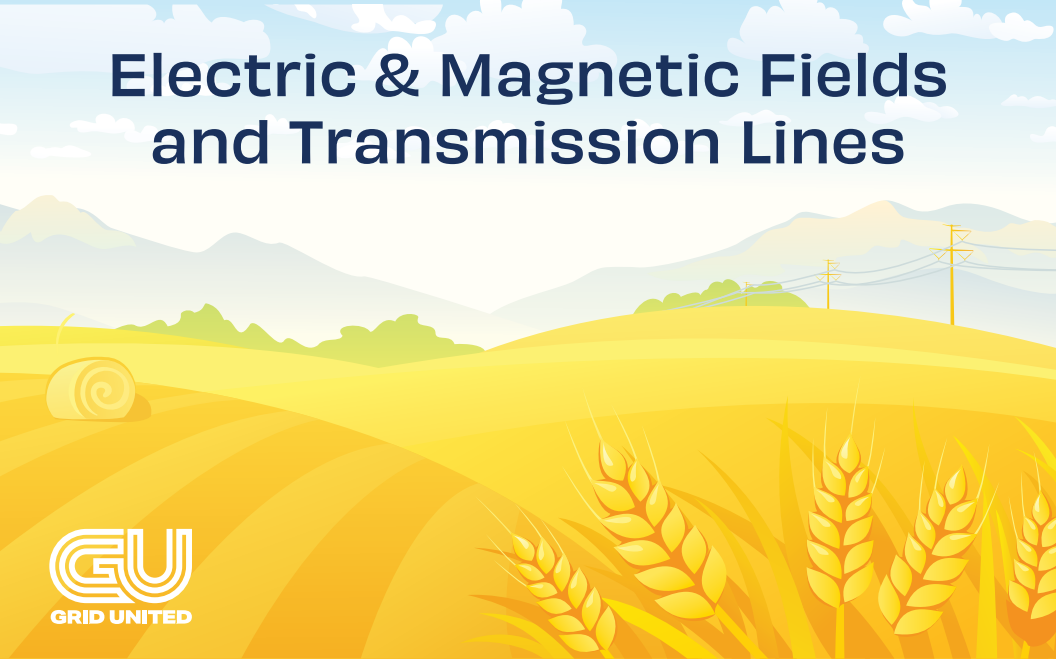
# Electric & Magnetic Fields and Transmission Lines



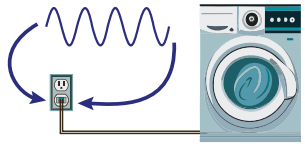
GRID UNITED

## What are transmission lines and how do they move electricity?

Transmission lines transport electricity from one area to another along wires. Transmission lines use alternating currents (AC) or direct currents (DC) to efficiently transport electricity, and this occurs at voltages far higher than the 120 volts used in our homes, schools, and businesses.

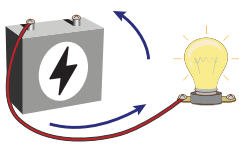
### Alternating Current

Most existing transmission lines have historically carried alternating current (AC) electricity. AC electricity changes its direction 60 times per second.Transmission line voltages are reduced to lower levels at substations for local use.



### Direct Current

Many long-distance transmission lines transport electricity via DC, which is more efficient than AC over long distances. DC electricity (like that from a battery) needs to be converted to AC electricity to supply power to homes and devices.



# What are electric and magnetic fields (EMF) and how are theyproduced by transmission lines?

Electricity carried by AC and DC transmission lines creates **electric and magnetic fields (EMF)**.

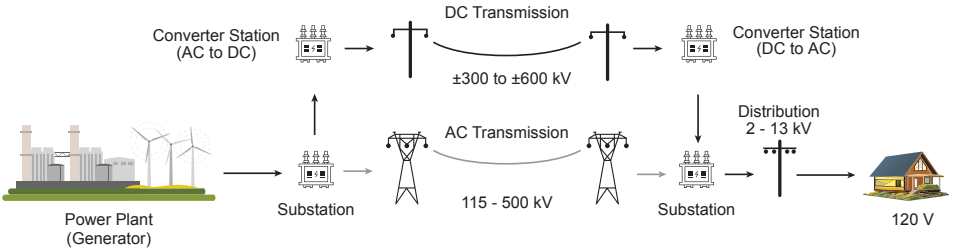
**Electric fields** are produced by the voltage applied to transmission line wires, also known as conductors. The higher the voltage, the greater the electric field.

**Magnetic fields** are produced by the flow of electrical currents. Magnetic fields are measured in units of milligauss. The greater the current flow, the higher the magnetic field.

We encounter magnetic fields from various sources, including everyday household items. For example, vacuum cleaners can produce magnetic fields of 100 to 700 milligauss (mG) at six inches away, but these fields decrease rapidly with distance—dropping to less than 5 to 50 mG at just two feet away *(NIEHS, 2002)*.

Like household appliances, transmission lines generate EMF that decrease rapidly with distance. Because transmission lines are typically constructed on dedicated rights-of-way away from residences, their EMF levels are small at homes.

EMF differs between AC and DC lines because they operate at different frequencies, and therefore create EMF of different frequencies. The EMF frequency determines how EMF interact with the environment around the lines.

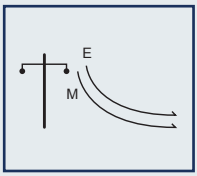



# What are the sources of electric and magnetic fields from AC and DC transmission lines?

The figure above shows how electricity flows from power generation sources, through converter stations and/or substations that increase and decrease the voltages for AC or DC transmission, to lower-voltage distribution lines that carry the power to our homes and businesses. Typical ranges of voltages at which electricity is transmitted are shown for the AC and DC transmission and also distribution lines.

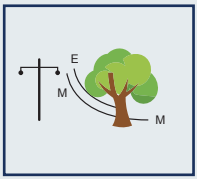
Current flows are not shown in this figure. At a constant power, higher-voltage lines will have lower current (i.e., power = voltage x current) and produce weaker magnetic fields. However, higher-voltage lines can transport more power and are often constructed with larger (and sometimes more) conductors, which then allows them to carry higher currents (and hence may also produce higher magnetic fields).

# How are electric fields and magnetic fields similar or different?




## SIMILARITIES

- The frequency of the electric field and the magnetic field is the same as the electricity carried by the line.
- The strength of both fields diminishes quickly with distance from conductors or other sources.




## DIFFERENCES

- Electric fields are blocked by grounded conductive objects such as trees, shrubs, fences, and buildings.
- Magnetic fields are not blocked by most materials.

The low levels of the electric fields from transmission lines are difficult for most people to perceive, and the magnetic fields are not perceptible.

# Do AC or DC fields harm people, animals, or crops?

Multiple authoritative reviews of scientific research on AC and DC fields confirm that the fields we typically encounter in our communities and under transmission lines are not harmful to human or animal health or crops *(e.g., IARC, 2002; NRPB, 2004; WHO, 2006, 2007; SCENIHR, 2015; Malkemper et al., 2018; Pophoft et al., 2023; SCHEER, 2024; SSM, 2025).*

Transmission lines must also meet the requirements of the National Electrical Safety Code. Adhering to this code protects people from hazardous shocks under all transmission lines and, for AC lines, also from contact with grounded objects (DC lines do not induce voltages in nearby objects the way AC lines do). Exposures to AC and DC fields under transmission lines and elsewhere in communities also are below biologically-based limits set by scientific agencies to avoid known effects of fields *(ICNIRP, 2009, 2010, 2020; WHO 2016; ICES, 2020).*

The electric and magnetic fields from our electric system and the natural DC fields from the earth and atmosphere do not couple well with smaller objects, including people, livestock, and plants. AC electric fields are mostly blocked by the body, and DC electric fields are further blocked from the body interior, so under power lines, only sensations at the body surface might be noticed. Magnetic fields are not blocked by most materials, but the levels near the transmission lines are too weak to be perceived or harm people, animals, and crops.

## Do EMF from transmission lines affect the performance of electrical appliances in homes, cars or tractors, or reception of GPS or mobile phone signals?

Magnetic fields from transmission lines are too weak to affect the majority of electrical devices. The voltage on the transmission line conductors can also create radio-frequency noise. This occurs when nicks, insects, debris, or water drops protrude from the normally smooth conductor surface. The electric field is concentrated on these protrusions and can release small amounts of energy — called corona activity — resulting in weak radio-frequency noise. The frequencies of these corona-generated fields are too low to interfere with the vast majority of today's electrical devices and appliances, such as cell phones and GPS, that operate at higher frequencies than transmission lines and corona. The reception of AM radio stations is an exception, and when driving directly under or very close to a transmission line, static can sometimes be heard.

## Do DC or AC lines produce audible noise?

When corona activity on the conductors occurs, the release of small amounts of energy may produce audible crackling or humming noises. The volume is generally low to moderate at transmission line right-of-way edges, and audible noise from project transmission lines would meet Environmental Protection Agency's guidelines *(USEPA 1974)* for acceptable noise levels.

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This information was prepared by scientists and engineers at Exponent, an international scientific and engineering firm, to present a current summary of the status of EMF research as reflected in reviews by science and health organizations. This brochure is limited to the scientific literature reviewed and may not include all information in the public domain.

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