

TRANSPower NEW ZEALAND LIMITED: NORTH ISLAND GRID UPGRADE PROJECT

BOARD OF INQUIRY HEARING

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3a	Transpower New Zealand Limited Consultation Guideline for Major Projects
3b	Transpower New Zealand Limited Maori Relationship and Consultation Framework
4	Transpower Easement Terms in Memorandum under section 155 of Land Transfer Act 1952
5	<i>Security of Supply into Auckland Assessment of Alternative Solutions</i> , Transpower, October 2004
6	<i>Security of Supply into the Upper North Island Comparison of High Voltage Direct Current and High Voltage Alternating Current Grid Upgrade Alternatives</i> , Transpower, May 2005

VOLUME TWO	
7	<i>Assessment of HVDC Transmission Options between Whakamaru and Auckland</i> Transpower, May 2005
8	<i>ELF Electromagnetic Fields and the Risk of Cancer – Report of an Advisory Group on Non-Ionising Radiation</i> , National Radiological Protection Board, 2001
9	<i>Environmental Health Criteria 238 – Extremely Low Frequency Fields</i> , World Health Organisation, 2007, pages 1 – 20 (Summary and Recommendations for Further Study) (the full report is at: http://www.who.int/peh-emf/publications/Compleet_DEC_2007.pdf)

VOLUME THREE	
10	<i>Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)</i> , International Commission on Non-Ionizing Radiation Protection, 1998
11	<i>IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz</i> , IEEE Standards Coordinating Committee 28, October 2002
12	<i>Stakeholder Advisory Group on ELF EMFs (SAGE) – Precautionary approaches to ELF EMFs</i> , R K Partnership Ltd, April 2007 and <i>Supporting papers to the First Interim Assessment</i>

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MWH NZ Ltd, North Island 400kV Backbone Investigation Project, Area Report, September 2004 (Part 1 Report, Part 2 Maps)
MWH NZ Ltd, North Island 400kV Backbone Investigation Project, Corridor Study, September 2004 (Part 1 Report, Part 2 Maps)
MWH NZ Ltd, North Island 400kV Backbone Investigation Project, Route Study, October 2004 (Part 1 Report, Part 2 Maps)
MWH NZ Ltd, North Island 400kV Backbone Investigation Project, Summary Report, October 2004
MWH NZ Ltd, North Island 400kV Backbone Investigation Project, Hunua Options, February 2005
MWH NZ Ltd, North Island 400kV Backbone Investigation Project, Report on Interim Route Decision, May 2005 (Part 1 Report, Part 2 Working Papers Volumes 1 – 3)
MWH NZ Ltd, North Island 400kV Backbone Investigation Project, Final Route Decision Report, July 2005 (Part 1 Report, Part 2 Specialist Reports Volumes 1 to 4)
MWH NZ Ltd, North Island 400kV Backbone Investigation Project, Interim Report on Underground Cable Section, Transition Station and Substations, August 2005 (Volume 1 Report, Volume 2 Maps, Volume 3 Supporting Documents)
MWH NZ Ltd, North Island 400kV Backbone Investigation Project, Final Underground Cable Route, November 2005
MWH NZ Ltd, North Island 400kV Grid Upgrade Project, Review of Route Section 1, Alternatives, December 2005
MWH NZ Ltd and Transpower NZ Ltd, North Island 400kv Backbone Investigation Project, Easement Report, January 2006
MWH NZ Ltd, North Island Grid Upgrade Project Amended Proposal, Interim Report on Northern End Modifications, October 2006
MWH NZ Ltd, North Island Grid Upgrade Project, Amended Proposal, Final Report on Northern End Modifications, February 2007
MWH NZ Ltd, North Island Grid Upgrade Project Amended Proposal, Brownhill Substation, Dodd Property Option, July 2007
Truescape Visual Simulations and Video, Lake Karapiro Crossing – Monopoles, 7 August 2007

TAB 12

Stakeholder Advisory Group on ELF EMFs (SAGE) Precautionary approaches to ELF EMFs



**First Interim Assessment:
Power Lines and Property, Wiring in Homes, and Electrical Equipment in Homes**

Date of issue: 27/04/2007

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The SAGE process was initiated by National Grid but is now under the lead of the Department of Health. It is funded equally by the Department of Health, the Electricity Industry (National Grid and the Energy Networks Association) and the charity CHILDREN with LEUKAEMIA.

The process was designed and facilitated by Rob Angell of RK Partnership Ltd and by Brendan Hickling of TW Welch & Partners. The facilitators hold no formal position on any of the substantive issues that have been, or might be, considered. It is for the participants to decide what issues are raised, how they might be addressed and how any observations, conclusions and recommendations might be recorded and communicated.

The R K Partnership website www.rkpartnership.co.uk has a full description of the process, as well as papers considered by the participants and assessments produced from the process.

PLEASE NOTE

The remit of SAGE is to provide advice to Government. It is for Government to take decisions on policy relating to EMFs and health, based on this advice and whatever other inputs it deems necessary.

This Assessment represents a record and a distillation of the discussions that have taken place within SAGE. It is not a single definitive set of universally agreed conclusions and recommendations, but rather captures the point our evolving discussions have reached. We are aware of places where particular issues need further consideration, and intend to progress our work. Merely by having participated in the process, no stakeholder is thereby bound to agree with every statement in the Assessment, or deemed to agree with every recommendation.

Government officials are a part of the process, informing the debate and supplying factual input to the Assessment. The Government supports the production of the Assessment and welcomes the material and the contribution it makes to consideration of the EMF issue. However, this does not necessarily imply that Government is aligned with the views expressed or the conclusions stated in this Assessment and Government representatives will not be formally supporting any particular conclusions and options outlined in the Assessment, as that is a matter for Government as a whole to consider once it has received the Assessment.

Recognising that this Assessment reflects some degree of agreement but not total agreement, each stakeholder has been given the opportunity to make a statement of their view of the point the SAGE discussions have reached. These are contained in the appendix on page 57.

Stakeholders (individuals and organisations) are not bound by this Assessment in their future activities or commercial decisions.

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Overview

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This first SAGE Assessment represents a record and a distillation of the discussions that have taken place within SAGE. It is not a single definitive set of universally agreed conclusions and recommendations, but rather captures the point our evolving discussions have reached. We are aware of places where particular issues need further consideration, and intend to progress our work. Merely by having participated in the process, no stakeholder is thereby bound to agree with every statement in the Assessment, or deemed to agree with every recommendation, or constrained by the contents of the Assessment in their future activities.

This Assessment considers EMFs from two groups of sources: high-voltage overhead power lines; and sources inside the home (home wiring, and domestic equipment and appliances). SAGE intends to go on to consider other sources such as low-voltage distribution wiring, railways, etc.

This Assessment opens with an introductory Section 1. This summarises the state of the science on EMFs, the history of protection from EMFs and the events which led to the creation of SAGE, and describes how we have gone about our work.

Section 2 details the decisions we have made that are generic to all our work. This is where we set out the assumptions we have made about how big the possible risk is, and how we assess the different precautionary options, including how we consider costs and benefits, and public opinion.

The next three sections consider EMFs from particular sources: Section 3 for home wiring, Section 4 for equipment in the home, and Section 5 for power lines. In each case, we describe very briefly the source of the fields; we list the various options for reducing exposures and discuss how we narrowed these options down; then we discuss which options we recommend or not.

Recognising that this Assessment reflects some degree of agreement but not total agreement, each stakeholder has been given the opportunity to make a statement of their view of the point the SAGE discussions have reached. These are contained in the Appendix.

Much of the factual material which informs our discussion is contained in Supporting Papers which are available from the SAGE web site. As with the main Assessment, these reflect the discussions that have taken place among stakeholders, without all stakeholders necessarily agreeing with all the content. Within the SAGE process, however, there has been more emphasis on the main Assessment, and the Supporting Papers should be seen as more provisional and interim. Also on the SAGE web site is a section of documents submitted as contributions to the wider debate by SAGE participants.

Abbreviations and Acronyms

AC	Alternating Current
ALL	Acute Lymphocytic Leukaemia
ALS	Amyotrophic Lateral Sclerosis, the most common form of Motor Neurone Disease
AM	Arithmetic Mean
AMDEA	Association of Manufacturers of Domestic Appliances
BS	British Standard
BSI	British Standards Institution
CLA	Country Land and Business Association
CML	Council of Mortgage Lenders
CPC	Circuit Protective Conductor
CPO	Compulsory Purchase Order
DC	Direct Current
DCLG	Department for Communities and Local Government (formerly part of ODPM)
Defra	Department of Food and Rural Affairs
DfES	Department for Education and Skills
DH	Department of Health
DNO	Distribution Network Operator
DTI	Department of Trade and Industry
EDM	Early Day Motion
ELF	Extremely Low Frequency
EF	Electric Field
EIE	Electrical Installations and Equipment (SAGE Working Group)
EMFs	Electric and Magnetic Fields
ENA	Energy Networks Association
EPA	Environmental Protection Act 1990
EPA	Environment Protection Agency (US body)
ESQCR	Electricity Safety, Quality, and Continuity Regulations 2002
FUW	Farmers' Union of Wales
GM	Geometric Mean
HPA	Health Protection Agency (part of which was formerly NRPB)
HPA-RPD	HPA Radiation Protection Division
HSE	Health and Safety Executive
Hz	Hertz (unit of frequency)
IARC	International Agency for Research on Cancer
ICNIRP	International Commission for Non-Ionizing Radiation Protection
IEE	Institution of Electrical Engineers, now part of IET
IET	Institution of Engineering and Technology, successor body to IEE
kV	Kilovolt

MF	Magnetic Field
MND	Motor Neurone Disease
MOA	Mobile Operators' Association
NCRP	National Council on Radiation Protection and Measurements (US body)
NFU	National Farmers' Union
NGT	National Grid Transco (former name of National Grid)
NI	Northern Ireland
NICE	National Institute for Health and Clinical Excellence
NIEHS	National Institute of Environmental and Health Sciences (USA body)
NRPB	National Radiological Protection Board (now part of HPA)
ODPM	Office of the Deputy Prime Minister, now DCLG
Ofgem	Office for Gas and Electricity Markets
PLP	Power Lines and Property (SAGE Working Group)
PME	Protective Multiple Earthing
QALY	Quality Adjusted Life Years
RCBO	Residual Current Circuit Breaker with Overload Protection
RCD	Residual Current Device
RCM	Rate of Change Metric
RCMS	Rate of Change Metric Standardised
RF	Radio Frequency
RIA	Regulatory Impact Assessment
RICS	Royal Institute of Chartered Surveyors
RPD	Radiation Protection Division (of HPA)
SAGE	Stakeholder Advisory Group on ELF EMFs
T	Tesla (unit of magnetic field)
THD	Total Harmonic Distortion
TWA	Time Weighted Average
UKCCS	United Kingdom Childhood Cancer Study
V/m or V m ⁻¹	Volts per metre (unit of electric field)
WHO	World Health Organization
μT	Microtesla

1 Introduction

EMFs

1.1 Context

Over the course of the last 30 years there has been a growing understanding of the effects of electric fields (EF) and magnetic fields (MF) on people. Together EFs and MFs are known as electromagnetic fields EMFs.

In 2004 the UK adopted new guidelines which set magnetic field levels (a reference level of $100 \mu\text{T}$) above which members of the public should not usually be exposed. However this left open the question of what effects the fields have (if any) on people below these levels. This question is highly controversial partly because it includes levels which can be found in homes, from their wiring circuits, and in homes that are near to power lines.

The Stakeholder Advisory Group on ELF EMFs was set up in November 2004 to involve all key stakeholders to address this question. This group process deliberately set out to change the dynamic and type of relationships that had existed between stakeholders over the preceding 20 or so years, which had been characterised by constant conflict and “standing on opposing sides at inquiries”.

The state of relations between stakeholders at the start of this process was therefore not good. Significant progress has been made on this front since then.

The Project

Aim

The aim of the process was agreed by stakeholders in November 2004 as:

“To bring together the range of stakeholders to identify and explore the implications for a precautionary approach to ELF EMF (electric and magnetic fields) and make practical recommendations for precautionary measures”.

The Process

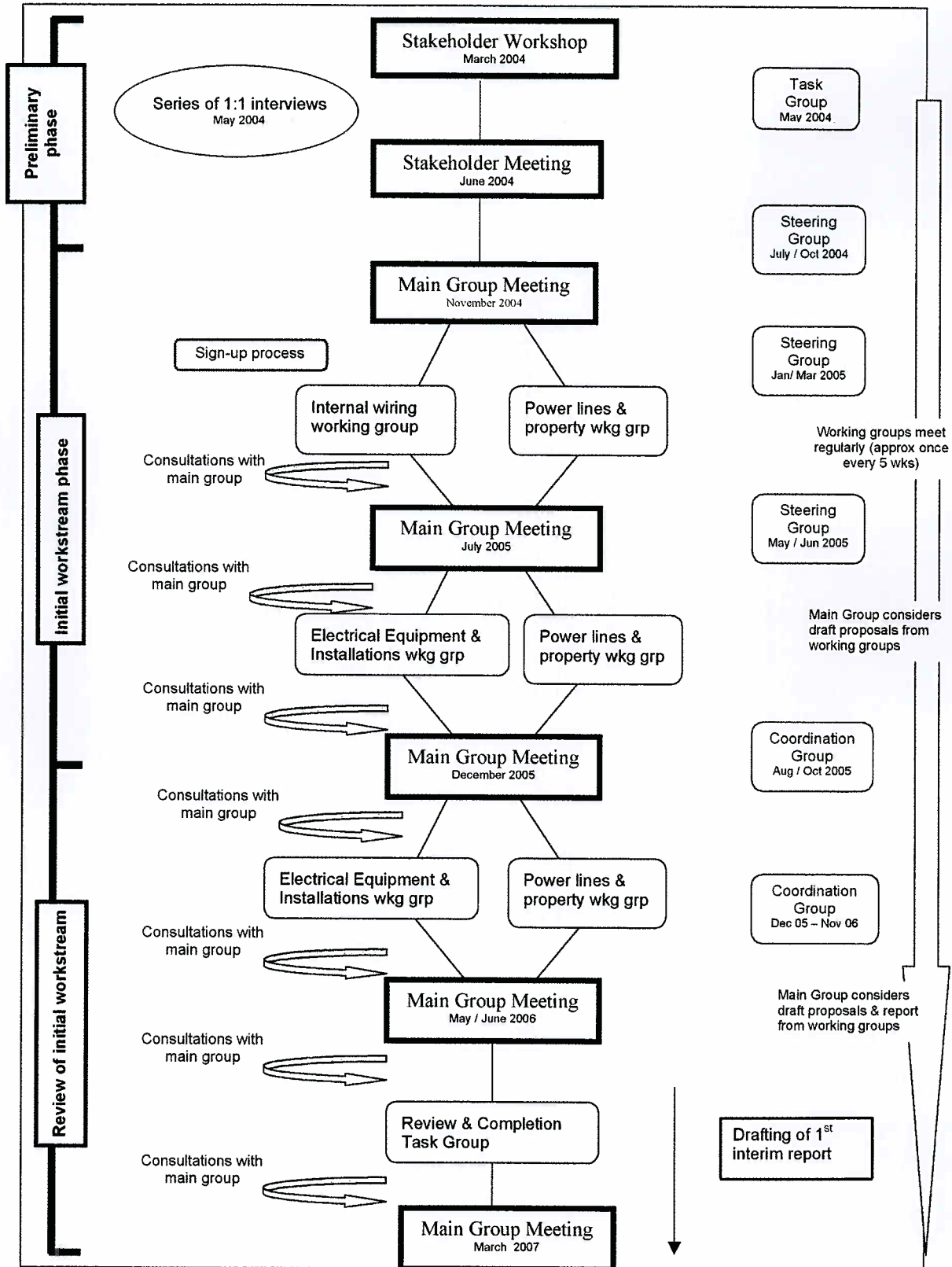
This stakeholder group is not a formally constituted body nor are the participants formally appointed by government. Rather the dialogue process has been constructed to involve all the key stakeholders as defined by their knowledge, experience, professional responsibility, and the impact on them of any future government decisions. This has included a mix of industry, national government departments, regulators & advisory bodies, academics, individuals, local & national campaign groups and professional bodies. It is recognised that the make up of the group may not have completely reached the ideal intended but it is believed that it is close enough to validate the work.

One of the ways of working that was agreed from the start was not to have “a high profile chair” and follow a conventional path. Instead, stakeholders agreed to keep the structure more informal and work with a professional facilitator. R K Partnership Ltd were engaged in this role and are acting as process consultants and managers, with Rob Angell leading the facilitation for SAGE.

There are about 40 Stakeholders directly involved in the process (see the list of participants at the end of this Assessment). Together, they are referred to as the Main Group . This "main group" is the overall decision making body within the process . However this group is too large to undertake detailed work so it was agreed to set up working groups to consider the issues in depth and a coordination group to help guide the process. Two groups have been active so far with two still to come, as described in Section 1.4. The structure of how the process "hangs" together is shown in the process diagram on P10.

It has been one of the core principles of the process that decisions be taken by consensus. However, it was recognised that this was not always going to be possible so it was also agreed that, as well as identifying where consensus exists, the areas where consensus does not exist should also be identified and the reasons set out. This principle is carried through the work into this SAGE Assessment.

The Stakeholder Dialogue Process



EMFs

1.2 Background to the science of EMFs

Electric and magnetic fields

Electric and magnetic fields (EMFs) are produced wherever electricity is generated, transmitted or used. In the UK, the power system is an alternating current system, operating at 50 cycles per second (50 Hertz or Hz) so the EMFs also alternate at 50 Hz. This is known, scientifically, as “extremely low frequency” (ELF). It is distinct from the much higher frequency radiofrequency (RF) EMFs, produced by broadcast and cellular communication systems, which interact with the body in different ways, and also from static fields such as the earth’s geomagnetic field. Unlike static fields, ELF EMFs are almost entirely of human origin. All further references in this Assessment to fields are basically to ELF fields, but where appropriate we include other frequencies up to a few kilohertz.

At 50 Hz, the electric and magnetic fields are effectively separate entities. Electric fields are produced by voltage, magnetic fields by current, and their magnitudes vary depending on the source producing them. Both fields fall with distance from the source.

Magnetic fields (MFs) are measured in teslas, or, for practical purposes, more often in microteslas (μT , one millionth of a tesla). Electric fields (EFs) are measured in volts per metre (V/m) or kilovolts per metre (kV/m, one thousand volts per metre).

The average ELF magnetic field in UK homes is around $0.05 \mu\text{T}$. Typically, in homes, this comes mainly from the low-voltage distribution wiring supplying electricity to the home. About 0.4% of homes have a field in the home of $0.4 \mu\text{T}$ or more, and in these higher-field homes, the balance of sources is different. In about half of these homes, the field comes from a nearby high-voltage overhead power line. In the other half, the source is a mixture of distribution wiring and wiring within the home. Electrical equipment in the home can produce high localized fields, but people are not generally exposed to these fields for long periods of time. The average ELF electric field in homes is in the range 5-25 V/m, but with localized regions of higher fields. More information on fields and their sources can be found at www.emfs.info.

There is no doubt that ELF EMFs can have effects on the body if the fields are high enough. Specifically, external EMFs induce internal electric fields in the body tissue, which can interfere with the action of nerves. There is uncertainty as to the exact level of field required to produce these effects, but the threshold for observable induced-field effects on nerves from ELF EMFs is, according to most advisory bodies, above $1000 \mu\text{T}$ and 50 kV/m. Electric fields below this level can also produce indirect effects such as microshocks and contact currents due to surface charge effects.

We are aware of a body of literature concerning how birds and other animals use the geomagnetic field and the variations in it, of order $0.2 \mu\text{T}$, for navigation, and how some fish detect low electric fields, but we have not considered these further in this Assessment. Similarly, we are aware that there is a body of literature on geomagnetic activity and human health. The exposures and diseases involved have similarities but also differences to those we are considering. We have not taken this literature into account in our work and have not made any judgment as to how relevant it is.

There are demonstrable physical effects from EMFs at the levels produced by electricity supply systems in some equipment whose design may render it sensitive to EMFs, such as interference with computer screens

(above about 0.1-1 μT) and with some heart pacemakers (above about 100 μT). Hand-held fluorescent tubes glow in the electric fields under power lines.

At levels below about one microtesla, well below those required to interfere with nerves through induced fields, there are numerous suggestions of other effects on people. Historically, early suggestions concerned childhood cancer, and childhood leukaemia in particular. Other health outcomes for which, with varying degrees of certainty, there have been suggested links to ELF EMFs include (in alphabetical order): adult leukaemia, adult brain cancer, Alzheimer's disease, amyotrophic lateral sclerosis (ALS, the most common form of motor neurone disease), breast cancer, other childhood cancers, depression, electrical sensitivity symptoms, certain types of heart disease, miscarriage, and suicide.

The evidence for these possible health effects has been variously considered by a number of national and international review bodies. Not all bodies reviewed all the outcomes, and the bodies have come to a variety of conclusions. However, for the purposes of this Assessment, we have found it helpful to describe the range of views by reference to just two positions, recognising that this is a simplification.

Views of external bodies on the science of EMFs

We will identify two broad viewpoints on the science, and we will label these by reference to representative bodies which have adopted them. We stress, however, that these viewpoints are not limited to the precise formalism or conclusions reached by HPA, WHO or California (see below) or anyone else; these are simply convenient labels to describe broad viewpoints that exist in the scientific community.

One view is, with minor differences, adopted, among other bodies, in the UK by the Health Protection Agency (HPA, formerly the National Radiological Protection Board, NRPB), and internationally by the International Agency for Research on Cancer (IARC), the World Health Organization (WHO) (though their latest detailed Report is not yet published and may change from what is currently reported), and the EU's Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR). We refer to this view in shorthand as "WHO/HPA".

The other view, again with variants, has been set out in a number of places, for instance in draft Reports for the US National Council on Radiation Protection and Measurements (NCRP) and the US Environment Protection Agency (EPA) (though neither of these were adopted by those institutions or published). The National Institute for Environmental and Health Sciences (NIEHS), in a 1999 Report which informed both IARC and California in their reviews, supported this view in part. However, this view has perhaps been most clearly expounded in the Report from the California Department of Health Services¹, and for convenience, we refer to this view in shorthand as "California".

Around the world, most review bodies with an official status seem to have adopted the "WHO/HPA" view, and in particular, in the UK the HPA itself has a statutory role in providing advice. However, on other issues, views which depart from the current orthodoxy, as "California" does, have at times proven to be correct. These considerations do not, of course, prove that either view is necessarily correct.

¹ <http://www.dhs.ca.gov/ps/deodc/ehib/emf/RiskEvaluation/riskeval.html>

Both the "WHO/HPA" and "California" views agree that a consistent statistical association (which may or may not reflect causation) exists in epidemiological studies between unusually high background magnetic fields found in homes and a raised risk for childhood leukaemia. This scientific evidence on childhood leukaemia has led:

- IARC to classify magnetic fields as "possibly carcinogenic" (a category used for agents "for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals").
- NRPB (now HPA-RPD) "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."
- SCENIHR to state "The previous conclusion that ELF fields are possibly carcinogenic, chiefly based on childhood leukaemia results, is still valid. There is no known mechanism to explain how electromagnetic field exposure may induce leukaemia. The effects have not been replicated in animal studies."
- California to state: "Using the Guidelines developed especially for the California EMF program, one of the reviewers "strongly believes" that high residential EMFs cause some degree of increased risk of childhood leukaemia, another was "prone to believe" that they do, and another was "close to the dividing line between believing or not believing."

The WHO/HPA view is that it is only for childhood leukaemia that the evidence is as strong as this. For each other adverse health effect considered, though to varying extents, the evidence is significantly less. Thus:

- IARC classified the evidence from humans for all cancers other than childhood leukaemia as “inadequate”, a category one below the “limited” used for childhood leukaemia.
- WHO state *“A recent comprehensive health risk assessment by the WHO ELF Task Group ... found, for example, that the evidence “does not support an association between ELF exposure and cardiovascular disease” (WHO, in press). The evidence for breast cancer was also considered to be effectively negative, while for other diseases it was judged to be inadequate.”*
- NRPB (now HPA-RPD) *“There is no clear evidence of a carcinogenic effect of ELF EMFs in adults...Studies of occupational exposure to ELF EMFs do not provide strong evidence of associations with neurodegenerative diseases. ... Studies of suicide and depressive illness have given inconsistent results ... evidence for a link with cardiovascular disease is weak”*
- SCENIHR state *“For breast cancer and cardiovascular disease, recent research has indicated that an association is unlikely. For neurodegenerative diseases and brain tumours, the link to ELF fields remains uncertain. A relation between ELF fields and symptoms (sometimes referred to as electrical hypersensitivity) has not been demonstrated.”*

The “California” view does not see the same difference in the strength of evidence between childhood leukaemia and some other health effects. Thus:

- The NIEHS concluded that ELF EMF exposure should be regarded as a *“possible human carcinogen”* in the IARC classification, saying that the decision was largely based on *“limited evidence of an increased risk for childhood leukemias with residential exposure and an increased occurrence of CLL (chronic lymphocytic leukemia) associated with occupational exposure”*. In this sense NIEHS implicated two health outcomes: both child and adult leukaemia, which is a significant addition insofar as adult leukaemia is much more prevalent, although the evidence cited relates to occupational rather than residential exposure.
- The California Report placed five health effects in the same *“possibly carcinogenic”* category (or equivalent for non-cancers) that IARC used for childhood leukaemia: childhood leukaemia, adult leukaemia, adult brain tumours, miscarriage, and ALS.
- The California Report used another assessment method leading to a Degree of Certainty (between 0 and 100%) for each of 11 specific health outcomes in respect of which there was published scientific evidence. The Degree of Certainty was for the proposition that ELF exposure *“increases [the specific] disease risk to some degree”*. The resulting figures, averaged for the three reviewers, ranged from 25% for childhood brain cancer and 26% for Alzheimer’s disease to 57% for adult leukaemia, 64% for adult brain cancer and 72% for childhood leukaemia. In that sense, all 11 health outcomes are given a possibility of risk from ELF, even though only 5 of them would, in the California reviewers’ assessment, meet the IARC classification requirements for a *“possible human carcinogen”*.

