# Powerlines, substations, underground cables and net currents

### **Powerlines**

The cheapest way to transport electricity from power stations to consumers is by means of overhead cables, supported by large transmission towers or pylons. The cables strung between the pylons emit magnetic and electric fields, but the towers themselves do not as they are shielded from the cables by the string of insulators, which can be seen in this photograph of a 400kV line.

The largest powerlines, 400kV and 275kV are owned and maintained by National Grid Transco. Some of the 132kV lines are owned by



National Grid Transco but most are now owned by the regional energy distribution companies. The 132 kV se lines are often 'unbalanced', that is, the current on one side of the line cables is very different to that on the other. This leads to much higher electromagnetic fields than if they were both the same.

Most 132kV and all lower voltage lines (e.g. 66kV, 33kV, 11kV, 415 volts and 230 volts) are owned by the power companies (British or internationally owned), and some are wooden poles rather than the large metal structures of the high voltage towers. The Stakeholder Advisory Group on ELF EMFs (SAGE) interim report in April 2007 recommended that some powerlines (particularly the 132 kV distribution lines, quite commonly located close to houses) that are not currently "reverse-phased" to minimise magnetic fields are reconnected to achieve this. There are approximately 40,000 houses within 30 metres of 132 kV lines.

National Grid Transco and the power companies usually avoid putting high voltage lines near to residential areas. This is partly to provide easy access for maintenance purposes, and to make it easier to conform to health and safety regulations with regard to cable height restrictions. Lower voltage lines, especially the 230 volt lines are found in residential areas supplying power to houses. Many of the companies plan to underground new cables, but existing ones will generally still be overground.

The land under powerlines is often cheap. This can attract developers who may build estates of high density housing, often social housing, on this land. There are no planning regulations to prevent this sort of development. If the houses are made available for rent by housing associations or councils, the tenants may have little choice in whether they wish to live in close proximity to powerlines.

There are two types of field produced by the powerline cables. The electric field is proportional to the voltage and is there all the time; the magnetic field is caused by electric current flowing when people use electrical power and can therefore vary considerably.

Electric fields reduce with distance and are also stopped by most building materials, one exception being glass, so you are unlikely to detect very high electric fields from powerlines within a building, except possibly near a window, but they may be high in outside areas, such as gardens, playgrounds, etc.

If you live within 200 metres from the cables between pylons, you may be in electromagnetic fields which are high enough potentially to affect your health (see the article 'Power frequency EMFs and health risks'). High voltage powerlines may need greater clearance, some low voltage powerlines may need less, depending on factors such as how large the load is and whether the load is balanced.

Research done at Bristol University shows that the electric fields surrounding overhead cables cause air ionisation, attracting fine particles which can include carcinogenic (cancer-producing) particles, which are then wind-blown or carried in the rain up to 600 metres or more from a 400 kV electricity transmission line. The electric fields also charge these particles making them more likely to stick in your lungs, or to your skin.

For all practical purposes magnetic fields cannot be stopped and will travel through building materials as if they were not there.

Although there will not be very high electric fields in houses from outside sources, such as powerlines, a significant number of houses have high electric fields inside, caused by the way the houses are wired. If you get high electric and magnetic fields together, the increased risk is not added, but can be as much as 11 times higher.

A new powerline is going up in Tsawwassen, a town in Canada. The proposed line will take it through residents' back yards and school. Residents' protests are being met with force from the utility workers and the police; see a moving half-hour video. http://saveourrivers.tv/crossing\_the\_lines.html.

Sussex County school in the USA closed in September 2009 because of powerlines near the playground. School closure may often be decided on many factors, but the report suggested the magnetic fields were decisive in this case.

http://www.nj.com/news/index.ssf/2009/09/sussex\_county\_school\_to\_close.html

We do not believe it is safe for children to play near high-voltage overhead lines above 11kV, especially with the new concerns about electric field aerosol effects. Evidence also shows that magnetic fields over 0.3 microtesla (300 nanotesla (nT), or 3 milliGauss (mG)) is associated with a doubling of the incidence of childhood leukaemia.

If you have a powerline crossing your property, see the wayleaves and easements section below.



Living in India, powerlines can look a little different!

The European Parliament in 2009 adopted by 559 votes to 22 a resolution on health concerns associated with EMFs.

- MEPs want the criteria for setting up new high-voltage powerlines to be part of negotiations with all bodies concerned. The resolution wants schools, crèches, retirement homes and health care institutions to be kept at a reasonable distance from such developments.
- MEPs called on the Member States to make available to the public maps showing exposure to high-voltage powerlines and that these maps should be available on the internet.
- A yearly report should be presented on the level of electromagnetic radiation in the EU, its sources, and actions taken in the EU to better protect human health and the environment.
- The resolution encouraged the introduction of a single standard designed to ensure that local residents would be subjected to as low a degree of exposure as possible when high-voltage grids were being extended.

In contrast to European precautionary statements, the UK government issued a consultation document for responses by February 2010. They are hoping to produce the document by the end of 2010. It included the following flow chart, which clearly gives them *carte blanche* to do exactly as they please, without any concern for nearby residents with health concerns.



# Substations

Low power substations are found about 150-200 metres apart in a typical urban area. So you will never be that far away from one. Rural areas are more variable. The size of substations varies quite a lot, depending on whether they serve mainly residential properties, or also commercial and industrial units. Schools and institutions such as hospitals, often have their own substation.

Substations can be grey metal boxes in a fenced or walled enclosure. Sometimes they are inside a metal or brick box. They can also be found in plastic (glass fibre and strengthened polycarbonate/ABS type material) structures. These are usually grey or cream/buff coloured.

In cities, some substations, or transformers, have been built into the structure of flats, workplaces and even houses, possibly in the basement. Two studies looking at the measured magnetic fields in blocks of flats with an in-built transformer (Thuróczy 2008, Ilonen 2008), found that in the flat above the transformer, fields were as high as 0.98 and 0.62 microtesla ( $\mu$ T) respectively, in flats on the same floor, they measured 0.13 and 0.21  $\mu$ T and in upper floors 0.1 and 0.11  $\mu$ T. Certainly, in floors immediately above, field levels were higher than those associated with serious ill-health problems, such as leukaemia, and the Ilonen study also concluded that "the higher magnetic field level in first floor apartments indicates that they should not be considered 'unexposed' in epidemiological studies."

Substations have a 'Danger of Death' yellow sign attached to the installation. This is to warn the public of the danger of electric shocks, which can be fatal. Substations change a high voltage, often 11,000 volts, into 415/230 volts to feed power to nearby houses. Rural areas may have small grey box transformers part way up a wooden pole.

Sometimes on the outskirts of a town there may be a large 'nest' of transformers, and overhead cables leading to them. There may also be underground cables leading to or away from the transformers.

Magnetic fields are generated by the equipment inside substations. They tend to drop away quite rapidly, and unless the property is very close, or the substation is very powerful, the magnetic fields are unlikely to be at the sort of level associated with health problems.

It is important however, if there is a substation next to the garden, that you do not build a patio, or other seating area next to it, that children do not play close to the substation equipment enclosure, and you do not place a baby in a pram next to it.

The main source of magnetic fields from substations is the low voltage (230 / 415 volt) underground cables, either going to the substation if there are no overhead cables, and those leading away from the substation to the properties which draw power from it. These underground cables can run next to the house or garden and can produce high localised magnetic field levels. This can be important if the nearby structure is a child's play area, a patio, a barbecue area, a downstairs bedroom or a sitting room with a chair next to the outside wall which is occupied for extensive periods of time.

The strength of the electric field depends on the voltage. Electric fields from substation equipment are unlikely to extend beyond the equipment housing, as they are screened by practically all building materials.

Substation transformer oil used to contain polychlorinated biphenyls (PCBs) as intentional oil contaminants. However, all UK electricity substation transformers were meant to have their oil changed and suitably disposed of by the year 2000 and the Energy Networks Association (ENA) claim that this was done. Large substations, e.g. those between 11kV and 132kV may provide more environmental contamination, though the ENA is meant to monitor the levels around their installations.

REVOLT newsletter 279 (September 2009) reports. "Two appeals for schemes on the same south-west London site have been rejected on the basis of the potential harmful impact associated with an electricity substation." "Both schemes involved repositioning an electricity substation. Two local residents highlighted that it would then be in close proximity to their daughter's bedroom. They argued that low-frequency EMFs could contribute towards childhood leukaemia. The fear of such effects was a material planning consideration, the inspector decided."

# **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.

### **Underground cables**

The electric fields from underground cables will be zero as they are screened by earth, concrete, sand etc. The magnetic fields are very high near to the cable, higher than from overhead cables because they are closer to you. They fall off more rapidly than the fields from overhead wires, because the cables are closer together and cancel out each other's effects more quickly.

Houses, or ground floor or basement flats, with very small or no front garden, may have high magnetic fields in their front rooms from distribution cables running underneath the pavement.

According to an announcement by the Irish government in July 2008, underground cables are 10 times more likely to give power continuity problems than overhead lines. They also state that the capital cost of constructing underground cables would be approximately 5 times greater than the cost of overhead lines and 3 times the lifecycle costs.

# **Net currents**

In many built up areas the electricity companies often connect neutrals from different substations together, this can produce 'net currents' which flow round the system the wrong way and can give rise to high magnetic fields over wide areas (e.g. round 4 or 5 streets). This is a major cause of high domestic magnetic field levels and the only way to find out if it is happening in your area is to measure the magnetic fields at a peak time (say between 4.30 and 6.30 p.m. on weekdays). Fields should be well below 0.1 microtesla in the summer, and 0.2 microtesla in the middle of winter. UK average is 0.04 microtesla.

We have found net currents in one quarter of the properties that we have surveyed. In 109 measurements taken by National Grid, 6% of Eastern customers had a significant net current, but 21% of Yorkshire customers did; a 3½ fold difference.

Another modern practice that can cause widespread elevated EMFs is Protective Multiple Earthing (PME) where the Neutral is physically connected to a grounding rod every few hundred metres around a 415/230 volt distribution circuit.

Unbalanced (net) currents can also occur with the 'ring wiring' used in UK houses and offices used to feed the electrical socket outlets. We dislike this wiring technique and believe all wiring should be 'radial' which forces the return current to return alongside the supply current. In many countries in the EU, the standard way of wiring is the radial system.

# The health risks

There have been links between powerfrequency EMFs and many adverse health effects, including serious illnesses such as cancer, depression, etc., made by international research studies. For details see the article 'Powerfrequency EMFs and health risks'.

# Corona ions (air ionisation)

The intense electric field on the surface of powerline cables is sufficient to ionise the air, producing corona ions. This process is the cause of the characteristic buzzing or crackling of powerlines. Corona ions are routinely emitted from high voltage powerlines, especially in wet conditions. Corona ion effects have been measured up to 7 kilometres from powerlines both in the UK and in Germany.

Corona ions are small electrically-charged particles which, when emitted from powerlines attach themselves to particles of air pollution, making these particles more likely to be trapped in the lung when inhaled. This phenomenon is sufficiently well recognised that pharmaceutical companies making inhalers are developing methods of charging up those aerosols to improve their effectiveness.

In this way people living near powerlines may be exposed to increased levels of air pollution. Crucially, corona ions can be carried several hundred metres from powerlines by the wind, so effects may be felt much further away than for magnetic fields. Fews and Henshaw, and colleagues at Bristol University (see refs) have estimated that corona ion effects, significant to adversely affect human health, extend to at least 400 metres from powerlines.

Bristol University found similar levels of corona ion pollution from 132kV lines as well as the much higher voltage lines studied in the Draper report (see refs). 132kV lines are much more common and straddle many houses and housing estates around the UK.

Because of the quantity of research pointing towards serious health problems as a result of exposure to EMFs from power lines, etc., Powerwatch believes the Government should issue clear guidance to a) prevent any new building, especially homes, schools, nurseries, etc. within 250 metres of high-voltage powerlines and b) enable the industry to start remedial work, such as undergrounding powerlines. The regulator, OFGEM, should allow the industry to increase electricity prices slightly to fund this necessary work.

Although research has shown there is an increased risk of illness in high fields, most people, including most children, will not be seriously affected by them. It is important not to panic, but to take reasonable precautions.

### **Government precautionary guidelines**

Below is a summary of regulations and advisory exposure limits to magnetic fields. Some countries, notably Sweden, Switzerland and parts of Italy have already moved to introduce either advisory or regulatory limits of exposure for new installations.

UK National Radiological Protection Board, NRPB, Spring 2004	100.0 microtesla (μT)
International Commission on Non-Ionising Radiation Protection, ICNIRP	100.0 microtesla (μT)
1996 Swedish Advisory Bodies suggest power distribution should avoid above average exposures	0.2 microtesla (μT)
Swiss Government 1999 limit for new installations	1.0 microtesla (μT)
2000 Three Italian Regions: Veneto, Emilia-Romagna and Tuscana limit for new installations	0.2 microtesla (μT)
2002 New substation in Queensland, Australia: Energex Ltd settle out of court	0.4 microtesla (μT)
2003 California Education Department exposure limit for schools	0.1 microtesla (μT)

# The effect on property values

No legislation exists within the UK to restrict the development of land where high voltage overhead lines are sited. The only limitation on new development is statutory safety clearances, and as a result a large amount of residential development has been carried out beneath, and adjacent to, overhead lines.

The demand for new residential property has increased from 3.8 million households in 1996 to 24 million anticipated by 2021. The government has encouraged the use of cleared 'brownfield' sites for this new building in Planning Policy Guidance Note 3 (2000) and John Prescott's statements to Parliament, 1998 and 2002. By 2008, 60% of new housing is to be on brownfield rather than greenfield sites. Many brownfield sites are crossed by powerlines that still service adjacent areas, even though the land immediately beneath and nearby has been cleared of previously existing buildings. This has the advantage that new building would have amenities already on site. Using brownfield sites also slows the urban spread into greenbelt land or into country areas.

The Royal Institute of Chartered surveyors (RICS) Red Book, in 2003, said, "*The possible effects of electric and magnetic fields have been the subject of occasional media coverage, with results that, where there is high-voltage electrical supply equipment close to the property, there is a risk that public perception may affect marketability.*" They went on to say that property transactions in the UK are usually

*private* between vendor and purchaser (in other countries the process is more public), and as such tend to be shrouded in secrecy. This secrecy makes it quite difficult to find reliable data.

Up to the 1990s there did not seem to be much of a difference in the type of housing built near to powerlines. Now, it is likely that the nearest housing is likely to be low-cost and social housing. Increasingly, it is made part of the development deal that the developers pay the utility, wherever possible, to move and re-site lines, either undergrounded or elsewhere.

However, in a recent communication (February 2008), we heard that in a small development of houses, where some were being sold for £695,000, others were being sold for £495,000 and they had a 132kV powerline running directly over the gardens of the lower-priced houses. Some were 4 bedroom and some were 5 bedroom, but I would have thought that this only goes some way to explaining the difference in price.

A study by Sims & Dent (2005) showed that house prices were reduced by up to 18% for a property within 150 metres of a powerline, and 20% within 50 metres. The price was reduced by up to 26% if a pylon could be seen. Visible substations and cables also reduced the value of a property.

#### Wayleaves and easements

A property which has a powerline running across it is reduced in value compared with a similar property without such a line. Electricity Companies are required to compensate landowners or occupiers for their loss. This is primarily done in one of two ways, a wayleave or an easement. It is likely that more restrictions will be brought in regarding high voltage powerlines and housing in 2006 or 2007, and people with permanent easements will have signed over the rights indefinitely, in most cases, unlike wayleaves which are a temporary agreement and can be cancelled.

#### Wayleaves

A wayleave is a personal agreement between the electricity company and the landowner to allow the installation of the electric line on payment of a consideration. A wayleave will set out the terms of the agreement and will usually contain a termination clause. However, as a wayleave is a personal agreement, it will cease to have effect if the owner or occupier disposes of their interest.

If the electricity company is unable to negotiate a consent with the landowner, the Electricity Act 1989 gives the company the right to apply for a) compulsory purchase or b) a necessary wayleave. A wayleave hearing is a formal one in front of a Department of Trade and Industry Engineering Inspector. The outcome can vary from outright "move the line" (VERY unusual), to "do nothing, the powerline stays where it is" (quite common), through things like "move the line 100 metres" or "underground the line", but often with the cost being shared between the electricity company and the person wanting the change. That can be very expensive. If the landowner decides not to go ahead, the company is likely to drop the issue too. There can be other compromises where groundworks or cable burying is done at the cost of the electricity company. Colin Gell (below) is likely to have more information about how frequently each type of resolution has emerged.

The E.ON 132kV distribution line at Wolverhampton was allegedly in breach of normal safety clearances from house roofs and allegedly without a wayleave (reported in REVOLT newsletter

279 in September 2009). The home owner most affected reports in August 2009 that E.ON finally agreed to buy the property at full market value (as without the powerline) and to pay removal costs.

#### Easements

An easement is usually a permanent right, but it is possible to negotiate one for a set number of years. The easement grants the electricity company the right to install the line and to retain it permanently.

If you have a powerline crossing your property, and you want to seek professional advice on wayleaves and easements contact Colin Gell, Seraph Surveying Services, Nottingham, (0115 962 2888), who is a specialist in these issues. He is technically based and can usually work out feasible solutions to problems.

# **Electrical hypersensitivity**

Electrical hypersensitivity (EHS) is a condition whereby the person suffers ill-health effects in the presence of electric or magnetic fields. Proximity to powerlines, substations and cables is likely to make people suffering from this condition feel worse than the general population.

EHS is most commonly triggered by computer monitors (VDUs), fluorescent lights, chemical exposure, or working in high magnetic fields. Mobile phones or digital cordless phones can trigger a general electrical hypersensitivity, but such a trigger may lead to a reaction to microwave and not power frequency radiation. Some people however, react to both.

Up to 20% of the population can develop a degree of electrical sensitivity, which can become a very serious and debilitating condition. If you suspect you or someone you know has a sensitivity problem, it is important to take measures to reduce the EMFs around the affected person, as sensitivity increases with continued exposure, and after a time, can become irreversible. See our articles 'Electrical Hypersensitivity, a Modern Illness'.

# What to do

In your own home, you can measure the electric and magnetic fields with an EMFields PRO electric and magnetic field meter, for details see www.emfield.org. This enables you to make any necessary changes to reduce your exposure to EMFs wherever possible.

Where you sleep is probably the most important place to minimise fields. This is especially the case with children, convalescents and anyone with a compromised immune system.

If you are thinking of buying a property near a source of powerfrequency radiation such as powerlines, substations, or cables, you might want to consider measuring the fields first, and evaluating the corona ion situation before you make an irreversible decision. You might find our publication 'Buying an "EMF safe" Property' helpful.

### References

**Draper G** et al - 2005, *Childhood cancer in relation to distance from high voltage power lines in England and Wales: a case-control study* British Medical Journal 1290-1293

**Fews AP** et al - 1999, *Corona ions from powerlines and increased exposure to pollutant aerosols* International Journal of Radiation Biology 75(12), 1523-1531

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

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

**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