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Australian Government
Australian Radiation Protection and Nuclear Safety Agency

ARPANSA Forum on ELF Standard:

Precaution and Childhood Leukaemia

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Framework

Guiding public health policy options in areas of scientific uncertainty

With particular reference to Electromagnetic Fields

World Health Organization

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Geneva 2006

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WHO Guidance
(based on ELF EHC)

- For high-level short-term exposures to EMF, adverse health effects have been scientifically established (ICNIRP, 2003).
- International exposure guidelines designed to protect workers and the public from these effects should be adopted by policy makers.
- EMF protection programs should include exposure measurements from sources where exposures might be expected to exceed limit values.

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WHO Guidance
(based on ELF EHC)

Regarding long-term effects, given the weakness of the evidence for a link between exposure to ELF magnetic fields and childhood leukaemia, the benefits of exposure reduction on health are unclear. In view of this situation, the following recommendations are given:

- Should monitor science and promote research programmes to further reduce the uncertainty of the scientific evidence on the health effects of ELF field exposure (gaps in knowledge - basis of research agenda).
- Establish effective and open communication programmes with all stakeholders to enable informed decision-making (stakeholders in planning stage).
- Explore low-cost ways of reducing exposures with new facilities and equipment. Appropriate exposure reduction measures will vary from one country to another. However, policies based on the adoption of arbitrary low exposure limits are not warranted.

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Precautionary submissions

The draft proposes "some elements of precaution in general public exposures is warranted" but completely avoids taking proper account of the IARC assessment that ELF magnetic fields are officially assessed as being possibly carcinogenic to humans based on the findings of excess leukaemia in children exposed to long term average levels of 4mG.

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Precautionary submissions

…precautionary principles are discussed in Annex 6 (which is not to be regarded as part of the actual standard) and we are advised before hand in the actual standard not that "elements of precaution are warranted" but that "the incorporation of arbitrary prescriptive safety factors beyond the exposure limits of this standard are not warranted".

The fact is the cancer risk and health and safety of the public is not capable of being adequately protected without very large additional safety factors. And the fact is those safety factors already exist in the real world in a great many places, but not in all situations. The proposed reference values are at least 2 orders of magnitude out of date and bear no relationship to the average long term ELF EMF levels that actually exist in the human working and domestic environment.

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Precautionary submissions

Consistent with current thinking and action, the precautionary approach should be spelled out better in terms…
of minimising, as appropriate, EMF exposure providing that this can be done without undue inconvenience and at zero or very low cost.

Much of section 5 covering general and occupational exposure should be redrafted to reflect this similarly and clearly.

The increased use of warning signs in public areas required by the draft Standard could be expected to increase community concern about the EMF issue rather than reduce it.

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Precautionary submissions

I am all for adopting the precautionary principle, but to do this you must fully recognise that EMF's do cause considerable health problems that cannot necessarily be measured by "sound science".

Debilitating symptoms such as teeth and gum pain, joint pain, heart palpitations, memory loss, brain scrambling, incoherent speech, constant fatigue and miscarriage are not seen in animal studies or recognised as an official disease, yet are very common symptoms that myself, neighbours, acquaintances and pets have suffered due to low, but constant levels of EMF's coming into our homes.

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Precautionary submissions

The precautionary principle in relation to childhood leukaemia should be adopted.

However, I believe that communication and education of the public is not effective enough. Exposure to high-voltage overhead lines can be reduced with planning. Reduction of magnetic fields in the design of home appliances and in existing homes is needed.

Young parents in the 16 to 40 age group should not be left with the full responsibility of reducing childhood leukaemia. A regulatory adoption of the Standard is needed, especially relevant to the possibility of childhood leukaemia.

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Precautionary submissions

In light of the significant limitations of the standard, there is a need for strong precautionary recommendations to be included in the body of the standard in line with recommendations of the WHO.

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Precautionary submissions

It is inappropriate for a document ostensibly designed to "protect" public health, to qualify protection according to how much it costs. To do so is to cast doubt on the impartiality of the committee and the political will for genuine health protection.

Economic considerations are not the role, nor does the committee have the expertise to consider them.

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Precautionary submissions

… also believes ARPANSA has missed the opportunity in the draft standard to provide meaningful information to the community on possible precautionary measures for EMF exposure below community reference levels.

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Precautionary submissions

For Australia, it is unfortunately left up to other organisations to take precautionary actions in the vacuum of ARPANSA's inability to protect public and workers' health. As an example I have attached a paper commissioned by the Royal Australian Institute of Architects that calls for an EMF precautionary approach in building design. Additionally, there are now moves within the trade union movement to consider precautionary policies (and recommended exposure limits) for both ELF and RF.

Access to support documents via the ARPANSA website is not an acceptable alternative to including this information in the standard.

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Standard: Precautionary clause

Clause 5.7 (e) of Standard:
'*Minimising, as appropriate, ELF and/or static electric and magnetic field exposure provided this can be readily achieved without undue inconvenience and at reasonable expense. Any such precautionary measures should follow good engineering and risk minimisation practice. Planning practice and relevant codes of practice should also be followed. Precautionary measures should be proportional to the risk. (eg. Additional precautions may be considered appropriate). The incorporation of arbitrary additional safety factors beyond the exposure limits of this Standard is not supported.*'

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ELF Standard: Precautionary Options

Options	Details	Factors for consideration
Do Nothing	Take no formal action; maintain the status quo	Has no effect on disease, no progress in reducing uncertainty and increasing knowledge.
Research	Enhanced research to remove uncertainties in the science. Further research on sources and distribution of exposure to allow more informed decision making.	Funding for large scale research is difficult. But small targeted studies are possible. Knowledge of exposure distribution important in this context
Communication	Increased provision of information to make it easier for members of the public to adopt individual precautionary approaches if that is their choice.	This is a low cost option and should be made use of. However, without knowledge of high localised sources this may not result in significant changes to annual exposure.

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ELF Standard: Precautionary Options

Options	Details	Factors for consideration
Engineering measures	Enforcement of existing approved wiring practices in distribution systems and buildings to reduce magnetic fields	An important approach for new construction and in some cases may be cost-effective for existing buildings
	Changes to distribution wiring practices to reduce ground currents	Cost of detection could be as high as the cost of mitigation
	Optimisation of engineering design of distribution or transmission systems	Large variation in costs for changes such as rephasing, bundling and undergrounding.
	Changes to design of domestic appliances to reduce magnetic fields	Cost will be a factor but could be presented as a consumer choice with appropriate information. This approach may not decrease average exposure.

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ELF Standard: Precautionary Options

Options	Details	Factors for consideration
Planning measures	Changes to planning procedures to minimise exposures from high-voltage overhead lines	Some quite low-cost options are available.
Exposure limits	A precautionary approach is about reducing exposure but not about changing the exposure limits.	

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Childhood leukaemia in Australia

- ELF survey of 296 homes in Melbourne conducted by ARPANSA (results not published yet), 2% of homes had TWA levels above 4mG in the child's bedroom (youngest or nominal)
- AIHW indicate there were 239 incident cases of childhood leukaemia (0-14 yo) in 2003
- The pooled analysis by Ahlbom et al (2000) reported a doubling of the risk of childhood leukaemia for exposure above 4mG
- If exposure to magnetic fields above 4mG does actually cause leukaemia at the level indicated by Ahlbom et al (2000), then, on average, 5 of the cases in Australia per year would be due to magnetic fields.

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Cost Benefit Analysis: Considerations

- This approach raises questions of equity (poorer communities and individuals and less willing/able to pay for mitigation)
- Problems related to the process of assigning a monetary value to life and health
- A transparent cost-benefit analysis provides a platform for negotiations between stakeholders
- Assume: measures that reduce any aspect of average exposure across the population would indeed reduce the risk if there is one
- Recognition: Any specific measure that reduces exposure is unlikely to reduce precisely the relevant aspect of exposure

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Cost Benefit Approach

- Most precautionary approaches to reducing exposure to ELF MF cost money
- A person may spend own money to reduce exposure
- Society (through govt) may require the power industry to spend money to reduce magnetic fields from power lines. Cost will then be passed on to either consumers or the tax payer.
- In a small number of cases, early design changes may allow reductions in potential exposures at zero cost but these situations will be unusual
- Pooled data show an apparent doubling of the incidence of leukaemia for those children exposed to time-weighted average fields greater than 4 mG
- The exposures in the community are generally heavily skewed towards the lower range of exposures so we will assume the average time-weighted average exposure of these children was 6 mG
- Assume these children were exposed for 3 years.

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Cost Benefit Approach

- How much to save a life?
- Children/leukaemia $1m to $10m
- Incidence rate of (ALL) leukaemia in Australia of children aged 0 – 14 years is about 4 per 100,000 ~ death rate of 20%
- If link causal, then assign a risk of $0.2 \times 4 \times 10^{-5}$ to TWA exposure of 6 mG for 3 years or 0.44×10^{-6} per mG child year
- At $10 M per life saved, we would expect to be prepared to pay $4 to avoid exposing a child to each mG for a year
- Cost is towards the upper limit as uses a high value for cost per life saved and assumes certainty for the risk being due to magnetic fields
- Other models of the exposure-risk relationship could be used.

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Estimated Mitigation Costs

Scenario	Exposure mG-child-years	Remedial Action	Reasonable Cost	Likely Cost
Cable under living room of flat	400	Re-route cable	$2,000	$1000 during construction/$10,000 after construction
Suspicious of high fields – no reason	3	Hire meter to check	$15	$40
Suspicious of high fields – good reason	20	Hire meter to check, then…	$100	$40
Localised high fields in bedroom	60	Re-locate child	$300	$200 for new furniture?
Very close, high current, distribution wiring	250	Aerial bundling	$1,250	$1,000 - $2,000
HV Transmission line	250	Undergrounding	$1,250	$200,000
HV Transmission line	250	Moving house	$1,250	$30,000 - $50,000

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Information on mitigation – internet?

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Transmission system – High voltage

Precautionary measure	Comments
•Restrict building of HV and high current lines in proximity to homes and employment.	Expensive in urban locations and undergrounding may be more economic and quite expensive.
•Underground the line with phase conductors in close proximity to each other, triangular layout preferred to side by side.	Expensive but effective in reducing areas of high fields. Triangular layout requires ducting to achieve consistency and ease of maintenance. Incurs additional costs.
•Build lines higher when above designs not possible.	Expensive for existing lines and not possible for some constructions. Higher lines more prone to lightning discharges.
•Build compact line with lower fields.	Not currently normal practice, however experimental lines being considered overseas. Requires more conductors, more insulators.
•HVDC lines for high power and long distance.	Viable for very large power transfer over long distances.
•Change phasing of multiple circuits to permit field minimisation.	Relatively easily achieved with multiple circuits of similar loadings running side by. This is common practice.
•Balance loading of multiple circuits	Applicable with the above design.
•Shield the fields at the line.	Difficult to achieve for electric fields, and not viable for magnetic fields

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Distribution system – High and Low voltage

•Use higher voltages and lower currents in preference to lower voltages and higher currents.	For the same power transmission, magnetic fields can be reduced with higher voltages. Electric fields are proportional to voltage and may then increase however they are significantly reduced by any earthed objects, plants, buildings etc.
•Run aerials as bundled conductors. (Actives and neutrals in insulated and twisted bundle).	Effective method to reduce ELF fields. Conductors more expensive but pole hardware can be reduced. Lines less prone to storm damage. Fields can be reduced by 90%.
•Lay the line underground with phase conductors and neutral in close proximity to each other, quadrature layout preferred.	More expensive than aerials particularly in established urban areas. For new areas can easily be incorporated at design stage. Initial expenses can be offset by reduced maintenance costs in the long-term.
•Maintain neutral conductor as close as practical to associated actives.	This is normal practice. Separation of neutral and actives results in higher magnetic fields.
•Do not permit connections where neutral can carry return currents not generated from associated active conductors	This is normal practice, sometimes overlooked. Applies to consumer wiring also.
•Distribute actives and neutrals in radial layout.	The neutrals must run beside their associated actives and must terminate when the actives do. Connecting neutrals from one distribution system to another can result in serious unbalances and increased magnetic fields. System reliability can be compromised when neutrals are not inter-linked.
•Locate transformers away from sites where people may gather for extended periods.	Pole transformers are preferable for small loads. High current secondary cables need to be laid to give minimum local fields, particularly at base of poles.
•For single phase ac systems, such as electric railways, locate the return conductor as near as practical to the active catenary wire.	Most systems use the rail as a cost-effective return conductor; however in congested urban areas a separate return conductor connected in parallel to the rail can reduce the magnetic fields. Refer recommendations of "Swiss agency for the environment, forests and landscape, SAEFL".

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Consumer wiring – Commercial and Industrial

•Adhere to existing wiring rules	Strict compliance with the Wiring rules AS3000 will limit many cases of elevated ELF fields. Compliance is law in Australia and any breaches are illegal. Most breaches occur when existing systems are modified or extended.
•Locate staff away from sub-stations and high current busbars	Low voltage, high current cables and busbars in sub-stations are the source of elevated ELF fields which extend through most walls. Magnetic shielding can assist in reducing the fields.
•Locate staff away from open span street distribution wiring. e.g. through windows.	Walls of 1st storey buildings are frequently close enough to street wires to receive elevated ELF fields. Effects are significantly reduced when open span wires are replaced by bundled conductors.
•Provide shielding for high ELF fields.	Electromagnetic shielding at the source can reduce fields to acceptable levels.
•Provide education on how to limit exposure.	Education is required for Electricians, Plumbers, and Electrical Designers and Occupational Health personnel. Present wiring rules are designed to eliminate risk of electrocution and they need to be extended to include minimising ELF fields.

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Consumer wiring – Domestic

•Adhere to existing wiring rules	Refer to section above.
•Locate electricity meter boxes and distribution boards away from areas such as bedrooms and lounges and other areas where people spend extended time.	The rotating disc kilowatt-hour meters, and the necessary separation of active and neutral conductors create elevated magnetic fields. Relocation of meter boxes is expensive. Electronic kw-hr meters have significantly lower fields and can be used in difficult situations. Suitable shielding within the box is also a cheaper alternative. For new dwelling designs location of the box in a more suitable location can be a no cost solution.
•Use earth stake for main earthing.	This is compulsory requirement of AS 3000
•Bond metallic piping to earth stake.	This is also a compulsory requirement of AS 3000
•Do not permit water pipes to act as return conductor for neutral currents.	Insert suitable device(s) to prevent current flow in pipe. Refer notes and references following.
•Wiring for heavy current appliances such as electric stoves and water heaters should be run to avoid close proximity to areas where people spend extended times.	Even wiring with active and neutral conductors running together will have elevated magnetic fields for short distances from the cable. At the design stage prudent location can be a no cost option. For existing dwellings relocation can be expensive and shielding may be a more cost-effective solution.
•Wiring for multiple control switches (such as light switches) should ensure the return currents oppose the fields generated by the active currents.	The magnetic fields will be significantly reduced when the twin actives are run beside the neutral wire.
•Use electric under-floor heating that produces minimum ELF fields.	The return neutral wire must be laid closely beside the active heating wire. This can only be implemented at the design stage. Required by law in some Scandinavian countries.
•Reduce electric fields by installing demand switches.	Demand switches will remove the electrical supply to a circuit when in a no-load situation. Moderate cost solution for reduction of electric fields.

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Appliance design and use

•Design appliances to ensure active and neutral conductors are located beside each other and are not separated.	**When active and neutral conductors are separated, elevated magnetic fields occur. Modest to low costs may be incurred at the design stage.**
•Locate control transformers away from the operators (e.g. at the rear of domestic appliances, not the front).	**Use electronic transformers and switch mode power supplies in place of electromagnetic transformers. Modest to low difference in cost.**
•Keep devices with motors or transformers at least 50cm away from users. Take care with LV devices using step-down transformers (e.g. Low-voltage halogen lights produce the strongest magnetic fields of all forms of electric lighting).	**Applies to long-term exposure only.**
•Shield motors that are operated close to the body (e.g. commercial vacuum cleaners).	**Moderate cost for significant reduction in electromagnetic fields.**
•Provide education on how to minimise exposure.	**Equipment designers and the public need to be informed of the simple steps that can be taken to reduce electromagnetic fields.**

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