32 Electric and Magnetic Fields

32.1 Introduction

32.1.1.1 This chapter presents an assessment of the proposed project in terms of electric and magnetic fields. The proposed project, as described in detail in Chapter 10, includes the proposed 400kV overhead transmission line, the dismantling of the existing 132kV overhead transmission line, works associated with six substations (for further details see Volume 4 – Substation Reports), formation of access tracks and other ancillary works. The approach to this assessment has been developed in accordance with the agreed methodology for the overall proposed project, taking into account responses received from the scoping exercise undertaken by (SHETL) and (SPT), as well as the outcomes of specific consultations undertaken to inform the content of this chapter. Further information on consultations is provided in Chapter 5 and Appendices E, F and G.

32.1.1.2 Electric and magnetic fields (often referred to as EMFs) and the electromagnetic forces they represent are an essential part of the physical world. Their sources are the charged fundamental particles of matter (principally electrons and protons). Electromagnetic forces are partly responsible for the cohesion of material substances and they mediate all the processes of chemistry, including those of life itself. Electric and magnetic fields occur naturally within the body in association with nerve and muscle activity. People also experience the natural magnetic field of the Earth (to which a magnetic compass responds) and natural electric fields in the atmosphere.

32.1.1.3 Electric-field strengths are measured in volts per metre (V/m) or kilovolts per metre (kV/m). The atmospheric electric field at ground level is normally about 100 V/m in fine weather and may rise to many thousands of volts per metre during thunderstorms.

32.1.1.4 Magnetic fields are usually measured in microteslas (μT) or nanoteslas (nT). One nanotesla is one thousandth of a microtesla. Microteslas are used throughout this chapter. The Earth has a natural magnetic field, which is approximately 50 μT in this country.

32.1.1.5 The Earth's fields are normally in the same direction, varying in size only slowly over time, and are referred to as static or dc fields. Other fields alternate backwards and forwards and are referred to as alternating or ac fields.

32.1.1.6 Energised high-voltage power-transmission equipment is a source of power-frequency or extremely-low-frequency (ELF) alternating electric and magnetic fields, which add to (or modulate) the Earth's steady natural fields. The strength (or amplitude) of the electric-field modulation depends on the voltage of the equipment, which remains more or less constant as long as the equipment is energised. The strength of the magnetic-field modulation depends on the current (often referred to as the load) carried by the equipment, which varies according to the demand for power at any given time. Future mention of field strengths in this chapter will mean the root-mean-square amplitude of the power-frequency modulation of the total field, which is the conventional way of expressing these quantities.

32.1.1.7 There are no statutory regulations in the UK that limit the exposure of people to power-frequency electric or magnetic fields. Responsibility for implementing appropriate measures for the protection of the public from EMFs lies with Government. In 2004, the National Radiological Protection Board (NRPB), which had[1] statutory responsibility for advising Government on non-ionising radiation protection, including power-frequency fields, and whose responsibility included Scotland, recommended to Government[2] the adoption in the UK of

[1] On 1 April 2005 the NRPB became part of the Health Protection Agency (HPA), forming the Radiation Protection Division (HPA-RPD). This Environmental Statement continues to refer to NRPB for statements made prior to that date.

[2] "Advice on Limiting Exposure to Electromagnetic Fields (0-300 GHz)" Documents of the NRPB Volume 15 No 2 2004

guidelines published in 1998 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP)[3].

32.1.1.8 The details of the ICNIRP guidelines are discussed in Section 32.3.2 but Table 32.1 provides a summary.

Table 32.1: Summary of the ICNIRP Exposure Guidelines Applicable in the UK

	Electric Fields	Magnetic Fields
Basic restriction for general public	2 mA/m^2 (Induced current density in central nervous system)	
Reference level (trigger for further investigation)	5,000 V/m	100 μT
Field corresponding to basic restriction	9,600 V/m	360 μT

32.1.1.9 The Government, in a letter from the Minister for Public Health to the Chair of the NRPB[4], written on behalf of the whole UK including Scotland, accepted this recommendation in the terms of a 1999 EU Recommendation[5]. This recommendation specifies that the limits should be applied after a cost-benefit analysis and when the time of exposure is significant. At present, the Government is still developing the details of how the new exposure recommendations would be applied. However, the general approach of Government is clear.

32.1.1.10 SHETL and SPT have therefore designed the proposed new 400kV overhead transmission line to comply with the Government policy of adopting the 1998 ICNIRP Guidelines in the terms of the 1999 EU Recommendation. This is discussed in more detail in Section 32.3 below. SHETL/SPT believe that compliance with Government policy on exposure levels, which in turn is based on the advice of the Government's independent scientific advisers, the HPA-RPD, ensures the appropriate level of protection for the public from these fields.

32.2 Field Magnitudes

32.2.1 General Characteristics of Fields

32.2.1.1 The magnetic field produced by a current in a conductor falls with distance from the conductor. Where there is more than one current forming part of one or more electrical circuits, there is also partial cancellation between the magnetic fields produced by the individual currents, and that cancellation generally becomes better at greater distances. Overall, the magnetic field is highest at the point of closest approach to the conductors and falls quite rapidly with distance. Similarly, there is partial cancellation between the electric fields produced by the voltages on individual conductors, and the electric field is usually highest at the point of closest approach to the conductors and falls quite rapidly with distance.

32.2.2 Fields Produced by the Proposed Overhead Transmission Line

32.2.2.1 Calculations are performed here for the proposed design of line for both electric fields and magnetic fields. Calculations are the best way of assessing fields in these circumstances and are acceptably accurate. All calculations presented in this Section were performed on the program "EM2D" at National Grid Transco using the approximations of infinitely long straight conductors and ignoring zero-sequence currents and voltages, which are appropriate approximations for these circumstances, and are of unperturbed fields.

[3] Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Physics April 1998, Volume 74, Number 4:494-522

[4] Letter dated 22 July 2004 from Minister for Public Health to Chairman of NRPB plus Annex

[5] Council Recommendation of 12 July 1999 (1999/519/EC)

32.2.2.2 Electric fields depend on the voltage of the line and the clearance of the conductors above ground, but not on the load. Calculated electric fields are given in Table 32.2, for two different ground clearances: 7.6m, which is the minimum clearance a 400kV line is allowed to have (and hence produces the highest fields), and 12m, which is a more typical clearance. One circuit has a voltage of 400kV overhead transmission line, the other 275kV.

Table 32.2: Calculated Electric fields in V/m at 1 m Above Ground Level

	Ground clearance of conductors	Lateral distance from route centreline of overhead line (on the side of the line with the higher field)			
		Maximum under line	25m	50m	100m
400kV, 275kV	7.6m	9800	898	217	53
	12m	4800	936	153	48

32.2.2.3 Magnetic fields depend on the load. In general, loads carried by overhead lines operating as part of an interconnected power system are much lower than their ratings. Calculations of magnetic field are presented in Table 32.3 for various different loads.

Table 32.3: Calculated Magnetic Fields in µT at 1 m Above Ground Level

	Ground clearance of conductors	Lateral distance from route centreline of overhead line (on the side of the line with the higher field)			
		Maximum under line	25m	50m	100m
Estimated loads in early years immediately after construction					
Under normal operation (1299 A, 1260 A)	7.6m	30.3	6.55	1.169	0.173
	12m	16.2	5.09	1.083	0.171
When other circuits are switched out (1732 A, 1689 A)	7.6m	40.4	8.72	1.553	0.230
	12m	21.7	6.78	1.439	0.226
Estimated loads ten years following construction					
Under normal operation (1732 A, 1680 A)	7.6m	40.4	8.73	1.559	0.232
	12m	21.7	6.79	1.444	0.228
When other circuits are switched out (2237 A, 2099 A)	7.6m	51.8	11.36	2.061	0.315
	12m	27.6	8.827	1.904	0.310
Maximum loads the line would ever be capable of carrying					
3040 A, 3040 A	7.6m	71.3	15.21	2.675	0.387
	12m	38.6	11.84	2.48	0.382

32.2.2.4 The calculations in Tables 32.2 and 32.3 are for the proposed design that would comprise the majority of the length of the line. In the last section from Sheriffmuir to Denny North, an alternative design would be used which produces slightly different fields.

32.2.2.5 The design used for the majority of the length has two conductors in each phase bundle on the same horizontal level. Other sections of the line would have "rotated" bundles, where the two conductors are not on exactly the same level. In these sections, the electric fields are always lower. The maximum field under the line at 7.6m clearance with rotated bundles is 9600V/m. The magnetic field is unaffected.

32.2.2.6 The last southern section of the line from Sheriffmuir would be built to a slightly different design known as "L12". This produces lower fields, by just a few percent directly under the line but by up to 20% at larger distances from the line. The final 3km into Denny North substation would utilise existing towers of a design known as "L6", which produces fields intermediate between the other two designs.

32.2.2.7 Close to substations the proposed 400kV overhead transmission line would converge on existing power lines. In principle, the total field at any point then comes from more than one line. In practice, the maximum field from any line, found directly underneath that line, is changed only negligibly by the presence of the other lines. The lower fields found to the sides of a line may be increased by the presence of other lines, but because of the way in which fields from different sources add, the overall field is never much greater than the largest of the contributions from each line on its own.

32.2.2.8 In the future, it is possible that the proposed overhead transmission line could be operated with both circuits at 400kV instead of one at 400kV and one at 275kV. Because the field depends not just on the voltage or current in each circuit separately but on the cancellation between the two circuits, the effect of this would be complex. The maximum fields under the line would reduce, but only by less than one percent for the electric field and around 10% for the magnetic field. To the sides of the line, some fields would increase and some decrease.

32.2.2.9 The closest residential property to the proposed 400kV overhead transmission line is at Logie Burn outside Bridge of Allan which is approximately 40m from the route centreline. The fields at Logie Burn during normal operation in the early years after construction would be approximately 280V/m and 1.7μT.

32.2.3 Fields Produced by the Proposed Substations

32.2.3.1 Electric and magnetic fields at and outside the perimeter fence of a substation, produced by equipment inside the substation, are not readily calculable. However, for substations such as the ones proposed here, the highest fields found round the perimeter are normally those produced by the overhead lines or underground cables entering or leaving the substation. The fields produced by the equipment within the substation are generally rather smaller. The proposed substation at Beauly (and possibly also the substation at Denny North) would contain an item of equipment called a Static Var Compensator (SVC), which can produce quite high magnetic fields. However, the SVC would be designed so as to be sufficiently far inside the perimeter fence for the fields produced by it outside the perimeter fence to be less than 100μT.

32.2.4 Fields from Other Sources

32.2.4.1 For comparison, in homes in the UK which are not close to high-voltage overhead lines or underground cables, the average “background” magnetic field (the field existing over the whole volume of the house) is approximately 0.05μT. The highest magnetic fields to which most people are exposed arise close to domestic appliances that incorporate motors and transformers. For example, close to the surface, fields can be 2000μT for electric razors and hair dryers, 800μT for vacuum cleaners, and 50μT for TVs and washing machines. The electric field in most homes is in the range 1-20V/m, rising to a few hundred V/m close to appliances.

32.3 Compliance with Exposure Guidelines

32.3.1 Policy of Compliance with Exposure Guidelines

32.3.1.1 SHETL/SPT’s policy in planning this proposed project is that it should comply with Government policy on EMFs and in particular with the Government’s EMF exposure guidelines.

32.3.2 EMF Exposure Guidelines in the UK

32.3.2.1 In March 2004 the NRPB provided new advice to Government[6], replacing previous advice from 1993, and recommending the adoption in the UK of guidelines published in 1998 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP)[7].

32.3.2.2 Government formally responded to these new recommendations from the NRPB on 22 July 2004, in the form of a letter from the Minister for Public Health to the Chairman of the NRPB[8]. The Annex to this letter states, in part:

"7 For all other sources [other than mobile telephony, and therefore including power lines] the Government expects the NRPB guidelines to be implemented in line with the terms of the EU Recommendation, that is, taking account of the risks and benefits of action. Preliminary discussions have already taken place to identify what reasonable actions might be taken."

32.3.2.3 The letter also refers, in the context of mobile telephony, to a "Code of Best Practice on Mobile Phone Network Development", and goes on to say:

"*A similar approach could be adopted for power frequencies (power lines being one example), where the detailed costs and practicalities of implementation of the guidelines are arguably more complex. Officials from Government departments concerned are currently discussing pragmatic approaches to implementation with the main electricity transmission company*."

32.3.2.4 The EU recommendation of 1999[9], in line with whose terms the Government expects the NRPB recommendations to be implemented, states, in part:

"Member States, in order to provide for a high level of health protection against exposure to electromagnetic fields, should:

adopt a framework of basic restrictions and reference levels using Annex I.B as the basis;

implement measures according to this framework, in respect of sources or practices giving rise to electromagnetic exposure of the general public when the time of exposure is significant …[with exceptions for medical purposes]

aim to achieve respect of the basic restrictions given in Annex II for public exposure"

32.3.2.5 From these various statements, it is apparent that Government policy is that power lines should comply with the ICNIRP guidelines:

- when the time of exposure is "*significant*"
- taking account of the risks and benefits of achieving compliance
- where the actions required to achieve compliance are "*pragmatic*" and "*reasonable*".

32.3.2.6 Government have indicated that they are likely to regard the time of exposure as "*significant*" in private homes, gardens, and maybe some other defined land uses, but not in the generality of land under or close to power lines.

32.3.3 Numerical Values of Exposure Guidelines

32.3.3.1 The 1998 ICNIRP guidelines give a "*basic restriction*" on the induced current in the central nervous system for the general public of 2mA/m^2. They also give "*reference levels*", which are, at power frequencies, 5,000V/m for electric fields and 100μT for magnetic fields. The 1999 EU Recommendation uses these identical values.

32.3.3.2 In the ICNIRP guidelines and the EU Recommendation, the actual limit is the basic restriction. The reference levels are not limits, but are guides to when detailed investigation of compliance

[6] "Advice on Limiting Exposure to Electromagnetic Fields (0-300 GHz)" Documents of the NRPB Volume 15 No 2 2004

[7] Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Physics April 1998, Volume 74, Number 4:494-522

[8] Letter dated 22 July 2004 from Minister for Public Health to Chairman of NRPB plus Annex

[9] Council Recommendation of 12 July 1999 (1999/519/EC)

with the actual limit, the basic restriction, is required. If the reference level is not exceeded, the basic restriction cannot be exceeded and no further investigation is needed. If the reference level is exceeded, the basic restriction may or may not be exceeded.

32.3.3.3 This is spelled out explicitly by the NRPB. In their recommendations to Government of March 2004[10], they state, in part:

"*Recommendations*

The ICNIRP basic restrictions on induced current density should be used for restricting occupational and general public exposure to electric and magnetic fields of frequencies less than 100 kHz (see the appendix).

The ICNIRP reference levels should be used at the initial stage of assessing compliance with basic restrictions on exposure.

Further investigations of compliance, that are indicated by exceeding these reference levels, should use the most up to date dosimetry methods."

32.3.3.4 Similarly, in a separate Information Sheet published in 2005[11], HPA RPD state:

"*Where compliance assessment includes the need for measurement and/or calculation of the external fields, RPD suggests the following structured approach based on three stages of increasing complexity.*

First stage

The external fields to which people may be exposed should be evaluated and compared with the ICNIRP reference levels. If the results are at or below the reference levels, then compliance should be assumed. Otherwise, assessment should proceed to the second stage.

Second stage

The results of the evaluation should be compared with the values of external fields required to produce the basic restrictions in the body. Such values can be derived from calculations using anatomically realistic models of the body and examples are given in figures 1-4 of the published NRPB Advice (NRPB, 2004b). The associated values are tabulated in the peer-reviewed publications by Dimbylow (1998, 2000). The latest dosimetry from Dimbylow (2005) concerning the development of a female voxel phantom includes further calculations of induced current density and internal electric fields in the frequency range from 50 Hz to 10 MHz.

These calculations indicate that for occupational exposure an electric field strength of approximately 46 kV m^{-1} and a magnetic flux density of approximately 1800 µT correspond to an induced current density of 10 mA m^{-2}. Corresponding values for the general public equivalent to 2 mA m^{-2} are approximately 9 kV m^{-1} and approximately 360 µT."

32.3.3.5 The third stage concerns non-uniform exposures, which are not relevant here.

32.3.3.6 Therefore, if the fields produced by an overhead line are lower than the 9,000V/m and 100µT, the fields required to produce the ICNIRP basic restriction, it is compliant with the ICNIRP guidelines and hence with NRPB recommendations and Government policy. If the fields are greater than these values, it is still compliant with Government policy if the time of exposure to those fields is not significant, or the risks of achieving compliance outweigh the benefits, or the actions required to achieve compliance are not "*reasonable*" or "*pragmatic*".

32.3.4 Compliance of this Project with Exposure Guidelines

32.3.4.1 In Section 32.2.2.3 above, the maximum magnetic field that could ever be produced by the proposed line was calculated as 71µT. That is less than the ICNIRP reference level, so the line complies with Government policy for magnetic fields.

[10] "Advice on Limiting Exposure to Electromagnetic Fields (0-300 GHz)" Documents of the NRPB Volume 15 No 2 2004, p22

[11] "Application of ICNIRP Exposure Guidelines for 50 Hz Power Frequency Fields "
http://www.hpa.org.uk/radiation/understand/information_sheets/icnirp_exp_guidelines.htm

32.3.4.2 The maximum electric field that could be produced was calculated as 9800V/m. That is slightly greater than the value that corresponds to the ICNIRP basic restriction. However, that field is produced only in a small area directly under the middle of some low-clearance spans of the line. The line does not pass directly over any private homes or gardens or other areas where Government are likely to regard the exposure as being for "*significant periods of time*". Therefore, SHETL and SPT consider the line also complies with Government policy for electric fields.

32.3.4.3 Specifically, the fields produced by the line at the nearest private home or garden were calculated as 280V/m and 1.7μT. These are both much less than the ICNIRP reference levels, confirming that the fields produced by this line would comply with Government policy.

32.3.4.4 The levels recommended by NRPB for occupational exposure are five times higher than the values for public exposure.

32.4 Effects on People

32.4.1 The Current Scientific Position

32.4.1.1 A power-frequency magnetic field induces a small current in a person exposed to it. In a magnetic field of strength 100μT, the total induced current could reach approximately 30 microamperes (μA). By contrast, the current required to light a typical small torch bulb is 100,000μA, and the smallest current which most people can perceive is around 500μA. Magnetic fields have no directly perceptible effects on the body.

32.4.1.2 A person standing in the electric field beneath a 400kV overhead transmission line power line would have an alternating surface charge induced on his or her body and an associated alternating current induced within the body. The induced surface charge could interact with the electric field to cause vibration of body hair, although the vibration would generally be too feeble to notice. In a power-frequency electric field of about 9,000V/m, the induced current in the body could reach approximately 120 microamperes (μA).

32.4.1.3 In certain circumstances, a person exposed to a high electric field could experience small spark discharges (microshocks) on touching other objects, producing a prickling sensation similar to that caused by the static discharges commonly experienced in dry atmospheric conditions after frictional contact with a nylon carpet or car seat. Normally, any sensation is confined to the momentary spark discharge as contact is made or broken.

32.4.1.4 In its 2005 Information Sheet[12], HPA-RPD state:

"…on the basis of the available evidence, the direct effects of microshocks on the body are not considered capable of producing lasting harm. The response to some extent will depend on the sensitivity of the individual. Although the possibility of microshocks cannot be ruled out, in field strengths up to about 5 kV m^{-1} *they are unlikely to be painful to the majority of people*."

32.4.1.5 Over the past 20 years it has been suggested that exposure to power-frequency magnetic or electric fields of the magnitude encountered in the environment could be linked with various health problems, ranging from headaches to Alzheimer's disease. The most persistent of these suggestions relates to childhood cancers.

32.4.1.6 A number of epidemiological studies, particularly in the United States and in Scandinavia, have suggested an association between the incidence of childhood cancers and the proximity of homes to power transmission and distribution wires or power-frequency magnetic-field strengths in the homes. Other studies, notably the world's largest ever study of its type, conducted in the UK during the 1990s and published in 1999, have failed to confirm such associations, but the statistical association remains. However, no causal link has been established between cancer (or any other disease) and magnetic or electric fields and indeed there is no established mechanism by which these fields could cause or promote the disease.

[12] "Application of ICNIRP Exposure Guidelines for 50 Hz Power Frequency Fields"
http://www.hpa.org.uk/radiation/understand/information_sheets/icnirp_exp_guidelines.htm

32.4.2 Reviews of the Science by NRPB and IARC

32.4.2.1 The question of possible health effects of environmental power-frequency fields has been thoroughly reviewed in recent years by a number of national and international bodies, including the National Radiological Protection Board and the International Agency for Research on Cancer.

32.4.2.2 In a major review of the evidence for a possible association between exposure to power-frequency electric and magnetic fields and the incidence of cancer published in March 2001, the NRPB Advisory Group on Non-Ionising Radiation concluded[13]:

"*Laboratory experiments have provided no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer, nor do human epidemiological studies suggest that they cause cancer in general. There is, however, some epidemiological evidence that prolonged exposure to higher levels of power frequency magnetic fields is associated with a small risk of leukaemia in children. In practice, such levels of exposure are seldom encountered by the general public in the UK. In the absence of clear evidence of a carcinogenic effect in adults, or of a plausible explanation from experiments on animals or isolated cells, the epidemiological evidence is currently not strong enough to justify a firm conclusion that such fields cause leukaemia in children. Unless, however, further research indicates that the finding is due to chance or some currently unrecognised artefact, the possibility remains that intense and prolonged exposures to magnetic fields can increase the risk of leukaemia in children.*"

32.4.2.3 The context of the report makes clear that "*prolonged exposure to higher levels of power frequency magnetic fields" and "intense and prolonged exposures to magnetic fields*" refer to magnetic fields, in the home and often specifically in the child's bedroom, assessed in epidemiological studies as having average values over 24 hours or longer of 0.4μT or greater. The figure of 0.4μT arises because it is a cutpoint that has been used in certain analyses of epidemiological studies. However, it would be wrong to regard 0.4μT as a precise threshold above which there is a possibility of a risk and below which there is no possibility of a risk.

32.4.2.4 In November 2001 the NRPB's Advisory Group published a further report on electromagnetic fields and neurodegenerative disease[14]. The conclusion was:

"*There is no good ground for thinking that exposure to extremely low frequency electromagnetic fields can cause Parkinson's disease and only very weak evidence to suggest it could cause Alzheimer's disease. The evidence that people employed in electrical occupations have an increased risk of developing amyotrophic lateral sclerosis is substantially stronger, but this could be because they run an increased risk of having an electric shock rather than any effect of long-term exposure to the fields per se*."

32.4.2.5 Although the various reports of the NRPB Advisory Group concentrate on cancer and neurodegenerative disease, the studies which the Board take into account when setting exposure guidelines include other suggested health effects.

32.4.2.6 In 2004 the NRPB published new "Advice on Limiting Exposure to Electromagnetic Fields (0-300GHz)"[15] and accompanied it with a "Review of the Scientific Evidence for Limiting Exposure to Electromagnetic Fields (0-300GHz)"[16]. The former summarises epidemiological evidence as follows (p15):

54 "In the view of NRPB, the epidemiological evidence that time-weighted average exposure to power frequency magnetic fields above 0.4μT is associated with a small absolute raised risk of leukaemia in children is, at present, an observation for which there is no sound scientific explanation. There is no clear evidence of a carcinogenic effect of ELF EMFs in adults and no plausible biological explanation of the association that can be obtained from experiments with animals or from cellular and molecular studies. Alternative explanations for this

[13] "Elf Electromagnetic Fields and the Risk of Cancer", Documents of the NRPB, Vol 12, No 1, 2001, p164

[14] "Elf Electromagnetic Fields and Neurodegenrative Disease", Documents of the NRPB, Volume 12 No 4 2001.

[15] Advice on Limiting Exposure to Electromagnetic Fields (0-300 GHz)" Documents of the NRPB Volume 15 No 2 2004

[16] "Review of the Scientific Evidence for Limiting Exposure to Electromagnetic Fields (0-300 GHz)" Documents of the NRPB Volume 15 No 3 2004.

epidemiological association are possible: for example, potential bias in the selection of control children with whom leukaemia cases were in some studies and chance variations resulting from small numbers of individuals affected. Thus any judgements developed on the assumption that the association is causal would be subject to a very high level of uncertainty.

55 "Studies of occupational exposure to ELF EMFs do not provide strong evidence of associations with neurodegenerative diseases…..

56 "Studies of suicide and depressive illness have given inconsistent results in relation to ELF EMF exposure, and evidence for a link with cardiovascular disease is weak.

57 "The overall evidence from studies of maternal exposure to ELF EMFs in the workplace does not indicate an association with adverse pregnancy outcomes, while studies of maternal exposure in the home are difficult to interpret.

58 "Results from studies of male fertility and of birth outcome and childhood cancer in relation to parental occupational exposure to ELF EMFs have been inconsistent and unconvincing.

59 "All these conclusions are consistent with those of AGNIR (2001).

60 "NRPB concludes that the results of epidemiological studies, taken individually or as collectively reviewed by expert groups, cannot currently be used as a basis for restrictions on exposure to EMFs."

32.4.2.7 The International Agency for Research on Cancer (IARC) is an agency of the World Health Organisation. Its Unit of Carcinogen Identification and Evaluation has, since 1972, periodically published Monographs, which assess the evidence that various agents are carcinogenic and classify the agents accordingly. In June 2001, a Working Group met to consider static and extremely-low-frequency electric and magnetic fields. The complete results have been published as Monograph number 80 and a summary of the key findings and classifications has been released by IARC[17]. Power-frequency magnetic fields were classified *as "possibly carcinogenic*", on the basis of "*limited*" evidence from humans concerning childhood leukaemia, "*inadequate*" evidence from humans concerning all other cancer types, and "*inadequate*" evidence from animals. Power-frequency electric fields were *judged "not classifiable*" on the basis of "*inadequate*" evidence from both humans and animals. These classifications are consistent with the conclusions reached by the NRPB's Advisory Group.

32.4.3 Recent Studies of Childhood Cancer in the UK

32.4.3.1 In June 2005, a new epidemiological study was published in the British Medical Journal, looking at childhood cancer in England and Wales in relation to proximity of birth domicile to transmission lines. The study was conducted by the Childhood Cancer Research Group at the University of Oxford, with collaboration from the electricity industry through National Grid Transco.

32.4.3.2 The study finds no increased risks for central nervous system, brain or "other" tumours, but does find an increase in leukaemia rates near power lines. The increase is approximately 70% within 200m of transmission lines and approximately 20% between 200m and 600m. At these distances, the magnetic fields produced by transmission lines are much lower than implicated in previous epidemiology studies, and the study raises the possibility that there is some effect operating other than EMFs, possibly some characteristic of the populations living near power lines.

32.4.3.3 The study concludes:-

"While few children in England and Wales have a birth domicile close to high-voltage power lines, there is a slight tendency for the birth domiciles of children with leukaemia to be closer to those lines than those of matched controls. An association between childhood leukaemia and

[17] "IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Static and Extremely Low Frequency Electric and Magnetic Fields (Vol. 80) (19-26 June 2001) (in preparation). IARC announcement 9 July 2001

power lines has been reported in a number of studies, but it is nevertheless surprising to find the effect extending as far from the lines as it does in this study. We have no satisfactory explanation for our results in terms either of causation by magnetic fields or association with other factors. Neither the association reported here nor previous findings relating to level of exposure to magnetic fields are supported by convincing laboratory data or any accepted bilological mechanism".

and

"We emphasise again the uncertainty about whether this statistical association represents a casual relation".

32.4.3.4 SHETL and SPT fully recognise the importance of this study. HPA-RPD and Government will wish to consider whether any changes to policy relating to power lines is appropriate, and SHETL and SPT would completely comply with any such policy. However, the uncertainty about whether this result reflects a causal relation, and if it does, exactly what it is due to, makes the implications far from obvious. The HPA-RPD response to this study states in part: "*By virtue of the longer time period covered, the new study provides more precise information on childhood cancer rates in the proximity of high-voltage power lines than does the UK Childhood Cancer Study. However, the absence of field measurements in homes and the lack of information on potential confounders make it difficult to know whether the raised risks reported for leukaemia represent a direct effect of electromagnetic field exposure….However, certain findings, such as the weaker evidence for a raised risk when an alternative set of controls is used and the raised risk reported more than 200 metres from the line, where the magnetic fields from lines are at or below background levels, would suggest that at least some of the increased leukaemia risk may be associated with factors other than electromagnetic fields*.

32.4.3.5 "Professor John Toy, Medical Director of Cancer Research UK, one of the UK's major cancer charities, stated: "*This study reports a very slight increase in the risk of childhood leukaemia for children born near power lines, but the researchers could not link this to the power lines themselves. These results may indeed be entirely due to chance. What this paper does not show is that power lines directly cause childhood leukaemia. This may seem confusing, but there may be other more common factors that exist in these areas that contribute to the apparent increased risk."*

"The numbers of cases are small. This apparent very slight increase in risk would, if real, equate to five extra cases of childhood leukaemia in a total of around 400 that occur in a year."

"People who currently live or have lived near power lines in the past need not panic about this research. The triggers that cause childhood leukaemia are most likely a random course of events over which a parent has no control."

32.4.3.6 The previous major epidemiological study of magnetic fields and childhood cancer in the UK was the United Kingdom Childhood Cancer Study (UKCCS). This study found no evidence that exposure to magnetic fields associated with the electricity supply or to proximity to powerlines in the UK increases risks for childhood cancer. In a statement reviewing the overall results from the UKCSS in April 2005, Professor Mel Greaves FRS, Head of the Section of Haemato-Oncology, The Institute of Cancer Research, stated[18]

"However, it is clear that perceived risk factors such as living near sources of electromagnetic fields or natural radiation like radon are not principal causes, if at all, of leukaemia in children."

32.4.4 Other Suggestions of Health Effects of EMFs

32.4.4.1 In 1996 and in 1999, a group from the University of Bristol headed by Professor Henshaw published papers suggesting that the electric fields from high-voltage overhead power lines might influence the behaviour of airborne particles (the main example given being radon

[18] "Experts chart pathway leading to childhood leukaemia", Leukaemia Research Fund New Release, http://www.lrf.org.uk/en/1/22apr05.html

daughter products) in such a way as to be harmful to human health. The NRPB's Advisory Group Report of 2001 contained the following statement[19]:

"*The physical principles for enhanced aerosol deposition in large electric fields are well understood. However, it has not been demonstrated that any such enhanced deposition will increase human exposure in a way that will result in adverse health effects to the general public*."

32.4.4.2 Both the 1996 and the 1999 papers were considered by the IARC Working Group which decided the evidence that electric fields cause cancer was "*inadequate*" for both humans and animals, and that as a consequence electric fields were "*not classifiable*" with respect to carcinogenicity.

32.4.4.3 The NRPB's Advisory Group on Non-Ionising Radiation established an Ad Hoc Group on Corona Ions to consider these suggestions further. It reported in 2004[20]:

"*The potential impact of corona ions on health will depend on the extent to which they increase the dose of relevant pollutants to target tissues in the body. It is not possible to estimate the impact precisely… However, it seems unlikely that corona ions would have more than a small effect on the long-term health risks associated with particulate air pollutants, even in the individuals who are most affected. In public health terms, the proportionate impact will be even lower because only a small fraction of the general population live or work close to sources of corona ions*."

and

"*Any health risks from the deposition of environmental particulate air pollutants on the skin appear to be negligible*."

32.4.4.4 A different group at the University of Bristol headed by Dr Preece is analysing the incidence of certain cancers in areas of Avon and the South West close to or downwind of power lines. Various preliminary results have been reported in the media and at scientific conferences, but the work is not yet finished, final results are not available, and the work has not been reported in the peer-reviewed scientific literature. There are various methodological issues raised by such work. Unless and until both the methods and the results are properly published it is not possible to assess the validity of the work or to place reliance on any results.

32.4.5 Reviews of the Science by other Organisations

32.4.5.1 In May 2002 the California Department of Health Services published a Risk Evaluation[21] on EMFs written by three of its scientists. The conclusions reached appear to be inconsistent with those reached by, for example, the NRPB, its Advisory Group, and IARC. Serious criticisms of the draft report have been made by various eminent independent scientists as part of the process of public comment on earlier drafts. SHETL/SPT considers that the appropriate advice to follow in the UK is that given by the NRPB/HPA-RPD and the UK Government, and not by California Department of Health Services, and that the view of the science expressed by the NRPB is a fairer one than that expressed by California Department of Health Services.

32.4.6 Views of the UK Government

32.4.6.1 In their March 2004 recommendations to Government[22], the NRPB were clear that:

"*60 NRPB concludes that the results of epidemiological studies, taken individually or as collectively reviewed by expert groups, cannot currently be used as a basis for restrictions on exposure to EMFs*."

[19] "ELF Electromagnetic Fields and the Risk of Cancer", Documents of the NRPB, Vol 12, No 1, 2001, p23

[20] "Particle deposition in the vicinity of power lines and possible effects on health" Documents of the NRPB Volume 15 No 1 2004

[21] California EMF Program "An evaluation of the possible risks from electric and magnetic fields (EMFs) from power lines, internal wiring, electrical occupations, and appliances" Final Report June 2002, prepared by R R Neutra, V DelPizzo, G M Lee.

[22] Advice on Limiting Exposure to Electromagnetic Fields (0-300 GHz)" Documents of the NRPB Volume 15 No 2 2004, p15

32.4.6.2 However, they also stated[23]:

"*Recommendation*

139 The Government should consider the need for further precautionary measures in respect of exposure of people to EMFs. In doing so, it should note that the overall evidence for adverse effects of EMFs on health at levels of exposure normally experienced by the general public is weak. The least weak evidence is for the exposure of children to power frequency magnetic fields and childhood leukaemia."

32.4.6.3 In the Minister for Public Health's response to the NRPB's recommendations[24], she stated:

"[previous stakeholder discussions] have generated the proposal that the Department of Health lead this process forward through wider stakeholder discussions. In this way, it is hoped that collective approach can be owned by a range of participants including EMF public concern groups and industrial interests on the need for a precautionary policy and what that might entail."

32.4.6.4 Thus, discussions are in progress that might in due course result in precautionary measures relating to overhead power lines. However, no such precautionary measures or policies are yet in place. The only Government policy currently affecting power lines and EMFs is compliance with the ICNIRP exposure guidelines in the terms of the EU Recommendation.

32.4.6.5 This was emphasised recently in a Parliamentary Written Answer on 8 September 2004[25]. Greg Knight MP asked:

"*The Deputy Prime Minister what guidance he has issued concerning the building of residential properties under or near power lines*."

32.4.6.6 Keith Hill, Minister of State, Office of the Deputy Prime Minister, replied:

"*The Government have not issued guidance concerning the building of residential properties near power lines.*

However, following the publication of the National Radiological Protection Board's (NRPB) new Electromagnetic Field (EMF) guidelines in March 2004 and the associated advice to Government, the Government are committed to taking forward the issue of building near power lines in consultation with all the relevant stakeholder groups."

32.4.6.7 Another way in which the view of the Government is expressed is through decisions on Consents and Wayleaves for new or existing overhead lines. For example, on 11 October 2001, the Department of Trade and Industry wrote to National Grid giving section 37 Consent to a new electricity line in Lincolnshire[26]. The letter contains the following paragraph:

"*3.11 The Secretary of State recognises that concerns have been expressed over the health effects of exposure to electro-magnetic fields from electricity powerlines. On this matter she relies on the advice of the Government's scientific advisers, the National Radiological Protection Board (NRPB). The NRPB keeps a close watch on developments such as the latest research, and its view remains that the results of published epidemiological studies do not provide a basis for quantitative restrictions in respect of exposure of the public to electro-magnetic fields from overhead lines or other electricity supply apparatus. She therefore concludes that health effects do not provide sufficient grounds for refusing consent to the Development. Neither can they supply adequate justification for a planning condition requiring that the line be a certain distance from residential properties…*"

[23] Advice on Limiting Exposure to Electromagnetic Fields (0-300 GHz)" Documents of the NRPB Volume 15 No 2 2004, p28

[24] Letter dated 22 July 2004 from Minister for Public Health to Chairman of NRPB plus Annex

[25] Hansard, House of Commons Written Answers, 8 September 2004, column 1251W

[26] Letter from Department of Trade and Industry Energy Regulation to The Secretary, National Grid Co plc, 11 October 2001

32.5 Other Effects of Fields

32.5.1 Cardiac Pacemakers

32.5.1.1 Power-frequency electric and magnetic fields constitute a possible source of interference with the operation of some types of implanted cardiac pacemakers or other active implants.

32.5.1.2 Most pacemakers are designed to 'fail safe' by reverting to fixed-rate operation when they sense the presence of interference above a certain level. The field strengths necessary to induce such behaviour vary from one pacemaker model to another but are generally higher than the magnetic fields produced by the proposed project.

32.5.1.3 There has been no recorded case in Britain of a patient coming to any harm as a result of fields produced by the power system. The UK Department of Health, Medicines and Healthcare Products Regulatory Agency (MHRA), formerly the Medical Devices Directorate, does not consider that transmission line electric or magnetic fields constitute a significant hazard.

32.5.2 Visual Display Units

32.5.2.1 Magnetic fields may, in some circumstances, affect the steadiness of the image on visual display units (VDUs) which use cathode-ray tubes. This can occur if the frame frequency of the VDU is close to but different from the power frequency (50Hz) or a multiple of it. The effect is to cause the image to wobble at a frequency that depends on the difference between the frame frequency and the power frequency.

32.5.2.2 Some VDU models may typically be sensitive to fields of 0.5µT, although LCD, plasma and other modern display technologies are virtually immune from such problems.

32.5.2.3 The power-frequency magnetic field strength is unlikely to exceed 0.5µT at more than 70-80m from the proposed line under normal conditions and therefore problems are unlikely in practice.

32.5.3 Livestock and Crops

32.5.3.1 Studies in the USA, Sweden and elsewhere have found little evidence that exposure of crops, farm animals and natural ecosystems to transmission line electric and magnetic fields has any agriculturally significant consequences. One positive finding concern bee-hives installed in the highest-field-strength areas beneath high voltage overhead lines. Voltages induced in the hive structure can cause the bees to experience electric shocks, which affect their behaviour and honey production.

32.6 Summary

32.6.1.1 The magnetic-field strength at 1m above ground level directly underneath the lowest point of the proposed overhead transmission line over the land in question is likely to be approximately 30µT under normal load conditions and should not ever exceed 70µT. The electric-field strength should not ever exceed 9800V/m and should not exceed 300V/m over areas where people are likely to spend significant periods of time such as homes and gardens. These values comply with the Government policy of compliance with the 1998 ICNIRP Guidelines in the terms of the 1999 EU Recommendation.

32.6.1.2 The NRPB's 2004 advice to adopt the ICNIRP levels was reached after extensive review of the evidence for possible health effects of power-frequency fields. The NRPB advise that there is no convincing evidence that electromagnetic fields are a cause of cancer, that no biological mechanism has been established in support of this idea, and that the epidemiological evidence reviewed by them and their Advisory Group on Non-Ionising Radiation cannot be used as a basis for restrictions on exposure to EMFs.

32.6.1.3 The advice of the NRPB, endorsed by various Government ministers when answering Parliamentary Questions, gives no reason on grounds of a health hazard as to why this 400kV overhead transmission line should not be constructed and operated, given that it complies with the relevant exposure guidelines. This conclusion has been further endorsed by the Secretary of State for Trade and Industry, who in various recent decisions has not regarded the evidence on possible health risks as sufficient grounds to refuse to grant either Consent or Necessary Wayleaves for high-voltage overhead lines.