2024

EirGrid

Your guide to understanding electric and magnetic fields (EMFs)

in the electricity transmission system

EirGrid.ie

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Introduction

Protecting Ireland's future

EirGrid develops, manages, and operates Ireland's electricity grid, also known as the transmission system. We make sure that Ireland has a secure and sustainable supply of electricity. This is essential to power communities and drive the economy.

ESB Networks manages the distribution system. Together, the transmission and distribution systems supply the electricity that is brought to homes, businesses, schools, hospitals and farms across the country.

The challenge

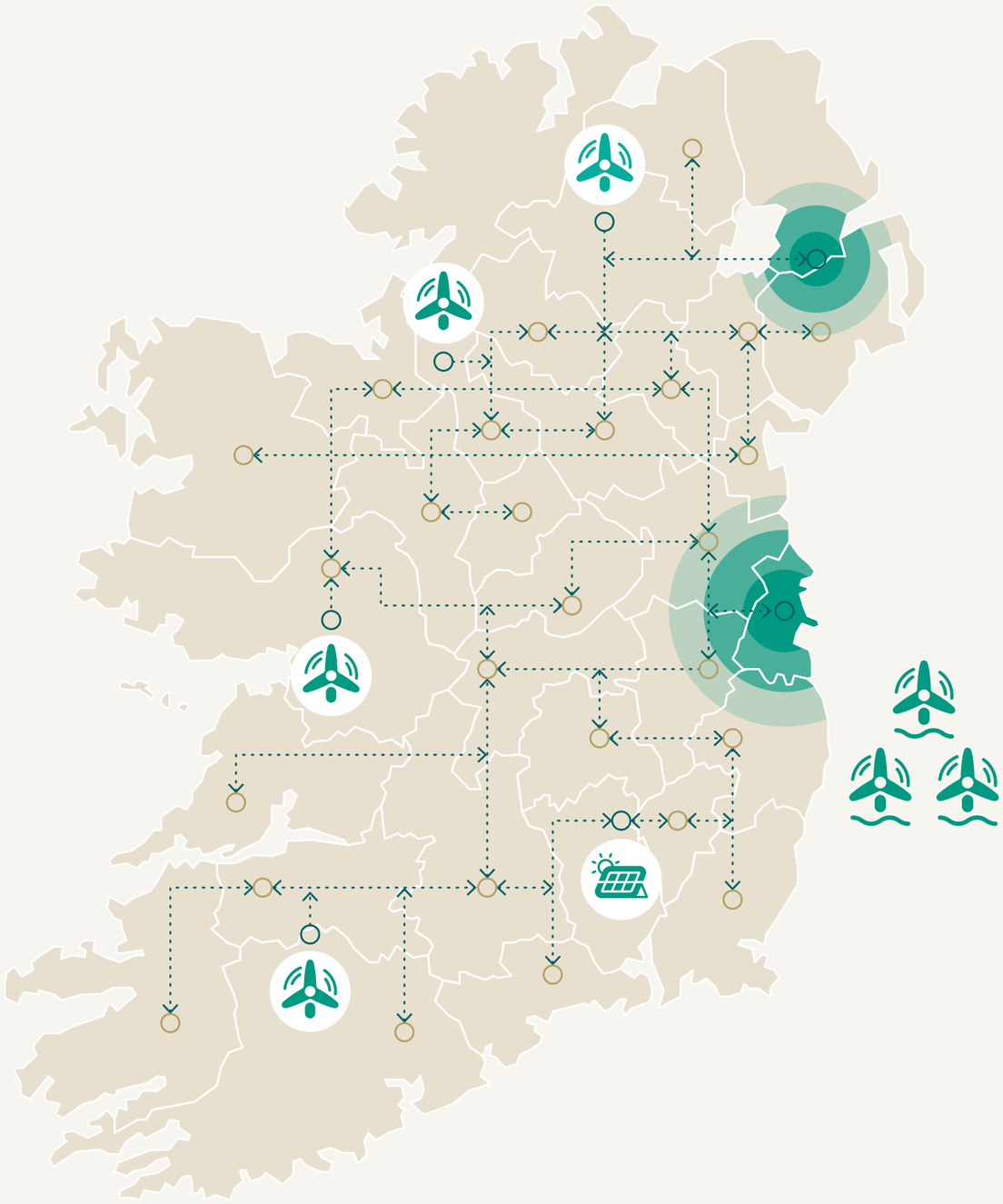
Ireland needs more electricity to meet the growing demands of our country. We also need our electricity to be more sustainable. This means moving away from burning fossil fuels for our electricity, and instead using renewable sources of energy such as wind and solar.

EirGrid has a unique role to play in transforming our power system, to make Ireland renewable ready.

A stronger, more flexible grid

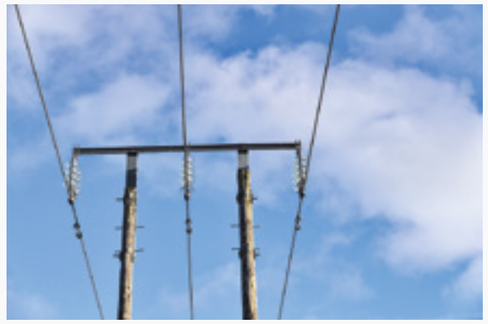
Part of transitioning to more renewable energy sources means building a stronger, more flexible electricity grid. This means more pylons, more overhead lines, more substations and more underground cables.

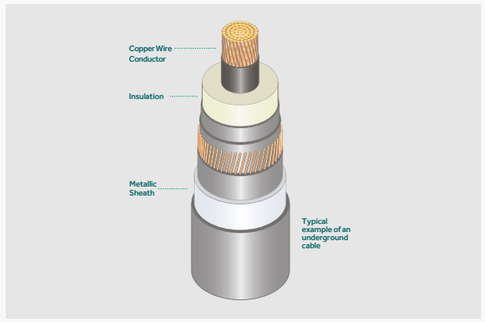
This critical infrastructure underpins our societal and economic development. And work carried out now will help create a more sustainable future for generations to come.



How electricity is transported

There are two main ways electricity is transported around Ireland: overhead lines and underground cables.





Overhead lines

What is an overhead line?

Overhead lines transport electricity all over the country through the electricity grid. The lines are supported by wooden polesets and steel pylons.

What are the different types of overhead lines?

In Ireland, our grid lines operate on different voltages. The typical voltages for the lines and cables operated by EirGrid are: ***110 kilovolts*** *(kV),* ***220 kV*** *and* ***400 kV.***

In general, higher voltages are needed to transport electricity over longer distances.

Why are overhead lines used?

Overhead lines are the most efficient way to transport electricity. In the event of a fault, they can be accessed easily to minimise the time it takes to repair and restore service. This means electricity can continue to be transported, powering homes, hospitals, farms and businesses.

Underground electricity cables

What is an underground electricity cable?

Underground cables are insulated wires that run underground to transport electricity.

When are underground cables used?

Underground electricity cables are used in cases where it is decided, following multiple criteria assessment, that this is the most deliverable solution and that it is technically feasible.

How deep are underground electricity cables?

Underground electricity cables are insulated and are typically buried at a depth of 950mm to minimise the possibility of damage from surface work.

Types of current

Alternating current (AC)

AC or 'alternating current' is the most common way to move electricity around an electricity grid. It is called alternating current because it continuously changes direction.

Direct current (DC)

DC or 'direct current' is used for long distances and for undersea cables. Direct current flows in one direction only.

Electric and magnetic fields

Introduction

Electric and magnetic fields are produced both naturally and as a result of human activity. The earth has both a magnetic field and an electric field. And wherever electricity is used, electric and magnetic fields also exist.

We know that some people have genuine concerns about electromagnetic fields (EMFs) and health. Here, we explain the facts about electric and magnetic fields, based on the most up-to-date information from Irish and world-leading health and scientific agencies.

Electric fields

Electric fields occur naturally, as well as around sources of electric current. For example, electric fields are produced by a number of natural events such as storm clouds, blowing snow and swirling dust clouds.

Common electric fields also include static electricity such as the electric shock felt after walking across a carpet and the 'static cling' that develops on a comb, balloon or on clothing.

When occurring because of electric current, the strength of the electric field depends on the voltage within the wire. The higher the voltage, the stronger the electric field.

Electric fields are strongest when close to a power source and their strength reduces quickly with distance. Electric fields are blocked by grounded conducting objects like buildings, trees and walls.

For underground cables, the electric field from the voltage applied to the inner conductor is blocked by the outer grounded metallic sheath. This means the external electric fields associated with underground cables are insignificant.

Electric fields are measured in volts per metre (V/m) or kilovolts (thousands of volts) per metre (kV/m).

Magnetic fields

The earth is a source of a static magnetic field produced by constant flow of current deep within its core. This is called the 'geomagnetic field', and it is this field that is used for compass navigation. We also encounter higher strength magnetic fields from natural or manmade metal magnets.

Magnetic fields are also produced by moving electric charges (also known as electric current). The strength of the magnetic field depends on the current flow in the lines or cables and their physical design.

Unlike electric fields, magnetic fields are not blocked by common grounded conductive objects such as buildings and trees. Like electric fields, magnetic fields are strongest when close to an electricity line or cable and their strength reduces quickly with distance from the line or cable.

Magnetic fields are measured in units of microtesla (μT).

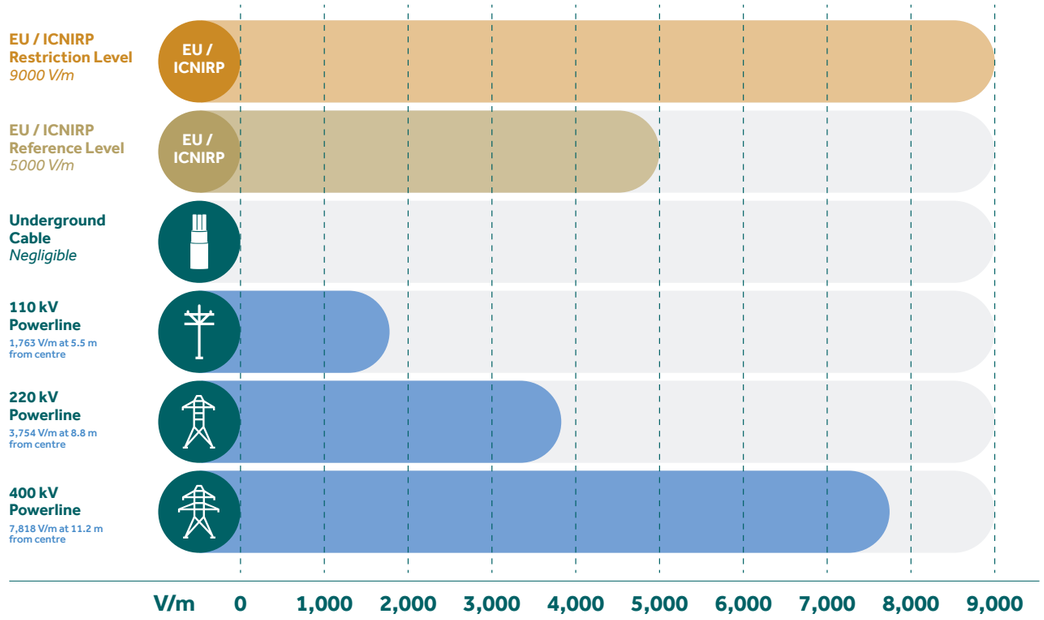
Electric and magnetic fields and Ireland's electricity grid

The European Union recommendation (1999/519/EC) outlines a set of basic restrictions and reference levels for limiting overall exposure of the general public to electromagnetic fields and ensuring an increased level of protection.

This recommendation is based on ICNIRP guidelines (International Committee on Non-Ionising Radiation Protection) for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz) as the scientific basis.

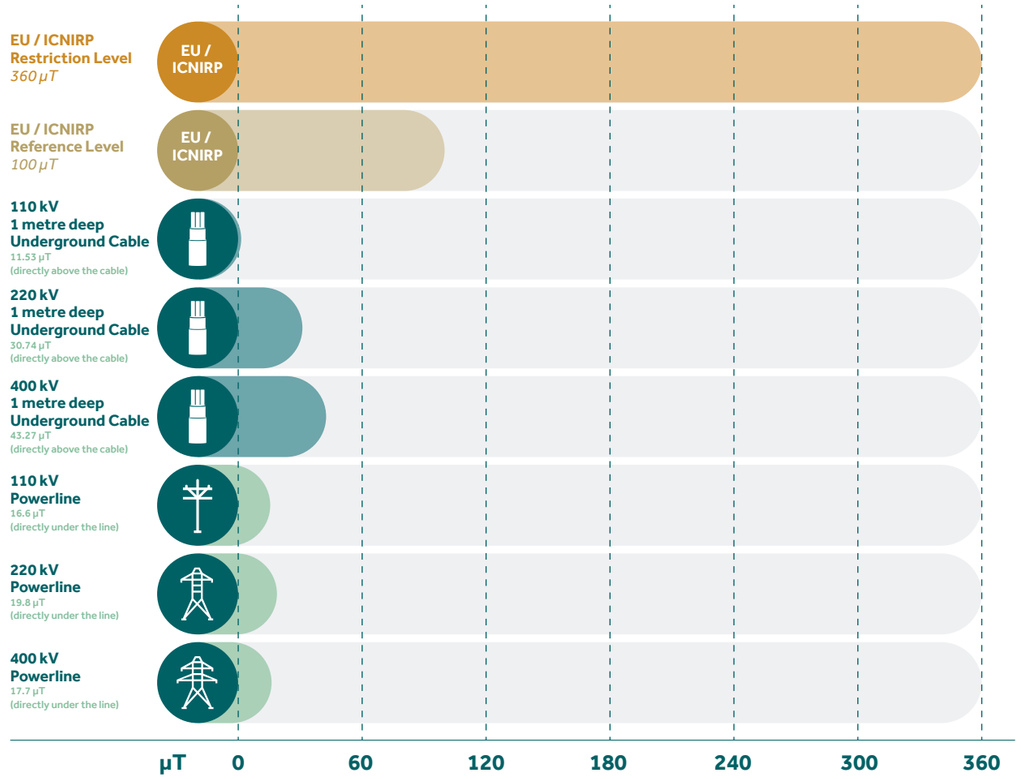
The electric and magnetic fields associated with Ireland's transmission grid do not exceed the EU recommendation (1999/519/EC). This is demonstrated in the infographics to the right where we have used the highest recorded values from this year's review (more information below).

Highest electric fields recorded from the transmission grid (with guidelines)



5kV/m is a reference value, 9.2KV/m is maximum allowable electric field as per the EU (1999/519/EC) recommendations (using the Dimbylow 2005 calculations).

Highest magnetic fields recorded from the transmission grid (with guidelines)



Electromagnetic fields (EMFs)

What are electromagnetic fields (EMFs)?

When electric current flows, both an electric and a magnetic field form around this current.

Electric and magnetic fields are separate fields. However, we refer to them as 'electromagnetic fields' or EMFs.

The electromagnetic spectrum

Electromagnetic fields are very common and can be found in the home, in the workplace, and anywhere we use electricity. This includes electrical appliances such as microwaves, mobile phones, ovens and hairdryers.

The frequency of a field determines where it lies on the electromagnetic spectrum which starts at 0 Hz and goes all the way up to X-rays.

The electric current transmitted through Ireland's power lines (as well as most appliances) is alternating current (AC) and has a frequency of 50 Hz.

The electric and magnetic fields that form around the electric current have the same frequency (50 Hz).

How do we characterise EMFs?

EMFs are characterised by their energy, frequency and wavelength.

Frequency is the number of complete cycles that pass a given point per second. Its unit is the Hertz (Hz), which is defined as one cycle per second.

Wavelength (λ) is the distance between two points of a field that define a complete cycle. These three characteristics are related, so the higher the frequency of the field, the greater the energy transported and the shorter its wavelength.

Extremely low frequency

The electromagnetic spectrum shows the range of frequencies that exist in our universe. Included in this spectrum is sunlight.

The main frequency of electric and magnetic fields produced by power lines (and all devices supplied with electricity) is 50 Hz and is classed as 'extremely low frequency' (ELF). At ELF frequencies, the electric and magnetic fields are independent from each other. This contrasts to higher frequency electromagnetic fields (such as TV or radio) where the electric and magnetic fields are coupled together.

Non-ionising

All of the fields on the electromagnetic spectrum fall into one of two categories: ionising or non-ionising. Fields with frequencies below ultraviolet are called non-ionising.

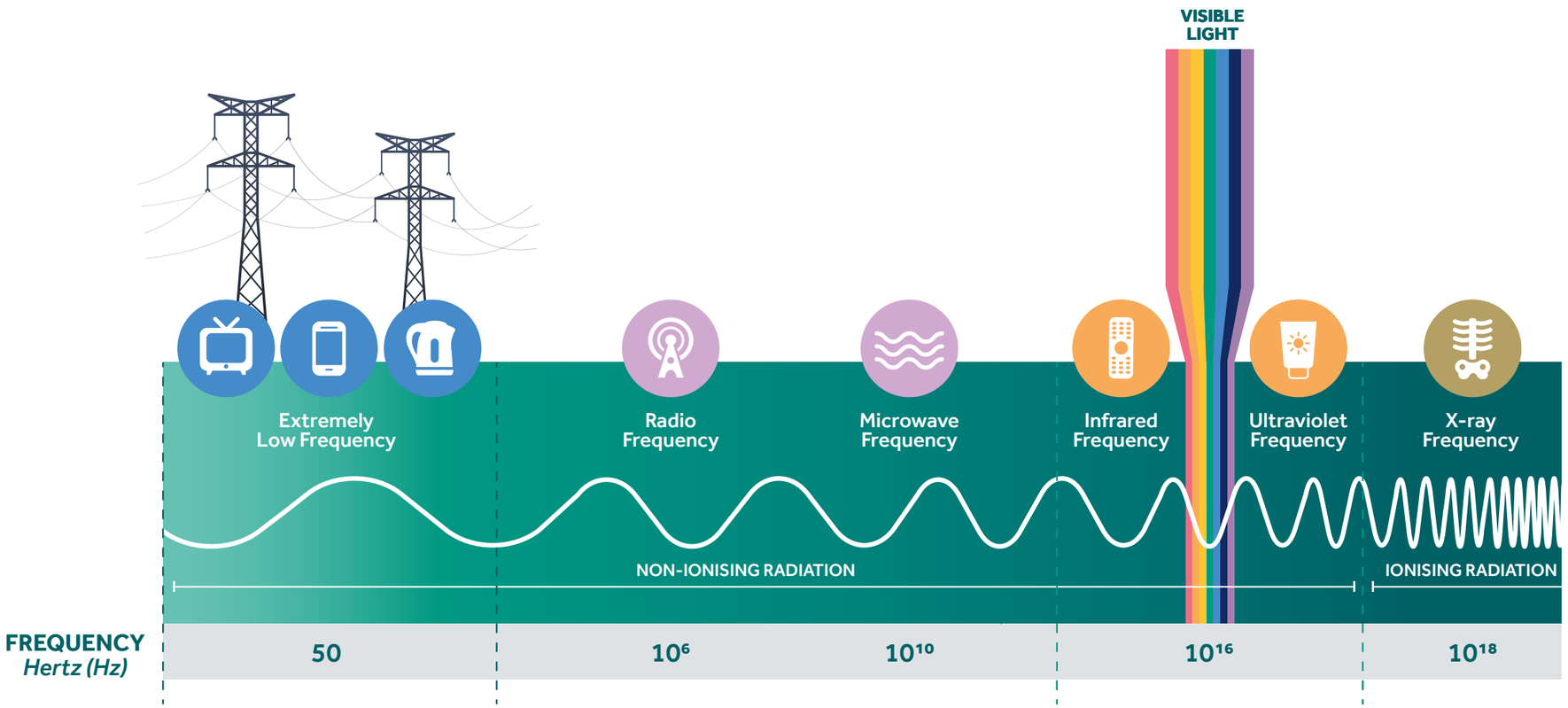
The electromagnetic fields that are produced by Ireland's electricity grid are non-ionising. Non-ionising fields are not strong enough to damage DNA.

Distance

Distance affects the intensity of an extremely low frequency electric or magnetic field significantly. The strength of the field depends on how close you are to the source, with that strength weakening greatly the farther away from the source.

Therefore, the magnetic field from a household appliance can be similar – or even stronger – than that from more distant power lines.

The electromagnetic spectrum



EirGrid review

In 2024, EirGrid reviewed the electric and magnetic fields produced by overhead lines and underground cables across Ireland's transmission system.

The purpose of this review was to ensure EirGrid's best practices are consistent with international safety standards and to include the data for 400 kV cables.

For this study, EirGrid reviewed the current and voltage of every transmission circuit in the country every hour for a year. These averages were then used to calculate* the typical electric and magnetic fields near our lines.

About our safety standards

EirGrid operates the electricity grid to stringent safety recommendations set out by the EU as well national and international agencies. These recommendations are based on peer-reviewed medical and health studies, independent of any grid operator.

The European Union recommendation (1999/519/EC) outlines a set of both 'reference' and 'restriction' levels for limiting overall exposure to electromagnetic fields and ensuring an increased level of protection.

The purpose of the reference levels is to prompt further investigation to ensure the restriction levels are not exceeded.

EirGrid designs the electricity network to make sure that public exposure to EMFs does not exceed EU restriction levels.

You can read more about reference and restriction levels on EirGrid.ie/EMF.

*If you would like to know more about how we have calculated these averages, please see our website.

What were the results?

Below are the highest levels for both electric and magnetic waves produced by Ireland's electricity grid. We have also included the safety restriction levels we work to for reference.

Overhead lines

Type of field:	EU / ICNIRP restriction level:	Highest level calculated for 400 kV	Highest level calculated for 220 kV	Highest level calculated for 110 kV
Electric field (V/m)	9000	7,818 (at 11.2m from centre)	3,754 (at 8.8 m from centre)	1,763 (at 5.5m from centre)
Magnetic field (μT)	360	17.7 (directly under the line)	19.8 (directly under the line)	16.6 (directly under the line)

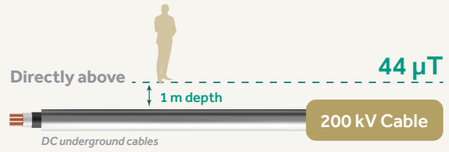
Underground cables (AC)

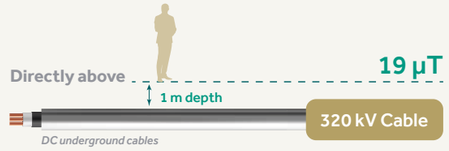
Type of field:	EU / ICNIRP restriction level:	Highest level calculated for 400 kV	Highest level calculated for 220 kV	Highest level calculated for 110 KV
Electric field (V/m)	9000	N/A	N/A	N/A
Magnetic field (μT)	360	43.27 (1m above the ground directly above the circuit)	30.74 (1 m above the ground directly above the circuit)	11.53 (1m above the ground directly above the circuit)

Underground cables (DC)

Type of field:	International restriction level:	Highest level measured for 200 kV	Highest level calculated for 320 kV
Electric field (V/m)	N/A	N/A	N/A
Magnetic field (μT)	400,000	44 (1m above the ground directly above the circuit)	19 (1m above the ground directly above the circuit)

DC underground cables



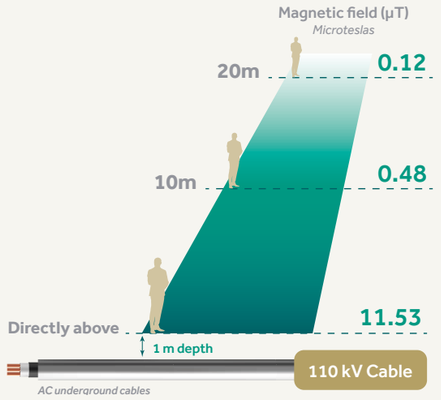


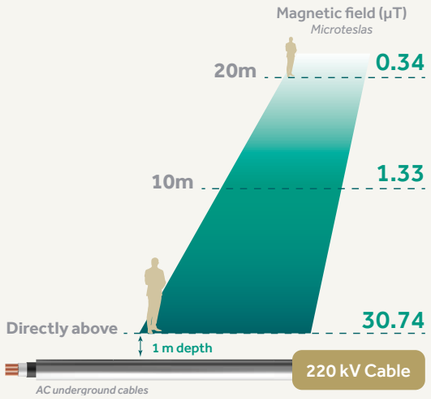
About these tables

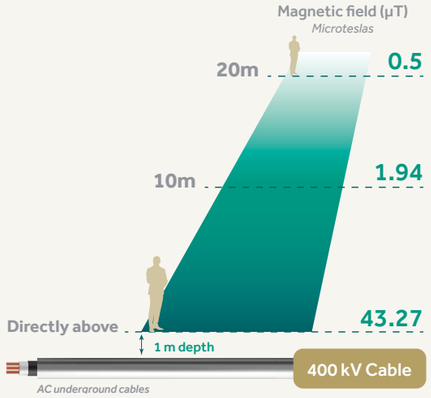
Restriction level: The restriction levels in these tables are the ICNIRP 1998 restriction levels. These are just some of the many safety restrictions that EirGrid adheres to.

Highest level calculated: These tables show the highest values captured for both the electric and magnetic fields throughout the year. At closer distances the field levels are higher but still fall under the EU 1999/519/EC and ICNIRP (1998) restriction levels.

To learn more about the levels and how they are calculated, please go to EirGrid.ie/EMF.







How does distance impact the strength of electric and magnetic fields?

It's important to know that the strength of both magnetic and electric fields drops significantly with distance (away from the source) which you can see in the diagram to the right:

What can I take from the study?

For both the magnetic fields and the electric fields, the levels recorded are below the restriction levels set by ICNIRP.

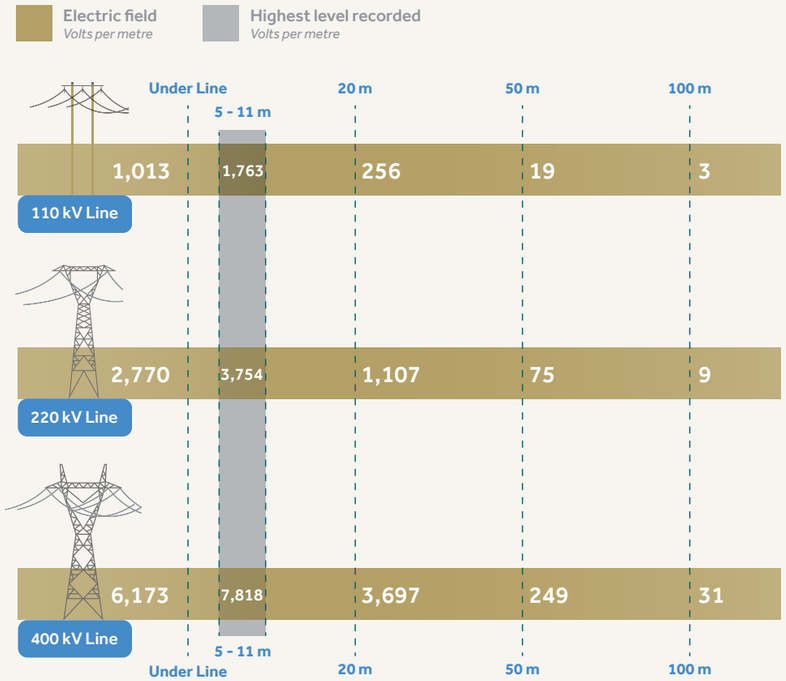
To further demonstrate EirGrid's stringent safety precautions, ICNIRP released a new set of restriction levels (in 2010) which allow higher limits than the 1998 levels. However, EirGrid continues to adhere to the stricter, 1998 levels.

The EMFs created by the electricity grid are not high enough to be considered harmful to humans.

To view more details on the EirGrid study, visit EirGrid.ie/EMF.

To view more details on the EirGrid study, visit EirGrid.ie/EMF or scan the QR code.

Electric field levels & proximity



For more information on why the highest electric fields are not directly under the line, please visit EirGrid.ie/EMF.

Magnetic field levels & proximity

Your questions answered

Are EMFs safe?

We understand some people have genuine concerns about EMFs which is why it's important we address this concern.

Based on a 2007 in-depth review of the scientific literature, the World Health Organization (WHO) concluded that current evidence does not confirm the existence of any health consequences, including cancer, from exposure to low level electromagnetic fields.

Extensive scientific research has found no hazardous effects from long-term exposure to low levels of EMFs. This includes the small amounts of extremely low frequency EMFs produced by electricity infrastructure.

Are electromagnetic fields the same as radiation?

No. The electromagnetic fields resulting from electricity are fundamentally different from x-rays and gamma rays.

The term 'radiation' usually refers to electromagnetic energy that is ionising. This kind of energy is capable of breaking bonds in molecules, which damages our basic biological building blocks – the DNA of our cells.

Only high frequency electromagnetic energy is ionising.

Extremely low frequency EMFs are non-ionising. This means that they do not have enough energy to cause damage to human or animal cells.

Extensive scientific research has found no hazardous effects from long-term exposure to low levels of EMFs. This includes the small amounts of extremely low frequency EMFs produced by electricity infrastructure.

Extremely low frequency EMFs are non-ionising. This means that they do not have enough energy to cause damage to human or animal cells.

There is no scientific evidence that exposure to low levels of electromagnetic fields (EMF) at extremely low frequencies causes damage to human health.

Current evidence does not confirm the existence of any health consequences, including cancer, from exposure to low level electromagnetic fields.

Why are there recommendations on exposure to EMFs?

There is a wide spectrum of electromagnetic frequencies from extremely low frequency EMFs – such as those that are produced by the electricity grid – all the way up to ionising radiation such as x-rays. Because of this, ICNIRP has produced clear guidelines, based on scientific research, to let people know what is safe. These safety levels cover all EMF types from low frequency EMFs such as Wi-Fi and Bluetooth, up to higher frequency EMFs such as radiology equipment.

In 2010, ICNIRP released a new set of restriction levels which are less strict than the original 1998 levels. However, EirGrid continues to work to the more stringent 1998 levels to ensure we remain well below the recommended restriction levels.

There is no scientific evidence that exposure to low levels of electromagnetic fields (EMF) at extremely low frequencies causes damage to human health. However, recommended EMF exposure limits are in place at a European level to protect from well-known biological and health effects of exposure to high EMF levels.

Do EMFs impact livestock?

Research does not show that EMFs from transmission lines, or the presence of power lines and structures, result in adverse effects on the health, behaviour or productivity of domestic or wild animals, including livestock.

Are there any extra precautions to take if you have a pacemaker?

The likelihood of an adverse impact to a pacemaker or other implanted cardiac device from power lines is extremely small given the low levels of electric and magnetic fields typically measured close to the line where the fields would be highest. In addition, modern implanted cardiac devices have many technological and design features (such as shielding through the use of a metallic casing and filters to block 50 Hz fields) to minimise the potential for interference.

If you have any concerns about your pacemaker, we recommend you speak to your doctor.

Does exposure to low frequency EMFs cause adverse effects including cancer?

Extensive research has shown that there is no evidence to conclude that exposure to low level electromagnetic fields – such as those from the electricity grid – is harmful to human health.

Based on a [2007] in-depth review of the scientific literature, the World Health Organization (WHO) concluded that current evidence does not confirm the existence of any health consequences, including cancer, from exposure to low level electromagnetic fields.

I have found information online that links EMFs and cancer. Why is this?

Unfortunately, there is much unverified and incorrect information online. That is why at EirGrid, we rely on up-to-date factual results from official, regulated bodies such as ICNIRP, the Environmental Protection Agency, the World Health Organization and the European Union. We use scientific research and peer-reviewed factual information to guide our safety restrictions and we continue to listen to these authorities to ensure we keep the public safe.

Our safety promise

The consensus from health and regulatory authorities is that extremely low frequency electromagnetic waves – like those from power lines – do not present a hazard to our health.

We obey all laws and meet all applicable health and safety standards. We work for the benefit and safety of every citizen in Ireland.

Electricity is a very safe way to provide energy to homes and businesses, and we use a lot of it in our daily lives. This requires EirGrid to transmit large amounts of electricity.

Want to know more?

If you would like to investigate further, here are some useful links to information on EMFs from national and international agencies.

International Commission on Non-Ionizing Radiation Protection
www.icnirp.org/

World Health Organization
www.who.int/news-room/questions-and-answers/item/radiation-electromagnetic-fields

European Commission
www.health.ec.europa.eu/index_en

Environmental Protection Agency
https://www.epa.ie/environment-and-you/radiation/emf/emf-and-your-health/emf-guidelines-/

HSA (Health and Safety Authority)
https://www.hsa.ie/eng/topics/physical_agents/electromagnetic_fields/electromagnetic_fields/

Irish Government
www.hsa.ie/eng/topics/physical_agents/electromagnetic_fields/electromagnetic_fields

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR)
https://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf

US National Institute of Environmental Health Services
www.niehs.nih.gov/health/topics/agents/emf/index.cfm

Find out more

Visit EirGrid.ie/EMF or scan the QR code.

Glossary

Annual peak load
The highest level of load on a circuit which occurs 1% or less of the time. The peak load is at or below this value for 99% of the time.

Conductor
A type of material that allows the flow of electric current.

Electric current
Current refers to the number of electrons flowing between two points. It is measured in Amperes or more commonly, Amps.

Electrified
Electrified means that an electric current is passing through.

Electric field
An electric field is a region that forms around a charged particle or object. The strength of an electric field is determined by the voltage. Electric fields are measured in Volts per metre.

Electromagnetic spectrum
There are different types of electromagnetic fields. Those that are extremely low frequency (such as those produced by power lines) and those that are higher, such as sunlight. We can put these in order of frequency called the electromagnetic spectrum.

Frequency
The strength and direction of electromagnetic fields vary in a continuous cycle that repeats multiple times per second. The number of cycles per second is the frequency of the field.

Hertz (Hz)
Hertz is the unit used to measure frequency. For example, the electric and magnetic fields from the electricity we use in our homes have a frequency of 50 Hz.

ICNIRP
International Commission for Non-Ionizing Radiation Protection (ICNIRP). This is an independent body, funded by public health authorities around the world. ICNIRP has investigated the safety of EMFs for decades and provides guidance on safe levels of exposure.

We design the electricity network to make sure that public exposure to EMFs complies with these guidelines.

Insulator
A substance or material that does not allow electrical current to flow easily.

Magnetic field
Magnetic fields are produced by moving electric charges (also known as electric current). The strength of the magnetic field depends on the current. Magnetic fields are measure in Microteslas.

Microtesla (μT)
The unit of measurement used for magnetic fields (see above).

Overhead line
A transmission (or distribution) electricity line which is strung overhead between pylons or wooden polesets.

Polesets
Wooden poles used to hold up overhead lines. They are similar to pylons.

Pylon
Pylons are tall structures used to support high-voltage overhead lines. They keep these lines high enough from the ground so they don't come into contact with passing vehicles, people or animals.

Underground cable
A transmission or distribution cable which is buried underground. These are most commonly used in urban, congested areas, or in environmentally sensitive areas.

Voltage
Voltage refers to the amount of electrical force or 'push' behind an electrical current, flowing between two points. It is measured in volts.

EirGrid

The Oval, 160 Shelbourne Rd,
Dublin 4, D04 FW28
01 627 1700 | EirGrid.ie

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