YARRANLEA SOLAR PROJECT

Electromagnetic Radiation Assessment

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1 EXECUTIVE SUMMARY

A preliminary electromagnetic assessment has been made on the proposed Yarranlea Solar Farm, with reference to published guidelines, standards and reports.

The project preliminary design was found to be typical of a modern photovoltaic power station. The EMR generating equipment has been noted to conform with all assessed standards and guidelines; more generally, the plant designs suggest conformance with best industry practice.

2 PURPOSE

This document provides a preliminary assessment of the electromagnetic radiation (EMR) generated by the proposed photovoltaic power station. This report considers health exposure to the general public only, and may be supplemented with an additional assessment for plant operators when operating guidelines are produced for the plant.

3 BACKGROUND

Electromagnetic radiation is a form of energy transfer as a stream of particles or electromagnetic waves. Other methods of energy transfer are conduction or convection.

Humans are exposed to EMR daily generated by many common man-made objects such as mobile telephones and computers. EMR exposure also is obtained naturally through food and the earth. In fact, a study in the United States has shown more than half of the radiation dose absorbed annually comes from natural sources (United States Nuclear Regulatory Commission). Most of this background exposure comes from radon in the air, with smaller amounts from cosmic rays and the Earth itself.

Electromagnetic radiation or energy (EMR or EME) is a wave consisting of time-varying electric and magnetic field components that travel or radiate through space. EMR is classified according to its frequency or wavelength; some classifications used are: Extremely Low Frequency (ELF), Very Low Frequency (VLF), Radio Frequency (RF) and Microwave (MW).

3.1 EXTREMELY LOW FREQUENCY RADIATION

Extremely low frequency (ELF) radiation refers to the electromagnetic radiation with frequencies and energies less than 2000 Hz (or 2 kHz) such as power line radiation (50 Hz in Australia). It cannot transfer significant amounts of energy to human tissue because it is low energy and doesn't match the vibration frequencies of molecules in the human body. ELF radiation will be the key consideration of this report, as the infrastructure which is proposed to be installed in areas accessible by the general public will operates at a frequency near 50Hz.

3.2 VERY LOW FREQUENCY RADIATION

Very low frequency (VLF) radiation refers to the electromagnetic radiation that has frequencies ranging from 2 - 100 kHz such as emissions from common analogue electrical equipment such as traditional cathode ray tube television screens.

3.3 RADIO FREQUENCY RADIATION

Radiofrequency (RF) radiation is the commonly used term for describing emissions with frequencies ranging from 100 kHz - 300 GHz. Mobile phone communications, radio and TV stations operate in the RF band.

3.3.1 Microwave Radiation

MW radiation is a subset of RF radiation and, like infra-red radiation, has frequencies that are close to (or match) the natural frequency of vibration of many of the molecules making up the human body and it is therefore potentially biologically active. Microwave radiation represents frequencies from 1 - 300 GHz.

3.4 ELECTRIC FIELDS AND MAGNETIC FIELDS

Electric fields arise from voltage, or a difference in electric energy. Their strength is measured in Volts per metre (V/m). Electric field strength decreases with distance from the source, or when an object is placed in between the source and the receiver. Most building materials shield electric fields to some extent. For example, a household appliance such as a lamp creates an electric field when plugged into a socket; even when the appliance is not in operation.

Magnetic fields arise from current flows. Current flows when a device is switched on and is using energy. The strength of Magnetic Fields is measured in amperes per meter (A/m). Commonly, EMF investigators use a related measure, flux density (in microtesla (μT) or millitesla (mT) instead. Magnetic field strength decreases with distance from the source. Magnetic fields are not attenuated by most materials.

4 HEALTH EFFECTS

The results of all background EMF studies on typical renewable electricity distribution or generation infrastructure to date have indicated either no association or a weak association with adverse health effects. Despite some study outcomes suggesting a link between cancer and electromagnetic fields, the evidence for any effect remains highly controversial. The results to date contain many inconsistencies, but no large increases in risk have been found for any cancer in children or adults, though scientists are actively continuing to research this area all across the world (World Health Organization 2010).

Even though there is no conclusive scientific evidence of a direct relationship between cancer and chronic exposure to background EMR, there is sufficient concern in the general public to warrant an understanding of exposure limits.

4.1 EXPOSURE RISKS – ELF AND VLF

4.1.1 Electric fields

At frequencies up to 100 kHz, the human body is completely penetrated by the electric field because the wavelengths are equal to or larger than 3000 meters. However, the internal organs will be shielded from these fields because the human body can act as a conductor. Therefore, the main effects of electric fields are due to surface charges and small skin currents. The biological effects due to induced currents by electric fields are summarised in *Table 4.1* (UNEP/WHO/IRPA, 1987).

Current Density	Biological Effect
Below 1 mA/m^2	No known effects. The background current densities in most body organs are in this range.
1 to 10 mA/m^2	Subtle biological effects such as changes in calcium metabolism or suppression of melatonin production (controls the day/night rhythm). The background current densities of the heart and brain are in this region.
10 and 100 mA/m^2	Clearly demonstrated effects, such as changes in protein and DNA syntheses and in enzyme activity, evident visual and possible nervous effects. The healing process of fractured bones can be accelerated or brought to a standstill.
100 and 1000 mA/m^2	Clearly demonstrated effects, such as changes in protein and DNA syntheses and in enzyme activity, evident visual and possible nervous effects. The healing process of fractured bones can be accelerated or brought to a standstill.
Above 1000 mA/m^2	Extra systoles and ventricular fibrillation (heart dysfunction) can occur (acute health hazards).

Table 4.1 – Biological Effects Due to Electric Fields of Frequency less than 100 kHz

4.1.2 Magnetic Field Exposure Limits

It is possible to calculate magnetic flux densities that would produce potentially hazardous current densities in tissues. The biological effects due to induced current densities generated by magnetic flux densities from whole body exposure to sinusoidal homogeneous fields are summarised in *Table 4.2* (UNEP/WHO/IRPA, 1987).

Magnetic Flux	Biological Effect
0.5 – 5 mT	Minor biological effects have been reported
5 – 50 mT	there are some well-established effects, including visual and nervous system effects
50 – 500 mT	stimulation of excitable tissue is observed; possible health risks
Above 500 mT	Clearly demonstrated effects, such as changes in protein and DNA syntheses and in enzyme activity, evident visual and possible nervous effects. The healing process of fractured bones can be accelerated or brought to a standstill.
Above 1000 mA/m^2	Extra systoles and ventricular fibrillation (heart dysfunction) can occur (acute health hazards).

Table 4.2 – Biological Effects Due to Magnetic Fields of Frequency less than 100 kHz

5 EXPOSURE LIMITS

At the time of this assessment, Australia does not have an existing standard regulating exposure to the electric or magnetic fields; often EMF studies default to the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) recommended exposure limits. ARPANSA refer to 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 NHMRC/ARPANSA guidelines will be referenced in this report and are repeated in Table 5.1 below.

Exposure Characteristics	**Electric field strength kV/m (rms)**	**Magnetic flux density mT (rms)**
OCCUPATIONAL		
Whole working day	10	0.5
Short term	30[a]	5[b]
For limbs	-	25
GENERAL PUBLIC		
Up to 24 hours/day[c]	5	0.1
Few hours/day[d]	10	1

NOTES

a. The duration of exposure to fields between 10 and 30 kV/m may be calculated from the formula t ≤ 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 duration is two hours per workday.
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.
d. These values can be exceeded for a few minutes per day provided precautions are taken to prevent indirect coupling effects.

Table 5.1 – Summary of Exposure Limits for 50/60Hz

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) European power frequency exposure guidelines are the same as the above NHMRC recommended levels.

6 SOURCES OF EMF

With reference to the existing design drawings and project plans, key sources of EMR from the proposed Yarranlea solar plant are inverter stations, overhead lines and the Yarranlea Solar farm 110/33kV substation. Medium voltage cables within the project are expected to comprise three phase construction with metallic screens and therefore are expected to comply with exposure guidelines due to the physical arrangement and screen containing the magnetic and electric fields.

6.1 INVERTER STATIONS

Inverter stations comprise a large inverter and a step-up transformer. The inverters proposed for Yarranlea solar farm are larger scale versions of inverters commonly installed in residential solar installations, are megawatt scale, mass produced and type tested against various norms.

All modern inverters contain high frequency switching electronics which emit EMR. International standards and guidelines have been established to assess the conformance of inverters to performance criteria with respect to electric and magnetic field emissions; these standards are termed Electromagnetic Compatibility (EMC).

The proposed inverters conform to the following standards:

- IEC / EN 61000-6-4 (EMC emission),
- IEC / EN 61000-6-2 (EMC immunity),
- EN 55011/ CISPR 11 (EMC emission),
- EN 55022 / CISPR 22 (EMC emission),
- FCC Part 15 Class A (EMC emission).

The transformers which form part of the inverter stations are typical to those installed within distribution kiosks commonly found in public spaces.

As the inverter stations are installed centrally within the project, and are expected to be over one hundred meters from the secured boundary fence-line, no further assessment will be undertaken in this report as the impact to the public is considered to be negligible.

6.2 SUBSTATION

Some modifications or additions to the existing Ergon Yarranlea 110/33kV substation would be necessary, and a new Yarranlea solar farm 110/33kV substation is proposed in line with the project plans.

While it is expected that the proposed Yarranlea solar farm substation will have a similar EMR profile to the existing Yarranlea substation, it is prudent to compare the magnitude of prospective EMR from the new Yarranlea solar substation with established guidelines for health.

The United Kingdom National Grid Company has conducted a survey of suburban substations to determine the level of EMFs produced. Measurements were taken at 0.5 metres above ground level within one metre of these enclosures. The results revealed mean magnetic flux densities of about 19mG, halving at an average distance of 1.3 metres and becoming indistinguishable from the background due to other domestic sources within five metres (HPA;Public Health England, 2004).

It is expected that fencing around the substation and the location of the substation and any nearby control buildings would ensure that the EMF exposure to the public are well below the 1,000mG levels determined for public health.

6.3 OVERHEAD POWERLINES

Several overhead lines exist in close proximity to the project site and are estimated to be operating at 33kV and 110kV.

A new 110kV overhead line and modifications or additions to the existing 33kV overhead line would form part of the project.

The magnetic and electric fields associated with a transmission line at any moment in time depend on a range of factors, including the amount of power flowing in the line, the arrangement, size and quantity of conductors, atmospheric conditions and the distance of the observer from the conductors.

The configuration of the relatively short span of overhead line will not be fully understood until the completion of the detailed design phase.

It is expected that new infrastructure and any modifications to existing infrastructure will achieve compliance with ARPANSA, NHMRC and ICNIRP requirements, as a result of recommendations in AS/NZS 7000 (Australian Standard for overhead line design) and Ergon Energy's EMF Design Recommendations (Ergon document NA000403R471 Ver 1).

7 OPERATIONAL CONSIDERATIONS

This report is provided in support of the development application for the Yarranlea solar project. As such, operational considerations fall outside of the scope of this report and may need to be further considered when the project operating procedures and designs are in place.

8 CONCLUSIONS

The proposed Yarranlea solar project resembles a typical large scale solar generator installation, of which there are numerous in operation in Australia.

All EMR sources within the main PV array (namely inverter stations) are placed at a sufficient distance from the project perimeter fencing to consider the EMR risk to the general public is negligible.

The proposed 1km length of 110kV overhead line to be run from the Yarranlea Substation to the new Yarranlea Solar substation is a short addition to the two 110kV circuits currently in operation which run over 40km from Middle Ridge to the existing Yarranlea substation; this new, relatively short length of line is expected to comply with best practice design standards and therefore published guidelines for EMR exposure. The additional high voltage infrastructure aligns with the existing risk profile of infrastructure in the area and is expected to comply with referenced EMR exposure guidelines.

The cumulative effects of the proposed PV Solar farm will not exceed safe limits for Human Exposure to EMR

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