

Draft for the Precautionary Principle Workshop

1. Introduction

The Precautionary Principle

“ We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology.”

This observation by Carl Sagan helps explain why scientific and technical innovations can be both welcomed and feared, often by the same people; and why the pace of technological change, like a roller-coaster ride, can generate excitement and fear in equal measure. Indeed there have been few technical developments so benign as not to be accompanied by some risk. By passing laws and promoting cautionary advice society tries to minimize these risks, while still enjoying the benefits. In making this risk-benefit trade-off society is guided by its culture, its traditions, its experience and its scientists. This arrangement works well when there has been time for experience to accumulate and scientists are trusted. When, however, the risk is a new one, where its impact cannot be gauged, and where trust in science has declined, we enter the province of the Precautionary Principle.

The Precautionary Principle is intended to prevent or limit the possible harm caused by agents or activities before it has been established that the activity or exposure constitutes a harm to health. As threats to human health and the environment become more complex, uncertain, and global in their nature and while recognising that injudicious measures could lead to disruptions to trade and other unanticipated costs, the value of adopting the Precautionary Principle as a risk management tool in providing guidance in this environment is under active debate[1].

Possible health effects arising from exposure to extremely low frequency (ELF) electromagnetic fields (EMF) have been the subject of research for many years, but without definitive scientific resolution. At radio frequencies (RF), the rapid growth of new technologies such as mobile wireless telecommunications has raised concerns that exposure to fields from mobile phones and base stations could have long-term health consequences.

Given the widespread exposure of the general public and of workers to ELF and RF fields, this workshop will focus on these regions of the non-ionizing frequency spectrum as candidates for application of the Precautionary Principle. The two key questions are:

- Should the Precautionary Principle be invoked for ELF and/or RF fields?
- If so, how do we decide what actions should be taken?

The workshop

The aims of the workshop are threefold:

- *to arrive at a common framework for the Precautionary Principle,*

- 46 - *to apply this framework to human health effects from exposure to electromagnetic*
47 *fields and specifically to develop two case studies for ELF and RF fields, and*
48 - *to recommend risk management approaches for ELF and RF fields.*

49

50 The workshop brings together scientists, engineers, lawyers, health professionals and
51 concerned citizens with knowledge of the Precautionary Principle to contribute
52 perspectives from health, government, academia, environmental advocacy groups and
53 industry. The European Commission text, published in 2000, has been used as one of the
54 key starting points for this Working Group report on the application of the Precautionary
55 Principle [2].

56

57 *Outputs of the workshop will include the proceedings, containing all of the*
58 *presentations given at the open session, and a scientific article summarizing the*
59 *results and conclusions of the working group meeting. In addition, the meeting*
60 *results will contribute to the WHO International EMF Project's development of*
61 *policy options for EMF, and to general WHO policy on the use of Precautionary*
62 *Principle on health issues.*

63

64 **2. Objectives of the Precautionary Principle**

65 ***Protecting public health***

66 When developing policies and actions to protect public health it is important that the
67 definition of health is clearly stated. WHO defines **health** as a *state of complete*
68 *physical, mental and social well being and not merely the absence of disease or infirmity.*
69 Public health policies have always had measures aimed at disease prevention. These
70 measures can be extended to include potential risk factors that have not yet been
71 established as the cause of the effect or where much uncertainty remains. In this way the
72 Precautionary Principle can be naturally integrated within public health policy and
73 actions.

74

The Precautionary Principle is

75

76

77

78

79

80

***a risk management concept that provides a flexible approach to identifying and
managing possible adverse consequences to human health even when it has not
been established that the activity or exposure constitutes harm to health.***

81

Objectives of the Precautionary Principle in health policies

82

83

84

85

86

87

88

89

90

There are three important reasons to invoke the Precautionary Principle within a public health policy:

- to be more anticipatory in terms of health and dealing with unknowns,
- to address public concern, which may be more directed at ensuring a potential problem is not ignored, in contrast to scientists who are often reluctant to give credibility to unproven possibilities. The Precautionary Principle can provide a framework within which these different positions can be reconciled.
- to provide an alternative to exclusively technology-based environmental management, in order to bring ethics into the discussion and give environmental

91 rights a voice. The Precautionary Principle may also challenge the singularity of
92 strictly financial cost-benefit analysis as a decision-making tool.

93

94 While appropriate action should be taken even when there is lack of scientific certainty,
95 this does not necessarily mean that precautionary measures are required or justifiable
96 when there is no particular evidence, scientific or otherwise, of the presence of possible
97 harm.

98

99 The Precautionary Principle represents an anticipatory approach by nature, and
100 precautionary measures have to be viewed as provisional (or temporary) rather than
101 permanent, i.e. it should be subject to review in the light of new scientific findings.

102 ***Balance between scientific and social considerations***

103 The Precautionary Principle is a risk management tool that is complex in its application.
104 This complexity depends on the degree of scientific uncertainty, the potential severity of
105 harm and the interplay between science and social factors. Risk is a complex social
106 construct and its many facets can lead to different responses by individuals and to diverse
107 reactions by the various stakeholders to the proposed risk-management options. The
108 general public and scientists differ in their willingness to make a mistake about the
109 existence of risk. Scientists usually require considerable certainty before accepting that a
110 risk is real. This attitude is embodied in hypothesis testing used to evaluate statistically
111 whether a risk is real or not. Conceptually, scientists will normally support a positive
112 association (i.e. the risk is real) if the probability that the risk has arisen by chance is
113 below 5%. Scientists are also often willing to 'miss' a real association (i.e. conclude the
114 risk does not exist, when it actually does) with a probability of 20%. The public,
115 however, is more concerned that any potential hazard or risk is not overlooked,
116 irrespective of statistics. The Precautionary Principle needs to recognise these issues, and
117 whilst remaining based on scientific evidence, must recognise the validity of social
118 concerns as well.

119

120 ***Relation between Exposure Standards and the Precautionary Principle***

121 All international and nearly all national guidelines limiting human exposure to EMF are
122 based on health effects established by research results that are consistent, reproducible
123 and confirmed by different laboratories. In addition, the exposure limits and guidelines
124 incorporate safety factors to allow for some of the uncertainty in the thresholds for these
125 established effects.

126

127 Thus, broadly speaking, Exposure Standards apply where there is scientific certainty,
128 whereas the Precautionary Principle applies where there is uncertainty. The two should
129 not be in conflict. The Precautionary Principle can provide a helpful framework to allow
130 possibilities to be considered which would be excluded from the approach employed to
131 develop traditional exposure limits. Nonetheless, where international guidelines exist, it
132 is important that the application of the Precautionary Principle does not undermine the
133 scientific basis of the limits.

134

C

O

N

A

C

E

M

135 *Different ways of deciding on precautionary actions*

136 It is worth repeating that the objective of applying the Precautionary Principle is to
 137 deliver appropriate protective measures against uncertain hazards. Just as is the case with
 138 established hazards, the protective actions must be appropriate and proportionate. Not all
 139 established hazards are important enough to justify regulation. Even in dealing with
 140 established hazards, there has to be a weighing-up of the benefits and the costs of
 141 regulation. These costs will usually include ones that cannot be quantified easily in
 142 money terms (e.g. the value of a life). These factors apply equally when considering the
 143 precautionary actions to be taken in relation to uncertain hazards.

144
 145 Central to the application of the precautionary principle presented here is a balancing of
 146 the consequences and benefits. This is conventionally referred to as cost-benefit analysis.

147 Later sections discuss how “cost” is used in a wider sense than just financial. Nor does a
 148 cost-benefit analysis imply that the approach taken is purely utilitarian. Issues of social
 149 justice between individuals and communities, and ethical factors such as whether
 150 exposure is voluntary or involuntary, are also included. What is advanced here is an
 151 approach that allows all these different facets of health protection to be accommodated in
 152 a framework that nonetheless allows objective and defensible decisions to be made.

153
 154 Precautionary approaches to EMF have already been advocated and adopted in various
 155 countries. These have rarely involved an adequate balancing of consequences and
 156 benefits. Instead, most existing approaches have tended either to specify the costs to be
 157 incurred, without balancing these costs against the benefits, or to set out the intended
 158 benefits without regard to their cost.

159
 160 Examples of approaches that specify costs without placing a value on the benefits
 161 include:

- 162 • Requiring a certain percentage levy on the cost of a project to be spent on EMF
 163 mitigation measures, as has happened with some new transmission line projects
- 164 • Requiring a fixed sum to be spent on EMF mitigation in a defined situation, such as
 165 providing money to schools to be used to reduce exposures
- 166 • Advocating a variety of low-cost measures to reduce emissions or public exposures to
 167 EMF

168
 169 Examples of approaches that, on the other hand, provide defined benefits without regard
 170 to costs include:

- 171 • Setting precautionary exposure limits (e.g. 1 μ T or 0.5 μ T)
- 172 • Advocating measures to reduce exposures (e.g. time limits on use of mobile phones
 173 or restrictions on children’s use of phones)
- 174 • Requiring exposures to be reduced by a stated amount or percentage compared to
 175 what they would have been previously
- 176 • Requiring exposures to be no higher than those already existing in an area
- 177 • Requiring use of best-available technology to reduce or minimize exposures

178
 179 These examples of ways employed to reduce public exposure to EMF can be described as
 180 measures which reflect the policy of “prudent avoidance”. “Prudent avoidance” is an
 181 umbrella term for approaches that favour taking whatever field-reduction measures may

C

O

N

A

C

E

M

182 be possible subject to the cost being financially “modest”. Prudent avoidance therefore
183 fits in the category of setting (modest) costs without valuing or quantifying the benefits.

184

185 These approaches can not be completely satisfactory, as none properly weigh up or
186 balances costs and benefits. With some of these schemes, costs and benefits are weighed
187 implicitly rather than to a specific individual situation. For example, a decision to
188 recommend 4% as an appropriate fraction of project cost to be applied to EMF reduction,
189 could in principle be the result of a balancing of costs and benefits. However, this
190 balancing, if done at all, could only have been done in a general way, averaged over
191 many projects. There would be particular projects where 4% of the project cost could
192 yield huge reductions in exposures and others where little reduction, if any, is possible.
193 Thus, whilst each of these approaches may at times be able to generate the appropriate
194 precautionary actions, there would also be situations where each generates inappropriate
195 actions, and are therefore unsatisfactory.

196

197 Once a correct and full application of the Precautionary Principle has been achieved it is
198 recognized that there may be value in expressing conclusions in a form that makes them
199 readily applicable to practical situations. Such simplified “action rules” could look
200 similar to some of the existing schemes listed above, but would differ in that (a) they
201 would apply only to the limited and specified range of circumstances for which they are
202 valid, and (b) they would follow from the full application of the Precautionary Principle,
203 rather than reflect some arbitrary position.

204

205 As an example of “action rules”, a new proposed Charter between city halls and mobile
206 phone operators has been developed by the French government [3] for improved
207 management of new mobile phone mast installations. A number of administrative
208 actions are initiated, based on criteria designed to evaluate the impact of a new base
209 station, which include technical details concerning location (e.g. distance to urban areas,
210 proximity to school) and social impact (e.g. aesthetics and public reaction).

211 **3. When to apply the Precautionary Principle**

212

213 Risks are present in all aspects of our lives, and there will always be some uncertainty
214 associated with those risks. As individuals and as a society we regularly make decisions
215 under uncertainty, without a full knowledge of the extent of the risk. While the
216 possibility of risk does not in itself require action, uncertainty in itself does not justify
217 inaction. The question then is: “When to act?” What **strength of evidence** is required to
218 trigger action or invoke the Precautionary Principle? (e.g. a possible cause, no conclusive
219 scientific proof, or sufficient evidence).

220 ***Risk Analysis***

221 The analysis of risk encompasses three main elements, namely risk assessment, risk
222 management and risk perception. Within this framework, the Precautionary Principle is
223 relevant when considering the range of **risk management** options available. To be
224 effective it must take into account both measured and perceived risk.

225

226 Several factors add to the public’s perception of risk, and increase the potential for
227 concern. The following factors, developed in a German report [4], are expanded and
228 adapted here to the EMF issue:

C

O

N

A

C

E

M

- 229 • **Extent of damage:** Adverse effects can be quantified in different ways, depending on
230 the end-point considered (e.g. in terms of number of lives lost to cancer, or
231 production losses from electrically hypersensitive (EHS) people who cannot work
232 due to their condition).
- 233 • **Probability of occurrence:** The existence of a potential adverse effect from an
234 environmental exposure could trigger the Precautionary Principle. Knowledge of the
235 probability of the adverse effect as a function of the level of exposure greatly
236 enhances decisions; these probabilities are one of the most uncertain aspects of risk
237 assessment, especially for EMF.
- 238 • **Uncertainty:** Uncertainties exist at every level of evaluation, from uncertainty about
239 the presence of a hazard to uncertainty in the levels of exposure a person receives.
240 The relevant metric is the most important uncertainty for the application of the
241 Precautionary Principle to EMF.
- 242 • **Ubiquity:** Most common EMF exposures come from the use of cell phones and
243 appliances as well as from electrical wiring in and outside of homes and proximity to
244 mobile phone masts in urban areas. Ubiquity of this exposure is an important driver
245 for the Precautionary Principle.
- 246 • **Pattern of Exposure:** In general, pattern of exposure including length, intensity, and
247 fractionation can play a key role in their influence on disease incidence. This could
248 be due to the existence of a threshold, complex dose-response pattern and adaptive
249 response. Potential differences in effects due to low long term exposures from power
250 lines and base stations vs. more intermittent but much higher exposure from
251 appliances and cell phones have been suggested but not adequately examined.
- 252 • **Delayed effect:** Latency is the time between the initial exposure and evidence of
253 disease. One of the main diseases of interest is cancer, which has latency from
254 several years to decades. Thus, consideration of latency is important, particularly in
255 the case of cell phones, where ubiquitous exposure is recent and where potential
256 development-of brain cancer might be years away, thus calling for an anticipatory
257 consideration of the Precautionary Principle.
- 258 • **Inequity and injustice** associated with the distribution of risks and benefits over
259 time, space and social status (e.g. routing of power lines or erection of base stations
260 in low-income areas)
- 261 • **Psychological stress and discomfort** associated with the risk or the sources of risk
262 (e.g. people particularly sensitive to EMF). This has clearly been a driver for the
263 application of the Precautionary Principle to EMF
- 264 • **Potential for social conflict and mobilization:** Degree of interest and pressure from
265 advocacy groups and associations. Again, this has occurred with the EMF issue,
266 especially when new facilities such as base stations or power lines are proposed or
267 built.
- 268 • **Voluntary vs. involuntary exposure:** People feel differently about risk when the
269 choice is theirs. For EMF, higher exposures from cell phones and appliances have
270 been of less concern to the public than lower but involuntary exposures from base
271 stations and power lines.

272 *Scientific Uncertainty*

273 While the Precautionary Principle applies by definition to situations characterized by
274 scientific uncertainty, its application to the EMF issue is especially problematic, because
275 there is uncertainty not only as to whether exposure is associated with increased risk or
276 not, but also:

C

O

N

A

C

E

M

277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304

- **Uncertainty about the magnitude and specificity of the risk.** The risk from exposure to EMF, if real, could be small but affect a large number of people. Alternatively, the risk could be large but affect only a small number of susceptible individuals. Other possibilities might include simultaneous exposure to another factor. Different possible relationships between risk and exposure may require different precautionary measures to reduce risk, making application of the Precautionary Principle particularly difficult.
- **Uncertainty as to which aspect of exposure might be harmful.** Certain actions, while reducing some aspects of exposure, might inadvertently increase risk by increasing some other, as yet unknown, aspect that might turn out to be the true cause. The concept of precautionary action is often rooted in the assumptions that less exposure is better and that reducing one aspect of exposure will also reduce other aspects that might be harmful. Neither of these assumptions, in the context of electric and magnetic fields, is necessarily valid. In fact, some laboratory research has suggested that biological effects due to EMF can vary within windows of field frequency and intensity. While such a complex and unusual pattern is unlikely and would defy most accepted tenets of toxicology and epidemiology, the possibility that it may be real must be considered when applying the Precautionary Principle to EMF.

The absence of a clearly elucidated, robust, and reproducible mechanism of interaction of EMF with biological systems and the plethora of field characteristics that could be relevant, make avoidance strategies that fall short of eliminating EMF exposure entirely both difficult to analyze and potentially counterproductive. Complete elimination of exposure could only be accomplished if no one were to use electricity or modern communications technology.

305 *Triggers for the application of the Precautionary Principle to EMF*

306
307
308 The Precautionary Principle should be invoked when:

- there is good reason, based on empirical evidence or a plausible causal hypothesis, to believe that harmful effects to people might occur, even if the likelihood of harm is remote; and
- a scientific evaluation of the consequences and probabilities reveals such uncertainty that it is **not yet possible** to assess the risk with sufficient confidence to inform decision-making.

315
316 *adapted from the UK Interdepartmental Liaison Group on Risk Assessment [5]*

317
318
319
320
321
322
323
324

There are three factors that might, in general, trigger the application of the precautionary principle:

- Recognition that there is objective scientific evidence that amounted to the possibility of a health risk. This is the situation where (as is the case with ELF magnetic fields) the International Agency for Research on Cancer (IARC) or a body with equivalent status classifies an agent as “possibly carcinogenic” or “possibly” a cause of other

C

O

N

A

C

E

M

325 forms of ill health. Where there is no such classification, applying this criterion is
326 less objective and less satisfactory.

327 • A recognition that there may be a very low cost intervention available, in which case
328 an action may be justified even when the scientific evidence is weak, specifically
329 when it is too weak even to be classified as “possible”. This is the case for the use of
330 hands-free devices for mobile phones and limiting the amount of time children spend
331 on these phones. This criterion needs to be applied with care to ensure that an
332 apparently “low cost” option really is low cost. In principle, no matter how low the
333 apparent cost of an intervention, at least a rudimentary cost-benefit analysis should be
334 undertaken.

335 • Public pressure. This would often result in consideration of precautionary actions
336 even in circumstances where the evidence is weak and subjective, but nonetheless
337 must be recognized as a practical consideration.
338

339 Note that these are triggers, not for *taking* precautionary action, but for *applying* the
340 Precautionary Principle, that is, for making a detailed assessment of the benefits and
341 consequences of action that may or may not be taken. The Precautionary Principle, when
342 applied properly, should not result in unjustifiable or disproportionate actions. Therefore,
343 in principle, it can be applied no matter how weak the evidence. The reasons for
344 requiring a trigger are pragmatic; applying the Precautionary Principle properly entails
345 much work. There is always the possibility of a superficial application resulting in
346 inappropriate actions. It is therefore sensible not to invoke the Precautionary Principle
347 without adequate justification.
348

349 **In the EMF context, there is sufficient evidence, judged against these criteria, to**
350 **invoke the Precautionary Principle both for extremely low frequencies (ELF) and**
351 **radio-frequency (RF) electromagnetic fields.** This conclusion is based on several
352 factors:

- 353 • the classification by IARC in 2001 of ELF magnetic fields as a possible carcinogen
354 based on studies of childhood leukaemia
- 355 • the comparable radiation levels of existing mobile phones to established international
356 guidelines,
- 357 • the availability of some low cost exposure reduction options
358

359 Initially, the Precautionary Principle needs to be applied separately to each health end-
360 point being considered, as the calculations and hence conclusions can be quite different.
361 However, once this is completed, the potential benefits accruing from each given
362 exposure reduction need to be aggregated over all the different health outcomes being
363 considered, so as to obtain the overall benefit.
364

365 *Legal context of the precautionary principle*

366 In some societies or sections of society, there is a reticence to adopt precautionary
367 measures in case this is seen as an admission that the health risk is real. In part, this
368 concern relates to public perception of the issue. This concern can be ameliorated, though
369 not necessarily completely removed, by sensitive communication. In part, however, the
370 concern is legal: that adopting precautionary measures could be construed as an
371 admission of liability; that it might be taken to imply responsibility for similar exposures
372 prior to taking precautionary action; and that it may put the person or company taking

373 such actions in the position of having to justify, in a legal arena, why they took the
374 actions they did and did not go further.

375

376 Such concerns about liability and admissions are detrimental to optimum operation of the
377 Precautionary Principle and hence to optimum protection of public health. As far as
378 possible the Precautionary Principle should be implemented in a way that is free from
379 such legal connotations. How this is achieved will depend on the legal and regulatory
380 frameworks of the countries concerned.

381

382 **4. General Considerations for the Precautionary Principle**

383

384 Where action is deemed necessary, measures based on the Precautionary Principle should
385 take into consideration a number of application criteria. As set out by the EU (1) the
386 criteria are: proportionality, non-discrimination, consistency, an examination of the
387 benefits and costs of action or lack of action, a review in the light of new scientific
388 developments, and assignment of responsibility for producing the scientific evidence
389 required for a further risk assessment.

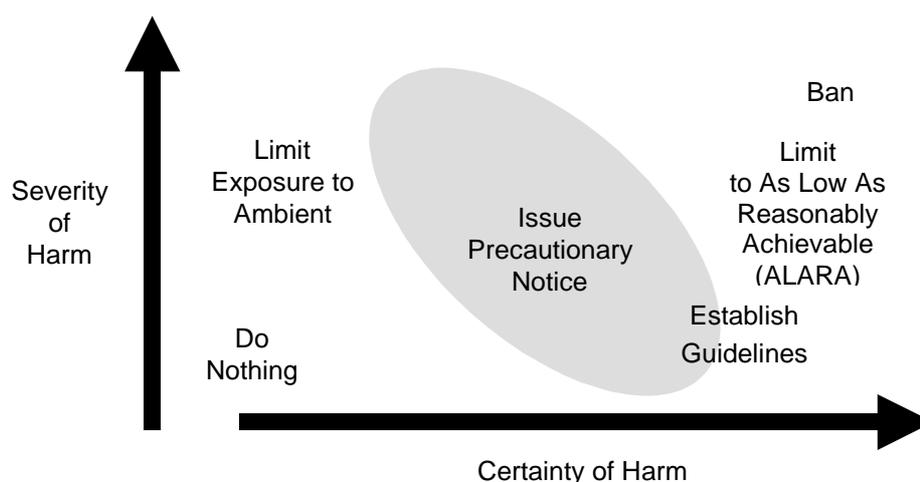
390

391 As a general criterion, special consideration should be given to precautionary measures
392 for sensitive populations, especially children. This is both because children might be
393 more susceptible to environmental exposures and because of a societal value judgement
394 that children deserve greater protection. In quantitative risk assessment additional
395 “safety” or “uncertainty” factors are invoked for children and, in absence of data to the
396 contrary, should be applied in the same way for exposures to ELF and RF.

397 ***Proportionality***

398 “Proportionality” means tailoring to the chosen level of protection. Risk can rarely be
399 reduced to zero, and a total ban will not be a proportional response to a potential risk in
400 all cases. The range of options are given in Figure 1(adapted from [6]).

401



402

403 Figure 1 - Range of actions under uncertainty. The shaded area shows combinations of
404 severity and certainty of harm for which the precautionary principle may be useful.

405

406 In the final analysis, the chosen level of protection will be a political decision that will
407 depend on many factors, among them the nature of the adverse health effects being
408 considered.

409 *Non-discriminatory*

410 “Non-discriminatory” means that comparable situations should not be treated differently,
411 and that different situations should not be treated in the same way, unless there are
412 objective grounds for doing so. Exposures to ELF come from multiple sources that are
413 often the responsibility of different organizations. Radio-frequency exposures come
414 from all radio transmitters, including TV and radio, as well as mobile phone handsets and
415 base stations. All such sources of exposure should be given equal consideration. While
416 it may still be legitimate to decide to implement interventions that affect one source and
417 not others, this is only justifiable following a fair process of assessment, and not simply
418 the consequence of administrative convenience, political expedience, or public relations.

419
420 In the absence of information to the contrary, one must assume that biological effects due
421 to EMF exposure do not differ between countries. Therefore, any precautionary
422 measures should be considered equally in different countries, although the conclusions
423 reached may well differ as a result of different philosophies, priorities and costs involved.

424 *Consistency*

425 “Consistency” means that the measures should be of comparable scope and nature to
426 those already taken in equivalent areas where all scientific data are available. Most
427 societies have frameworks for deciding when and how to intervene when dealing with
428 established risks. The Precautionary Principle should not be used to justify actions
429 beyond those that would be taken for an established risk. In many developed societies, a
430 known risk of cancer to an individual member of the public greater than one in ten
431 thousand per year would usually be subject to regulatory action. Actions taken for more
432 subjective outcomes such as headaches or sleeplessness are less quantified.

433 *The benefits and costs of action or inaction*

434 Examining the benefits and costs of action or lack of action requires an estimate of the
435 overall cost to the community in both the short and long term. This is not simply a
436 narrow economic cost-benefit analysis: its scope is much broader, and includes non-
437 economic considerations, such as the efficacy of possible options and their acceptability
438 to the public. However, given that economic costs, non-economic consequences, and
439 health effects are quite disparate concepts, some common measure must be adopted to
440 allow comparisons. The only realistic method is to equate all consequences and benefits
441 to a financial quantity such as money, **recognizing that this is only to facilitate the**
442 **comparisons of options and does not imply that all consequences can actually be**
443 **reduced to financial values.** In the conduct of such an examination, due account should
444 be taken of the general principle that protection of health takes precedence over economic
445 considerations. This is discussed in greater detail in Section 5.

446 *Subject to review*

447 Precautionary measures should be temporary: they apply only for as long as scientific
448 uncertainty persists. They should therefore be periodically reviewed in the light of
449 scientific progress, and amended as necessary. Thus continuing scientific research is
450 often needed and cost-effective.

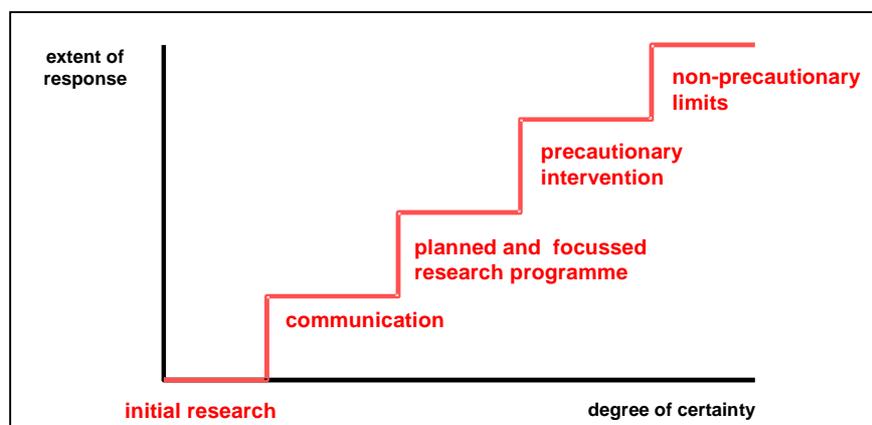
451 ***Capable of assigning responsibility***

452 A corollary to the need to review precautionary measures periodically to see if they are
 453 still justified by the state of scientific uncertainty is that responsibility should be assigned
 454 for gaining new scientific knowledge and for reviewing it. Industry and Government
 455 should share the responsibility for reducing uncertainty, because the benefits of reducing
 456 uncertainty would not be limited to the industry. Furthermore, shared responsibility is
 457 likely to lead to a more focused and credible research. It is often efficient to pool
 458 resources to fund research and have it managed by an independent institution. There are
 459 several successful examples of this shared effort in the EMF area. As additional
 460 scientific information, becomes available, individuals and industry may change their
 461 behaviour, while the responsible government department could make recommendations
 462 on whether to amend any precautionary measures that have been put in place.

463 **5. Developing a comprehensive action plan**464 ***Identify possible actions under the Precautionary Principle***

465 Generally speaking, there will be a sequence of possible actions under the Precautionary
 466 Principle, which would be invoked successively should the evidence for a health risk
 467 emerge. Weak evidence usually justifies communication and information provision;
 468 better evidence would warrant a planned and focussed research programme; while strong
 469 evidence would justify the introduction of precautionary actions to reduce exposures.
 470 Ultimately the issue moves beyond precaution into formal protective exposure controls.

471
 472



473
 474
 475
 476
 477
 478
 479

Figure 2 – Extent of response under uncertainty

477 Action under the Precautionary Principle depends not only on the strength of evidence
 478 but also on what potential actions are available.

480 At one extreme, banning an agent or activity will depend on whether or not an alternative
 481 is available. If so, the implications of the alternatives for potential health effects, costs
 482 and benefits must be evaluated. Where no alternative is available, the evaluation needs to
 483 focus on the benefits provided by the agent or activity against its potential detrimental
 484 effects. Clearly, the use of electricity, mobile phones and other goods and devices that
 485 produce EMF has clear benefits not only in terms of convenience but also for their
 486 positive contributions to health. Forsaking the use of electricity is not a viable option.

487 Consideration of the Precautionary Principle in the case of EMF therefore must focus on
488 an evaluation of the available options to reduce exposure rather than an elimination of the
489 exposure.

490
491 At the other extreme, the option of doing nothing should be also evaluated employing a
492 similar methodology. Although ‘doing nothing’ is often assumed to be the most benign
493 option, it can incur substantial costs. Increase in public concern and anxiety can produce
494 both adverse health consequences and higher economic costs as illustrated by the current
495 difficulties in rolling out 3G mobile phone technology.

496
497 Between these extremes, a range of other actions and interventions needs to be
498 considered. Some will carry minimal costs. For example, the reduction of exposure to
499 EMF from appliances and mobile phones can be achieved through a personal decision to
500 limit use or to reduce proximity to the appliances. To invoke such measures would
501 require less evidence than would be needed for more costly actions.

502
503 In some circumstances it may be that actions to minimize the seriousness of the health
504 outcome are viable and should be evaluated as alternatives to actions to reduce exposure.

505
506 Each possible intervention needs to be separately identified and assessed. Different
507 considerations apply to different interventions. Likewise, the retrospective application of
508 the same intervention and its application to a new construction also need separate
509 assessment.

510 *For each candidate intervention, assess the costs and consequences*

511 The consequences of an intervention can be broken into three components:

- 512
- 513 - **Initial cost:** This is the actual cost of implementing the intervention. In the EMF
514 context this is, for example, the cost of burying a power line, moving a service panel,
515 designing a cell phone of lower power, or supplying a hands-free kit.
 - 516 - **Ongoing cost:** Some interventions will create ongoing costs. For example, a split-
517 phase distribution line may be more expensive to maintain; and an underground
518 power line may have greater electricity loss. Alternatively, the ongoing “costs” may
519 actually constitute financial benefit when the intervention results in plant with a
520 longer life or greater efficiency as a result of newer technology.
 - 521 - **Consequential costs:** These encompass all remaining costs of the intervention.
522 Again, there may be benefits as well as costs. Consequences to consider include
523 effect on property values, changes to reliability and security of supply, safety
524 consequences from the implementation or operation of the intervention, any further
525 effect on concern or anxiety in the public’s willingness to use the modified activity or
526 service, and any legal liabilities created or averted.
- 527

528 As already stated, in order to facilitate comparisons it is necessary to reduce all costs to
529 financial values. It is recognised that this is an imperfect measure. Furthermore, the cost
530 calculations based on current technology tend to be an overestimate as innovation often
531 leads to cheaper solutions when these are needed.

532
533 It is assumed that the final assessment of costs and benefits will be performed at the level
534 of a whole society, ideally by Government. It will therefore encompass all costs

535 regardless of who might bear them, be they on industry, electricity users, cell phone
536 users, homeowners, taxpayers or others. Costs always have consequences, not least
537 through the established association between disposable income and health. The proper
538 application of the Precautionary Principle must address those consequences.

539 ***For each candidate intervention, assess the putative benefit***

540 At this stage the assumption is that there is actually a health risk. We are now assessing
541 the benefit arising from the elimination or reduction of the health risk under
542 consideration. The uncertainty as to whether the risk actually exists is dealt with later.

543

544 There are two stages involved in assessing the putative benefit:

545

546 Stage One

547 Firstly the effect of the intervention under consideration on the exposures is assessed.
548 This can be quite complex. An intervention may have different effects on different
549 aspects of exposure (the risk offset). In the power-frequency context, some interventions
550 will reduce both average and peak exposures, and possibly affect many other exposure
551 parameters as well, though to a different extent. Other interventions may reduce average
552 exposure but increase peak exposure. For cell phones, hands-free devices reduce
553 exposure to the head but may increase exposure to other parts of the body.

554

555 Secondly, an intervention may re-distribute exposures among different people or
556 populations (risk transfer). For example, moving a service panel in a school may reduce
557 prolonged exposures to a group of children in one classroom but increase short-term
558 exposures to a larger group of children elsewhere in the school. Even more complex is
559 the choice between building more small base stations in highly populated areas or a lesser
560 number of more powerful transmitters on the outskirts of the cities.

561

562 Thirdly, an intervention focused on new facilities might have unintended consequences.
563 If the building of new facilities becomes too expensive, a decision not to build a new
564 power line or link will increase loads and hence EMF in the vicinity of the existing
565 networks. Similarly, the inability to build new mobile phone base stations will increase
566 the traffic at the existing ones. In principle, it is necessary to capture a complete picture
567 an intervention has on the pattern of exposures across the population. In practice, this is
568 never totally possible. However it is important to avoid assuming that the consequences
569 can be adequately expressed in terms of a single number representing reduced exposure.

570

571 Stage Two

572 Firstly, available information on the exposure-response for the health endpoint under
573 consideration should be assessed. Inevitably, given that the Precautionary Principle
574 applies only where there is lack of certainty, there will be uncertainty in this exposure-
575 response relationship that needs to be quantified and carried forward.

576

577 It is then possible to combine the impact of the candidate intervention on exposures with
578 the exposure-response to assess the consequences the intervention would have for risk or
579 incidence of disease. Given the uncertainty in the exposure-response relationship, and
580 the different effects an intervention may have on different aspects of exposure, there will
581 also be a degree of uncertainty in the estimate of the reduction in risk. Where an

582 intervention reduces one aspect of exposure whilst increasing another, there may even be
583 a finite probability that an intervention might increase risk rather than reduce it.

584

585 The reduction in risk needs to be expressed in units that make clear whether it is per
586 person affected, per member of some defined affected population, or applies to the whole
587 population. In addition, the outcome of interest needs to be clearly specified: for instance,
588 different answers will be obtained if the outcome is defined as number of fatalities, as
589 opposed to disease incidence or to years of life lost. In general, disease incidence is the
590 preferred parameter, provided childhood disease is given appropriate emphasis
591 elsewhere. National governments however could choose to put the emphasis on other
592 measures of the outcome.

593

594 ***Value for the reduction in risk/disease***

595 As already stated, there should be no intent to place an actual financial value on a human
596 life or on disease. However, it is necessary to assign a notional figure to allow
597 comparisons and decisions. In fact, many societies already use figures for the “value of a
598 fatality prevented”. This approach is used in assessing highway improvements, for
599 example. This tends to be an empirical figure rather than a principled statement. It is an
600 observation that societies, when faced with competing priorities in the health and safety
601 arena, generally do have to employ a rule of thumb in assessing and prioritising specific
602 proposals.

603

604 Because this figure representing the value of a fatality prevented stems from an
605 observation of what societies are prepared to spend money on, it varies with the
606 circumstances. Societies exercise valid value judgements and are prepared to spend more
607 on preventing fatalities where the person concerned has no choice in facing the risk,
608 where the potential fatality affects children, and where the fatality arises from a
609 particularly dreaded disease, such as cancer. Therefore the value a society will attach to
610 preventing a fatality will be more for EMF, where all three criteria apply, than for
611 highway engineering where, essentially, none apply.

612

613 Even more difficult is the evaluation of softer outcomes such as headaches and
614 sleeplessness that are reported by some to be associated with living near to base stations.
615 These outcomes are not only difficult to study; their costs to society and individuals are
616 also highly uncertain.

617

618 ***Allow for the uncertainty in whether there actually is a risk or not***

619 The figure derived for the value a society places on the reduction of risk or disease
620 arising from a particular intervention assumes the reduction would actually occur, i.e.
621 there is an established risk. Where, as with application of the Precautionary Principle,
622 the risk may not actually exist, it is necessary to adjust this figure. Conceptually, it
623 becomes necessary to derive a figure for the likelihood that the exposure actually does
624 cause the disease. This likelihood could then be incorporated in the analysis in various
625 ways. The simplest approach is to multiply the benefit (the reduction in risk or disease)
626 by the probability it actually occurs. This purely utilitarian approach should be the
627 starting point, despite its shortcomings.

628 ***Compare the costs and benefits***

629 Once measures of the benefits and costs of each candidate intervention are obtained, they
630 can be compared to assess which interventions are justified.

631

632 The utilitarian approach would be to reduce exposure until the cost of the last reduction
633 equals its benefit. However, society may wish to err on the side of caution and incur
634 greater costs, in excess of the expected benefit. This may be the case for all risks, but is
635 particularly relevant as an insurance policy against a small risk of a serious consequence,
636 and may apply in particular to circumstances involving involuntary exposure, exposures
637 of children, and to certain diseases. This is a value judgement and is entirely legitimate,
638 and can either be taken into consideration at this stage by making the test for comparing
639 costs and benefits “not disproportionate” rather than “equal” or at the earlier stage of
640 deriving a value for a fatality prevented. Obviously this factor must be included only
641 once and not at both places in the analysis.

642

643 While some costs will arise only once, others are on going as, in general, are the benefits.

644 The applied costs and benefits must therefore be discounted using an appropriate model.

645 Any attempt to restrict the comparison of costs and benefits to a fixed time period would
646 be arbitrary and unsatisfactory.

647

648 Uncertainties that have arisen at each stage of the process should have been carried
649 forward to this point. Therefore, as well as providing a single answer to the question: “Is
650 this intervention justified?” there will also be a measure of the robustness of this answer.

651 If the uncertainties are considerable, a decision as to whether an intervention is justified
652 may be rather marginal.

653

654 **6. Discussion**

655

656 If the application of the Precautionary Principle has been completely logical and
657 rigorous, and if similar logic and rigour apply to all other areas of health and safety, then
658 the answer reached will be the correct one, whether viewed in isolation or when
659 compared to practice elsewhere. However, given that in matters involving human
660 judgement on emotive issues strict logic may not always be followed, it is sensible to
661 apply three “reality checks” to the conclusions reached on those interventions which are
662 initially considered justified.

663

664 The following questions need to be asked:

665 (i) Is the result consistent with decisions on action or inaction taken in other
666 areas of health protection?

667

668 In other words, as was discussed in the EC 2000 Communication, “Is the
669 action *consistent with the chosen level of protection*? It is hard to organise or
670 logically rationalise standards of health and safety protection, which have
671 often been developed piecemeal. However, in many societies it would be
672 safe to say that a known risk to an individual of less than one in a million per
673 year would be unlikely to attract regulatory action or require intervention. On
674 the other hand, in many developed societies, an identified risk to members of
675 the public greater than one in ten thousand per year would usually be enough

C

O

N

A

C

E

M

C

O

N

A

C

E

M

676 to bring about regulations aimed at reducing the risk. Risks posed by EMF
677 need to be assessed against these criteria. Precautionary interventions would
678 probably be unacceptable if the risk, even if true, were too small.

679

680 (ii) Is the result fair and just?

681

682 A conclusion to route power lines or build additional base stations among
683 deprived communities, even if it is more cost-effective, would probably be
684 unacceptable on social justice grounds. There are many situations where
685 society adopts measures for the overall benefit of the community but where
686 the burden falls disproportionately on subsections of society. However, any
687 such suggestions should be particularly suspect if the burden concerned
688 involves an extra risk to health, or if the subsection of society concerned is
689 already disadvantaged.

690

691

692 (iii) Is the “opportunity cost” acceptable?

693

694 Money spent on EMF reductions is money not available for spending on other
695 health improvement measures: there is therefore an opportunity cost. The
696 “opportunities” will, of course, depend on who is doing the assessment.
697 Electric power and telecommunications industries have a limited horizon of
698 opportunities that mainly revolve around their own employees and the
699 communities they serve, whereas governments can compare EMF problems
700 with the whole range of other health problems that affect their citizens.
701 International organizations, for their part, will compare between developed
702 and developing countries. If separate judgements have been reached on each
703 health issue (including EMF) using the same criteria, there should be no
704 opportunity cost. Nonetheless, this third reality check should still be made.

705

706 **20th February 2003**

707 **Key References:**

708

709 [1] Foster K, Vecchia P and Repacholi M. Science and the Precautionary Principle.
710 *Science*; 288: 979-981 (2000).

711

712 [2] European Commission Communication on “The Precautionary Principle“, 2000,
713 http://europa.eu.int/eur-lex/en/com/cnc/2000/com2000_0001en01.pdf

714

715 [3]Lorrain J-L, Raoul D. Téléphonie mobile et santé. Office Palementaire d’évaluation
716 des choix scientifiques et technologiques, No. 346 Assemblée Nationale and No. 52
717 Sénat, France (2002).

718

719 [4] Klinke A, Losert C, Renn O. The Application of the Precautionary Principle in the
720 European Union. Report from the Workshop on “The Application of the
721 Precautionary Principle”, held in Herrenberg/Stuttgart, Sept. 2001.

722

723 [5] UK Interdepartmental Liaison Group on Risk Assessment, “The Precautionary
724 Principle: Policy and Application”, 2002, <http://www.hse.gov.uk/dst/ilgra/pppa.pdf>

725

726 [6] Kheifets L. et al., “The precautionary principle and EMF: implementation and
727 evaluation“, *Journal of Risk Research* 4 (2), 113-125, 2001.

728

729 **Additional References**

730

731 A Canadian Perspective on the Precautionary Approach/Principle
732 http://www.dfo-mpo.gc.ca/ccpa/HTML/pamphlet_e.htm

733

734 Abelson PA. Risk assessment of low level exposure, *Science*; 265: 1507 (1994).

735

736 Adams MD. The precautionary principle and the rhetoric behind it. *Journal of Risk*
737 *Research*; 5(4): 301-316 (2002).

738

739 Ames BN, Gold LS. Environmental pollution, pesticides and the prevention of cancer.
740 *Faseb J*; 11: 1041-52 (1997).

741

742 Arrow KJ, Cropper ML, Eads GC, *et al.* Is there a role for benefit – cost analysis in
743 environmental, health and safety regulations? *Science*; 272: 221-22 (1996).

744

745 Ashford NA. Implementing a Precautionary Approach in Decisions Affecting Health,
746 Safety and the Environment: Risk Technology Alternatives and Tradeoff Analyses in The
747 Role of Precaution in Chemicals Policy. Freytag E, Jakl T, Loibl G, Wittmann M (eds.)
748 Diplomatic Academy, Vienna, pp 128-140 (2002).

749

750 Ashford N. A Conceptual Framework for the Use of the Precautionary Principle in Law.
751 In Carolyn Raffensperger and Joel Tickner (eds.), *Protecting Public Health and the*
752 *Environment: Implementing the Precautionary Principle*. Washington: Island Press,
753 (1999).

754

C

O

N

A

C

E

M

- 755 Balzano Q and Sheppard A. The influence of the precautionary principle on science-
756 based decision-making: questionable applications to risks of radiofrequency fields.
757 *Journal of Risk Research*; 5(4): 351-369 (2002).
758
- 759 Barrett K and Raffensperger C. Precautionary Science. In Carolyn Raffensperger and
760 Joel Tickner (eds.), *op. Ci*, (1999).
761
- 762 Breyer S. Breaking the vicious circle: towards effective risk regulation. *Harvard*
763 *University Press* (Cambridge, Mass, USA) (1993).
764
- 765 Burgess A. A Precautionary Tale: The British Response to Cell Phone EMF. *IEEE*
766 *Technology and Society Magazine*; 21(4): 14-18 (2002/2003).
767
- 768 California Risk Evaluation Guidelines
769 <http://www.dhs.ca.gov/ehib/emf/RiskEvaluation/riskeval.html>
770
- 771 Cameron J and Abouchar J. The precautionary principle: a fundamental principle of law
772 and policy for the protection of the global environment, *Boston College International*
773 *Comparative Law Review*, XIV 1, 1–27 (1991).
774
- 775 Cranor CF. Asymmetric Information, The Precautionary Principle, and Burdens of
776 Proof. In Carolyn Raffensperger and Joel Tickner (eds.), *op. Cit* (1999).
777
- 778 Cross FB. Paradoxical perils of the precautionary principle. *Washington and Lee Law*
779 *Review*; 53: 851-925 (1996).
780
- 781 Dekay ML et al. Risk-based decision analysis in support of precautionary policies.
782 *Journal of Risk Research*; 5(4): 391-417 (2002).
783
- 784 European Environmental Agency. Precautionary Principle: Late Lessons from Early
785 Warnings. Available on the Internet at:
786 http://reports.eea.eu.int/environmental_issue_report_2001_22/en
787
- 788 Excell P. Choosing Threshold Levels for Electromagnetic Hazards. *IEEE Technology*
789 *and Society Magazine*; 21(4): 32-39 (2002/2003).
790
- 791 Florig K, Bernstein B, Sheppard A et al. Managing Magnetic Fields in California Public
792 Schools <http://www.dhs.ca.gov/ehib/emf/mmffd.html> (2001).
793
- 794 Foster K. The Precautionary Principle – Common Sense or Environmental Extremism?
795 *IEEE Technology and Society Magazine*; 21(4): 8-13 (2002/2003).
796
- 797 Gee D. Late Lessons from Early Warnings. *European Environmental Agency* (2001).
798 http://reports.eea.eu.int/environmental_issue_report_2001_22/en/Issue_Report_No_22.pdf
799
- 800 Godard O. The precautionary principle: matching economic axiomatics and reasoned
801 heuristics to tackle collective risks. 4th Journées Green-Cirano “Environmental and
802 resource economics”, Montreal November 17-18 2000 (2000).
803

C

O

N

A

C

E

M

- 804 Goklany IM. The Precautionary Principle. Washington DC: The Cato Institute (2001).
805
- 806 Goldstein BD. Editorial: The precautionary principle and scientific research are not
807 antithetical. *Environ Health Perspectives*; 107: 594-595 (1999).
808
- 809 Gollier C, Jullien B and Treich N. Scientific Progress and Irreversibility: An Economic
810 Interpretation of the 'Precautionary Principle'. *Journal of Public Economics*; 75(2):
811 229-53 (2000).
812
- 813 Graham JD and Wiener JB. Risk vs. Risk: Tradeoffs in Protecting Health and the
814 Environment, Cambridge, MA: *Harvard University Press* (1995).
815
- 816 Graham JD and Hsia S. Europe's precautionary principle: promise and pitfalls. *Journal*
817 *of Risk Research*; 5(4): 371-390 (2002).
818
- 819 Howard J. Environmental "Nasty Surprise" as a window on Precautionary Thinking.
820 *IEEE Technology and Society Magazine*; 21(4): 19-22 (2002/2003).
821
- 822 Independent Expert Group on Mobile Phones. Mobile Phones and Health. *National*
823 *Radiological Protection Board* (UK) (2000). See:
824 <http://www.iegmp.org.uk/IEGMPtxt.htm>
825
- 826 International Commission on Non-Ionizing Radiation Protection (ICNIRP). Guidelines
827 for limiting exposure to time varying electric, magnetic and electromagnetic fields (up to
828 300 GHz). *Health Physics*; 74(4): 494-522 (1998). See: <http://www.ICNIRP.de/>
829
- 830 Keeny RL and von Winterfeldt D. Appraisal of the precautionary principle applied to
831 electric and magnetic fields. *Journal of Risk Research* 3 (submitted) (1999).
832
- 833 Kourilsky P, Viney G. Le principe de précaution. Rapport au Premier Ministre, Odile
834 Jacob, Paris (2000).
835
- 836 Lave LB. Benefit-Cost Analysis: Do the Benefits Exceed the Cost in Risks, Costs and
837 Lives Save, Getting Better Results from Regulation. Robert W Hahn Editor, Chapter 6:
838 104-122 *Oxford University Press New York* (1996).
839
- 840 Lave LB. Hormesis: implications for public policy regarding toxicants. *Annu Rev Public*
841 *Health*; 22: 63-67 (2001).
842
- 843 Lemons J and Brown DA. The Role of Science in Sustainable Development and
844 Environmental Protection Decisionmaking. In John Lemons and Donald A. Brown (eds),
845 *Sustainable Development: Science, Ethics and Public Policy*. Dordrecht (Netherlands):
846 Kluwer Academic Publishers (1995).
847
- 848 Margolis H. Dealing with Risk, Why the Public and Experts Disagree on Environmental
849 Issues. *U of Chicago Press*, Chicago (1996).
850

C

O

N

A

C

E

M

- 851 Matthews RAJ. Facts Versus Factions: The Use and Abuse of Subjectivity in Scientific
 852 Research. In Julian Morris (ed), *Rethinking Risk and the Precautionary Principle*.
 853 Oxford: Butterworth Heinemann (2000).
- 854 Morris J. Defining the Precautionary Principle. In Julian Morris (ed), *op. cit.* (2000).
 855
- 856 Nair I, Morgan MG, Florig HK. Biological Effects Of Power Frequency Electric And
 857 Magnetic Fields. Background Paper. Office of Technology Assessment, *Congress of the*
 858 *United States*, OTA-BP-E-53 (1989).
 859
- 860 National Board of Occupational Safety and Health, National Board of Housing, Building,
 861 and Planning, National Electrical Safety Board, National Board of Health and Welfare,
 862 Radiation Protection Institute. Low-frequency electrical and magnetic fields: The
 863 precautionary principle for national authorities, *Guidance for Decision-Makers*,
 864 Stockholm: National Board of Occupational Safety and Health (1996).
 865
- 866 Neutra RR. Indications for the surgical treatment of suspected acute appendicitis: a cost-
 867 effectiveness approach. In: *Costs, Risks and Benefits of Surgery*, J. P. Bunker, B. A.
 868 Barnes, and F. Mosteller (eds). New York: Oxford University Press: 277-307 (1977).
 869
- 870 NIEHS. NIEHS Report on Health Effects from Exposure to Power-Line Frequency
 871 Electric and Magnetic Fields. Prepared in Response to the 1992 Energy Policy Act (PL
 872 102-486, Section 2118). *Report No. 99-4493*. Research Triangle Park, N.C.: National
 873 Institute of Environmental Health Sciences, National Institutes of Health (1999).
 874
- 875 O'Brien M. Making Better Environmental Decisions: An Alternative to Risk Assessment
 876 *MIT Press*, Boston (2000).
 877
- 878 Ozonoff D. The Precautionary Principle as a Screening Device. In Carolyn
 879 Raffensperger and Joel Tickner (eds.), *op. cit.* (1999).
 880
- 881 Pearce D. The Precautionary Principle and Economic Analysis. In Tim O'Riordan and
 882 James Cameron (eds), *Interpreting the Precautionary Principle*. London: Earthscan
 883 Public (1994).
 884
- 885 Petrin C and Vecchia P. International Statements and Definitions of the Precautionary
 886 Principle. *IEEE Technology and Society Magazine*; 21(4): 4-7 (2002/2003).
 887
- 888 Porta M. Biologic plausibility in causal inference. *Am J Epidemiol*; 150: 717-718 (1999).
 889
- 890 Precautionary Policies and Health Protection: Principles and Applications; Rome Italy
 891 May 2001. See: <http://www.euro.who.int/document/e75313.pdf>
 892
- 893 Presidency Conclusions – Nice European Council meeting 7-9 Dec. 2000, Annex III –
 894 Council Resolution on the precautionary principle.
 895
- 896 Quinn S. Precautionary Behavior and Informed Decisions in the Information Age. *IEEE*
 897 *Technology and Society Magazine*; 21(4): 28-31 (2002/2003).
 898
- 899 *Rachel's Hazardous Waste News*, No. 339, May 27 1993 (1993).

- 900
901 Raffensperger C and Tickner J. Protecting Public Health and the Environment:
902 Implementing the Precautionary Principle. *Island Press*, Washington DC (1999).
903
904 Rosen G. A history of public health. *John Hopkins Univ. Press*. Boston (1993).
905
906 Rubin CT. Asteroid Collisions and Precautionary Thinking. In Julian Morris (ed), *op. cit.*
907 (2000).
908
909 Sahl JD and Murdock BS. Electric and Magnetic Fields and Human Health, Second
910 Edition, Irwindale, CA: *Southern California Edison* (1997).
911
912 Sandin P et al. Five charges against the precautionary principle. *Journal of Risk*
913 *Research*; 5(4): 287-299 (2002).
914
915 Slovic P. Perception of risk. *Science*; 236: 280–285 (1987).
916
917 Stilwell JH. Walking the high wire: Practical possibilities for regulatory responses to the
918 electromagnetic field quandary. *The Review of Litigation*; 15: 141–168 (1996).
919
920 Sunstein CR Risk and Reason. *Cambridge University Press* (2002).
921
922 Swedish Environmental Protection Act. International Digest of Health Legislation 21
923 (1971), p. 180. (1969).
924
925 Swiss Federal Council. Regulation on Protection Against Non-Ionizing Radiation.
926 Available at <http://www.buwal.ch/recht/f/finkridx.htm> (1999).
927
928 Tickner J. ed. Environmental Science and Preventive Public Policy. Washington, DC:
929 *Island Press* (2002).
930
931 Tickner J, Raffensperger C, and Myers N. The Precautionary Principle in Action: A
932 Handbook. Windsor (North Dakota): *Science and Environmental Health Network* (1999).
933
934 Treaty of Maastricht. *International Legal Materials* 31 (1992).
935
936 Tubiana M. Actual and virtual risks. In: Technology and health. Proceedings of 13th
937 Convocation Caes-Cadas, *Institut de France, Paris*, 133-164 (1999).
938
939 United Nations. United Nations Conference on Environment and Development:
940 Convention on Biological Diversity, Preamble (1992a).
941
942 United Nations. United Nations Conference on Environment and Development: UN
943 Framework Convention on Climate Change, Article 3 (3) (1992b).
944
945 United Nations. United Nations Conference on Environment and Development: Rio
946 Declaration on Environment and Development, LFNCEd document A/CONF,
947 151/5/Rev. 1, June 13 (1992c).
948

C

O

N

A

C

E

M

- 949 U.S. Congress, General Accounting Office. Environmental Protection Agency: Use of
950 Precautionary Assumptions in Health Risk Assessments and Benefits Estimates.
951 Washington (2000).
952
- 953 VanderZwaag D. J. Env. Law and Practice, 8, 355 (1999). See also
954 http://www.ec.gc.ca/cepa/ip18/e18_00.html.
955
- 956 VanderZwaag D. The precautionary principle and marine environmental protection:
957 Slippery shores, rough seas, and rising normative tides. *Ocean Develop. and Int. Law*;
958 33(2): 165-188 (2002).
959
- 960 Vecchia P and Foster F. Precaution and Controversies: Regulating Radio-Frequency
961 Fields in Italy. *IEEE Technology and Society Magazine*; 21(4): 23-27 (2002/2003).
962
- 963 Villa S and Ljung L. Magnetic fields and cancer [Swedish], Stockholm, Sweden:
964 National Electric and Safety Board (1993).
965
- 966 Von Moltke K. The Vorsorgeprinzip in West German Environmental Policy, in Twelfth
967 Report of the Royal Commission on Environmental Pollution, Annex 3, p. 57. London:
968 H.M. Stationery Office (1987).
969
- 970 Von Winterfeldt D, Eppel T, Adams J, et al. The Powergrid and Land Use Policy
971 Analysis, 2000 <http://www.dhs.ca.gov/ehib/emf/pwrgrdfd.html>
972
- 973 Weed D. Is the Precautionary Principle a Principle? *IEEE Technology and Society*
974 *Magazine*; 21(4): 45-48 (2002/2003).
975
- 976 Wiener JB, Rogers MD. Comparing precaution in the United States and Europe.
977 *Journal of Risk Research*; 5(4): 317-349 (2002).
978
- 979 Wilson R. Precautionary Principles and Risk Analysis. *IEEE Technology and Society*
980 *Magazine*; 21(4): 40-44 (2002/2003).

C

O

N

A

C

E

M