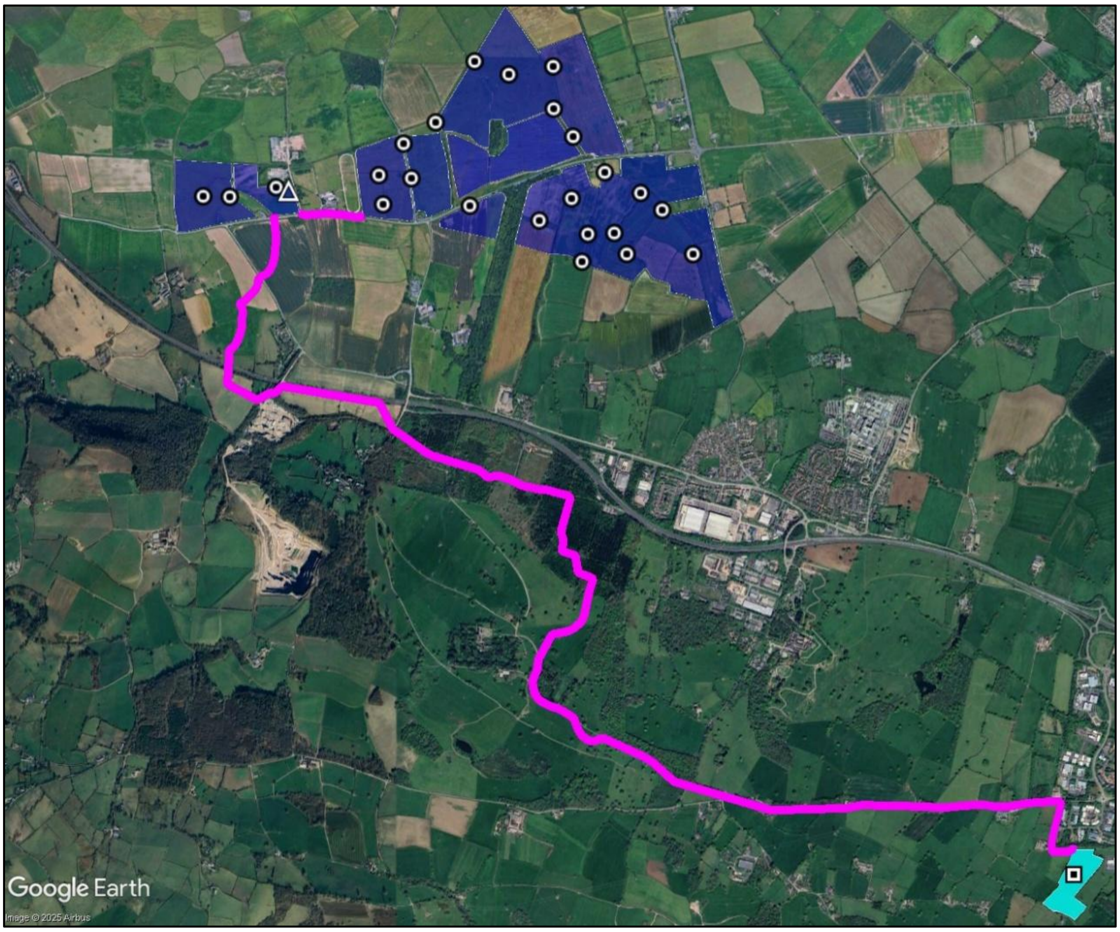

Figure 2 *Assessed infrastructure locations*

1.4 Assessed Infrastructure Technical Information

The technical information considered in this assessment is presented in Table 1 below. Table 2, below outlines the cable route information. Information in italics is to be confirmed and are subject to change as design progresses, but the worst case parameters has been assumed for the purpose of this assessment.

Assessed Infrastructure Technical Information		
Underground cables	Voltages	33kV to 400kV cables
	Locations	Highlighted in Figures 1 and 2
	Minimum Depth	0.75m
33kV Sub-distribution switchroom	Voltages	33kV
	Locations	Highlighted in Figure 2
Substation	Voltages	Assumed to be 400kV as worst-case scenario
	Location	Highlighted in Figure 2
BESS	Proposed locations	Site Highlighted in Figure 1
Conversion Units (PV inverters)	Proposed locations	*Positioned across the proposed development*

Table 1 *Assessed infrastructure technical information*

Cable Route Technical Information	
Cable route locations	Trench Configurations
Solar Site to BESS Site	33kV 2 circuits
Panel area connection	33kV 2 circuits
BESS to Bodelwydden substation	400kV assumed to be 2 circuits for worst-case scenario

Table 2 *Cable route technical information*

2 TECHNICAL BACKGROUND

2.1 Emissions

All electrical equipment emits electric and magnetic radiation. Power cables produce both electric and magnetic fields which can potentially affect human health. Radiation from underground cables is generally less than radiation from overhead lines because emissions from adjacent conductors within a cable tend to cancel each other out. When assessing the impacts of overhead powerlines, it is important to consider the impact of both electric and magnetic fields.

Underground cables generally cause a negligible electric field above ground but can cause a significant magnetic field which is dependent on the current in the conductors.

2.2 Electromagnetism

The movement of electric charge causes electric and magnetic fields to be produced in the space surrounding the charge. Human exposure to such fields can cause health problems if persistent and/or they are of high strength. The magnitude of the effects is dependent on both the field strength and the exposure time.

2.3 Health Concerns – Potential Effects

The potential effects on human health caused by time-varying magnetic fields, such as those generated by AC[2] cables, are due to induced current on functions of the central nervous system. There are various international bodies which provide maximum safe exposure levels to time varying electromagnetic fields.

Various sources of information relating to safe exposure levels have been reviewed as part of this study.

The UK Policy on public exposure limits to EMF radiation is designed to comply with the 1998 ICNIRP (International Commission on the Non-Ionizing Radiation Protection) guidelines in terms of the 1999 EU Recommendation. In 2010 ICNIRP produced new guidelines but these have not yet been incorporated into UK Policy. The public exposure limits in UK policy define reference levels for electric and magnetic fields. Where field levels exceed these reference levels in significantly occupied spaces, further investigation is warranted.

Another relevant resource consulted is the EMFs.info webpage[3], where the UK electricity industry have collected the relevant studies pertaining to safe limits on exposure in the UK and elsewhere in the world. The relevant sections are analysed in the next chapter.

[2] Alternating Current

[3] Accessed 28th March 2024

2.4 Radiation from Home Electrical Equipment

The World Health Organization (WHO) publishes data regarding electromagnetic fields including the following typical levels for home electrical equipment, shown in Table 3 below.

Appliance	Electric field strength (Volts per metre)	Magnetic field strength (micro-Tesla) (at 1 metre)
Hair Dryer	80	0.01 – 7
Iron	120	0.12 – 0.3
Vacuum Cleaner	50	2 – 20
Refrigerator	120	0.01 – 0.25
Television	60	0.04 - 2

Table 3 *Typical emissions from home electrical equipment*

2.5 Radiation Reduction with Distance

Radiation levels reduce with distance which means, for example, the typical magnetic field from a vacuum cleaner reduces from 800 micro-Tesla to 2 micro-Tesla when the separation distance increases from 3 centimetres to 100 centimetres.

This means radiation levels from the cables, transformers, PV inverters, substations and BESS will tend to reduce with distance in any direction – including towards a receptor.

3 OVERVIEW OF ELECTROMAGNETIC FIELDS

3.1 Overview

The Electricity Networks Association[4] provides a comprehensive overview of electromagnetic fields (EMFs) and the issues associated with these on their webpage[5]. Regarding health issues caused by EMFs they state the following:

However, there are suggestions that magnetic fields may cause other diseases, principally childhood leukaemia, at levels below these limits. The evidence for this comes from epidemiology studies, which have found a statistical association - an apparent two-fold increase in leukaemia incidence, from about 1 in 24,000 per year up to 1 in 12,000 per year, for the children with the top half percent of exposures. The evidence is strong enough for magnetic fields to be classified by the World Health Organization as "possibly carcinogenic". But because these studies only show statistical associations and do not demonstrate causation, and because the evidence from the laboratory is against, the risk is not established, it remains only a possibility.

3.2 Exposure limits in the UK

As set out in the previous section, the limits in the UK come from the 1998 ICNIRP guidelines. The original guidance in 1999 specified:

i) Basic Restrictions

   These are the levels at which radiation is potentially harmful to humans. This is a current density[6] given in mA m^{-2} (milliamps per metre squared).

ii) Reference Level (Investigation Level)

   Provided for practical exposure assessment purposes to determine whether the basic restrictions are likely to be exceeded. Compliance with the reference level will ensure compliance with the relevant basic restriction.

iii) Field Actually Required

   This is the field strength at which the basic restriction is likely to be exceeded.

The values for the above stated in the ICNIRP 1998 paper are shown in Table 4 on the following page. These are the public exposure values, not the occupational exposure values – the former is more conservative than the latter by a factor of five.

---

[4] This is an industry body for the companies which run the UK and Ireland's energy networks. The group comprises 14 members including National Grid.

[5] www.emfs.info [Accessed 28th March 2024]

[6] Current density is the amount of electric current flowing through a unit area.

ICNIRP 1998 – Public Exposure Limits				
Basic Restriction (mA m^{-2})	Magnetic Fields Reference Level (µT)	Electric Fields Reference Level (kV m^{-1})	Magnetic Field Actually Required to Exceed Basic Restriction (µT)	Electric Field Actually Required to Exceed Basic Restriction (kV m^{-1})
2	100	5	360	9

Table 4 *ICNIRP Exposure Limits 1998*

The public exposure limits in Table 4 will be considered within this analysis.

3.3 Height Above Ground Used for Testing Compliance

EMFs.info specifically states the following with regard to the height to be used to test compliance:

The standard height for measuring fields, especially from power lines, is 1 m above ground level … This isn't just because it's a convenient round number, it's because roughly half way up the height of a standing person is actually the height that gives the best approximation to the induced current in the body.

3.4 Safe Levels – Summary

The values of interest are those shown in Table 4 above. Effectively, this means that in locations of significant exposure time, such as residences, levels should be below:

- 100µT (magnetic fields).
- 5kV m^{-1} (electric fields).

Values exceeding the limits above, at one metre above ground level, would suggest that further investigation is required.

4 TECHNICAL ASSESSMENT

4.1 Field Levels – 400kV Underground Cables

Field level data from various cable configurations have been sourced from EMFS.info. The data below and on the following page shows the magnetic fields for 400kV cables, which represent the maximum assumed voltage for underground cables in the proposed development, considering a worst-case scenario. Typical values for magnetic fields are approximately a quarter of these maximum values[7]. The assessment accounts for varying cable voltages in the proposed development, with the analysis based on the maximum and shallowest depths to adopt a conservative approach. Maximum field data has been used where possible to provide a more conservative assessment. It's important to note that there are no electric fields above ground associated with underground cables. The relevant chart is shown in Figure 3 below. Table 5 on the following page provides the associated indicative numerical values at set distances[8].

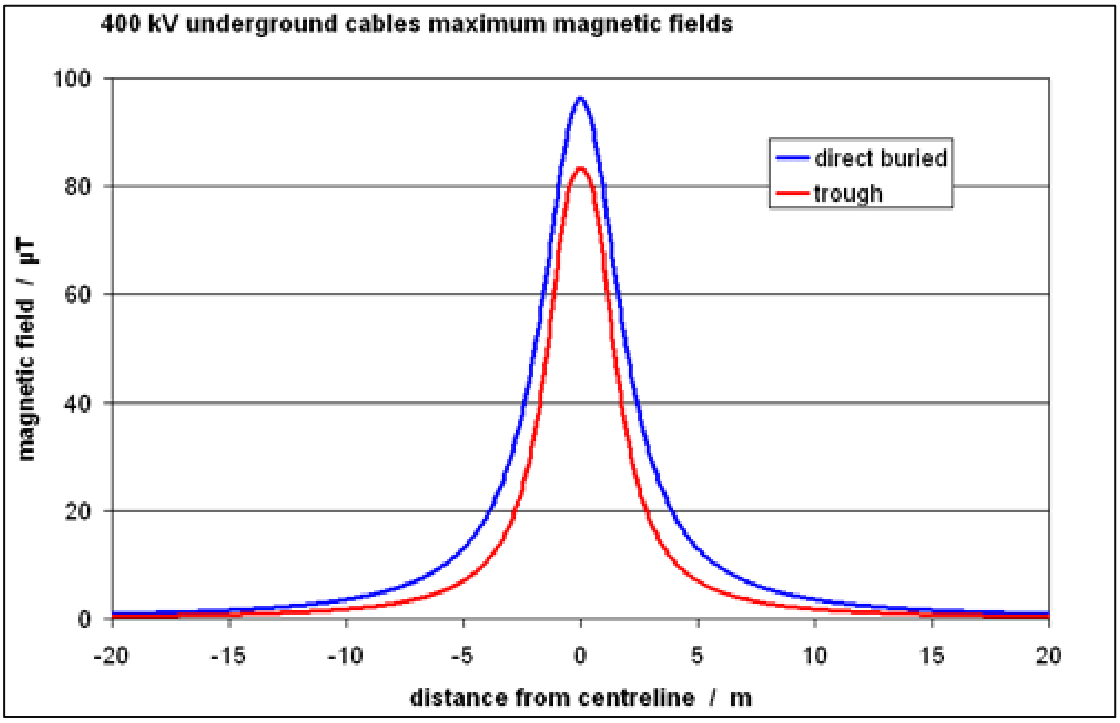

Figure 3 *Maximum magnetic fields associated with 400kV underground cables*

[7] Source: https://www.emfs.info/sources/overhead/specific/400-kv/ [Accessed 28th March 2024]
[8] www.emfs.info [Accessed 28th March 2024]

Distance from Centreline (m)	Magnetic Field (trough double circuit cable with 0.13m spacing and 0.3m depth)	Magnetic Field (direct buried single cable with 0.5m spacing and 0.9m depth)[9]
0	83.30 micro Teslas	96.17 micro Teslas
5	7.01 micro Teslas	13.05 micro Teslas
10	1.82 micro Teslas	3.58 micro Teslas
20	0.46 micro Teslas	0.92 micro Teslas

Table 5 *Maximum magnetic field levels for an underground 400kV cable*

4.2 Field Levels – 33kV Underground Cables

The data below shows the magnetic fields for 33 kV cables. The relevant chart for the magnetic fields associated with 33kV underground cables is shown in Figure 4 below. Table 6 below provides the associated indicative numerical values at set distances.

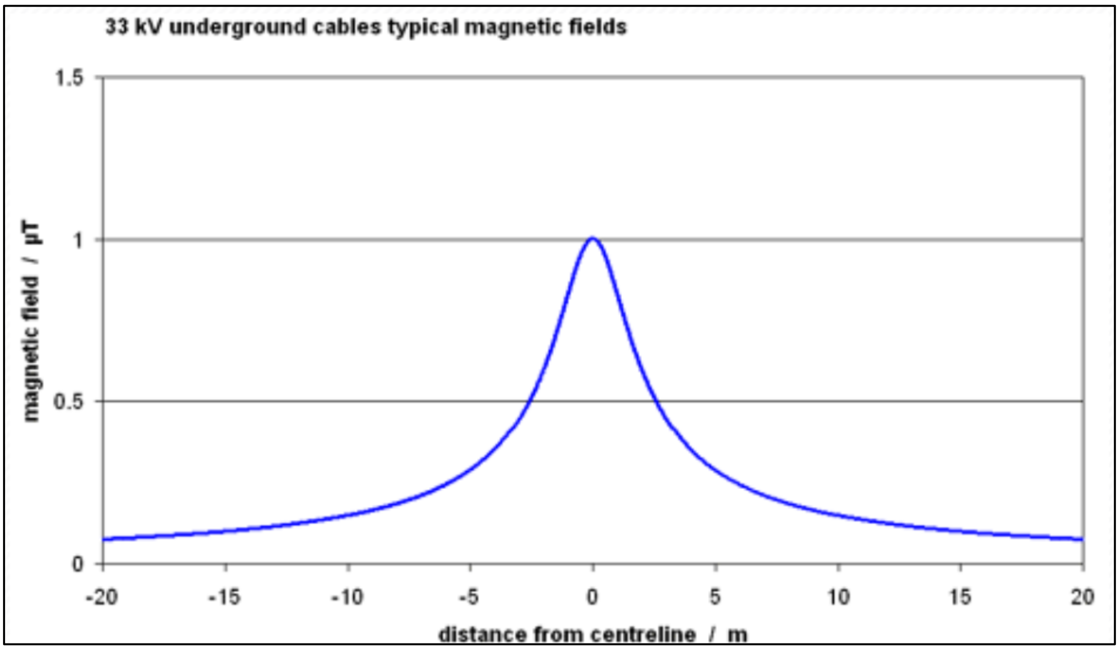

Figure 4 *Typical magnetic fields associated with 33 kV underground cable*

Distance from Centreline (m)	Magnetic Field (single 33 kV cable at 0.5m depth)
0	1.00 micro Teslas
5	0.29 micro Teslas

[9] This cable was used for the assessment in the following sections.

Distance from Centreline (m)	Magnetic Field (single 33 kV cable at 0.5m depth)
10	0.15 micro Teslas
20	0.07 micro Teslas

Table 6 *Typical magnetic field levels for an underground 33 kV cable*

4.3 Recommended Minimum Clearance Distances

The recommended minimum clearance distances for underground cables based on the public exposure limits previously referenced in this report for magnetic and electric fields are presented in Table 7 below.

The dataset provided maximum values and typical values for single circuit configurations of the cables that have been evaluated – in all cases the 'maximum' option has been chosen where possible in order to remain conservative.

Type of Line	Estimated Maximum Magnetic Field (micro-Tesla)	Recommended minimum Clearance Distance (m)	Estimated Maximum Electric Field (kV/m)
400kV underground cable	96.17 (below 100 limit)	None	-
33 kV underground cable	1.00 (below 100 limit)	None	-

Table 7 *Recommended clearance distances for single circuit underground cables*

Table 7 confirms that clearance distances are not required for any proposed single-circuit underground cables. The table demonstrates that the maximum magnetic fields generated by these cables remain below the acceptable exposure limit, and no significant effects on human health are anticipated.

For the trench configurations outlined in Table 2 in Section 1.4 the worst case is based upon the addition of source a and source b; however, it is important to note that this is only true for magnetic fields that are exactly in line. When the electromagnetic fields are not in line, the sum of these is less than 'a+b'. The estimated maximum magnetic fields and associated recommended minimum clearance distances are outlined in Table 8 below and on the following page.

Cable route locations	Trench configurations	Estimated Maximum Magnetic Field (micro-Tesla)	Recommended minimum Clearance Distance (m)
Solar Site to BESS Site	33kV 2 circuits	2.00 (below 100 limit)	None
Panel area connection	33kV 2 circuits	2.00 (below 100 limit)	None
BESS to Bodelwydden substation	400kV 2 circuits	192.34 (above 100 limit)	None

Table 8 *Recommended clearance distances for assessed trench configurations*

One of the assessed trench configurations exceeds the ICNIRP 1998 public exposure reference limit for magnetic fields (100 µT). However, this remains well below the threshold of 360 µT required to exceed basic restrictions. A worst-case conservative assessment indicates that these exceedances are marginal and occur only for receptors with prolonged exposure directly above the cable route centreline.

A 5m clearance distance is recommended for these sections, as receptors beyond this distance are unlikely to experience magnetic fields exceeding the reference limits. A review of aerial imagery, as shown in Figure 5 below, confirms that the nearest building (commercial use) is 52m from the worst-case cable route. Given this separation, no significant impacts are predicted.

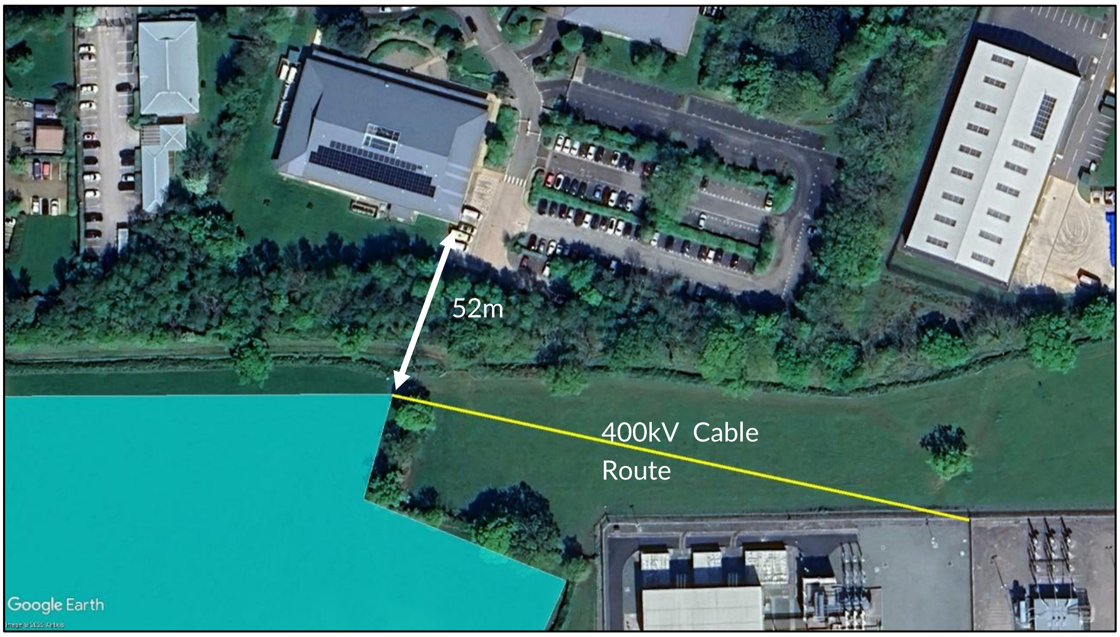

Figure 5 *Nearest building to the assessed cable route*

4.4 Radiation from Other Sources

4.4.1 Transformers and PV Inverters

Notable sources of radiation, other than the underground cables, will include the transformers and PV inverters positioned across the proposed development. As of the time of this report, the specific locations for these have not been finalised.

The transformers and PV inverters should be CE marked (Conformité Européene, or European Conformity marking), and/or 'UKCA' marked (UK Conformity Assessed). CE and UKCA marking indicates that a product has been assessed by the manufacturer and deemed to meet the safety, health and environmental protection requirements of the European Union[10] and the United Kingdom[11], respectively. CE marking requirements have been adopted and extended indefinitely in Great Britain until the UK left the EU in 2020. From 1 January 2021, the UKCA mark started to replace the CE mark for goods sold within Great Britain, and the CE mark has continued to be required for goods sold in Northern Ireland. This will be confirmed prior to installation.

The relevant EU Directive for CE marking is[12] Electromagnetic Compatibility Directive 2014/30/EU, and the relevant UK Statutory guidance for UKCA marking is the Electromagnetic Compatibility Regulations 2016[13]. This legislation should ensure that electrical and electronic equipment should not generate, or be affected by, electromagnetic disturbance.

Additionally, the transformers and PV inverters are also predicted to produce fields at a lower level than that of underground cables as the equipment will be housed in a protective enclosures.

4.4.2 Substations, BESS and Sub-distribution units

Other notable sources of radiation associated with the proposed development include the substations, BESS and Sub-distribution units.

Furthermore, as detailed in Table 1 within Section 1.4, the proposed development will include connection to Bodelwyddan Substation, one substation (assumed to be 400kV) within the BESS Site, and one 33kV Sub-distribution Switchroom within the Solar Site. The proposed locations of which are detailed in Section 1.

A detailed overview of the potential BESS and substation locations (light blue) and proposed 33kV Sub-distribution Switchroom (triangle icon) is presented in Figures 6 and 7 on the following pages.

---

[10] Source: https://europa.eu/youreurope/business/product-requirements/labels-markings/ce-marking/index_en.htm
[11] Source: https://www.gov.uk/guidance/using-the-ukca-marking
[12] Source: https://ec.europa.eu/growth/sectors/electrical-engineering/emc-directive_en
[13] Source: https://www.gov.uk/government/publications/electromagnetic-compatibility-regulations-2016/electromagnetic-compatibility-regulations-2016-great-britain

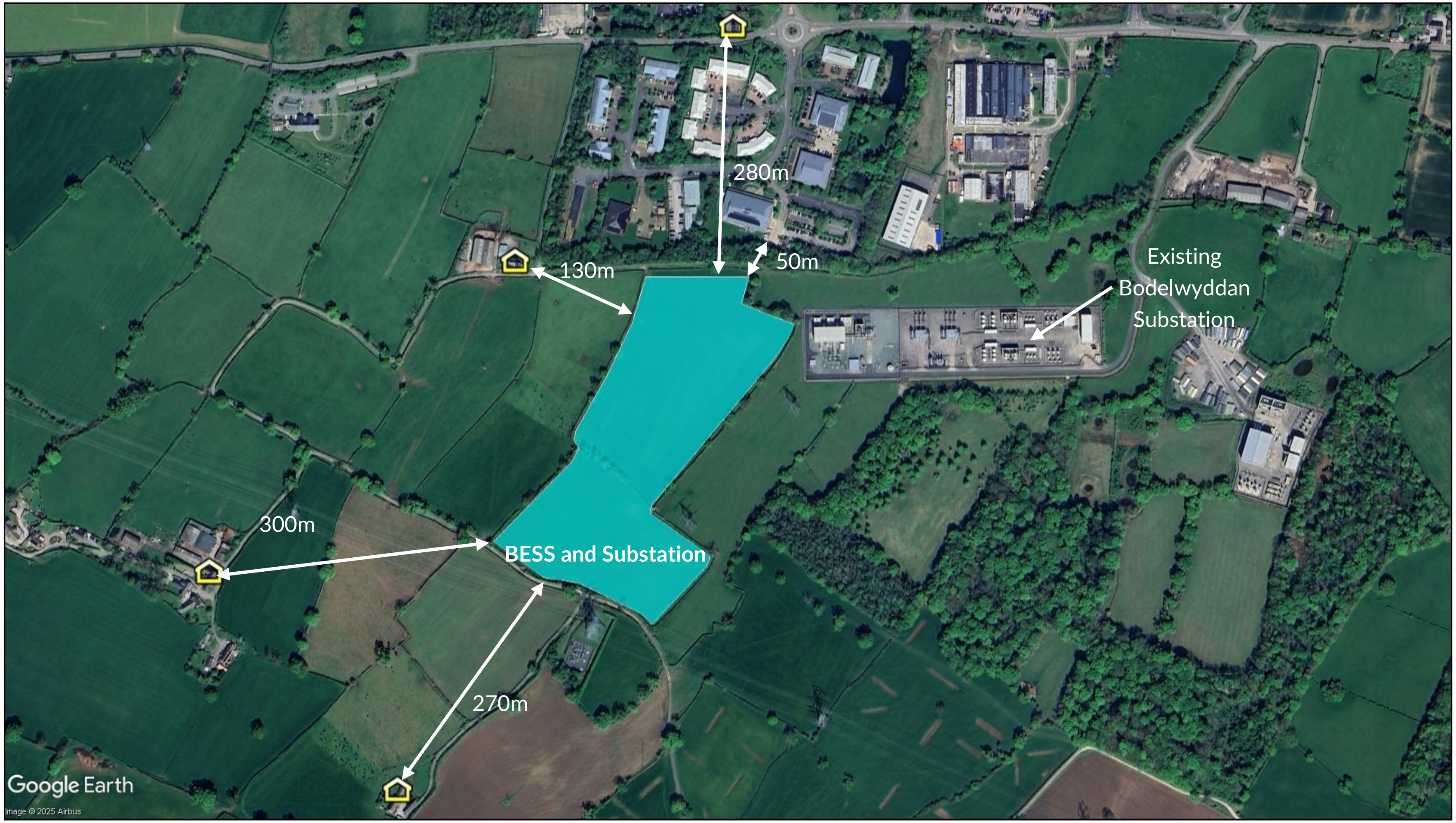

Figure 6 *Minimum distance between BESS and substation, and the nearest dwellings*

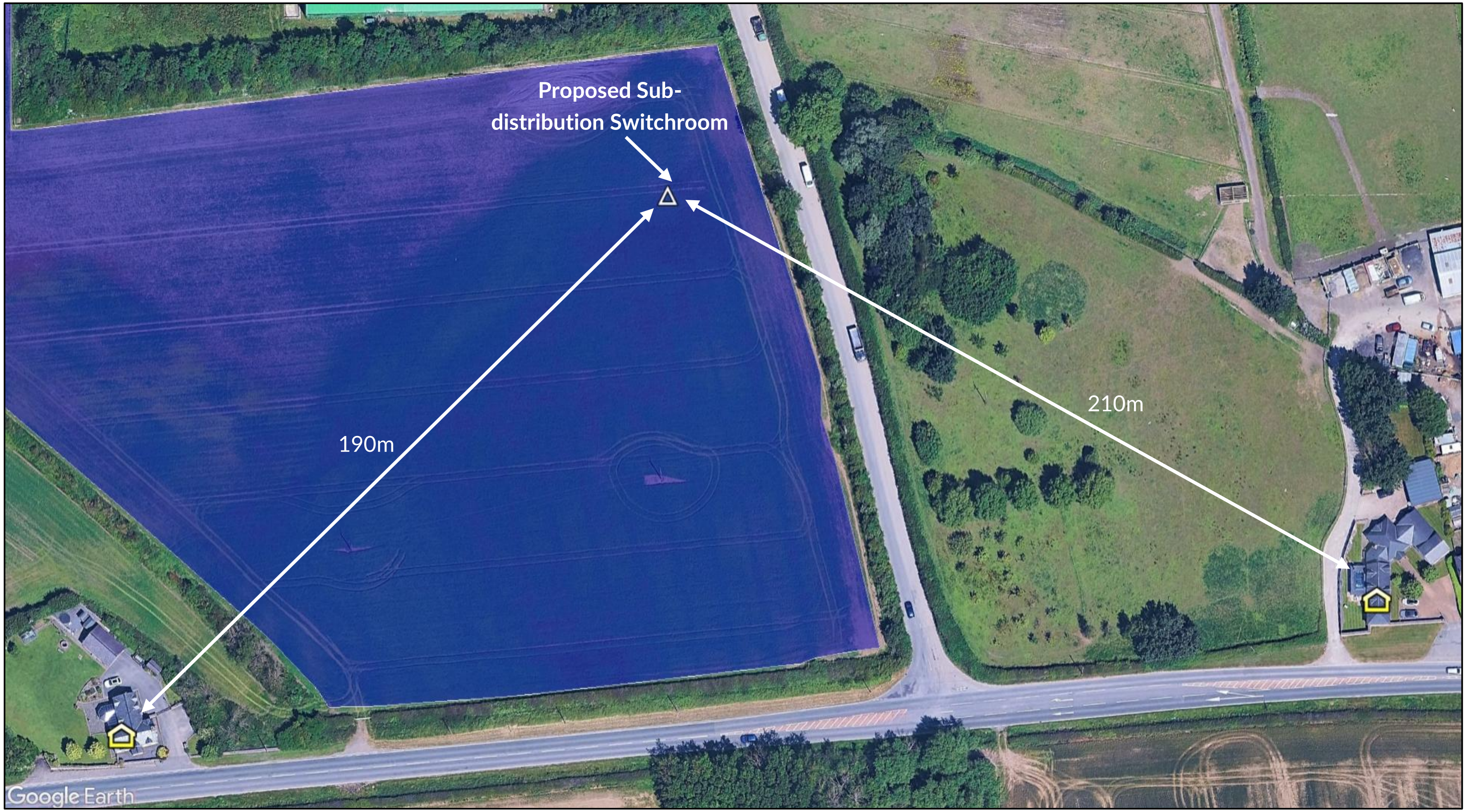

Figure 7 *Minimum distance between the proposed Sub-distribution Switchroom and the nearest dwellings*

The minimum horizontal distance between the proposed BESS and substation, and any dwelling is approximately 130m (50m from any workplace), and 190m between the proposed 33kV Sub-distribution Switchroom and any dwelling.

Based on a desk-based review of imagery, there are overhead powerlines surrounding the proposed BESS Site connecting to Bodelwyddan Substation. These are likely to be 400kV pylons. 400kV overhead powerlines would produce more significant electric and magnetic fields than any type of electrical infrastructure proposed as a part of this development. Therefore, the most significant source of radiation for these dwellings (and workplaces) is the existing overhead powerlines[14] connecting to Bodelwyddan Substation. These dwellings (and workplaces) are already considerably close to the existing substation and are in even closer proximity to the existing overhead power cables, which are a much more significant source of radiation. Additionally, the magnetic fields from the proposed underground cable routes have been assessed accordingly within this report for the nearest dwelling locations.

Similarly to the transformers and PV inverters, the additional proposed substation and Sub-distribution Switchroom, ranging from 33kV to 400kV, are expected to be comprised of equipment that is 'CE' and/or 'UKCA' marked. CE and 'UKCA' marking should ensure that electrical and electronic equipment does not generate, or is not unintentionally affected by, electromagnetic disturbance. The substations are also predicted to produce fields at a lower level than that of underground cables because the equipment is expected to be housed in protective enclosures.

Significant radiation is not predicted from the existing substation, proposed substations, BESS and sub-distribution units because:

- The perimeters of Bodelwyddan Substation and the proposed 400kV substations are more than 50 metres from any dwelling or workplace and would be required to comply with the relevant exposure limits for the general public, and the electromagnetic fields from the equipment inside a substation do not extend far if at all outside the perimeter fence.
- The proposed BESS and substation locations are more than 130 metres from any dwelling, and more than 50m from any workplace, meaning that all dwellings and workplaces are at a safe distance as electromagnetic radiation levels reduce as the separation distance increases.
- For users of Public Rights of Way (PRoWs), any radiation effects would likely be minimal as these are not continually occupied, rather they are moving receptors, as opposed to residential dwellings and workplaces.

[14] Understood to be 400kV

4.5 Comparative Assessment

The maximum magnetic field produced by household appliances like vacuum cleaners can reach up to 50 micro-Tesla[15]. It would follow that appliances with higher voltages would generate stronger magnetic fields. For instance, the proposed underground cables are projected to produce a maximum magnetic field of 96.17 micro-Tesla. While this value is notably higher than that of household appliances, it remains within acceptable exposure limits. Notably, the magnetic field strength is expected to drop to approximately 13 micro-Tesla just 5 meters from the source for 400kV cables less than 1 meter deep; a value even less than that of a vacuum cleaner. With the any depth of the high voltage 400kV underground cables over 0.5 meters for the proposed development, a likely reduction in the strength of the magnetic field is predicted.

Moreover, the transformers and PV inverters will produce magnetic fields at levels lower than the underground cables.

4.6 Cumulative Effects

When assessing the cumulative effects of electromagnetic fields, the worst case is based upon the addition of source a and source b; however, it is important to note that this is only true for magnetic fields that are exactly in line. When the electromagnetic fields are not in line, the sum of these is less than 'a+b'.

For the purpose of this assessment the worst case has been calculated i.e. based upon 'a+b'. As there are no proposed overhead powerlines to consider for the proposed development, there are no cumulative effects to assess of this regard.

As discussed in Section 4.5, the transformers, PV inverters, substations and BESS produce smaller magnetic fields than that of the underground cables, thus, considering all sources of radiation and their relative locations, it is predicted that the cumulative magnetic and electric fields are likely to be below the acceptable exposure limits.

The cumulative effects are not significantly impacted by the use of household items. Electrical household appliances will add to the overall exposure of electromagnetic fields; however, these levels will still remain below the recommended exposure limit, due to the lower voltages of the appliances, and are not used constantly, providing only a temporary addition to the resultant electromagnetic field levels.

It is not expected that there will be any significant cumulative effects with other known solar schemes. This is because of the absence of any known possibility for high-voltage cables to overlap.

The electrical design is considering multiple high-voltage cables within a single trench along certain sections of the cable route. The cumulative resultant fields and associated set back distances have been assessed in Table 9 in Section 4.4.

---

[15] Source: https://www.nationalgrid.com/electricity-transmission/document/141896/download#:~:text=Normally%20these%20underground%20cables%20will,do%20not%20emit%20electric%20fields

5 CONCLUSIONS

5.1 33kV to 400kV Underground Cables

The maximum magnetic field produced by the proposed underground cables (33kV to 400kV) in double circuit configurations is predicted to be 192.34 micro-Tesla, which exceeds the 100 micro-Tesla public exposure reference level. This will only occur for the 400kV cable connections to the substation.

To mitigate this, a 5m clearance distance is recommended for these sections, as magnetic fields beyond this distance measure less than the reference level. The closest identified dwellings and workspaces to the cable route are located further than this at over 50m away, which is a safe distance, given that electromagnetic field strength decreases exponentially with distance.

For users of PRoWs, any radiation effects are expected to be minimal due to their transient exposure as these are not continually occupied, rather they are moving receptors, as opposed to residential dwellings and workplaces.

Therefore, no significant impacts associated with the proposed underground cables are predicted.

5.2 Transformers, and PV Inverters

Notable sources of radiation other than the cables will be the conversion units (transformers/PV inverters) positioned across the proposed development.

The electrical equipment associated with the transformers and PV inverters should be 'CE' marked (Conformité Européene, or European Conformity marking), and/or 'UKCA' marked (UK Conformity Assessed). CE and UKCA markings indicate that a product has been assessed by the manufacturer and determined to meet the safety, health, and environmental protection requirements of the European Union and the United Kingdom, respectively. CE marking requirements were adopted and extended indefinitely in Great Britain until the UK left the EU in 2020. From 1 January 2021, the UKCA mark started to replace the CE mark for goods sold within Great Britain, and the CE mark has continued to be required for goods sold in Northern Ireland. The CE marking should ensure that electrical and electronic equipment does not generate, or is not unintentionally affected by, electromagnetic disturbance.

The transformers and PV inverters are also predicted to produce fields at a lower level than that of underground cables because the equipment is typically housed in protective enclosures. Therefore, no significant impacts associated with the proposed conversion units are predicted.

5.3 Substations and BESS

The proposed development will connect to Bodelwyddan Substation (an existing National Grid distribution substation). According to UK regulation, the substation conforms with the applicable exposure limitations for the general public, and the field from the equipment inside a substation does not extend far, if at all, outside the perimeter fence. Additionally, the proposed development will include connection to up to one substation (assumed to be 400kV) located within the proposed BESS Site. Electrical equipment associated with these substations are expected to be 'CE' or ‘UKCA’ marked and housed in protective enclosures and thus predicted to produce fields at a lower level than that of underground cables.

Additionally, the proposed 33kV Sub-distribution Switchroom is more than 190m from any identified dwelling and complies with public exposure limits, as electromagnetic fields from the equipment do not extend significantly beyond the perimeter fence.

The BESS and proposed substation contribute to the electromagnetic radiation produced by the proposed development and are situated within the BESS Site. The BESS Site is adjacent to Bodelwyddan Substation. The proposed BESS Site is situated more than 50m from any identified dwelling or workspace. As electromagnetic radiation levels reduce with increased distance, all nearby dwellings and workplaces are expected to be situated at a safe distance from the BESS and substation installations.

PAGERPOWER
Urban & Renewables

Pager Power Limited
Stour Valley Business Centre
Sudbury
Suffolk
CO10 7GB

Tel: +44 1787 319001 **Email:** info@pagerpower.com **Web:** www.pagerpower.com