# Magnetic and electric fields near the proposed Darfield solar and energy storage development

EMF Services
Professional EMF measurement and advisory services

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This report was prepared for:

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## About EMF Services and the author of this report

EMF Services is a division of Monitoring and Advisory Services NZ Ltd (MAASNZ), and provides professional measurement and advisory services related to possible health effects of electromagnetic fields (EMFs), such as the extremely low frequency (ELF) electric and magnetic fields found around any wiring, appliances or infrastructure generating or carrying mains electricity, and the radiofrequency (RF) fields produced by radio transmitters and some industrial equipment.

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# Magnetic and electric fields near the proposed Darfield solar and energy storage development

## 1 Introduction and summary

This report discusses the nature of magnetic and electric fields found near the proposed Darfield solar and energy storage development and how they compare with the health-based exposure limits incorporated in the Selwyn District Council Partially Operative District Plan (PODP).

The equipment at the proposed development does not emit electromagnetic radiation, but does produce extremely low frequency (ELF) electric and magnetic fields. The strengths of these fields decreases rapidly with increasing distance from the equipment producing them (principally the inverters and transformers). Based on the design plans for the proposed Darfield solar and energy storage development ("the development") any ELF fields it produces outside the site boundary will be well below the health-based exposure limits incorporated in the PODP, and in practice will make no discernible difference to existing ELF field levels there. Even within the solar farm, ELF field levels will be very low, except within a few metres of the inverters and transformers and in the site substation.

The proposed development complies with the ELF field limits in the PODP rule EI-REQ7.

## 2 Principal components of the proposed development

A schematic diagram of the proposed development is shown in figure 1.

A number of solar panels are combined together in a string. Each solar panel generates direct current (DC) electricity, and the DC electricity from each string is fed into an inverter. The inverter converts the DC electricity to alternating current (AC) electricity at the frequency of mains electric power (50 Hertz (Hz)). A transformer then changes the AC voltage to a value suitable for feeding to the site substation. There are several of these solar panel string/inverter/transformer modules distributed around the site.

All the AC power generated in this way is routed to the site substation. At the site substation the AC power can either be routed to another transformer that changes the AC voltage to a value suitable for feeding into the nearby Orion substation, or it can be sent to the battery storage area. Power sent to the battery storage area is routed to a number of modules which each have a transformer, inverter and batteries to store the electric energy. Energy stored in the batteries can also be fed into the site substation, and on to the Orion substation, by passing it back through the inverter and transformer.

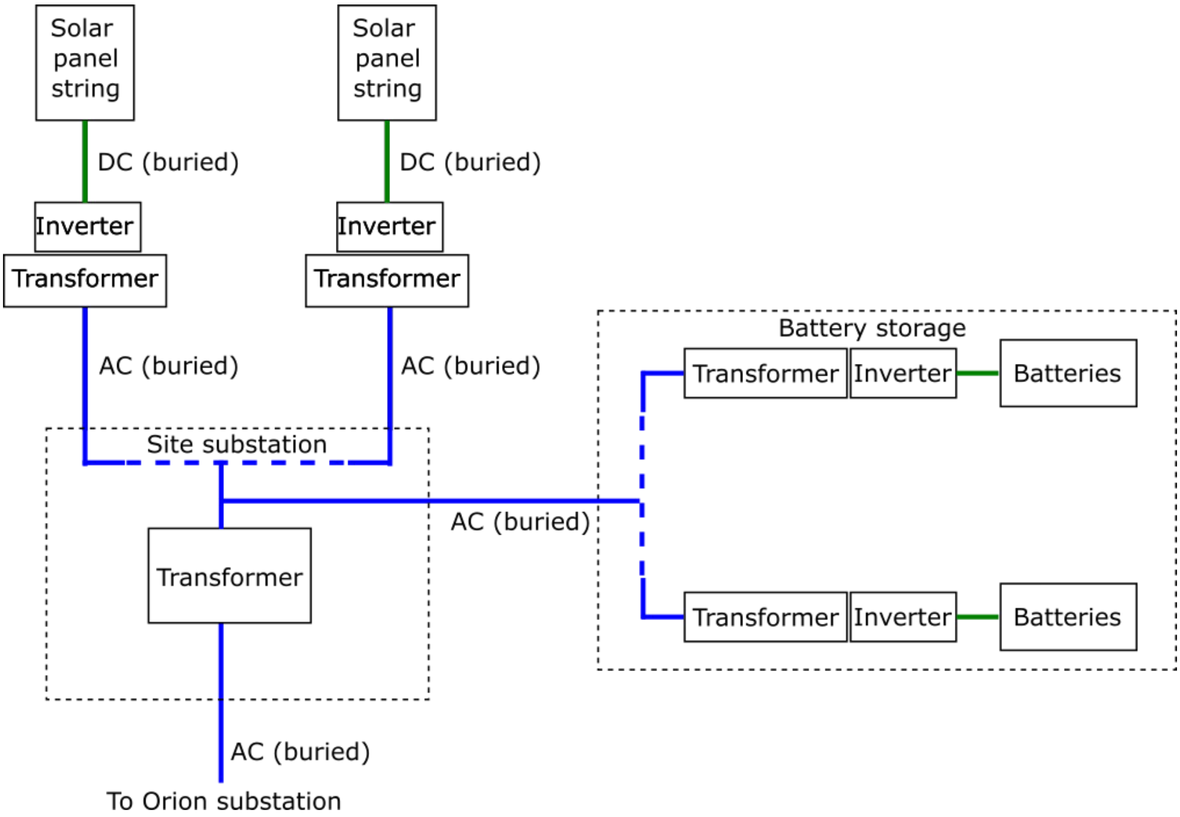


**Fig 1. Principal components of the proposed development. Cables carrying direct current (DC) electricity shown in green. Cables carrying alternating current (AC) shown in blue.**

Inverters (albeit of much lower capacity than planned for the development) are also found in an uninterruptible power supply (UPS), used in many places to ensure continuity of electric power in the event of a mains power cut. The UPS stores electric energy in batteries. If the mains supply fails, DC from the batteries is fed into the inverter, which then continues to supply any electrical device connected to it. (In fact in a UPS, the power to connected devices is normally always supplied by the batteries, and the batteries are kept charged by the incoming mains supply.) Transformers are found in local and national electricity distribution networks, either in substations or, in local distribution networks, mounted up power poles or by the side of the road.

# 3 Electric and magnetic fields generated by the development

## 3.1 DC carrying components

All the components (principally the cabling between the solar panels, batteries and the inverters, shown green in figure 1) carrying DC electricity generate static electric and magnetic fields. Static electric fields are present naturally in the atmosphere, and can be created by, say, rubbing an inflated balloon against a wool pullover. The earth has a static magnetic field.

Static electric fields would be very low, for three main reasons:

- Metal frames and housings near cables and supporting the solar panels would effectively shield any static electric fields produced.

- The arrangement of the wiring carrying DC electricity, with the positive and negative cables running side by side, results in any DC electric fields being self-cancelling (the static electric field created around the positive cable is cancelled by the field around the negative cable).
- Most of the cables are routed below ground, and the ground provides a very effective shield.

Static magnetic fields would also be low, because of the self-cancelling effect of running the positive and negative cables side by side. Any resulting field would be weaker than the earth's static magnetic field, and decrease very rapidly with distance.

Because of the very low levels of the static fields, they will not be discussed further.

## 3.2 AC carrying components

The principal components carrying AC are the inverters, the transformers and the cables connecting these components (shown in blue in figure 1, including the cable from the site substation to the nearby Orion substation). These create alternating electric and magnetic fields at the same frequency as the electric currents. These are often referred to as extremely low frequency (ELF) fields. As the frequency of the current fed to the electricity distribution network is 50 Hz, this is the main frequency of any ELF fields produced. There may also be weaker fields at higher frequencies (up to a few kHz) near the inverter.

ELF electric fields would generally be very low. The inverters and transformers are surrounded by metal housings, which effectively shield any electric fields. The ground shields electric fields from any buried cables carrying AC electricity.

There would be stronger electric fields near overhead wiring in the site substation. As the substation is located about 100 metres inside the security fence, the overhead wiring would make no difference to electric fields outside the development. Even inside the site substation I would expect electric fields to comply with the limits in the PODP.

ELF magnetic fields very close to the inverters and transformers would be strong, but decrease rapidly with increasing distance. Typically they decrease to the types of level found in many houses (due to electrical wiring and appliances in the house) within 5-10 metres. At a distance of 50-100 metres they would be indiscernible. The same is true of ELF magnetic fields found around transformers that are part of the electricity distribution network. As the inverters and transformers are located 100 metres or more from the site boundaries, I would not expect them to make any discernible difference to ELF magnetic fields outside the development.

ELF magnetic fields immediately above buried cables would be very low (similar to those found in houses), and decrease to indiscernible levels a few metres to the side of the cables.

ELF electric and magnetic fields are not a form of radiation. The word 'radiation' is a very broad term, but generally refers to the propagation of energy away from some source. Radiation comes in many forms: for example, light is a form of radiation, emitted by the sun and light bulbs. X-rays are a form of radiation, produced in specialised x-ray tubes. ELF fields do not travel away from their source, but are fixed in place around it and do not propagate energy away from it. They bear no relationship, either in their physical nature or their effects on the body, to true forms of radiation such as x-rays or microwaves.

### 3.3 Measurements of ELF fields at solar farms

I have measured the ELF fields around the equipment at an operating solar farm, and also around transformers and transmission lines that are part of the electricity distribution network. The results of these measurements confirm the statements made in section 3.2.

## 4 Recommended exposure limits

The New Zealand Ministry of Health recommends the use of exposure Guidelines published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP is a scientific body, recognised by the World Health Organisation (WHO) for its independence and expertise in this area. Their Guidelines are based on a careful examination of the research data on the health effects of exposure to electric and magnetic fields, and include margins for safety. ICNIRP periodically reviews its Guidelines to take account of new research data, and the most recent revision covering the frequencies of interest for this assessment was published in December 2010[1] and updated previous Guidelines published in 1998[2]. The 2010 revision is largely based on a comprehensive review of the relevant research data published by the WHO[3]. The underlying basis for the Guidelines has remained unchanged for more than twenty-five years. The ICNIRP guidelines have been adopted by a number of overseas health bodies.

Both sets of ICNIRP guidelines set fundamental limits, referred to as *basic restrictions*, on quantities directly based on electric and magnetic field interactions with the body. In the 1998 Guidelines the basic restrictions are on the current density induced in the body by external electric and magnetic fields: in the 2010 version the basic restriction is on the electric fields induced in the body[4] by external fields. As induced current density and electric fields are difficult to measure, the guidelines also prescribe *reference levels* in terms of the more easily measured external magnetic flux density and electric field strength. Compliance with the reference levels ensures compliance with the basic restrictions, and in most applications the reference levels can effectively be regarded as ICNIRP's "exposure limits" (although this term is not used by ICNIRP). If exposures exceed the reference levels, this does not necessarily mean that the basic restriction is also exceeded. However, a more comprehensive analysis is required in order to verify compliance with the basic restrictions.

A *National Policy Statement on Electricity Transmission* published in 2008 under the Resource Management Act requires that planning provisions dealing with ELF fields produced by the national grid be based on the 1998 version of the ICNIRP Guidelines and subsequent revisions (ie the 2010 version), as well as recommendations in the WHO review. A National Environmental Standard issued in 2009, which applies to changes to existing transmission lines and cables forming part of the national grid, also references the

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1 International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to time-varying electric and magnetic fields (up to 300 GHz). Health Physics, 99 (6), 818 – 836. Available at: www.icnirp.org.

2 International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz – 100 kHz). Health Physics, 74 (4), 494 - 522. Available at: www.icnirp.org.

3 WHO. Environmental health criteria 238. Extremely low frequency fields. WHO, Geneva, 2007. Available for download at: www.who.int/peh-emf/publications/elf_ehc/en/index.html

4 Current density and electric field are effectively two different ways to measure the same effect as they are related by the conductivity of the body: current density = electric field strength x conductivity.

1998 ICNIRP guidelines. While neither of these documents is applicable to the proposed development, they provide evidence of central government's stance on acceptable levels of exposure to ELF fields.

The main reason for the differences between the 1998 and 2010 reference levels is improved understanding of the relationship between external field strengths and electric fields and currents induced in the body.

Several local authorities require compliance with the ICNIRP 1998 or 2010 limits in district plan rules dealing with activities that generate 50 Hz EMFs.

Rule EI-REQ7 of the Selwyn District Council Partially Operative District Plan sets limits for EMFs in all zones (noting that this site is in a rural zone) at frequencies from 1 Hz to 100 kHz. These rules essentially adopt the ICNIRP 2010 limits at frequencies between 1 Hz and 100 kHz. As the principal frequency of the electric and magnetic fields generated by the equipment at the proposed development is 50 Hz, this rule clearly applies.

At a frequency of 50 Hz the magnetic field reference level for continuous exposures of the public is 200 microtesla (μT). The electric field reference level is 5 kilovolts per metre (kV/m). The PODP requires compliance with these limits.

The ICNIRP Guidelines are based on the prevention of interference with the body's nervous system by electric and magnetic fields. These were the most sensitive health effects of LF fields which could be established with any certainty by WHO. A lot of research has been carried out to try and determine whether there may be other effects at exposure levels much lower than the ICNIRP limits. Although the major focus of the research has been possible effects of exposure EMFs on cancer, other outcomes such as effects on pregnancy, neurodegenerative diseases (Alzheimer's disease, amyotrophic lateral sclerosis (ALS) etc) and cardiovascular disease have also been investigated. This data has been reviewed by the WHO, and also by other groups[5,6,7,8,9].

Overall, these groups find that there is a weak but relatively consistent association between prolonged exposure to relatively strong magnetic fields (fields greater than around 0.4 μT when averaged over long periods) and childhood leukemia. There is no known mechanism that could explain this association, and so there is doubt whether EMF magnetic fields actually cause the observed increase in childhood leukemia. Evidence of links between exposures and adult cancers are, at most, very weak, and generally

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5 Swedish Radiation Safety Authority (SSM). Recent research on EMF and health risk. Scientific Council on Electromagnetic Fields. Seventeenth report, 2024. Report no. 2024:05. Available at: www.stralsakerhetsmyndigheten.se/en/.

6 SCENIHR (Scientific Committee on Emerging and Newly Identified Health Risks). Potential health effects of exposure to electromagnetic fields (EMF). 27 January 2015. Available at: http://ec.europa.eu/health/scientific_committees/consultations/public_consultations/scenihr_consultation_19_en.htm

7 French Agency for Food, Environmental and Occupational Health & Safety (ANSES). Opinion on the Health effects associated with exposure to low-frequency electromagnetic fields. April 2019. Available at: https://www.anses.fr/en/system/files/AP2013SA0038EN.pdf

8 Schuz et al. 2016. Extremely low frequency magnetic fields and risk of childhood leukemia: a risk assessment by the ARIMMORA consortium. Bioelectromagnetics, 37(3) 183-189.

9 Health Council of the Netherlands. Power Lines and Health Part I: Childhood cancer. No. 2018/08. Available at: https://www.healthcouncil.nl/documents/advisory-reports/2018/04/18/power-lines-and-health-part-i-childhood-cancer

inconsistent. There is no good laboratory evidence suggesting any effect of ELF fields on the development of cancer. Research data on other outcomes does not provide persuasive evidence that there are any effects, and for some conditions (eg cardiovascular disease and unusual sensitivity to ELF fields) it is sufficient to rule out any relationship.

The WHO review concluded that the evidence of an association between ELF magnetic fields and childhood leukemia is too weak to suggest a cause and effect relationship and does not justify changing current exposure guidelines. On the other hand, implementing very low cost precautionary measures to reduce exposure is reasonable and warranted provided that the health, social and economic benefits of electric power are not compromised. The WHO has published an information sheet[10].

# 5 Summary

As discussed in sections 3.2 and 3.3, the ELF fields produced around equipment at the proposed development do not extend far from the equipment producing them and would be indiscernible outside the site boundary. High electric fields (but still complying with the PODP limits) might be found within the substation, and high magnetic fields could be found within a few meters of the inverters and transformers. The preliminary design shows that the site substation, inverters and transformers are all placed well away from (around 100 metres or more) the security fence around the site boundary. This means that the solar farm will have an indiscernible effect on ELF field levels outside the site boundary. In other words, ELF field levels measured outside the boundary will be the same before and after the development is operational.

Electric and magnetic fields outside the proposed Darfield solar and energy storage development would comply with the rules in the Selwyn District Council PODP, and on this basis there should be no concerns about them causing adverse health effects.

10 Available at https://www.who.int/teams/environment-climate-change-and-health/radiation-and-health/non-ionizing/exposure-to-extremely-low-frequency-field