Buying an 'EMF safe' Property

This article is separated into 6 sections, each of which can be individually downloaded. It is a 'work in progress' incorporating new information whenever time permits.

Section 3

Substations and transformers

1. Introduction; The need for more housing and potential EMF effects; Powerfrequency EMF exposure sources; Radiofrequency EMF exposure sources; how microwaves reflect off building surfaces and into buildings; impact on property value; location maps; in the face of uncertainty, measure and take action if necessary; references

2. Powerlines and pylons; when are powerlines 'needed'?; an easement; a wayleave; references; equipment for measuring powerfrequency electric and magnetic fields; summary of safety points to do with powerlines; powerlines worksheet (2 sides)

3. Substations and transformers; junction boxes; net currents; stray currents; references; equipment for measuring powerfrequency electric and magnetic fields; summary of safety points to do with substations and transformers; substations and transformers worksheet (2 sides)

4. Electrified railways; overhead lines; third rail; AC & DC power; diesel; references; summary of points to do with railway lines; equipment for measuring electric and magnetic fields; meters for measuring microwave radiation; electrified railways worksheet (1 side)

5. Mobile Phone base stations or masts; what base stations may look like, including hidden ones; effect on house prices; distance from the source where the microwave radiation meets the ground; drums; TETRA antennas; amateur radio operator's equipment; equipment for measuring microwave radiation; summary of safety points to do with mobile phone base stations; Mobile Phone Base Stations worksheet (2 sides)

6. EMFs inside buildings (including flats and caravans); wiring; electrical appliances; caravans; summary of safety points to do with your home, school, office, etc.; equipment for measuring electric and magnetic fields; equipment for measuring microwave radiation; EMFs inside buildings worksheet (2 sides)

Substations and transformers

Substations (or transformers) in urban areas can be found as frequently as every 150 metres or so apart. There does exist a risk of electrocution if someone gets in and touches the wrong thing by mistake, they are usually hidden behind some form of barrier, with a 'Danger of Death' sign prominently on display.

The substations themselves, if not visible, will be small box-like objects, hidden behind a wall or fence. Sometimes there are railings around a rather dull looking grey metal object.

Substations come in different sizes. The one pictured above is a small substation which will feed an electricity supply to a relatively small number of residential properties. Larger ones may feed an industrial estate, a mixture of commercial and residential properties, a large institution such as a hospital, etc. and may supply electrical power through the night as well as the day. Many schools have their own substation in the grounds. Some buildings, which are used for residential or workplaces have internal substations, often situated on the ground floor or basement. This can result in the people in the building being exposed to very high levels of electromagnetic fields.

There are some enormous substations on the outskirts of towns which are full of electrical equipment and lots of small transformers covering quite a large area of ground. It would not be a good idea to live within 100 metres of one of these, especially downwind. Work done at Bristol University has shown that the high electric fields around EMF-producing sources, such as the collection of transformers shown at the top of page 2, attract all sorts of airborne pollutant particles, including those associated with cancer, which may be in the air. They then charge these up, making them more dangerous, as they become 'sticky' and are more likely to attach themselves to skin or lungs. Depending on the prevailing wind (south westerly across most of Britain a lot of the time, when there are not too many hills or buildings nearby to distort the wind direction), the particles can be blown a few kilometres from the transformers themselves. If the property you are interested in is in an area where there is pollution from local industry or busy roads such as motorways, there could be an increased risk of toxic particle and aerosol contamination.

In rural areas, transformers are sometimes small(ish), usually grey, boxes attached to a pole of the 11 kV line that brings the electricity to the area.

The fields from these transformers fall off very rapidly and are usually negligible further than 3 metres away - the fields from the overhead wires are usually more concerning, and the 11 kV wires should not pass within 20 metres of the house.

Larger substations are associated with higher EMFs. The nearer they are to a property, the higher the levels of magnetic fields are likely to be inside.

Substations are not hazardous just because they are substations. It is because the equipment they contain produce electromagnetic fields (EMFs) that they have to be treated with caution. The notices attached to substation and transformer enclosures by the electricity companies give warning of the potential for electric shocks, and are intended to keep members of the public away from the installations themselves. It is the invisible, yet pervasive, electric and magnetic fields that extend beyond the equipment housing that we also need to be aware of.

The use of electricity produces electric and magnetic fields, together referred to as electromagnetic fields (EMFs). Electric fields are measured in volts per metre (V/m) and magnetic fields in the UK and Europe are usually measured in microtesla (μT). Gauss is the unit that is used in America and Australia. The equipment to buy or hire described below measure in microtesla.

Some businesses, offices, flats and houses have substations in the basement of the building. It is important to find out if this is the case, as the field levels in the floor above, and to the side of the substation could be subject to *very high* magnetic fields (Szabó 2007, Ilonen, 2008, Thuróczy 2008, Röösli 2011), and is above the level some studies have associated with cancer. These are likely to affect the health of people who are susceptible, see the article on "Powerfrequency EMFs and Health Risks" The fields can also cause computer 'wobble' which can make operators feel ill and is against Health and Safety at Work regulations.

The electricity supply to substations and transformers comes either from overhead powerlines (which will be visible) or from underground cables. If you are thinking about buying a property near to a substation or transformer, or want to investigate the area near your local substation, the local electricity board is able to provide you with a plan of the cable layout, to see how close the main cables are to you. They are not always accurate, but their actual position can easily be detected using a powerfrequency field meter, such as the ELF (PF4) meter or the MagneMeter, from EMFields. It is possible that the electricity company will only supply plans of cables to a property's owner, so some negotiation may be necessary if you haven't purchased the property yet. The cables may well run under pavements, in passages running by the side of a garden and/or house, or the side of rural roads, and can be responsible for surprisingly high magnetic field readings when you take measurements directly above them. If there is a buried cable under the pavement in front of a house where there is a very small garden, or no garden at all, the fields in the room(s) at the front of the house, especially on the ground floor, could be high.

The only way to get a reliable idea of the field from cables is to measure them. It is very difficult to calculate the estimated level because of the possible variability, due to trench size and depth and layout of the cables. Easy-to-use, accurate instruments designed for the layperson to get instant readings are readily and cheaply available to hire or buy from EMFields.

The level of EMFs is likely to vary throughout the day. It will be higher at times of peak electricity demand. These are likely to be between 7.30 to 9.00 a.m. and 3.30 to 7.00 p.m. during the week, in a residential area where the majority of residents are at work or at school. This may change during school holidays. Weekend peak times are likely to be different. In winter, the levels will be higher than in the summer, due to the extra power demand for heating. This may include overnight demand for night storage heaters. It is important to allow for this difference in field levels when you take readings. If the electricity company takes readings for you (in some areas this is a possibility), they may not be taking readings at these peak times.

Electric fields are reduced dramatically by most structures, brickwork, woodwork, railings, etc. Trees and bushes, especially evergreen or 'sappy' trees absorb much of the electric fields. The bushes themselves do not seem particularly affected by these; if there are any bushes around the substation, and they are not in the best of condition, they are more likely to be affected by the poor quality of soil and the lack of horticultural attention around substation structures, than the EMFs they are exposed to.

Magnetic fields go through practically everything. Magnetic fields will extend from the substation to a distance that partly depends on the way the equipment inside is laid out. The only thing that reduces magnetic fields is distance from the source.

Often a substation, even next to a house plot, is separated from the house and/or garden by a passage or garage. Walking through high fields is less likely to cause serious health problems, although some research indicates that regularly being exposed to rapid, large changes in magnetic field exposure can increase the risk of miscarriage.

For most people, it is where you spend a lot of time relatively unmoving that it is advisable to have low fields. If there is a substation adjacent to the house, perhaps a bedroom, it is very important to measure the field levels. Until you have done so, put any beds in the room as far as possible from the substation, with the bedhead at the furthest point. Remember the critical level for magnetic field levels (which cannot be reduced by screening) is below 0.1 microtesla in bedrooms and 0.15 microtesla in play or sitting areas.

Do not build a patio, a child's play area, or anything else where you or members of your family will want to spend a lot of time, next to a substation wall, or next to underground cables. Do not

put a pram where a baby sleeps next to a substation enclosure. Ideally, areas in the garden, which are used for play or relaxing should have fields of less than 0.2 microtesla. Thorny bushes (such as roses, etc.) planted in the garden next to a substation can keep people, especially children, away from areas of high field levels. Do not plant a tree that turns out to be an ideal place for a tree house, or bushes that make a good 'den'!

Junction Boxes

Junction boxes are usually small and beneath the pavement. If they have a lid, it is like a large telephone junction box lid but with the words 'Danger' and 'Electricity' on it. Sometimes you can get small freestanding electrical junction boxes. They are usually green and are no bigger than about 30cm x 1 metre x 1 metre and stand at the back of the pavement usually on or near road corners. As most magnetic fields come from cables, a junction box can be of concern as that is where cables arrive and are joined.

Net currents

Substations are connected together, to ensure supply delivery. To provide a consistent voltage, they can be connected in such a way that a high 'net' current is produced. This is current that is coming from one substation and returning to another. Such a current does not have an opposite and equal balancing current running alongside it and so it can produce high magnetic fields that fall off slowly. Such inter-connection is perfectly legal and an accepted practice. It can create very high magnetic fields in houses over wide areas (e.g. round 4 or 5 streets), usually with no way of reducing them, as the electricity companies do not believe high magnetic fields are a problem. In a study by Maslanyj (2007) looking at the data from the UK Childhood Cancer Study, low-voltage EMF sources (such as substations) accounted for 77% of exposures above 0.2 microtesla and 57% of those above 0.4 microtesla. Most of these exposures were linked to net currents in circuits inside and/or around the home.

The ONLY way to find out if this is a problem is to measure the magnetic fields at the house, preferably at a "busy" time - e.g. 8 am or 6 pm. If there is a 'net' current in the street, the magnetic field levels will be similar throughout the property, and most of the other nearby houses, not reducing much with distance from the substation. In our surveys about one quarter of the properties have had net current problems.

High electric field levels near inside walls will be due to house wiring faults not a net current. If you have high electric fields, see the article "Your low EMF Home 1. House Wiring", which will help you to reduce the family's exposure.

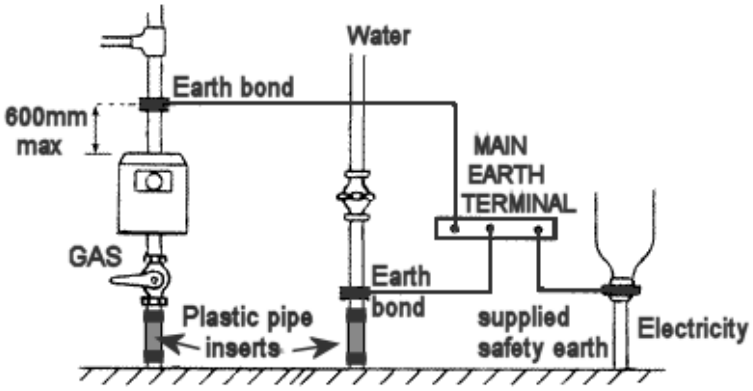
Stray Currents

Stray currents are due to faults in the neighbourhood electricity system that has transferred on to metal gas and/or water pipes and can be detected by holding the EMF measurement meter close to the pipes where they come into the house. In flats, measure close to all water and gas pipes. Stray currents are surprisingly common and can be stopped, but this is not always easy and there is a cost involved.

The procedure usually involves inserting a short section of plastic pipe into the metal gas or water pipe close to where they appear from under the ground and come into the house, as shown in the figure below.

This is a job for the professional. Metal pipes inside the house still need to be earth bonded – or 'earthed' – to prevent electric shocks, as specified in the UK Wiring Regulations. The incoming pipe should be isolated as near the ground as possible, and any exposed pipe must be covered

with insulating tape or sleeving, as under fault conditions it could give rise to a voltage shock hazard.



Reducing Net Currents by isolating incoming metal pipes

Sometimes stray currents come into metal-framed buildings through the girders that extend into the ground. This needs professional help to deal with.

In the UK and Germany and possibly some other European countries we practice Protective Multiple Earthing (PME) on our low-voltage (230 volt) distribution wiring around districts. This involves 'earthing' or 'grounding' the neutral every 100 metres around the distribution circuit. It is to prevent gross over-voltage problems if the neutral gets broken.

We use three-phase plus neutral. If all three phases are balanced then there is zero current flowing in the neutral. However, houses are wired to the supply in phase sequence and some phases end up more highly loaded than others. The imbalance current flows along the neutral. If the neutral isn't there, then you can get 40 volts on one phase and 330 volts on another and blow up all the bulbs and electronics in affected properties. By earthing the neutral every 100 metres there are always reasonable return paths available to the houses with a broken neutral in their feed so all three phases usually keep within the regulations (216.5 to 253 volts).

0.5 Amps stray current flowing on incoming main cold water pipe

The downside is that if the neutral conductor isn't in perfect condition, then the out-of-balance current transfers itself into the real earth, also on to any neighbouring metal water or gas pipes. This causes elevated magnetic fields over extended areas and, as everyone's electrics continue to work OK, nobody knows and nobody does anything to correct the fault. We have measured whole streets that have fields over 2 microteslas. The problem was due to a broken neutral conductor and the electricity company had used a type of distribution cable that doesn't have an earth conductor and the armoured wire around the cable is used as the neutral. The steel armour cable is less conductive than copper or aluminium and is hard to make a long-term reliable connection to at the regular jointing boxes in the circuit where it is also connected to an earth/ground stake.

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A study (2005) done by Sally Sims and Peter Dent in the Department of Real Estate Management at Oxford Brookes University showed that the visible presence of substations could reduce the number of potential buyers by up to 63%, depending on the type of property concerned.

The only way to know for sure if the property you are interested in is exposed to field levels higher than the precautionary levels recommended by the health research, is to measure them using an appropriate power-frequency meter. For details of how to buy or hire a meter that can do this, see the equipment described below. They are very easy to use, and hiring is inexpensive.

So, if you want to go ahead with the purchase of a property, near or over a substation or near or under a transformer, or if you already live in one, a question people often ask is, *"what can I do to protect my family from electric and magnetic fields?"*

Electric fields are reduced significantly by almost all building materials, with the exception of windows, double, triple or single glazed. If there are high electric fields coming in from an external source through the window, you can stop them with special screening material hung as a net curtain and earthed. Appropriate material can be purchased from EMFields. Trees and bushes also reduce electric fields that there may be in a garden. Deciduous trees are less good in winter when they lose their leaves. 'Sappy' trees (some pines, cherry, etc) are better than non-sappy trees at reducing field levels. Depending on the rules (if any) where you live, a 6-foot close-mesh wire fence behind or in the middle of two rows of tress, could also help considerably.

There is absolutely nothing you can do about magnetic fields. Lead sheets do not reduce fields, and steel sheets are not effective. There is a metal called mu-metal which reduces, but does not eliminate, the fields, but it is very expensive and difficult to use, and there is usually no practical way of effectively reducing magnetic field exposure from substations.

References

Ilonen K et al 2008 - *Indoor transformer stations as predictors of residential ELF magnetic field exposure* Bioelectromagnetics 29(3):213-8 PMID: 18044741

Maslanyj MP et al 2007 - *Investigation of the sources of residential power frequency magnetic field exposure in the UK Childhood Cancer Study* J Radiol Prot 27(1):41-58 PMID: 17341803

Röösli M et al 2011 - *Extremely low frequency magnetic field measurements in buildings with transformer stations in Switzerland* Sci Total Environ 409(18):3364-9 PMID: 21684576

Sims S & **Dent** P 2005 - Urban Studies Journal, April
http://usj.sagepub.com/cgi/content/abstract/42/4/665

Szabó J et al 2007 – *Survey of residential 50 Hz EMF exposure from transformer stations* Bioelectromagnetics 28(1):48-52 PMID: 16988992

Thuróczy G et al 2008 - *Exposure to 50 Hz magnetic field in apartment buildings with built-in transformer stations in Hungary* Radiat Prot Dosimetry 131(4):469-73 PMID: 18667401

Meter for measuring electric and magnetic fields

Pocket PF5 meter

To measure both electric and magnetic fields, you can buy EMFields pocket power frequency meter. The meter has been designed by Alasdair Philips (Powerwatch) and Andrew Cohen (EMFields).

The PF5 meter measures 5 - 200 V/m electric fields and 0.02 – 2.0 microtesla magnetic fields or (0.2 – 20 milligauss magnetic fields).

With either of these meters you can measure the EMFs in your property or the property you are considering buying, outside in the garden, inside your car and in other places of concern (schools, nurseries, workplace, etc.) from substations and other external sources of power frequency EMFs. A study by Ghadamgahi (2016) concluded that extremely low frequency magnetic field exposure from a high voltage substation within 50 metres of a school may have a negative impact on the working memory of children.

Contact: EMFields, 12, Mepal Road, Sutton, Ely, Cambs. CB6 2PZ www.emfields-solutions.com; or email info@emfields-solutions.com;

References:

Ghadamgahi M et al 2016 – *Memory loss risk assessment for the students nearby high-voltage power lines- a case study* Environ Monit Assess 188(6):355 PMID: 27194231

Summary of safety points to do with substations and transformers

- The bigger the substation, the higher the electromagnetic fields are likely to be and the further away a property has to be, to be in low fields. Measure the fields, it is easy and vital to do so.
- A substation serving a residential area only is likely to be lower powered than one which serves a variety of users, especially where electricity is needed 24 hours a day.

- If there is a substation in the building where you live or work, the field levels on the same floor and the floors above and below could easily exceed the levels at which serious health effects, such as cancer, dementia or depression have been reported.
- Magnetic fields are likely to be lower in areas where gas is available for domestic heating. Off-peak (overnight) electric storage heating causes very high currents to flow after midnight in cold weather - these currents increase magnetic field levels in the area by many times the daytime level. This is important if a bedroom is next to a substation or close to overhead or underground 230 / 400 volt distribution cables. This could apply to bungalows or downstairs bedrooms close to a pavement (including in basement flats in cities). Magnetic field levels of 0.3 microtesla and more have been associated with cancer, depression, miscarriages, Alzheimer's Disease etc.
- 'Net' currents and 'stray' currents are unpredictable, and can only be detected by measuring the field levels.
- Find out where the cables running from the substation go, especially if they may pass close to your house or garden.
- Check the area for high fields due to net currents by measuring the magnetic fields at times of the day when people are using electricity; 7.30 - 9.00 am and 5.00 - 6.30 pm are good times to measure. If there is no gas in the area, 1.00 a.m. (i.e. after midnight) is a good time to measure in cold weather when most off-peak heating systems will have switched on. Houses on corners seem to be more affected by these fields than others.
- Building materials and some trees reduce electric fields, but magnetic fields travel through pretty well everything.
- If you have a property, or decide to buy a property near a substation, plant thorny bushes between the nearest part of the plot and the substation to keep family members (and animals) at a safe distance.
- Land, garden and buildings downwind of the prevailing wind direction will be exposed to more toxic particles from large substations and associated high voltage lines of 33 kV or higher, than those upwind.
- Do not build a patio, play area, or other sitting area next to a substation.
- Do not put a pram (or tent) next to a substation.
- Substations close to the house make properties harder to sell, and reduce the price.

Worksheet Substations and Transformers (2 Sides)

What size is the substation you are concerned about? ……

How many properties does it serve? ……

Does it supply:

Shops?	Yes / No
Industrial premises?	Yes / No
Large establishments?	Yes / No

Do any of these need a 24 - hour supply of electricity? Yes / No

Do local houses use night storage radiators? Yes / No
(More likely if there is no gas supply)

Do the cables to and / or from the substation pass close by the property?

……. Metres

Has the property got a very small (or no) front garden Yes / No

Is the property on a corner? Yes / No

Is there a 'net' current? (see text page 4) Yes / No

Is there a 'stray' current? (see text page 4) Yes / No

Maximum field level measured at the nearest point of the property to the substation, transformer or cables.

Garden

Electric field …… V/m

Magnetic field …… microtesla

Property

Electric field …… V/m

Magnetic field …… microtesla

What time of day was the measurement taken? ……. a.m. / p.m.

Is this likely to be the highest reading of the day? Yes / No

Is this likely to be the highest reading of the year? Yes / No

Is the property price appropriately discounted? Yes / No

Could there be a problem with obtaining a mortgage on this property? Yes / No

Are the magnetic field levels lower than 0.2 microtesla

In the garden? On the patio? In the conservatory / sun lounge?

Children's play area?

If any part of the garden is above 0.2 microtesla, draw a plan in the space below to show where this high field area extends to.

In the house?

List any rooms in the house that are above 0.2 microtesla.

……
……

Are any of these places in bedrooms? Yes / No

Where people are likely to spend any length of time? Chairs, etc. Yes / No