ELECTROMAGENTIC RADIATION COMPLIANCE REPORT

WARWICK SOLAR FARM
15F001-RP-E-0-008

lendlease

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	Name	Position	Signature / Date
Prepared by	Dan Brophy	Electrical Engineer	
Reviewed by	Derrick Sutcliffe	Principle Electrical Engineer	
Authorised by	Samik Bhattacharya	Design Manager	

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1.0 EXECUTIVE SUMMARY

An electromagnetic radiation compliance assessment has been conducted on all significant elements of the proposed Warwick Solar Farm in accordance with published standards, guidelines and regulations.

This report confirms that EMR generating equipment within the proposed design complies with all applicable standards, regulations and guidelines, including the National Health & Medical Research Council's *Interim Guidelines on the limits of exposure to 50/60Hz electric and magnetic fields (1989).* It is therefore concluded that the solar farm does not present any health risk to persons working within or near the facility or to the general public.

2.0 INTRODUCTION

2.1 Background

The Warwick Solar Farm (WSF), with a total capacity of 78.17MWp, is to be installed and connected to two Ergon Energy Corporation Limited (EECL) 33kV feeders. Many fundamental components of a solar farm are equipment and devices which inherently produce varying levels of electromagnetic emissions. Specifically, power conversion units, substations and powerlines all produce some level of electromagnetic radiation.

Electromagnetic radiation (EMR) is the transfer of energy in the form of a stream of particle or electromagnetic waves. Electric and magnetic fields are present wherever electricity is generated, transmitted or distributed in cables or powerlines, or consumed in electrical devices such as TVs, computers or fridges. Since our modern lifestyle depends on the use of electricity, these fields are universally present in our environment. [1]

Depending on its frequency or wavelength, electromagnetic radiation can be arranged into the following general classifications: Extremely Low Frequency (ELF), Very Low Frequency (VLF), Radio Frequency (RF) and Microwave (MW). Extremely low frequency radiation is radiation which occupies the lower end of the electromagnetic spectrum, specifically, in the frequency range of 0-3000 Hz. An example of ELF radiation is the radiation produced by electrical infrastructure which, in Australia, operate at 50 Hz. ELF radiation will be the dominate focus of this report, as the proposed infrastructure will produce electric and magnetic fields at a frequency of 50 Hz.

2.2 Scope

The scope of this document is to assess the Warwick Solar Farm's compliance to electromagnetic radiation standards and regulations. Specifically, power conversion units, substation and powerlines are investigated to ensure compliance.

3.0 COMPLIANCE REQUIREMNTS

To ensure the protection and safety of all persons, electromagnetic radiation (EMR) levels from all WSF equipment and devices will not exceed the recommended levels outlined in the National Health and Medical Research Council's (NHMRC) *"Interim guidelines on limits of exposure to 50/60 Hz electric and magnetic fields (1989)."*

The research council provides their results categorised into two exposure characteristics, electric field strength and magnetic flux density. Electric field strength is a measure, in V/m, of the force exerted by an electric field on a unit charge. It arises from voltage potential and is present even when energy is not being consumed. Magnetic flux density is a measure, in teslas (T), of the force exerted on a charge moving in the field. It arises from a current flow and is only present when energy is being consumed. The emission of energy from these two sources is what characterises electromagnetic radiation.

The following limits (Table 1) are recommended by the NHMRC for occupational and general public exposures to 50/60 Hz electric and magnetic fields. [2]

Table 1: Limits of exposure to 50/60 Hz electric and magnetic fields

Exposure Characteristics	Electric Field Strength (kV/m)$_{(rms)}$	Magnetic Flux Density (mT)$_{(rms)}$	Magnetic Flux Density (mG)[d]
Occupational			
Whole working day	10	0.5	5000
Short term	30 [a]	5 [b]	50000
General Public			
Up to 24 hours/day[c]	5	0.1	1000
Few hours/day	10	1	10000

Notes:

(a) The duration of exposure to fields between 10 and 30 kV/m may be calculated from the formula $t \leq 80/E$ where t is the duration in hours per work day and E is the electric field strength in kV/m.

(b) Maximum exposure is two hours per work-day.

(c) This restriction applies to open spaces in which members of the general public might reasonably be expected to spend a substantial part of the day, such as recreational areas, meeting grounds and the like. [2]

(d) Converted to milli-gauss for consistency with figures in ARPANSA [3]

These requirements provide the basis in which to evaluate the compliance of EMR emitting equipment and devices within WSF.

4.0 EQUIPMENT COMPLIANCE

The components of the current Warwick Solar Farm design which have significant enough EMR emissions to warrant a compliance investigation are the power conversion units, substation and powerlines.

4.1 Power Conversion Unit

The power conversion units (PCU) elected in the design are Ingeteam INGECON40 Sun PowerStation. Potential EMR generating devices within these PCUs are three Ingeteam INGECON Sun PowerMax 1640TL B630 inverters and a 630V to 33,000V step-up transformer.

One EMR emissions source is the high frequency switching electronics used to convert DC power to AC power within the inverter. This is common for all kinds of inverter technology, including that used in residential rooftop PV installations and battery chargers. International standards and guidelines, known as Electromagnetic Compatibility (EMC), provide specific performance criteria and testing methods with which to assess the conformance of inverters to electric and magnetic field emission levels. The nominated inverters are certified to conform to the following EMC standards:

- EN 61000-6-1: Part 6-1: Generic Standards – Immunity for residential, commercial and light-industrial environments. (AS/NZS 61000.6.1)
- EN 61000-6-2: Part 6-2: Generic Standards – Immunity for industrial environments (AS/NZS 61000.6.2)
- EN 61000-6-4: Part 6-4: Generic Standards – Emission standard for industrial environments (AS/NZS 61000.6.4)
- EN 61000-3-11: Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current <75A and subject to conditional connection (AS/NZS 61000.3.11)
- EN 61000-3-12: Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and <= 75 A per phase (AS/NZS 61000.3.11)
- AS 3100: Approval and test specification – General requirements for electrical equipment

It is important to understand that these standards identify emission requirements so as to ensure that disturbances generated by equipment operating in industrial locations do not exceed a level that could prevent other equipment from operating as intended. As there is no emissions requirement specified in the frequency range of 50/60 Hz, a comparison against the NHMRC's requirements is not possible. Nevertheless, potential impact to the general public is deemed as negligible since all PCU's are, on average 218 metres from the boundary fence. (Refer Appendix A)

It should be noted that whilst these standards are listed as European standards (due to the origin of the PCUs) they are identical equivalences to the Australian versions.

The transformers located within the PCU's are typical of those installed within distribution kiosks commonly found within public spaces, and for which the EMR impact is deemed negligible.

4.2 Substation

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) stipulate that the electric and magnetic fields generated by substations are generally indistinguishable from typical background levels in the home when at a distance of 5-10m away. [3] These exposure levels are considerably lower than the compliance requirements recommended by the NHMRC.

As access within 10m of the substation will not be possible by the public (refer Appendix A), the EMR risk posed by the substation is deemed as negligible. Furthermore, substation design will be required to be reviewed and approved by Ergon Energy against their relevant EMR guidelines prior to its construction.

4.3 Powerlines

To facilitate connection to the National Electricity Market, the WSF will be connected to the Allora and Killarney feeders by way of two double circuit lines. Each double circuit line will operate at 33 kV and predominantly be run overhead. This infrastructure will be similar to many existing overhead powerline assets operated by Ergon and Energex throughout Queensland. The solar farm will also comprise an underground 33kV AC reticulation system within the site boundary that delivers power from each PCU to the substation.

Ergon Energy's *EMF Layout Design Recommendations* (Ergon document: NA000403R471), AS/NZS 7000, and Energy Networks Australia provide guidance on powerline design to minimise EMF levels and ensure compliance with Section 3.0 of the NHMRC guidelines. All connection infrastructure will be designed to these standards, with final powerline designs required to be reviewed and approved by Ergon Energy prior to their construction. As such, the risk to the general public from this infrastructure can be deemed as negligible.

The 33kV reticulation system within the Warwick Solar Farm is a network of cables that is primarily buried underground. Since the cables will be located at reasonable distance from the boundary fence it can be concluded that any EMR emitted from the AC retaliation will present a negligible risk to the general public.

5.0 CONCLUSIONS

The proposed Warwick Solar Farm's compliance to relevant electromagnetic radiation standards has been confirmed through the evaluation and compliance assessment of all significant EMR emitting equipment and devices. PCUs and substations will be located at such a distance inside the boundary fence that the EMR risk posed to the general public is deemed negligible. Furthermore, all powerlines will be designed to rigorous standards that conform to the relevant limits outlined by the NHMRC. Powerline designs will also be reviewed and approved by Ergon Energy against the relevant guidelines prior to their construction. The cumulative effect of this equipment will not generate EMR emissions above the recommended safe limits for human exposure.

6.0 REFERENCES

[1] World Health Organization, “Extremely Low Frequency Fields,” The International Labour Organization, The International Commission on Non-Ionizing Radiation Protection, and The World Health Organization, 2007.

[2] National Health and Medical Research Council, “Interim guidelines on limits of exposure to 50/60 Hz electric and magnetic fields (1989),” Australian Radiation Laboratory, Canberra, 1989.

[3] A. R. P. a. N. S. Agency, “Understanding Radiation - Electricty and Health,” 2018. [Online]. Available: https://www.arpansa.gov.au/understanding-radiation/radiation-sources/more-radiation-sources/electricity.

APPENDIX A

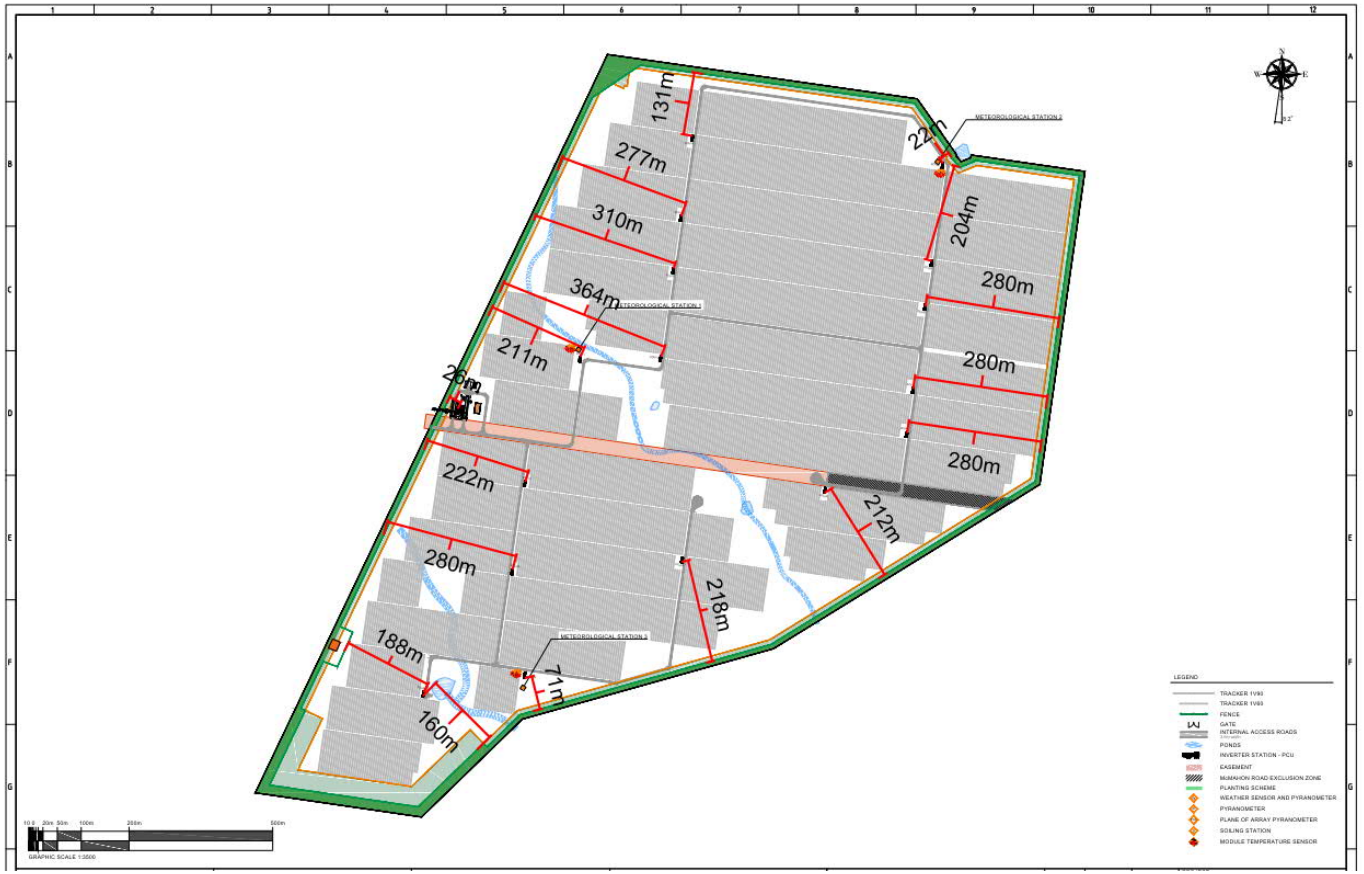

Figure 1: PCU distances from fence boundary