

# **California Health Department Report**

(Released for public discussion April 2001)

## **An Evaluation of the Possible Risks From Electric and Magnetic Fields (EMFs) From Power Lines, Internal Wiring, Electrical Occupations and Appliances\***

### **Summary and Commentary**

by

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\*Access at: <http://www.dhs.ca.gov/ehib/emf/RiskEvaluation/riskeval.html>  
or via  
<http://www.electric-fields.bris.ac.uk> "California EMF Health Report"

# **California Health Department Report on the Possible Health Risks Associated with Power Frequency Electric and Magnetic Fields (EMFs)**

## **Summary and Commentary by Professor Denis L Henshaw**

The California Health Department has released for public discussion a major report on the health effects of power frequency electric and magnetic fields. This comprehensive report and in-depth analysis examines 13 health conditions and suggests an added risk of miscarriage, childhood and adult leukaemia, brain cancer and a greater incidence of suicide as some of the health risks associated with electric and magnetic fields such as those that radiate from powerlines.

The Report runs to over 560 pages. The scientific evidence was first assessed by three expert Reviewers who then had to present and defend their assessments in the form of a draft report to a scientific committee within the California Health Department. A resulting second draft report was then sent to outside consultants and to members of the California Health Department's Science Advisory Panel. Comments received after this draft were incorporated to produce the draft for public comment now available on the Internet.

The Report for public comment is dated April 2001. It was released on the Internet in July 2001 under pressure from a California First Amendment Coalition lawsuit. The deadline for public comment was September 10<sup>th</sup> 2001.

This commentary summarises the main findings and the detailed arguments behind the conclusions. Below is a summary of the findings in tabular form (table 1) followed by a description of the degree of confidence in causality (table 2). Selected extracts from the Report then follow.

## Conclusions in tabular form

**Table 1** below summarises the risk assessment from exposure to magnetic fields given in the California Health Department Report. For a given condition, note that the probabilities of a link include a chance that EMFs have no effect. The table on the following page summarises the criteria used by the Assessors.

Condition	Probability of a link with exposure to power frequency magnetic fields
Cancer	
Childhood Leukaemia	Two of the reviewers said 50 – 80% likely; one reviewer said virtually certain (>98% likely)
Adult leukaemia	Two of the reviewers said 50% to 90% possible One reviewer said 10 – 50% likely
Adult Brain Cancer	50% - 90% likely
Childhood Brain Cancer	10% - 50% likely
Male Breast Cancer	10% - 50% likely
Female Breast Cancer	Two of the reviewers said 10% - 50% likely One reviewer said 50% - 90% likely
All Cancers	Very improbable, 2 – 10% likely
Other conditions	
Miscarriage	50% - 90% likely that exposure could add 5-10% to the baseline risk
Birth Defects	Very improbable, 2 –10% likely
Amyotrophic Lateral Sclerosis (ALS)	50% - 90% likely
Heart Disease	10% - 50% likely
Suicide	10% - 50% likely

**Table 2** below gives the degree of confidence in causality and the International Agency for Research on Cancer (IARC) classification for the conditions in table 1 that have been statistically associated with EMFs. The following introduction to this mode of presentation of the findings is given in the Report:

To help the reader calibrate this mode of presenting scientific judgments, we include one of the reviewer's judgments on two non-EMF issues. One is an accepted environmental association (air pollution and the exacerbation of asthma attacks) and the other a more controversial environmental association (fine particulate pollution and fluctuations in cardio-respiratory death). One can see that reviewer 2 was virtually certain that air pollution can trigger asthma attacks. The range of uncertainty was narrow. The reviewer was still quite confident that particulate air pollution could cause deaths, even though the mechanisms for this are not understood. However, the range of uncertainty is larger for this relationship.

We also show the initial or prior degree of confidence, prior to considering specific EM evidence, that EMFs could cause epidemiologically detectable disease. As with any new agent taken at random, all reviewers thought that, on average, it is improbable that EMFs would cause epidemiologically detectable disease at usual occupational and residential exposures and the range of uncertainty is fairly narrow.

TABLE 1 DEGREE OF CONFIDENCE IN CAUSALITY AND IARC CLASSIFICATION FOR CONDITIONS THAT HAVE BEEN STATISTICALLY ASSOCIATED WITH EMFS

CONDITION	REVIEWER	IARC CLASS	CONFIDENCE IN CAUSALITY	DEGREE OF CONFIDENCE IN CAUSALITY FOR POLICY ANALYSIS
Air Pollution Triggered Asthma Attacks (Example: Not EMF Related)	2	Human Risk	Virtually Cert.	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Particulate Air Pollution Triggered Deaths (Example: Not EMF Related)	2	Probable Risk	Highly Prob.	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Prior Confidence that EMFs Could Cause Epidemiologically Detectable Disease	1		<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2		Very Improb.	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3		<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Childhood Leukemia	1	Carcinogen	Virtually Cert.	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	Possible	>50% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	Probable	>50% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

CONDITION	REVIEWER	IARC CLASS	CONFIDENCE IN CAUSALITY	DEGREE OF CONFIDENCE IN CAUSALITY FOR POLICY ANALYSIS
Adult Leukemia	1	Carcinogen	>50% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	Possible	>50% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	Possible	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Childhood Brain Cancer	1	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Adult Brain Cancer	1	Possible	Virtually Cert.	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	Possible	>50% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	Possible	>50% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Breast Cancer, Female	1	Inadequate	>50% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Breast Cancer, Male	1	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

CONDITION	REVIEWER	IARC CLASS	CONFIDENCE IN CAUSALITY	DEGREE OF CONFIDENCE IN CAUSALITY FOR POLICY ANALYSIS
EMF Universal Carcinogen?	1	Inadequate	Very Improb.	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	Inadequate	Very Improb.	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	Inadequate	Very Improb.	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Spontaneous Abortion	1	Possible	Highly Prob.	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	Possible	> 50% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	Possible	>50% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Other Reproductive	1	Inadequate	Very Improb.	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	Inadequate	Very Improb.	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	Inadequate	Very Improb.	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
ALS	1	Possible	>50% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	Possible	>50% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	Possible	>50% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Alzheimer's	1	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	Inadequate	< 51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

CONDITION	REVIEWER	IARC CLASS	CONFIDENCE IN CAUSALITY	DEGREE OF CONFIDENCE IN CAUSALITY FOR POLICY ANALYSIS
Suicide	1	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Heart	1	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	3	Inadequate	<51% Possible	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

## Selected Extracts from the Report

### STATEMENT FOR THE GENERAL PUBLIC

*Page 1, line 1 on.* On behalf of the California Public Utilities Commission (PUC), three scientists who work for the California Department of Health Services (DHS) were asked to review the studies about possible health problems from electric and magnetic fields (EMFs) from power lines, wiring in buildings, certain jobs and appliances.

The following statements properly capture the range of their judgements:

It is “*more than 50% possible*” that EMFs at home or at work could cause a very small increased lifetime risk of childhood leukemia, adult brain cancer, and amyotrophic lateral sclerosis (ALS, Lou Gehrig’s Disease).

It is “*more than 50% possible*” that EMFs at home or at work could cause a 5-10% added risk of miscarriage....

It is “*10-50% possible*” that residential or occupational EMFs could be responsible for a small increased lifetime risk of male breast cancer, childhood brain cancer, suicide, Alzheimer’s disease, or sudden cardiac death.

It is “*very unlikely (2-10% possible) but not impossible*” that residential or occupational EMFs could be responsible for even a small fraction of birth defects, low birth weight, neonatal deaths or cancer generally.

As the above phrases imply there is also a chance that EMFs have no effect at all.

All of the three reviewers give a degree of confidence of at least “*10-50% possible*” that residential or occupational EMFs could be responsible for a small increased lifetime risk of adult leukemia or female breast cancer, and one gave a degree of confidence that was higher.

The reviewers compared the size of possible risks from EMFs to the size of possible risks from chemical and physical agents now being regulated. They agreed that:

*Page 1, lines 21 – 23.* If EMFs really contribute to the cause of these [the above] conditions, even these low individual risks and the low fractions of cases could be of concern to regulators. Indeed, when deemed real, **theoretical risks smaller than these have triggered regulatory evaluation and sometimes, regulatory control of chemical agents.**

*Page 2, lines 1 – 6.* [concerning miscarriage] While rodent and chicken egg studies provide little or no support, two new epidemiology studies in humans suggest that a substantial proportion of miscarriages might be caused by EMFs. Miscarriages are common in any case (about 10-15% of pregnancies) and the theoretical added risk for an EMF-exposed pregnant woman may be an additional **5 to 10% according to these two studies. If true, this would clearly be of concern to individuals and regulators.** However, the type of EMF exposures implicated by these two new epidemiological studies (short, very high exposures) probably come from being within a few inches of appliances and indoor wiring, and only rarely from power lines. It may not be possible to avoid all such exposures in modern life.

*Page 2, lines 7 – 8.* Even one exposure a day [short, very high exposures to magnetic fields] if typically experienced during pregnancy, seemed to increase the risk of miscarriage. Nonetheless, [the Report emphasises] the majority of pregnant women with such exposures did NOT miscarry.

## **SCIENTIFIC ABSTRACT OF EXECUTIVE SUMMARY**

### **HOW THE EVALUATION WAS DONE**

*Page 3, lines 2 – 10.* The three main reviewers examined epidemiological findings statistically linking EMFs and 13 health conditions and developed a degree of confidence that these statistical links might be causal in nature. .... They also provided a classification of the evidence using criteria developed by the International Agency of Research on Cancer (IARC).

Often these two evaluations were not consistent with each other. There are several reasons for this. The California Guidelines, which, unlike IARC require explicit pro and con justification for the classifications made, tend to consider emerging evidence that the more conservative IARC system discounts. The California Guidelines require the reviewers to provide a quantitative degree of confidence that is needed for the California program's policy projects. The IARC system is at base a "*quality of evidence*" classification, while the California Guidelines call for a "*degree of confidence*" classification.

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Elsewhere in the Report a detailed description of how the review process was carried out is given. The extract below

is taken from Chapter 1, Introduction, Section 1.5 "THE DHS REVIEW PROCESS OF THE CORE EMF TEAMS RISK EVALUATION".

A number of Epidemiologists and Toxicologists with the California Department of Health Services (DHS) and experienced in environmental health investigations, were asked to read parts of the literature reviewed for this evaluation. After the first draft of this document was completed, the scientists critically reviewed it ... They then participated in a 3-day workshop which included a training on probability elicitation [see Appendix 2 of the Report]. After this training, the core EMF Risk Evaluation Team [the three core Reviewers], who previously had received probability elicitation training, **presented and defended their evaluation.**

The DHS scientists were encouraged to ask probing questions and to challenge both the comprehensiveness and the validity of the pro and con arguments and subsequent discussion ... After the workshop the core team conscientiously reviewed the comments received and modified the first draft.

The second draft was sent to outside consultants and to members of the Department's Science Advisory Panel (see Appendix 1 of the Report for membership). Comments received after this second draft were incorporated to produce the present draft for public comment.

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This summary now continues with extracts from the section "STATEMENT FOR THE GENERAL PUBLIC":

#### **POTENTIAL POPULATION BURDEN OF ILL HEALTH AND THEORETICAL LIFETIME RISK FROM HIGH EMF EXPOSURE**

*Page 4, lines 22 – 27.* Two recent review articles calculated the proportion of all childhood leukemia cases that might be attributed to the rare highest residential EMF exposures to be around 4%. This would translate to about four deaths in California per year. ... If the same 4% were applied to the 11 conditions listed above that were not "very unlikely" to be caused by EMFs, the numbers of attributable cases **could be in the hundreds or thousands and comparable to the theoretical burden of ill health that has motivated other environmental regulation.** This would be true even if one were only 20% sure that EMF was a contributory cause of these various conditions.

*Page 5, lines 1 – 3.* The theoretical lifetime individual risk that derives from any agent that has an epidemiologically detectable effect will by definition be greater than the lifetime risk of 1/100,000 that triggers many regulatory processes. This means **most** of the epidemiological associations examined in this document **would clearly be of regulatory concern if real.**

[The Report then emphasises that apart from miscarriage, the risk to the individual is extremely small.]

*Page 5, lines 8 - 10.* Two new epidemiology studies suggest that a substantial proportion of miscarriages (40%) might be caused by EMFs. Miscarriages are common in any case (about 10-15% of pregnancies) and the theoretical added risk for an EMF-exposed pregnant woman may be 5 to 10% according to these two studies. If true, this would clearly be of regulatory concern.

## **EXECUTIVE SUMMARY**

### **HOW THE EVALUATION WAS DONE**

*Page 5, lines 20 – 22.* The reviewers also presented a judgement as to whether or not the epidemiological associations, if judged to be causal, suggested a magnitude of theoretical added risk above 1/100,000 or 1/1000 for highly exposed groups.

### **A SUMMARY OF WHAT HAS CHANGED SINCE THE CALIFORNIA EMF PROGRAM WAS FIRST PROPOSED IN THE EARLY 1990S**

*Page 5, lines 48 – 59.* Biophysical arguments based on physical principles and simplified biological models have produced lower and lower predictions as to what magnetic field intensities theoretically would be capable of producing biological effects. Nevertheless, theory would still claim that most residential and occupational epidemiological results are “*impossible*”. It would also claim that bioeffects from magnetic field experiments using intensities less than 100 mG (10  $\mu$ T) are “*impossible*”. Those who adhere to these biophysical theories still discount the relevance of experimental results at higher intensities to epidemiological findings because of this “*impossibility*” threshold and would require robust bioeffect laboratory results from ambient levels of exposure. **This is an unusual burden of proof since ambient levels of other pollutants often do not produce effects large enough to see in the laboratory.**

Under Mechanistic Research:

*Page 5, lines 66-67, page 6 lines 1-2.* One laboratory published studies and three other labs reported, but have not published, on the effect of low intensity (12 mG [1.2  $\mu$ T]) magnetic fields on the ability of melatonin to inhibit cancer cell proliferation *in vitro*.

Under Epidemiology:

*Page 6, lines 12 – 15.* Published statistical summaries of the body of epidemiological evidence have suggested that chance is an unlikely explanation for the associations seen for childhood leukaemia, adult leukaemia, adult brain cancer, male breast cancer and ALS.

*Page 6, lines 19 – 23.* The study of Linet *et al.*, originally interpreted as showing no effect has been shown to contribute **important support in pooled analyses that indicate that the association between the highest exposures to EMF and childhood leukaemia are unlikely to be due to chance.**

*Page 6, lines 24 – 29.* An epidemiological literature is developing that associates magnetic fields with **diseases and conditions that are more common, such as sudden cardiac death, dementia, suicide and spontaneous abortion.** From a **cost/benefit perspective**, the confirmation of the associations in these more-common diseases **would have greater policy implications than the confirmation of EMF associations with rare disease, such as childhood cancer or amyotrophic lateral sclerosis.**

#### **HOW CREDIBLE WAS THE EMF HYPOTHESIS TO BEGIN WITH?**

*Page 7, lines 8 – 10.* They [the Reviewers] were not much swayed by theoretical biophysical arguments that such [EMF] influences were impossible.

#### **THE WEIGHT ACCORDED TO THE EXPERIMENTAL EVIDENCE ON ANY MECHANISMS BY WHICH EMF MIGHT WORK**

*Page 7, lines 29 – 32.* [The reviewers pointed out that initially for many disease-causing agents there was not a well-documented mechanistic chain of events to explain causality]. Thus: The absence of a clear mechanistic story, and the failure of many experiments with aspects of the EMF mixture to produce any mechanistic effects, did not pull confidence of causality much below what it was initially.

*Page 7, lines 36 – 40.* Thus, this line of evidence did not contribute much to the reviewers' judgements. This is because, generally, the **lack of mechanistic understanding is initially so common in harmful agents that the absence of mechanistic understanding is not as strong an argument against causality as the presence of such an understanding would be in favor of causality.**

## WEIGHT ACCORDED TO ANIMAL PATHOLOGY EXPERIMENTS

Page 7, lines 50 – 52. ... they [the Reviewers] were also cognizant that there are known human carcinogens, such as cigarette smoke, alcoholic beverages, benzene and arsenic, for which no animal model existed for many decades.

## CONSIDERING THE RANGE OF EXPOSURE IN THE GENERAL POPULATION HOW MUCH MORBIDITY AND MORTALITY MIGHT BE ATTRIBUTED TO EMFs?

Page 16, lines 23 – 58. Greenland et al (2000)<sup>1</sup> and Wartenberg (2000) estimated that residential EMF exposure might account for 0% to 12% of childhood leukemia, with a mid-point estimate around 4%. A reanalysis of the Greenland data, supplemented by those of the UK (1998) study described in the body of this document, narrowed the confidence interval but concurred with the 4% mid-range estimate. This translates to four deaths per year from childhood leukemia in California. The miscarriage studies of Li (2000) and Lee (2000b) suggested that around 40% of the estimated 60,000 miscarriages in California each year might be attributable to exposure to maximum fields. The reviewers have insufficient information to provide similar figures for other disease endpoints.

While 4% sounds like a low number, the annual numbers in California would not be trivial if applied to the base-line incidence or mortality rate of various conditions that received degrees of confidence greater than “*very improbable to be a cause*”. Table 2 [in the Report] shows the mortality expected in about 9.6 million Californians younger than 20 and in the 23.4 million Californians over 20 years of age from these causes of death. Of these deaths, some fraction might be affected by EMFs. While the spontaneous abortions, ALS, and Alzheimer deaths are estimated using rates from special studies, the other deaths are derived from 1998 vital statistics. Even if the miscarriages are not treated as deaths, one is left with about 28,700 deaths. Four percent of this is about **1,150 deaths per year**. Forty percent of 60,000 miscarriages is **24,000**.

As a comparison, the California Comparative Risk Project (1994) (di Bartolomeis M, editor, *Toward the 21<sup>st</sup> Century: Planning for the Protection of California's Environment*. Final Report: California Comparative Risk Project, May 1994) estimated, from animal data, that there would be 49 cancers (not deaths) from chloroform in chlorinated drinking water, 100 cases of cancer (not deaths) from benzene in ambient air, and 124 cases of cancer (not deaths) from formaldehyde in indoor air (page 133). By extrapolating from occupational exposures to radon, they estimated 570 annual cases of cancer (not deaths) from naturally occurring indoor radon (page 427). **Thus, if one were certain that the epidemiological associations [with magnetic fields] were causal, the population burden of mortality would be more than that from many currently regulated**

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<sup>1</sup> A bibliography is given in the California Health Department Report

**environmental agents.** If one were to adjust these numbers by one's degree of confidence in causality in order to derive an "*expected number*" and one used **20% as the degree of confidence of causality**, the above numbers would change from 1,148 to **229** and from 24,000 to **4,800**. **This is still not trivial in the regulatory framework.**

## **POLICY RELEVANT AREAS FOR FURTHER RESEARCH**

*Page 18, line 25 on.* ...Deeply ingrained experimental research styles and an orientation to explaining mechanisms rather than describing phenomena has meant that investigator-initiated research and even programs which attempted to guide research have rarely been characterised by progressively refined descriptions of dose response relationships to produce stronger bioeffects.

This has been compounded by the expectation of a quick resolution of the question by those who fund the research, as was the case with the New York State program of the mid-1980s, the central California Program and the recent five year federal EMF program. As was discovered after President Nixon's "War on Cancer" in the early 1970s, research progresses slowly and in successive multi-year research cycles, with the results of each cycle governing the direction of the next.....

*Line 37 on.* This means that if one were serious about clarifying this issue, there would need to be a long-term commitment to steady research funding and funding for intermittent assessments of the state of the science and research directions.

*Line 60 on.* Such aspects include sudden exposures to the 60 Hz fields, such as micro shocks, stray ground currents and charged air pollutants. Such exposures would make it possible to reanalyse some of the existing worker cohorts to determine if these aspects are associated with diseases.

Rather than further pursuing new studies of rare diseases with long term incubation periods, further studies of the more common and policy-relevant conditions in which EMFs might have shorter incubation periods, such as spontaneous abortion, acute myocardial infarction and suicide, should be given priority.

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## **The body of the Report**

The body of the report deals with 13 health conditions: childhood leukaemia, adult leukaemia, childhood brain cancer, adult brain cancer, breast cancer (female), breast cancer (male), EMF as a universal carcinogen, spontaneous

abortion (miscarriage), other reproductive outcomes, ALS (Amyotrophic Lateral Sclerosis), Alzheimers disease, suicide and heart disease. For each condition the epidemiological evidence is reviewed and a level of risk attached to whether the incidence has any association with exposure to power frequency magnetic fields (as given in table 2 above). In each case the following arguments for or against causality are rigorously discussed: whether a given association is due to or influenced by chance, bias or confounding. Also considered is the strength of association, the consistency, homogeneity and dose response, the experimental evidence, the plausibility, analogy, temporality, specificity and relevance to other disease associations. These are the Hill (1965) criteria for causal inference of epidemiological associations.

It is this latter analysis for each of the 13 health outcomes that sets the California Health Report apart from any previous EMF health report. For each of the health outcomes, it gives the reader a clear explanation of the strengths and weaknesses of the epidemiological data considered and the rationale behind the conclusions reached by the Reviewers.

There are 6 appendices. Appendix 1 lists the Advisory Panel. Appendix 2 (67 pages) describes in detail the evaluation guidelines used by the Reviewers. The in-depth description is particularly valuable, especially the description of Bayesian analysis and its application to the evaluation of the evidence linking EMF exposure to the various health outcomes. Appendices 3 & 4 describe the (real but nevertheless rather meagre) evidence of hypersensitivity to electric and magnetic field exposures. Appendices 5 & 6 describe two major studies (in press) of miscarriage and exposure to magnetic fields.

Finally, a Policy Option document provides a cost-benefit analysis of the various options for reducing or avoiding exposure to power frequency electric and magnetic fields. This includes the burial of overhead high voltage powerlines (transmission lines).

#### **What is not in the Report?**

1. There is no detailed discussion of corona ion emission from high voltage powerlines and their action in charging

airborne pollutants. For separate evaluation see <http://www.electric-fields.bris.ac.uk>

2. The possible impact of exposure to magnetic fields and the effectiveness of the breast cancer inhibiting drug TAMOXIFEN.
3. There is no discussion on currently recommended exposure limits such as those of the International Commission on Non-ionising Radiation Protection, ICNIRP (100  $\mu$ T), the UK National Radiological Protection Board, NRPB (1,600  $\mu$ T) and that recently introduced by the Swiss Government for new installations (1  $\mu$ T).

In the pooled analyses of childhood leukaemia for example, a doubling of risk was associated with exposures above 0.4  $\mu$ T. Most average domestic exposures in the UK are below 0.1  $\mu$ T. Close to high voltage powerlines values up to 40  $\mu$ T can be found. Elevated exposures also arise from underground high and low voltage distribution circuits. Short term exposures to elevated magnetic fields can occur near domestic appliances such as hair dryers. In a recent statement the UK Institution of Electrical Engineers, IEE (Factfile March 2001) has suggested that if people wish to avoid exposure to magnetic fields, some of the things which contribute to above-average exposures are:

- Mains appliances such as clock-radios close to the bed;
- Electric blankets left on overnight;
- Homes close to high-voltage powerlines.

**How to get hold of the Report:** *"California Health Department Report on the Possible Health Risks Associated with Power Frequency Electric and Magnetic Fields (EMFs)"*

1. Access and download free from the web directly at:

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

or via the Bristol University Website:

<http://www.electric-fields.bris.ac.uk> "California EMF Health Report"

2. A hard copy may be obtained from:

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