Methodology of Energy Risk Comparisons

by F.R. Farmer

INTRODUCTION

As an introduction to the subject I propose not to offer one or other specific method, but rather to discuss general questions such as the need for method, its objective and the relationship between the model, the methodology and the objective.

Method is defined as a special form of procedure especially in any branch of mental activity, and methodology as an orderly arrangement of ideas.

This is an English definition. I like it, as it is important to get the ideas right — or in order — before embarking on a lengthy exercise on paper. Let me develop this point.

It is possible to embark on an exercise of risk comparisons over selected ranges of energy and risk, and to a varying degree of precision or depth, i.e. first, second or third order of ranking. The study might start by listing the energy systems; the system phases; the estimation sequence; parties at risk; types of consequences; methods of estimating probability and consequences — the selected criteria and types of risk evaluation and produce a chart.

Some exercises have taken a sample selection under the various headings, but I would rather begin by asking what is the purpose of this study as the purpose would surely have a strong bearing on the method.

OBJECTIVE

Let me raise some questions only:

1. Is the objective to establish a ranking order so as to select options with low risk and reject the high risks?
   - There is no evidence that this is done elsewhere as in our search for food; the fishing fleet still operates.
   - There is a strong indication that we will need all energy sources appropriate to the location and local needs.
   - If this is the objective it will have a bearing on other questions to follow.

Mr. Farmer is Safety Adviser to the United Kingdom Atomic Energy Authority (UKAEA) and Visiting Professor, Imperial College, London.

2. Is the objective to improve "risky" options? If so, we need to concentrate on selected options and not compare them.
   - It is doubtful whether this is the intent, but if it were we would follow such studies as the Rasmussen report, the German light-water study, the Canvey Island report, etc.
3. Is the objective to persuade opponents that nuclear power is safe, and soft options are not so soft?
   - Then the exercise is not essentially technical and should be directed to public perceptions. The argument against nuclear power is not based on its normal operation but on the long-term intangibles — referred to later.

WHAT PRECISION

In carrying out any study, what precision should be aimed at, or is important — a factor of 2, 4 or 10? A very large range of our industrial activities have occupational fatality rates within a factor of 4, from 25 to 100 deaths per million per year (UK) and the extremes range from 3.5 to about 150.

The middle range from electrical goods, textiles, etc., up to the chemical and allied industries does not appear to influence choice or indeed appear to be markedly different one from another in risk potential.

Either we accept that a factor of 2 to 4 is not important or, if we are concerned about such factors then we should be concerned about extrapolating from the last decade to the next century as any significant change in energy production will take 20 to 40 years, and will remain in service for 30–50 years.

I have touched on this point in a paper presented at the EEC Nuclear Discussions, Brussels, January 1978. I agree that the "dangerous" industries are likely to improve more rapidly than the "safe" industries; coal mining fatalities might be reduced by a factor of 2 to 3 within the time of interest.

WHAT RISK

Let me take six types of consequences — early or delayed fatality, injury now or delayed, genetic effects and composite.

What are we to do with these, how to compare. Before gathering data we should have some idea as to how it should be used. Should we follow Sir E. Pochin, ICRP No.27, or Reissland and Harries, "A Scale for Measuring Risks" Ref. [1]?

AVAILABILITY OF INFORMATION

Given a specific risk situation, it is possible in some cases to arrive at a range of possible consequences — even if probabilistic. This would apply to radiation exposure, occupational or public, based on a fairly well-established relationship between exposure

and effect — and the assumption of linearity. It is much more difficult to quantify the risks through exposure to chemicals; even if some toxicity data is available it is unlikely to extend to low-level exposures particularly as "nutritional and other variables which alter susceptibility to toxic effects by an order of magnitude or more are poorly understood and little studied" Ref. [2].

Estimates of the effect of gaseous discharges from coal-fired stations vary by at least one order of magnitude.

LONG TERM EFFECTS

This is important in itself but also a sub-section of availability of information. Many postulated long-term effects may be events of a low probability such as the escape of buried nuclear wastes, but are events which may affect a large number of people even at a low level of individual risk. The green-house effect is one which may develop slowly but could be irreversible and catastrophic. Accidents to major industrial plants — nuclear, chemical — or in transport — may have a low chance of causing large numbers of casualties but I do not know how to weight 10 000 deaths, whether immediate or delayed at an assessed risk rate of 10^{-4} per year. It is not seen by the public as one per year.

WHAT CRITERIA

(a) If we cannot establish a way of balancing:

death now	—	delayed death
death	—	injury
death/injury	—	genetic harm
an identifiable fatality rate	—	an assessed low risk of many deaths; and

(b) if information on radiation is theoretically good; and

(c) on chemicals, extremely poor; and

(d) on some short-term effects (accident frequency rates) relatively good;

(e) but on long-term effects almost non-existent,

then, what can we use?

I suggest if a logical decision were required, based on risk of alternative energy sources, then it might well depend more on the information we do not have than that which we have. Public objection to nuclear energy accords with this in its emphasis on accidents, waste disposal and proliferation.

References

[1] REISSLAND and HARRIES, "A Scale for Measuring Risks", New Scientist (13 September 1979).
[2] Long Term Toxic Effects, A Study Group Report, Royal Society (July 1978).