Australian Government
Australian Radiation Protection and Nuclear Safety Agency

CONSULTATION DRAFT

Regulatory Impact Statement

Radiation Protection Standard

Maximum Exposure Levels to Electric and Magnetic Fields 0 Hz – 3 kHz

This Standard in the ARPANSA Radiation Protection Series was developed by a working group of the Radiation Health Committee

Comment on the Regulatory Impact Statement should be forwarded by **28 February 2007** to:

Mr Alan Melbourne
Manager, Standards Development & Committee Support Section
ARPANSA
619 Lower Plenty Road
YALLAMBIE VIC 3085
Tel: (03) 9433 2355
Fax: (03) 9433 2353

Email: **secretariat@arpansa.gov.au**
(Electronic submissions preferred)

This Regulatory Impact Statement was prepared for ARPANSA by
The Allen Consulting Group
Email: info@allenconsult.com.au
Website: www.allenconsult.com.au

Contents

Executive summary

Whenever electricity is generated, transmitted, or used, electric and magnetic fields (EMFs) are created.

A Radiation Protection Standard has been prepared by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) that establishes exposure limits for EMFs in the frequency range of 0 Hz to 3 kHz. Such EMFs are known as extremely low frequency (ELF) EMFs.

The Standard deals in particular with occupational exposures in electrical industries and public exposure to fields from powerlines. It is proposed that the Standard will replace the NHMRC's 1989 *Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields* and will be adopted in each jurisdiction as a means of obtaining national uniformity in the approach to ELF EMF exposure.

There is considerable doubt as to whether a specific Standard is needed to address ELF EMF exposure. Research over the past 30 years has addressed the question of whether exposure to ELF EMF might adversely affect human health. For most health outcomes, there is no evidence that EMF exposures have adverse effects. There is some evidence from epidemiology studies that exposure to ELF EMF is associated with an increased risk of childhood leukaemia. This association is difficult to interpret in the absence of reproducible laboratory evidence or a scientific explanation that links magnetic fields with childhood leukaemia.

It is, however, preferable to adopt precautionary approaches for management of health risks in areas of scientific uncertainty.[1] The philosophy of the precautionary approach is that where there are reasonable grounds for concern about a risk and there is uncertainty, decision makers should be cautious.[2] In particular, the concept of *prudent avoidance* was initially developed as a risk management strategy to deal with concern about possible effects from ELF EMF from high-tension power lines.[3] It has evolved to mean taking simple, easily achievable, low cost measures to reduce exposure to electromagnetic fields, even in the absence of a demonstrable risk.[4]

In this light, it can be said that governments should have as their objectives:

- the management of exposure risks associated with ELF EMF, acknowledging the lack of demonstrated risk but adopting a precautionary approach consistent with the continuing scientific uncertainty associated with ELF EMF exposure; and
- educating the public about the magnitude and likelihood of such risks.

Given these objectives, three regulatory options have been identified by ARPANSA:

- *Option One — status quo* — this entails doing nothing and leaving the *Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields*[5] in place;

[1] See K. Foster, P. Vacchia and M. Repacholi 2000, 'Science and the precautionary principle', *Science*, vol. 288, pp.79-980.

[2] R. Harding and E. Fisher 1999, *Perspectives on the Precautionary Principle*, Federation Press, New South Wales.

[3] K. Nuttall, P. Flanagan and G. Melik 1999, 'Prudent avoidance guidelines for power frequency magnetic fields', *Radiation Protection in Australasia*, vol. 16, no. 3, pp. 2-12. See also Energex Ltd v Logan City Council & Ors [2002] QPEC 1 (11 January 2002), available at http://www.austlii.edu.au/au/cases/qld/QPEC/2002/1.rtf.

[4] Generally, government agencies have applied the policy only to new facilities, where minor modifications in design can reduce levels of public exposure. It has not been applied to require modification of existing facilities, which is generally very expensive.

[5] National Health and Medical Research Council 1989, *Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields*, Radiation Health Series No. 30.

- *Option Two — regulatory adoption of the Standard* — this option entails re-writing the guidelines, updating it to be consistent with international guidelines and standards, and taking into account more recent literature. The proposed Standard would provide a set of requirements to be adopted by State/Territory regulators as part of their regulatory frameworks; or
- *Option Three — publishing the Standard without incorporating it into regulation* — this option entails re-writing the guidelines, updating it to be consistent with international guidelines and standards, and taking into account more recent literature. State/Territory regulators and industry would use the Standard as an advisory document.

The benefits of Options Two and Three have been assessed in comparison to the *status quo* (i.e. Option One). Given the inherent uncertainty regarding many of the assumptions used in the analysis the results are presented in terms of probabilistic ranges as summarised in the table below.

COMPARISON OF SIMULATION RESULTS

	Option Two	Option Three
Mean net present value	Negative $360.9 million	Positive $4.0 million
Likelihood that net present value is positive	Less than 2%	Greater than 99%
90% chance that result is within the range	Low: Negative $694.8 million High: Negative $30.4 million	Low: Positive $1.4 million High: Positive $6.7 million

The analysis indicates that there is little chance of a positive net present value from adopting the Standard in legislation. Option Three, on the other hand, is likely to result in a net benefit, and so is the preferred option.

The difference between Options Two and Three is largely driven by the likelihood that capital investments worth over $1 billion that the electricity industry perceives would be required under Option Two would not be undertaken under Option Three.

Chapter 1

Introduction

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), through its Radiation Health Committee, is developing Standards in radiation protection.

Standards are drafted by working groups of the Radiation Health Committee. Working groups consist of nominated members from various stakeholder groups relevant to each Standard.

The standards cover various applications and the collection and analysis of relevant data is required to assess the impacts and the economic consequences of the impacts. In some subject areas, the standards will replace National Health and Medical Research Council (NHMRC) publications in the Radiation Health Series which are out of date.

In this case, a Radiation Protection Standard is being prepared to establish exposure limits for electric and magnetic fields in the frequency range 0 Hz – 3 kHz, known as extremely low frequency (ELF) electric and magnetic fields (EMFs). Hence, the Standard will deal in particular with occupational exposures in electrical industries and public exposure to fields from powerlines. The Standard will replace the NHMRC's 1989 *Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields*. It is intended that the Standard would ultimately be adopted in each jurisdiction as a means of obtaining national uniformity in the approach to ELF field exposure.

As part of the development process, the costs and benefits of the proposed Standard[6] and a range of other feasible approaches, needs to be subjected to analysis as part of a regulatory impact statement (RIS). This RIS has been independently prepared at the request of ARPANSA.

6 The development process is outlined at http://www.arpansa.gov.au/rhc_pubs.htm. For more information on the RIS process itself see http://www.pc.gov.au/orr/index.html.

Chapter 2

Debate about the impact of exposure to extremely low-frequency (ELF) electric and magnetic fields (EMF)

This chapter provides an overview[7] *of the potential link between exposures to extremely low-frequency (ELF) power-frequency electric and magnetic fields (EMF) and adverse health outcomes.*

Electric and magnetic fields (EMFs) are the forces generated by the charge and flow of electrons from both natural and human resources.[8]

Man-made electromagnetic fields are very common. There are electric fields present whenever there is energised electric wiring, whether or not electric appliances are operating. For example:

- an electrical substation, and the network of cables and wires which emanate from it, create electric fields. These fields exist in the space between the cables or wires and the ground, and the strength of the field is inversely proportional to the distance between them; but
- in a house the electric field can vary greatly and may be more influenced by the use of electrical appliances such as computer screens, washing machines etc, than any external power line.

There is a distinction between:

- electric fields, which arise from a difference in electric potential or voltage, which can be easily shielded by common objects such as trees, fences and walls; and
- magnetic fields, which arise from the flow of electricity or current, which are much more difficult to shield, and thus fields produced by external sources (e.g. power lines) can extend into people's homes.[9]

EMFs diminish in intensity in direct proportion to the distance from the source. This intensity is measured in units of Tesla (generally in micro Tesla — μT); The greater the number of Tesla, the greater the induced current in the human body.

The EMF produced by power lines is at an extremely low frequency (ELF) and ELF is part of the non-ionising radiation portion of EMF. Such EMF needs to be distinguished from:

- ionising radiation (e.g. X-rays) which is known to be a cause of cancer; and
- radio waves and microwaves, about which considerable debate exists. Those latter forms of radiation which are of much higher frequencies interact with matter, including human tissue, to cause heating. The amount of energy deposited in the human body from the EMF created even by large power lines is so small as to cause an undetectable rise in temperature.

A typology of radiation is provided in Figure 2.1, with ELF EMF at the bottom of the range.

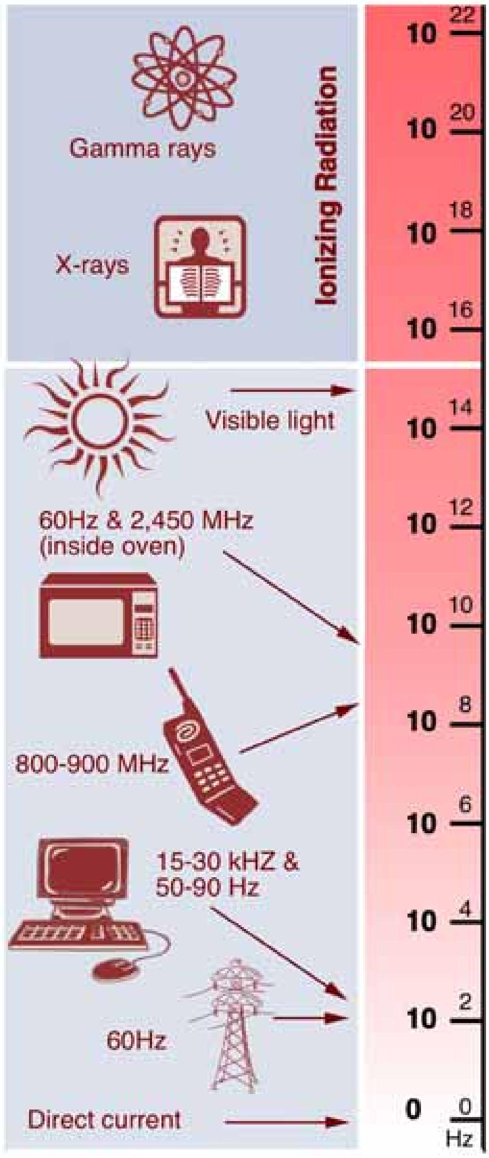
[7] The proposed Standard provides a more comprehensive discussion of scientific research and its implications.

[8] The Minnesota State Interagency Working Group on EMF Issues 2002, *A White Paper on Electric and Magnetic Field (EMF) Policy and Mitigation Options*, p. 6.

[9] D. Wartenberg 1996, 'EMFS Cutting Through the Controversy', *Public Health Reports*, vol. 111, p. 209.

Figure 2.1

TYPES OF ELECTROMAGNETIC FIELDS



2.1 Incidence of exposure to ELF-EMF

There is currently no established biological mechanism by which EMF causes disease, thus it has not been clear which 'exposure' should be measured and assessed. As a result, it has been difficult to pinpoint the incidence and extent of exposure to EMF.

Almost everyone is exposed to ELF EMFs as there are a wide variety of sources of exposure and they vary greatly over short distances. In 1979, Wertheimer and Leeper published a study that claimed that magnetic fields from high current installations such as power lines and substations in the proximity to residences were associated with increased risks of childhood cancer.[10] In particular, elevated risks for children residing within 100 metres of a power line has been reported.[11] Since then, a number of studies have focussed on this link.

While there is general consensus that there are established biological effects from acute exposures at high levels (e.g. well above 100 μT) that are explained by recognised biophysical mechanisms, there is no consensus as to the level that distinguishes low EMF exposure from high exposure.

In general, there is weak but consistent evidence from epidemiological studies that the risk of childhood leukaemia from EMF exposure above 0.4 μT is doubled.[12] It is this threshold that has been used to assess the degree of the public that is subject to ELF EMF. For example:

- An Advisory Group on Non-Ionising Radiation (AGNIR) report classified 0.4 μT as high exposure, but stated that such levels are seldom encountered by the general public in the United Kingdom.[13]
- In another study it was estimated that only approximately four per cent of the United States population is exposed to average levels of 0.4 μT and greater.[14]

Few studies have examined the effects of electric rather than magnetic fields, mainly due to difficulties with consistent measurement. A large UK study showed no association between electric fields and childhood leukaemia.[15]

2.2 Effect of exposure to electromagnetic fields

It is known that acute exposure to EMFs cause effects on the function of the central nervous system at low frequencies. However, these will only occur as a result of intense exposure and are *extremely* rare. They will not occur in people during their day-to-day living and should not occur at work.

Whilst the adverse effects of acute exposure above current ‘reference levels’ to EMFs on health are well established, it is exposure to low frequency levels that have disputed results due to scientific uncertainty. This is where problems associated with formulation of exposure reduction or elimination strategies arise.

The primary health concerns related to electric power use are the effects of chronic exposure to electromagnetic fields. There have been numerous epidemiological studies that examine the causes, control or distribution of diseases in populations or groups. These have shown varying results as to the linkages between exposure to electromagnetic fields and health concerns. Some have shown no statistically significant association,[16] whilst some have shown a weak association.

The strongest evidence for harmful effects of electromagnetic fields below current standards comes from studies of childhood leukaemia and EMFs in the home and studies of amyotrophic

---

[10] N. Wertheimer and E. Leeper 1979, Electrical wiring configurations and childhood cancer, *American Journal of Epidemiology*, vol. 109, pp. 273-84.

[11] M. Feychting and A. Ahlbom 1993, Magnetic fields and cancer in children residing near Swedish high-voltage power lines, *American Journal of Epidemiology*, 138, pp. 467-81.

[12] ICNIRP Report 2004, Medical magnetic resonance (MR) procedures: protection of patients, *Health Physics,* 87, pp. 197-216. However, there is no mention of the required duration of exposure.

[13] Advisory Group on Non-Ionising Radiation (AGNIR) 2001, ELF Electromagnetic Fields and the Risk of Cancer.

[14] L. Zaffanella and G. Kalton 1998, ‘Survey of Personal Magnetic field Exposure Phase II: 1000-person Survey EMFRAPID Program Engineering Project 6’,

[15] ARPANSA 2006, *Exposure Limits for Electric and Magnetic Fields — 0 Hz to 3 kHz*, p. 73.

[16] ARPANSA, op. cit., p. 73.

lateral sclerosis (ALS) and occupational exposures.[17] It was primarily the results from childhood leukaemia epidemiology studies that led International Agency for Research on Cancer (IARC) to classify electromagnetic fields as possibly carcinogenic to humans rather than unclassifiable.[18]

A large body of research shows a link between EMF exposure and adverse health effects including leukaemia and brain tumours in childhood and later in life, as well as breast cancer, cardiovascular disease and suicide. Overall, the most consistent result indicating a positive association is for childhood leukaemia. In the laboratory, studies have assessed responses in both whole animals (in vivo) and cell cultures (in vitro) to artificial magnetic fields.[19] In 2004, Draper suggested that children under 15 living near high voltage power lines could have a 69 per cent increased risk of getting leukaemia.[20]

The IARC, reflecting an enormous amount of work from many leading researchers in the field, presented the following conclusions:

> "There is *limited evidence* in humans for the carcinogenicity of extremely low-frequency magnetic fields in relation to childhood leukaemia."
>
> "There is *inadequate evidence* in humans for the carcinogenicity of extremely low-frequency magnetic fields in relation to all other cancers."
>
> "There is *inadequate evidence* in humans for the carcinogenicity of static electric or magnetic fields and extremely low-frequency electric fields."
>
> "There is *inadequate evidence* in experimental animals for the carcinogenicity of extremely low-frequency magnetic fields."
>
> "No data relevant to the carcinogenicity of static electric or magnetic fields and extremely low-frequency electric fields in experimental animals were available."[21]

The overall evaluation was:

> "Extremely low-frequency magnetic fields are *possibly carcinogenic to humans."*
>
> Static electric and magnetic fields and extremely low-frequency electric fields are *not classifiable as to their carcinogenicity to humans."*[22]

The term 'possibly carcinogenic to humans' denotes an agent for which there is limited evidence of carcinogenicity in humans, and less than sufficient evidence for carcinogenicity in experimental animals. The classification is the weakest of three categories used by IARC to classify potential carcinogens.

In terms of cause-and-effect analysis of EMF exposure and non-cancer effects, the research has been of limited value and results have been inconsistent and of mixed quality. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) suggested that:

> (1) Occupational EMF exposure was associated with amyotrophic lateral sclerosis (ALS);
>
> (2) The associations were unresolved for breast and other cancers, cardiovascular disease and suicide/depression;
>
> (3) The evidence was weak for Alzheimer's Disease; and

---

17 C. Johansen 2004, 'Electromagnetic fields and health effects — Epidemiologic studies of cancer, diseases of the central nervous system and arrhythmia-related heart disease', *Scandinavian Journal of Work, Environment & Health*, vol. 1, pp. 1-30.

18 IARC 2002, 'Non-ionizing radiation, Part 1: Static and extremely low-frequency (ELF) electric and magnetic fields, vol. 80.

19 Wartenberg, op. cit., p. 206.

20 http:www.omega.twoday.net/stories/542938 Accessed 15 September 2006.

21 ARPANSA, op. cit., p. 76

22 Ibid., p. 76

(4) There was no evidence that maternal EMF exposure (either residential or occupational) was associated with any adverse reproductive outcomes).[23]

This demonstrates a lack of conclusive evidence and a failure to identify a causative factor responsible for the statistical association between residential wiring configurations (called wire codes) that were found in multiple studies.

This position has been affirmed in Australian courts, with Senior Judge Skoien in the Planning and Environment Court of Queensland explicitly considering the risks associated with ELF EMF exposure, and concluding:

[37] There is a statistical association which some studies have identified between long term exposure to ELF/EMF and the onset of cancer, particularly childhood leukaemia. That has led to the World Health Organization listing ELF/EMF in its category C, or "possible" causes of cancer.

[38] At first blush that is an alarming fact. But as the witnesses (for example the epidemiologist Professor Elwood) pointed out the category C list is very extensive and contains very many things with which most of us have regular contact (for example coffee and petrol exhaust gases). Some evidence of a connection between a substance and cancer will cause it to be listed as a possible cause. To be removed from the list is an extreme rarity because it is virtually impossible to prove a negative.

[39] Even the statistical analyses themselves may not establish what they seem to, that is, a connection between ELF/EMF and cancer. Professor Elwood explained how that could be so, for example, because of the presence of some undetected complicating factor. An apparent statistical connection between factor A and result B does not necessarily prove that A is the cause or even a cause of B.

[40] It would be possible, over very many pages, to discuss the leading studies and the evidence given by the expert witnesses in relation to them. However I do not propose to do so because it is patently clear that no-one, persuasively, has been able to do more in relation to question (a) [i.e. whether that induced current can cause cancer] than answer, as has WHO, "possibly". Indeed it could be said that many experts would answer "doubtful". However responsible experts do not completely dismiss the possibility of a causal connection between the two.[24]

Whilst there appears to be insufficient evidence to prove an association between ELF EMF and health effects, there is also insufficient evidence to prove that ELF EMF exposure is safe or has no adverse health effects. Scientific research suggests that the greatest potential risk, although not demonstrated to be causative, relates to childhood exposure and the development of leukaemia.

---

[23] ICNIRP Report, op. cit., p. 75.

[24] *Energex Ltd v Logan City Council & Ors* [2002] QPEC 1 (11 January 2002), available at http://www.austlii.edu.au/au/cases/qld/QPEC/2002/1.rtf.

Chapter 3

The objective

This chapter sets out the objectives that should underpin government intervention with respect to ELF EMF.

The mission of Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is to provide the scientific expertise and infrastructure necessary to support the objective of the *Australian Radiation Protection and Nuclear Safety Act 1998* — to protect the health and safety of people, and to protect the environment, from the harmful effects of radiation.

In this case, it can be said that the objective is to:

- manage exposure risks associated with ELF EMF; and
- educate the public about the magnitude and likelihood of such risks.

The challenge here is that, as discussed in chapter 3, there is no scientific agreement that non-acute exposure to ELF EMFs actually causes cancer or other adverse health problems.

However, there is a movement to adopt precautionary approaches for management of health risks in areas of scientific uncertainty.[25] The philosophy of the precautionary approach is that 'where there are reasonable grounds for concern about a risk and there is uncertainty, decision makers should be cautious'.[26]

Several different policies promoting caution have been developed in different contexts to address concerns about public, occupational and environmental health issues in the face of scientific uncertainty:[27]

- The *Precautionary Principle* is a risk management policy applied in circumstances where there is scientific uncertainty. It is risk oriented and it is intended for use in drafting provisional responses to a specific, potentially serious health risk until more adequate data are available for a more scientifically based response. The precautionary principle should be considered as part of a structured approach to the analysis of risk, which comprises risk assessment, risk management and risk communication. The precautionary principle provides a means of applying the elements of risk management to situations where there is uncertainty.[28]
- The concept of *prudent avoidance* was initially developed as a risk management strategy to deal with concern about possible effects from ELF electromagnetic fields from high-tension power lines.[29] It has evolved to mean taking simple, easily achievable, low cost measures to reduce exposure to electromagnetic fields, even in the absence of a demonstrable risk. Generally, government agencies have applied the policy only to new facilities, where minor modifications in design can reduce levels of public exposure. It has not been applied to

---

25 See K. Foster, P. Vacchia and M. Repacholi 2000, 'Science and the precautionary principle', *Science*, vol. 288, pp.79-980.

26 R. Harding and E. Fisher 1999, *Perspectives on the Precautionary Principle*, Federation Press, New South Wales.

27 The concept of ALARA (i.e. 'As Low As Reasonably Achievable') is sometimes also considered in this context, but it is a policy to minimize *known* risks.

28 See United Nations General Assembly 1992, Report of the United Nations Conference on the Environment and Development, 3-14 June, Rio de Janeiro Brazil, available at http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm; Commission of the European Communities 2000, Commission adopts communication on precautionary principle, Commission of the European Communities, Brussels Belgium, available at http://europa.eu/rapid/pressReleasesAction.do?reference=IP/00/96&format=HTML&aged=0&language=EN&guiLanguage=en.

29 K. Nuttall, P. Flanagan and G. Melik 1999, 'Prudent avoidance guidelines for power frequency magnetic fields', *Radiation Protection in Australasia*, vol. 16, no. 3, pp. 2-12.

require modification of existing facilities, which is generally very expensive. Defined in this way, prudent avoidance prescribes taking low-cost measures to reduce exposure, in the absence of any scientific proof that the measures would reduce risk. Such measures are usually couched in terms of broad recommendations rather than fixed rules.

Despite the inherent attractiveness of such precautionary approaches, they are often difficult to put into practice. For example:

- Due to the weak nature of the evidence suggesting a possibility of occurrence and the severity of a hazard's impact on the health of a given population, many have argued that it is insufficient to 'trigger' a precautionary approach. There is a risk of adopting precautionary strategies purely in response to public controversy based on a mere suspicion that ELF-EMFs are a cause of human illness.

- Application of a precautionary approach to the EMF issue is also problematic because there is not only uncertainty as to whether or not exposure is associated with increased risk, but also uncertainty in relation to magnitude, specificity of the risk, and which aspect of exposure is harmful.[30]

Despite these concerns Australian courts have supported the adoption of prudent avoidance to ELF-EMF exposure:

> [48] The correct approach in my view is to apply the policy of 'prudent avoidance'. That policy has been adopted by the Electricity Supply Association of Australia which includes Energex. It embraces a range of actions which it is sensible to take, having regard to the current state of scientific uncertainty and involves doing what can be done without inconvenience and at moderate expense to avert the possible risk to health from exposure to new high voltage transmission facilities. That course emanates from a recommendation made by Sir Harry Gibbs, who conducted an inquiry into the problems faced by the industry in relation to EMF.[31]

Under the principles of prudent avoidance, ARPANSA's objective of managing exposure to risks would also include managing exposure to risks even where there remains some uncertainty about their potential scope and/or likelihood of impact.

In this light, it can be said that governments should have as their objective:

- *the management of exposure risks associated with ELF EMF, acknowledging the lack of demonstrated risk but adopting a precautionary approach consistent with the continuing scientific uncertainty associated with ELF EMF exposure; and*

- *educating the public about the magnitude and likelihood of such risks.*

[30] L. Kheifets 2001, 'The Precautionary Principle and EMF: Implementation and Evaluation', *Journal of Risk Research,* vol. 4, no. 2, pp. 113-125.

[31] *Energex Ltd v Logan City Council & Ors* [2002] QPEC 1 (11 January 2002), available at http://www.austlii.edu.au/au/cases/qld/QPEC/2002/1.rtf.

Chapter 4

Assessment of options

This chapter outlines three options to address the objectives identified in chapter 3, and provides an assessment of each.

Three regulatory options have been identified by ARPANSA:

- *Option One – status quo* — this entails doing nothing and leaving the *Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields*[32] in place;
- *Option Two – regulatory adoption of the Standard* — this option entails re-writing the guidelines and updating it to be consistent with international guidelines and standards and taking into account more recent literature. The proposed Standard would provide a set of requirements to be adopted by State/Territory regulators as part of their regulatory frameworks; or
- *Option Three – publishing the Standard without incorporating it into regulation* — this option entails re-writing the guidelines and updating it to be consistent with international guidelines and standards and taking into account more recent literature. State/Territory regulators would use the Standard as an advisory document.

The costs and benefits of the second and third options are assessed against the *status quo* (i.e. the first option).

The aim of this assessment is to provide a clear exposition of the nature of the costs and benefits associated with each option, and to quantify these impacts where possible.[33]

Two methodological issues are worth highlighting at this stage:

- In assessing the compliance costs to industry associated with the regulatory adoption of the Standard, a particular focus of the Australian Government is to ensure that compliance costs are fully factored into any decision so as to avoid unnecessary 'red tape'. To this end, the Commonwealth Office of Small Business has developed the Business Cost Calculator, and its use is encouraged for RISs.[34] The Business Cost Calculator breaks compliance costs down into a number of cost categories that are summarised in Box 4.1. Where appropriate, the costs of the options have been identified using these cost categories, although we note that it is possible to consider costs as falling within more than one category (e.g. some capital investment could be classified as 'Purchase Cost' or 'Procedural').
- As many uncertainties surround the estimated costs and benefits, it is important to determine the robustness of the standard set of results. In this study, a number of parameters were varied simultaneously around their estimated mean values and the benefit-cost model was recalculated to identify the sensitivity of results to these changes. A sensitivity analysis

[32] National Health and Medical Research Council 1989, *Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields*, Radiation Health Series No. 30.

[33] While cost-benefit analysis requires all costs and benefits associated with the options to be measured quantitatively in common units (either in monetary units or physical units) to the fullest extent possible, to the extent that quantification is not possible, a comprehensive list of the costs and benefits together with a strong qualitative analysis can often provide a simple but still compelling case. Indeed, this approach is preferable to one where unreasonably broad assumptions are made to generate quantified impacts which provide a false sense of accuracy.

[34] See http://www.industry.gov.au/content/itrinternet/cmscontent.cfm?objectid=BA1B2703-B8F9-15A5-D133F9301CDF7C1C&indexPages=/search/search.cfm. While we have some concerns that the analytical engine underlying the calculator is too simplistic and is not 'best of breed' (e.g. it does not provide a way to model compliance costs as they phase in and out over time, instead assuming constant costs), we use the calculator as a base and build upon its analysis.

around these input variables provides us with a measure of confidence about the evaluation results.[35]

Box 4.1

BUSINESS COST CATEGORIES

Nine different business cost categories have been identified in preparing RISs:

- Notification — This usually involves reporting transactions either beforehand or after the event, such as notifying an authority that an event has happened. This is different to Permission as Notification implies permission has been granted – implicitly or explicitly.
- Education — This cost category involves maintaining awareness of legislation and regulations, and the costs of keeping abreast of changes to regulatory details.
- Permission — This cost category involves applying for and maintaining permission for registration to conduct an activity, usually prior to commencing that activity. This includes applying for permits and licences.
- Purchase Cost — This cost category involves the costs of all materials, equipment, etc, purchased in order to comply with the regulation.
- Record Keeping — This cost category involves keeping statutory documents up-to-date.
- Enforcement — This cost category involves cooperating with audits, inspections and enforcement activities.
- Publication and Documentation — This cost category involves producing documents with regard to particular activities or things for third parties.
- Procedural — This cost category involves the cost of doing non-administrative (i.e. non-paperwork) tasks.
- Other.

Source: Department of Industry, Tourism and Resources 2006, *Business Cost Calculator: Cost Category Guide,* http://www.industry.gov.au/content/itrinternet/cmscontent.cfm?objectID=BA1FF220-C6E2-2B8B-FD56C67687705916, Accessed 11 September 2006

Sections 4.1 and 4.2 provide an overview of the nature and quantum of the costs and benefits associated with Options Two and Three. The costs and benefits of the two options are explicitly compared to the status quo in section 4.3, and the results are subjected to the sensitivity testing described above.

4.1 Option Two — Regulatory adoption of the Standard

Box 4.2 provides an overview of the proposed Standard and the measures that are required for occupational and general public exposure.

[35] The software program @Risk was used to undertake the analysis. This program calculates a probability distribution of net present value outcomes based on multiple iterations — in this case 10 000 random (i.e. Monte Carlo) iterations — using different values for each of the input variables. The range of possible values for the variables is specified by assuming a particular probability distribution for each variable, together with a corresponding mean value.

Box 4.2

OVERVIEW OF THE PROPOSED STANDARD

The ARPANSA Standard specifies limits of human exposure to electric and magnetic fields in the frequency range 0 Hz to 3 kHz, to prevent adverse health outcomes for both occupational and general public exposure. These limits are defined in terms of Basic Restrictions for exposure of all or part of the human body. Relevant derived Reference Levels are also provided as a practical means of showing compliance with the Basic Restrictions.

Occupational exposure measures required in the Standard include:

- workplace policies that include a risk management process that identifies the risks, specifies the procedures that must be implemented to control and manage them, and monitors and reviews the effectiveness of these measures;
- where there is potential for exposure above the limits, the hazard should be managed through application of the most appropriate control measures (the highest priority being elimination of the hazard and the lowest being the use of appropriate personal protective equipment);
- training and supervision of workers in safe work practices;
- medical assessment procedures;
- notification of any serious injuries to the Competent Authorities;
- provision of information to employees;
- keeping of records and personnel files of workers who are occupationally exposed to ELF and/or static fields; and
- post incident exposure management.

Measures for the protection of the general public include:

- determination of the boundaries of areas where general public exposure limits levels may be exceeded;
- restriction of public access to those areas where the general public exposure limits may be exceeded;
- appropriate provision of warning signs or notices;
- notification to the competent authority, as required, in the event of the exposure exceeding the relevant limits; and
- minimising, as appropriate, ELF and/or static electric and magnetic field exposure.

Source: ARPANSA 2006, *Radiation Protection Standard: Exposure Limits for Electric & Magnetic Fields – 0Hz to 3kHz*

Compliance costs to business

Most firms are already in compliant with at least some of the measures contained in the proposed Standard. This occurs for two principal reasons:

- Media coverage, and therefore public awareness of potential problems in specific industries, has, in most cases, forced firms who deal with ELF EMF (e.g. electricity companies, and in firms with induction welders and induction heaters) to conform with high industry specific standards (which generally follow NHMRC or ICNIRP guidelines).
- The management of general occupational health and safety (OHS) standards require employers to assess risks, take measures to reduce the risks identified and provide appropriate health surveillance. The OHS regulations do not specifically mention EMF as a potential health hazard, and consequently the level of awareness of the risk among most employers is probably low. However, the NHMRC publishes interim guidelines, which, although not legally binding, currently act as a benchmark.

Given these factors, it is expected that for the majority of firms' compliance costs for the adoption of the proposed Standard will be relatively small. The expected marginal nature of operational changes for the majority of ELF EMF intensive firms means that the development of compliance costs has involved considerable estimation, as discussed below.

Notification

Businesses will be required to report any serious injuries that are linked to ELF EMF exposure to the Competent Authorities. Given the low or negligible incidence of serious injuries due to ELF EMF exposure to date, it is likely that notification will not occur frequently and therefore the costs of complying will be marginal. In any case, an incident of significant EMF exposure would entail small costs to business in informing the relevant authority and documenting the incident.

Education

The proposed Standard requires that workers be trained in safe work practices and supervised when appropriate. Although workers are only exposed to risk above the basic restrictions, this provision will generally apply where workers are exposed to ELF EMFs since a risk assessment will have to be undertaken at ranges below the basic restriction levels.

For the purposes of the RIS, it is assumed that training and information is required for 10 per cent of workers from workplaces that are significantly affected by the Standard, that the transfer of training will take 4 hours per worker in the first year that the Standard is in effect and that the average full labour cost of employing such workers is $38 per hour.[36]

The inability to establish with certainty the total number of businesses affected by the Standard means that overall education costs (as well as other compliance costs) could only be tentatively estimated.

Assuming that only employees may be required to undergo training, this amounts to around 3500 employees.[37] It is assumed that these people will principally be drawn from the electricity generation, transmission, and distribution industries although some may be from the induction heating and aluminium smelting sectors.

The costs associated with training are those which arise in relation to hiring a trainer and purchasing training materials, as well as the loss in productivity that results because these employees cannot train and work at the same time. The direct cost of training is estimated to be $50 an hour, while the loss of productivity is estimated to be the hourly average wage, multiplied by an on-cost factor of 1.5,[38] amounting to about $57 an hour. In total, the cost of training comes to $1.5 million in the first year.

It is further assumed that there are no recurring costs in subsequent years, because only new employees will require training. The difference in costs associated with the training that new employees currently receive and the training that new employees will receive following implementation of the Standard is likely to be insignificant.

---

36 This is based on IBIS World 2006, *D3611 Electricity Generation in Australia*, Melbourne, p. 4; IBIS World 2006, *D3612 Electricity Transmission in Australia*, Melbourne, p. 4; IBIS World 2006, *D3613 Electricity Distribution in Australia*, Melbourne, p. 4.

37 It is estimated that there are around 35 000 employees in the electricity generation, transmission and distribution sectors.

38 An extensive literature review showed that an estimate of 50 per cent for on-costs (i.e. a factor of 1.5) was most appropriate to capture on-costs. This estimate is consistent with other recent impact analyses; for example, the a recent RIS from the Victorian Department of Justice uses an estimate of between 56 per cent and 60 per cent depending on the type of labour) — Department of Justice (Victoria) 2004, *Regulatory Impact Statement for Private Security Regulations*, Melbourne, p. 54. The approach is also consistent with advice from the Australian Vice Chancellor's Committee (who advise universities to use up to 52 per cent for on-costs for the purposes of research grant applications) — Australian Vice Chancellors' Committee (AVCC) 1996, *University Research: Some Issues*, Paper released by the AVCC, Canberra, p. 15. The estimate is broadly consistent with the ABS's estimates of direct on-costs (i.e. superannuation, payroll tax and workcover) at around 15 per cent to 20 per cent; however, these estimates do not include estimates of indirect and other business costs — Australian Bureau of Statistics 2004, *Labour Costs Australia*, cat. no. 6348.0.55.001, AusInfo, Canberra. On balance, the range of estimates for on-costs suggests that an estimate of 50 per cent is reasonable.

Record Keeping

Employers will be required to maintain personnel files of workers who are occupationally exposed to ELF EMF and/or static fields so that retrospective enquiries can be made. Industry advice suggests that record keeping is currently undertaken on a voluntary basis, although it is likely that the records are not consistently undertaken. For those organisations that are currently documenting the information, the impact from the regulation is likely to be marginal. It is thus surprising that the electricity industry claims that there will be additional costs associated with documentation in the order of $580.8 million. Where employers are currently not consistently documenting this information, it is likely that there are some costs of complying with the proposed Standard.

We have assumed that there are up to 80 enterprises that may incur additional costs. For each of these 80 enterprises, it is assumed that one person undertakes the record keeping, and that they spend a total of 40 hours a year on this task. The costs associated with the record keeping are either that the organisation must hire someone specifically to perform this task, or that an existing employee undertakes this role while relinquishing some of their other duties. As a result, the cost per hour is $38, multiplied by an oncost factor of 1.5 per cent, giving $57 per hour. In total, the costs of record keeping come to $183 900 per year.

Publication and Documentation

The proposed Standard requires employers to advise employees of the:

- precautions and procedures for certain personnel during the time they are engaged in ELF and/or static work;
- known biological effects of ELF and/or static fields;
- the procedures to follow in an event of any notifiable overexposure; and
- what to do if they become sick from exposure.

Under the *status quo*, it is likely that many organisations already produce this sort of documentation and printed material for their employees, particularly in light of the risks associated with the work. Consultations with relevant experts suggest that while the content or the subject matter of this material will change when the Standard is implemented, the level of effort and the costs associated with this change are unlikely to differ from those incurred under the *status quo*. The documentation and dissemination of the Standard as it affects an organisation are recognised as a cost; however, the implementation of the Standard does not impose an *additional* cost on any of the businesses in this regard. As a result, costs of producing printed material have not been estimated.

Procedural

The most significant cost incurred by industry, as a result of the implementation of this Standard, is the cost of physically altering the environment around cables so that the risk to the general public is reduced. While the industry does self-regulate in this regard, the standards that it has self-imposed are based on the NHMRC's reference levels. The proposed Standard is more rigorous. For example the NHMRC Reference Levels specify the maximum number of hours that an employee can be exposed to electric and magnetic fields of varying intensity. The proposed code does not specify the maximum number of hours. Instead, the standards for a Controlled Activity or a Controlled Circumstance require that the number of hours that an employee is exposed to electric or magnetic fields that exceed the normal occupational exposure reference levels is *minimised* at all times. There is no explicit allowance in occupational levels for exposures over short time periods (e.g. working for one or two hours), making compliance much more difficult for several issues.[39]

There are various ways in which companies can alter the environment to reduce exposure to ELF EMF. These include:

- raising towers to raise the height of the cables;
- erecting fences;
- purchasing land near areas of particular concern in order to restrict access;
- burying cables in trenches;
- putting up warning signs; or
- shielding.

Some of the firms from the affected industries (i.e. the electricity industry) have provided estimates of the costs of implementing these measures.

The first cost category considered relates to possible exposure caused by high tension transmission (e.g. 330 kV) lines. The electricity industry's assessment of the maximum electric field public exposure created on its system across NSW is of the order of 8kV/m under transmission lines, with the Standard requiring application of Controlled Activity/Circumstance wherever public exposure could exceed 5kV/m. Industry's view is that:

- this could occur in as many as 10 000 spans across NSW, and hence placing warning signs at 'entry points' is not a realistic measure (particularly as just identifying the 'entry points' and placing the signs there would be a massive task in itself); and
- where 'activity' on private land was attempted to be 'controlled', many landowners would be expected to seek compensation and even purchase of the 'controlled' land.

The industry suggests that physically raising the tower heights — at a cost of about $1.65 billion — would be the only other way to remove public exposure to levels below that required by the Standard.

ARPANSA questions this cost estimates. In particular:

- a comparison with other standards (see Table 4.1) reveals that:
  - under the NHMRC guidelines, which the electricity supply industry has endorsed since the early 1990s, there has always been the expectation that the general public should be limited to 5 kV/m except for 'a few hours/day'. In other words, there is already a recognition of a 'controlled circumstance';
  - there is no international standard which permits exposure above 5 kV/m without restriction — the IEEE standard allows 10 kV/m in specified locations and ICNIRP does not permit any field above 5 kV/m (and this is an instantaneous rather than averaged value);
- the fact that most, if not all, transmission towers presently have warning signs indicates that amending or attaching additional signs would not represent cost on the scale claimed.

39 The power industry members of the consultative group 2006, *Costs of the Draft ARPANSA Standard to the Electricity Industry*, Melbourne, p. 1.

Table 4.1

COMPARISON OF 50 HZ REFERENCE LEVELS FOR ELECTRIC FIELDS (kV/m)

	Proposed Standard	IEEE (2002)	ICNIRP (1998)	NHMRC Guidelines (1989)
Occupational				
Normal	10	20	10	10
Special	20	> 20 when not in reach of grounded conductor	20, when contact with electrically charged conductors is excluded	10 – 30 for 80/E (kV/m) hours (i.e. 30 kV/m for 2.67 hrs)
General Public				
Normal	5	5	5	5
Special	10	10 within power line rights-of-way	—	10 (few hours/day)[#]

[#] These values can be exceeded for a few minutes per day provided precautions are taken to prevent indirect coupling effects

This suggests that the Standard will not have the scale of impact claimed by business when compared to the obligations under the *status quo*. As such, no costs have been included specifically addressing the high tension power lines.

The second cost category considered relates to changes to existing signage. This has been estimated to be $1.967 million. It has been assumed that these costs will be incurred over two years.

The third cost category considered was an omnibus one that addressed a range of procedural compliance factors identified by industry (see Table 4.2), with a total estimated value of just over $1 billion. It is difficult to draw definitive conclusions about whether these possible costs would be created additionally by the Standard. As a result, we have included all the costs in Table 4.2 but discounted to take into account this uncertainty; we have assumed that there is an equal probability of all values between $0 and $1.085 billion.

Seeking Stakeholder Input

There is a range of opinions as to the potential procedural costs associated with compliance with the proposed Standard. Stakeholders are encouraged to provide evidence as to how the Standard differs from existing requirements and the level of additional compliance costs associated with the Standard, particularly addressing the costs identified in Table 4.2.

The other two procedural cost categories — medical assessment, and hazard identification and risk assessment — are likely to be negligible in comparison to the *status quo*. Almost all firms conduct these assessments due to self-regulation, adoption of best practice, or implementation of OHS principles. The costs associated with undertaking the assessments will not be too different to what is currently being undertaken.

Table 4.2

ADDITIONAL COMPLIANCE COSTS ESTIMATED BY INDUSTRY ($ ’000)

Issue	Possible solution	Cost
Transmission		
Mag field near air cored reactors	Fencing or switching out for maintenance	480
Mag field in close proximity to conductors while undertaking live line work	Restrict access to ~30cm or switching out; provide estimate hrs of live line work performed	400
Distribution		
Mag field in very close proximity to cable risers carrying full load	Shield to ~20cm or relocate or rearrange network	112 000
Mag field in close proximity to walls of indoor substations	Shield, rearrange substation (eg move LV board)	112 400
Mag field near air cored reactors	Fencing or switching out for maintenance	1 200
Mag field in very close proximity to the LV side of pad mounted kiosks carrying full load	Fencing	170 500
Mag field in close proximity to cables in tunnels, basements, substations	Restrict access to ~30cm or switching out, shielding, reduced reliability	144 000
Mag field in close proximity to cables in pits	Restrict access to ~30cm or switching out	240 000
Mag field in close proximity to conductors while undertaking live line work	Restrict access to ~30cm or switching out; provide estimate hrs of live line work performed	192 000
Generation		
Mag field near generator PIB and GCBs	Fencing, restrict access, change work process	111 200
Mag field near generator PIB and GCBs	Fencing, restrict access, change work process	600
Mag field near generator PIB and GCBs	Fencing, restrict access, change site induction process	300
Mag field near hydro gen high current cables in public access ways	Relocate cables, restrict access, change site induction process	180
TOTAL		**1 085 260**

Source: Industry estimates

Administrative costs to government

Education

With the introduction of any new code, the regulators themselves require some retraining and familiarisation. This would require an estimated one day in length for each of the regulators. Given that the Standard is not entirely new for the regulators, training and familiarisation is not likely to be as extensive as would be the case with an entirely new code or standard. Assuming that two employees per regulator would require training and familiarisation for a day (8 hours), using an average figure of around $30 per hour per staff member and on-cost multiplication factor of 1.5, the cost to the regulatory body for retraining/familiarisation would be around $720 in the first year. This figure can be estimated for the other jurisdictions giving a national total of approximately $6480. Ongoing education costs are likely to be minimal and will only be required for new staff.

Enforcement costs

Enforcement costs are likely to be minimal unless there are serious symptoms or injuries which are suspected to be linked to EMF exposure. It is estimated that under normal circumstances it will take a regulatory authority up to one week per year to enforce the measures in the proposed Standard. At $30 an hour, with an on-cost multiplication factor of 1.5, the total value of regulators' time devoted to enforcement is estimated to be around $3600 per year. Across the nine different regulators, total cost is expected to be around $32 400 per year. Over a ten year period and using a 7 per cent discount rate amounts to a total cost of $227 000.

Legislative costs

The introduction of a new Standard would likely mean that each jurisdiction would need to amend an Act and/or Regulations. Changing legislation or regulations governing these issues will require resources and costs on behalf of government. While somewhat stylised, the process will involve:

- policy approval:
  - policy officer time;
  - departmental approval;
  - cabinet approval;
- drafting:
  - policy officer time;
  - parliamentary Counsel's drafting time;
- legislative approval:
  - the Bill to be read, debated, and approved by legislative assembly or house of representatives;
  - the Bill to be reviewed by upper house;
  - the Act to be given Royal Assent by Governor or Governor General;
- promulgation:
  - printing; and
  - information and promotional material about changes.

These costs will be one-off and will have no further impact on the way in which jurisdictions regulate EMFs nor will they have any impact on industry, consumers of products that use EMFs, nor the public more generally. Hence such administrative costs are rarely costed, although it should be recognised that even machinery of government legislative changes will impose government costs. By way of example of what this might cost:

- in Western Australia, the average cost of legislative amendments drafted in 2003-04 was in the order of $52 000;[40] and
- in the United Kingdom it was estimated that to implement regulatory changes relating to European Works Councils would involve an administrative cost of amending legislation of approximately $400 000.[41]

---

40 Department of Local Government and Regional Development 2004, *Annual Report 2003-2004*, p. 21.

Using these estimates as a guide to the administrative cost of implementing the proposed Code, the total administrative cost of amending legislation in all jurisdictions is assumed to be $468 000. This assumes that all jurisdictions need to pass some legislative amendments.

Benefits

It is common practice in benefit-cost studies for avoided costs to be considered as benefits of a program.

Economic theory states that individuals make rational decisions in order to maximise their expected benefit or level of satisfaction. This model of behaviour generally assumes that people have all relevant or 'perfect' information on which to base their decisions. If this were the case, then the willingness to avoid EMF would be close to zero.

However, a range of psychological behavioural characteristics influence the way individuals process risk information, meaning that they do not process risk information in the rational manner that economic theory assumes.[42] For example:

- A number of studies have found that people are only partially rational (or 'boundedly rational') when making decisions involving uncertainty, which means that they may simplify and filter risk perceptions.[43] In his work on bounded rationality, Kahneman distinguishes between two modes of cognitive functioning, reasoning and intuition.[44] Kahneman argues that most judgements and most choices are made intuitively rather than according to reason. While intuition can be very useful, it can also be associated with poor judgements.
- Substantial publicity regarding a risk may lead to overestimation of that risk. This runs counter to the usual economic argument that additional information leads to more informed judgements.[45] According to the then WorkSafe Australia, biased risk perceptions 'are not assisted by inappropriate media coverage, which tends to focus on the sensational. This tends to cause ill-founded and ill-formed fears of some risks and not of others'.[46]
- When strong emotions are involved, people tend to focus on the consequence of a bad outcome, rather than on the probability that the outcome will occur. The resulting 'probability neglect' helps to explain excessive reactions to low-probability risks of catastrophe. For example, people are often far more concerned about the risks of terrorism than about statistically larger risks that they confront in ordinary life, such as car accidents.[47]

These factors combined possibly may lead to an excessive concern about risk, and a willingness to pay higher than that which is justified under scientific principles. That said, even if irrational, the fears are real and so a reduction in such fears should be seen as a benefit.

Avoiding negative health outcomes associated with EMF exposure produces two benefits:

---

41 Department of Trade and Industry (UK) 1998, *Implementation of the Regulations on European Works Councils — Regulatory Impact Assessment*, London, p. 10.

42 P. Dorman 1996, *Markets and Morality: Economics, Dangerous Work, and the Value of Human Life*, Cambridge, Cambridge University Press. Also see C. Sunstein (ed) 2000, *Behavioural Law & Economics*, Cambridge, Cambridge University Press.

43 H. Simon 1955, 'A Behavioural Model of Rational Choice', *Quarterly Journal of Economics*, vol. 69, no. 1, pp. 99-118. H. Simon 1979, 'Information Processing Models of Cognition', *Annual Review of Psychology*, February, pp. 363-96.

44 D. Kahneman 2003, 'Maps of bounded Rationality: Psychology for behavioural economics', *American Economic Review*, December, p. 1450.

45 K. Viscusi 2006, *Regulation of Health, Safety and Environmental Risks*, NBER Working Paper No.11934, p. 14.

46 Industry Commission 1995, *Work, Health and Safety*, AGPS, Canberra, p. 325.

47 C. Sunstein 2003, 'Terrorism and probability neglect', *Journal on Risk and Uncertainty*, vol. 26, p. 121. Terrorists show a working knowledge of probability neglect, producing public fear that may greatly exceed the discounted harm. Public fear, however, is a cost, and is associated with many other others produced by fear. Government should reduce even unjustified fear, if the benefits of the response can be shown to outweigh the benefits.

- avoidance of years of life lost due to premature mortality; and
- avoidance of a period lived in less than perfect health (morbidity).

It is often difficult to assess the impact associated with morbidity as it depends on the age of the person and the nature and extent of the health symptoms. Loss of life, however, can be more readily converted into a financial measure that can be directly comparable with the cost of introducing the Standard. This analysis uses an estimate based on the 'willingness to pay' for health, which is the amount people are willing to pay to prevent an impaired health state, inclusive of all impacts of that state (see Appendix B for a summary of studies and other valuation techniques). The value of a statistical life has been estimated to be around $2.5 million for a healthy prime-age individual in 2002.[48] Converting these estimates to 2005 dollars suggests that the value of a statistical life is around $2.7 million.

If the numbers of workers and children identified by the epidemiological studies to be at elevated risk is about one person every 1 to 2 years, and the value of a statistical life is around $2.7 million then the value of several deaths avoided over the next ten years would be around $11.3 million in 2006 (assuming a 7 per cent discount rate). Of course, because of the doubts about cancer causality, there is a good chance that the true impact is zero.

In the base analysis we have assumed that the value of a statistical life is $2.7 million represents the health benefits (and have assumed a value of $1.1 million and $4.4 million, as described in Appendix B, as alternative low and high values of life in the sensitivity testing).

International consistency

The implementation of the proposed Standard by the Australian, State and Territory governments will allow governments to meet the ICNIRP's developed international framework at power frequencies and thereby allow Australia to participate in the broader international EMF environment. The dollar value of greater international consistency has not been estimated but it is considered slight.

Domestic uniformity

In addition to health benefits, the proposed Standard is likely to result in benefits associated with better coordination and avoiding the adoption of arbitrary reference levels within local council areas:

- the material being published in the Standard will give clear up-to-date national guidance on safety obligations for all who deal with ELF and EMF; and
- regulatory obligations can be better promoted through a consistent massage from all jurisdictions regardless of location.

4.2 Option Three — Publishing the Standard without incorporating it into regulation and using educational strategies in relation to childhood leukaemia

As noted in chapter two, the weight of evidence suggests that both concern and action are unwarranted with resect to ELF EMF. That is, while the data might indicate a hazard, the information is too inconsistent at this time to warrant the substantial expenditures that would be necessary to reduce exposures.

48 P. Abelson 2003, 'The Value of Life and Health for Public Policy', *Economic Record, Special Issue*, vol. 79, June, pp. S2-S13.

The electricity industry, in general, argues that it is premature to reach a judgement on causation, and that there could be significant costs to the industry resulting from the Standard without the commensurate health benefits for the public and/or employees.

Taking a fairly passive stance with respect to the causal relationship between magnetic fields and adverse human health effects, an alternative to introducing the proposed Standard into regulation would be to publish the Standard without incorporating it into regulation, and using educational strategies in relation to childhood leukaemia. The purpose here would be to inform the public and implicitly recommend against a collective action by regulatory authorities at this point in time.

It is assumed that the formal support of the Standard by ARPANSA, even though it is not in legislation, will have a behavioural impact. This will occur because publication of the standard will mean that it is referenced by courts and occupational health and safety regulators when seeking to understand what a firm's duty of care is to employees and other people potentially exposed to ELF EMF.[49] In comparison to legislating, publication of the standard will:

- not change the level of non-capital compliance costs, but will likely delay when they are incurred because compliance with a new law may be seen as more urgent than addressing changes in interpretation of more general obligations. As a result, it is assumed that non-capital compliance costs would be incurred, but delayed by one year in comparison to the legislative option;
- likely mean that the significant capital costs foreshadowed by industry (i.e. particularly with respect to the need to bury or elevate 330kV lines) will not be incurred. A rational industry, when faced with additional compliance expenditure of $3.3 billion will not undertake such investment if their only exposure is to general duties, and the guidance material reinforces that there is no causal link between ELF EMF exposure and death;
- likely mean that the benefit associated with the avoidance of several deaths will be avoided every one to two years is foregone; and
- will reduce the level of training and education that would be undertaken. We have assumed that it would require up to one hour per person's time every year.

4.3 Comparison of options

The costs and benefits of the two identified options in comparison to the *status quo* are presented in Table 4.3. As the majority of costs are one-off, while the benefits to continue over the lifetime of introducing the Standard, the estimated costs and benefits have been converted into net present values assuming a forecast period of ten years and a discount rate of 7 per cent (the sensitivity analysis in the following section varies this discount rate). The principal difference, apart from dropping out some assumptions because their cost categories are not considered relevant (e.g. legislative costs), is that industry will no longer incur the significant capital costs under Option Three.

49 As an example of the way that guidance material is used see *Energex Ltd v Logan City Council & Ors* [2002] QPEC 1 (11 January 2002), available at http://www.austlii.edu.au/au/cases/qld/QPEC/2002/1.rtf.

Table 4.3

NET PRESENT VALUE OF ESTIMATED COSTS AND BENEFITS ($ MILLION)

	Regulatory adoption of the Standard	Publishing the Standard without incorporating it into legislation
COSTS		
Compliance costs for business		
Notification	-	-
Education	$1.51	$0.38
Record Keeping	$0.18	$0.18
Publication and Documentation	-	-
Procedural	$738	$1.78
Administration costs for government		
Training	$0.01	
Enforcement	$0.23	
Legislative changes	$0.47	
Total Costs	**$738.41**	**$2.3**
Benefits		
Improved health outcomes	$11.3	$6.3
International consistency	unquantifiable	unquantifiable
Domestic uniformity	unquantifiable	unquantifiable
Total benefits	**$11.3**	**$6.3**
Net benefit	**Negative $727.1**	**Positive $3.9**

Note: Totals may not sum due to rounding

The following table summarises the costs and benefits incurred by stakeholders under both options.

Table 4.4

IMPACT ON STAKEHOLDERS (PER CENT OF COSTS OR BENEFITS)

	Regulatory adoption of the Standard	Publishing the Standard without incorporating it into legislation
COSTS		
Business	99 per cent	100 per cent
Government	Less than 1 per cent	-
BENEFITS		
General public (including employees)	100 per cent	100 per cent

As many uncertainties surround the values of the model parameters and assumptions, particularly with respect to cost estimates, it is important to determine the robustness of the standard set of results. In this study, a number of parameters were varied simultaneously around their mean values and the benefit-cost estimates recalculated to identify the sensitivity of the results to these changes. The input parameters that were varied for the Option Two analysis are shown in Table 4.5, and for Option Three in Table 4.7.

Table 4.5

VALUES USED TO TEST THE SENSITIVITY OF RESULTS FOR OPTION TWO

Input variable	Unit	Min.	Mean	Max.	Probability Distribution
Costs					
Organisations principally affected	Number	50	80	110	Triangle
On-cost factors	Number	1.3	1.5	2.8	Triangle
Trainer wage	$/hour	40	50	60	Triangle
Capital investment	$ million/year	0	60	121	Uniform
Signage	$ million over 2 years	1.47	1.96	2.46	Triangle
Admin staff	Number	0	1	2	Discrete
Recording time	Hours	20	40	50	Triangle
Enforcement hours	Hours	20	40	50	Triangle
Legislative costs	$ million	0	0.5	1	Triangle
Benefits					
Value of statistical life	$ million	1.1	2.7	4.4	Uniform
General					
Real discount rate	Per cent	4	7	10	Triangle

Table 4.6

VALUES USED TO TEST THE SENSITIVITY OF RESULTS FOR OPTION THREE

Input variable	Unit	Min.	Average	Max.	Distribution
Costs					
Organisations principally affected	Number	50	80	110	Triangle
On-cost factors	Number	1.3	1.5	2.8	Triangle
Signage	$ million over 2 years	1.47	1.96	2.46	Triangle
Trainer wage	$/hour	40	50	60	Triangle
Admin staff	Number	0	1	2	Discrete
Recording time	Hours	20	40	50	Triangle
Enforcement hours	Hours	20	40	50	Triangle
Benefits					
Value of statistical life	$ million	1.1	2.7	4.4	Uniform
General					
Real discount rate	Per cent	4	7	10	Triangle

Simultaneously varying the assumptions specified in Table 4.5 and Table 4.6 provides a more sensitive portrayal of the likely results. The results from such a series of simulations is shown in Table 4.7.

Table 4.7

COMPARISON OF SIMULATION RESULTS

	Option Two	Option Three
Mean net present value	Negative $360.9 million	Positive $4.0 million
Likelihood that net present value is positive	Less than 2%	Greater than 99%
90% chance that result is within the range	Low: Negative $694.8 million High: Negative $30.4 million	Low: Positive $1.4 million High: Positive $6.7 million

The analysis indicates that there is little chance of a positive net present value from adopting the Standard in legislation. Option Three, on the other hand, is likely to result in a net benefit, and so is the preferred option.

Chapter 5

Other matters

5.1 Consultation in the development of the Standard

A working group was established under the auspices of ARPANSA's Radiation Health Committee (RHC) to draft a set of exposure limits for electric and magnetic fields in the frequency range 0 Hz to 3 kHz. In choosing the members of the working group, ARPANSA consulted widely with a range of relevant groups to achieve a spread of relevant interests and expertise. The working group included expertise on:

- electromagnetic fields bio-effects;
- dosimetry and measurement techniques;
- medical expertise on epidemiology and occupational health and safety aspects; and
- knowledge of technical standards.

Community representation was also included.

In view of the broad interest in the topic a Consultative Group was also formed to review drafts and provide additional input to the Working Group. The Consultative Group included expertise and representation from industry, community, unions, engineering, scientific, regulatory and medical fields.

ARPANSA's regulatory development process includes a period of public comment (i.e. for a minimum of one month). Drafts are published on the ARPANSA website along with the regulatory impact statement.[50] At this time, a wide range of interested groups and individuals are informed that the publication is available for comment, and for publications with a wide public interest, the comment period is advertised in relevant newspapers. Specific instructions for making submissions are released with each draft.

5.2 Review mechanisms

ARPANSA proposes to continue monitoring domestic and international scientific and industry findings pertaining to ELF EMF, and to consider adjustment of the Standard in response to any new evidence. This will be done through the Radiation Health Committee's process of regulatory review.

50 See http://www.arpansa.gov.au/for_comm.htm.

Appendix A

Abbreviations

AGNIR	Advisory Group on Non-Ionising Radiation
ALS	amyotrophic lateral sclerosis
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
ELF	extremely low-frequency
EMF	electric and magnetic fields
IARC	International Agency for Research on Cancer
ICNIRP	International Commission on Non-Ionizing Radiation Protection
NHMRC	National Health and Medical Research Council
OHS	Occupational health and safety
RIS	regulatory impact statement

Appendix B

Value of life

Numerous studies have attempted to measure the value of a human life — however, a consensus approach for measuring the value of human life does not exist.

Approaches used in the economic literature to value human life include:

- the frictional method — which assumes that individuals can be valued in terms of the loss of production, the time, and the resources consumed if the individual were to be replaced in the workplace;
- the human capital approach — which values individuals as income-generating assets. Premature death and disability of an individual would result in foregone earnings and the loss of value. Like any capital asset, its value is the present value of future earnings;
- the valuation of unpaid labour — which values time spent on unpaid yet productive activities in the household or community; and
- quality of life estimates — which employs contingent valuation and hedonic valuation (compensating wage) techniques.

These models or approaches tend to build on each other. The most limited of the models is the frictional method which focuses only on employer costs, while the most comprehensive is the quality of life approach, which takes account of the cost to individuals, families, the community as well as employers.

Of the studies surveyed and presented in Table B.1, the most common approaches used are the human capital and the quality of life approaches. The table highlights that there is no clear consensus, nor do the values tend to coalesce around a reasonable range from which we could estimate an average.

The differences in the value of human life estimated can depend on the demographic profile of persons accounted for in the analysis — for instance, the longer is the remaining life span of a person, the higher is their value of human life. It is therefore common to see the value of life expressed as an annualised value (i.e. the value of a life year, or the VOLY). However, to convert VOLYs into a value of a life estimate, information is needed about the average life span of a person, and the average age of the person at the time of death.

In terms of workplace incidents, it is likely that some fatalities will have higher values (such as deaths of younger persons) while other fatalities (such as deaths of older persons) will have lower values. In the absence of detailed data on the age expectancy of deceased persons in the workplace, this analysis adopts a simplifying assumption and applies a single value of life across all types of fatalities.

For this analysis, we have adopted the estimate of $2.7 million per human life, which is the figure (inflation adjusted) suggested by Abelson (2003) for public policy purposes in Australia.[51] This figure was derived from a review of various domestic and international studies. Effectively, the Abelson figure represents a mid-point between the more conservative human capital studies (ranging between $0.7 million and $2 million) and the very high values derived

[51] P. Abelson 2003, 'The Value of Life and Health for Public Policy' *The Economic Record* 79: S2-S13.

from quality of life techniques (with estimates ranging between $3.7 million and $23.4 million).[52]

---

[52] The human capital approach is conservative because it ignores costs such as pain and suffering. By comparison, contingent valuation analysis, which relies on survey data, can lead to very high estimates due to the subjectivity inherent in survey responses regarding the value of a life. This $2.7 million value assumed for the value of human life is comparable to the conventions used by the Health and Safety Executive in the United Kingdom. They adopt a benchmark value of about £1 million (in 2001 prices) for each fatality prevented in their cost benefit analyses. Health and Safety Executive 2001, *Reducing Risks and Protecting People: HSE's Decision Making Process*, p. 65. This equates $2.7 million when converted into real Australian dollars.

Table B.1

ESTIMATES OF THE VALUE OF LIFE

Study	Year of estimate(s)	Country	Approach used	Value of life estimate[53]	Adjusted estimate (2005 value)
Bureau of Transport and Communications Economics (1992)	1988	Australia	Human capital approach and household and community losses.	$575 000	$795 250
Industry Commission (1995)	1992-93	Australia	Includes employer (frictional) costs, individual costs, and community costs. Given compensation payments of $107 550 per fatality, the implied indirect-to-direct cost ratio is 3.2:1.	$449 120	$573 600
Watson and Ozanne-Smith (1997)	1993-94	Australia	Includes human capital approach, household and community losses, value of hospital and treatment costs, and other indirect losses.	$506 627	$625 500
Miller, Mulvey and Norris (1997)	1992-93	Australia	Compensating wage risk study	$11 million to $19 million.	$13.5 million to $23.4 million
Bureau of Transport Economics (2000)	1996	Australia	Sum of human capital approach ($540 000), household and community labour losses ($500 000) and quality of life based on maximum court awards and settlements ($319 030).	$1 359 030	$1 610 000
Viscusi and Aldy (2002)	1976-91	United States	Review of 26 compensating wage risk studies in the United States.	$US 0.5 million to $US 20.8 million. Median estimate of $US 7 million.	$10.2 million
Abelson (2003)	1991-01	Various	Review of contingent value studies and compensating wage risk studies.	$US 0.5 million to $US 9.7 million. The average of these studies was $US 3.5 to $US 4 million. Abelson suggests a value of $2.5 million for Australia based on the European studies.	$2.6 million
Leeth and Ruser (2003)	1996-98	United States	Compensating wage risk study	$US 2.6 million to $US 4.7 million	$3.7 million to $6.6 million

[53] Unless otherwise cited, values related to the date of the study.

Study	Year of estimate(s)	Country	Approach used	Value of life estimate[53]	Adjusted estimate (2005 value)
Mayhew (2003)	2001	Australia	Human capital approach	$1 190 000	$1 250 000
Bureau of Transport and Regional Economics (2006)	2003/04	Australia	Human capital approach with property damage	$2 170 000	$2 170 000

Source: Industry Commission 1995, *Work, Health and Safety: An Inquiry into Occupational Health and Safety*, Report No. 47, Bureau of Transport Economics 2000, Road Crash Costs in Australia, Report 102; P. Mayhew 2003, ‘Counting the costs of crime in Australia’, Australian Institute of Criminology; W. Watson, & J. Ozanne-Smith, 1997, The Cost of Injury to Victoria, Report No. 124, Monash University Accident Research Centre, Melbourne; J. Leeth and J. Ruser 2003, ‘Compensating Wage Differentials for Fatal and Nonfatal Injury Risk by Gender and Race’, *Journal of Risk and Uncertainty* vol. 27, no. 3; W. Viscusi and J. Aldy 2002, ‘The Value of a Statistical Life: A Critical Review of Market Estimates throughout the World’, Discussion Paper 392, John M. Olin Centre for Law, Economics and Business, Harvard Law School; P. Miller, C. Mulvey and K. Norris 1997 ‘Compensating differentials for risk of death in Australia,’ *Economic Record* vol. 73, p. 233, Bureau of Transport and Communications Economics (1992) *Social Cost of Transport Accidents in Australia*, Report No. 79, AGPS, Canberra; P. Abelson 2003, ‘The Value of Life and Health for Public Policy’ *The Economic Record* vol. 79, pp. S2-S13; Bureau of Transport and Regional Economics 2006, *Cost of Aviation Accidents and Incidents*, BTRE Report 113, Australian Government, Canberra. Adjusted figures are calculated by inflating estimates according to CPI up to June 2005. For US studies, CPI data was sourced from the US Bureau of Labour Statistics. US values were converted to Australian values using an exchange rate of one Australian dollar to $0.74 US dollars.

Appendix C

Sources

P. Abelson 2003, 'The Value of Life and Health for Public Policy', *Economic Record*, vol. 79, pp. S2-S13.

Advisory Group on Non-Ionising Radiation (AGNIR) 2001, ELF Electromagnetic Fields and the Risk of Cancer.

Allen Consulting Group 1998, *Competition and Other Impacts of Funding Options for Putting Cables Underground: Report to the Economic Sub-committee of the Working Group on Putting Cables Underground*, April.

Australian Bureau of Statistics 2004, *Labour Costs Australia*, cat. no. 6348.0.55.001, AusInfo, Canberra.

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) 2006, *Radiation Protection Standard: Exposure Limits for Electric & Magnetic Fields – 0Hz to 3kHz.*

Australian Vice Chancellors' Committee (AVCC) 1996, *University Research: Some Issues*, Paper released by the AVCC, Canberra.

Bureau of Transport and Communications Economics 1992, *Social Cost of Transport Accidents in Australia*, Report No. 79, AGPS, Canberra.

Bureau of Transport and Regional Economics 2006, *Cost of Aviation Accidents and Incidents*, BTRE Report 113, Australian Government, Canberra.

Bureau of Transport Economics 2000, *Road Crash Costs in Australia*, Report 102.

Consultative Group industry representatives 2006, *Costs of the Draft ARPANSA Standard to the Electricity Industry*, Melbourne.

Department of Industry, Tourism and Resources 2006, *Business Cost Calculator: Cost Category Guide*, http://www.industry.gov.au/content/itrinternet/cmscontent.cfm?objectID=BA1FF220-C6E2-2B8B-FD56C67687705916, Accessed 11 September 2006.

Department of Local Government and Regional Development 2004, *Annual Report 2003-2004.*

Department of Justice (Victoria) 2004, *Regulatory Impact Statement for Private Security Regulations*, Melbourne.

Department of Trade and Industry (UK) 1998, 'Implementation of the Regulations on European Works Councils — Regulatory Impact Assessment, London.

P. Dorman 1996, *Markets and Morality: Economics, Dangerous Work, and the Value of Human Life*, Cambridge, Cambridge University Press.

G. Draper 2004, 'Electromagnetic Hazard and Therapy", 1, vol. 15.

Energex Ltd v Logan City Council & Ors [2002] QPEC 1 (11 January 2002), available at http://www.austlii.edu.au/au/cases/qld/QPEC/2002/1.rtf.

M. Feychting and A. Ahlbom 1993, Magnetic fields and cancer in children residing near Swedish high-voltage power lines, *American Journal of Epidemiology*, 138, pp. 467-81.

H. Florig 1992, ‘Containing the costs of the EMF problem’, *Science*, vol. 257, no. 5069, p. 471.

K. Foster, P. Vacchia and M. Repacholi 2000, ‘Science and the precautionary principle’, *Science,* vol. 288, pp. 79-980.

R. Harding and E. Fisher 1999, ‘Perspectives on the Precautionary Principle’, Federation Press, New South Wales

Health and Safety Executive 2001, *Reducing Risks and Protecting People: HSE’s Decision Making Process*.

IBIS World 2006, *D3611 Electricity Generation in Australia,* Melbourne.

IBIS World 2006, *D3612 Electricity Transmission in Australia,* Melbourne.

IBIS World 2006, *D3613 Electricity Distribution in Australia*, Melbourne.

Industry Commission 1995, *Work, Health and Safety*, AGPS, Canberra

ICNIRP Report 2004, Medical magnetic resonance (MR) procedures: protection of patients, *Health Physics,* 87, pp. 197-216.

C. Johansen 2004, ‘Electromagnetic fields and health effects — epidemiologic studies of cancer, diseases of the central nervous system and arrhythmia-related heart disease, *Scandinavian Journal of Work, Environment & Health,* 1, pp. 1-30.

D. Kahneman 2003, ‘Maps of bounded Rationality: Psychology for behavioural economics’, *American Economic Review,* December, p. 1450.

L. Kheifets 2001, ‘The Precautionary Principle and EMF: Implementation and Evaluation’, *Journal of Risk Research,* vol. 4, no. 2, pp. 113-125.

J. Leeth and J. Ruser 2003, ‘Compensating wage differentials for fatal and nonfatal injury risk by gender and race,’ *Journal of Risk and Uncertainty*, vol. 27, no. 3.

P. Mayhew 2003, ‘Counting the costs of crime in Australia’, Australian Institute of Criminology.

P. Miller, C. Mulvey and K. Norris 1997, ‘Compensating differentials for risk of death in Australia,’ *Economic Record*, vol. 73, p. 233.

The Minnesota State Interagency Working Group on EMF Issues 2002, A White Paper on Electric and Magnetic Field (EMF) Policy and Mitigation Options.

National Health and Medical Research Council 1989, *Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields*, Radiation Health Series No. 30.

K. Nuttall, P. Flanagan and G. Melik 1999, ‘Prudent avoidance guidelines for power frequency magnetic fields’, *Radiation Protection in Australasia*, vol. 16, no. 3, pp. 2-12.

H. Simon 1979, ‘Information processing models of cognition’, *Annual Review of Psychology*, February, pp. 363-96.

H. Simon 1955, ‘A Behavioural model of rational choice’, *Quarterly Journal of Economics*, vol. 69, no. 1, pp. 99-118.

C. Sunstein 2003, ‘Terrorism and probability neglect’, *Journal on Risk and Uncertainty*, vol. 26, p. 121.

C. Sunstein (ed) 2000, *Behavioural Law & Economics*, Cambridge, Cambridge University Press.

United Nations General Assembly 1992, Report of the United Nations Conference on the Environment and Development, 3-14 June, Rio de Janeiro Brazil, available at http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm; Commission of the European Communities 2000, Commission adopts communication on precautionary principle, Commission of the European Communities, Brussels Belgium, available at http://europa.eu/rapid/pressReleasesAction.do?reference=IP/00/96&format=HTML&aged=0&language=EN&guiLanguage=en.

K. Viscusi 2006, *Regulation of Health, Safety and Environmental Risks*, NBER Working Paper No. 11934.

W. Viscusi and J. Aldy 2002, 'The value of a statistical life: A critical review of market estimates throughout the world', Discussion Paper 392, John M. Olin Centre for Law, Economics and Business, Harvard Law School.

D. Wartenberg 1996, 'EMFS Cutting Through the Controversy', *Public Health Reports,* vol. 111, p. 209.

W. Watson & J. Ozanne-Smith 1997, *The Cost of Injury to Victoria*, Report No. 124, Monash University Accident Research Centre, Melbourne.

N. Wertheimer and E. Leeper 1979, Electrical wiring configurations and childhood cancer, *American Journal of Epidemiology*, vol. 109, pp. 273-84.

L. Zaffanella and G. Kalton 1998, 'Survey of Personal Magnetic field Exposure Phase II: 1000-person Survey EMFRAPID Program Engineering Project 6'