Discussion

A Review of the Health Effects of Energy Development. (Volume 1, No. 1, March 1987, pp. 14–24.)

Two items published recently call for comment. They are the article by Myers and Werner in your first issue and my presentation to the New Democratic Party (NDP) inquiry, condensed in the CNS bulletin of Jan / Feb 1987.

After the Chernobyl experience, are changes needed in the management of safety in general and in nuclear safety in particular? Several of the worst technological disasters which have ever happened were like Chernobyl: the sinking of the Titanic, the Vaiont dam landslide in Italy, the aircraft collision at Tenerife. Each of these was the worst peacetime accident in its category. In all these four cases the principal 'machine' involved started in a substantially normal and viable condition; the disaster would have been easily forestalled and the loss of life averted if the smallest amount of modern safety thinking had been applied to the situation only a few hours or tens of hours beforehand; the trouble was in each case that those responsible for safety had been busily engaged in solving what proved to be only a part of the overall problem. It was not that the 'safety analysis,' such as it was, was inaccurate or lacking in detail; the problem was that it was too narrow.

In papers which I wrote in 1982 and 1985, I made these points about the estimation and management of technological risk:

1. Because we learn, we continually destroy the relevance of failure data. The data apply to the situation before we learnt; we are trying to predict experience in the future after we have learnt.
2. Failure data always suffer from a 'Heisenberg-like' uncertainty: if we want information about closely relevant experience, we find that there is almost none available; if we cast the net wider, the information increases but the relevancy diminishes.
3. Even if unlimited and closely relevant failure data were available, so that risk could be evaluated with certainty, actual future experience will be highly uncertain in cases where the risk is small, as it almost invariably is. For example, if the risk of an accident of the Three Mile Island kind is 0.0008 per reactor year, and 200 reactors are equally exposed to that risk for 6 years, there is about a 70% chance that one reactor will have such an accident and that 199 reactors will not. There may be no such accident at all. There would be no significance in which particular reactor had the accident. A uniform risk would have given rise to a highly stochastic and uncertain actual experience.

These factors are fundamental and cannot be circumvented. No amount of experience or research or calculation will alter the situation, either in general or in particular cases.

Chernobyl invokes all these points. A glaringly wrong misoperation undoubtedly 'went round the end' of a lot of otherwise adequate safety planning by the engineers concerned. Quite obviously, it might never have happened. Now that it has happened, what we need to manage is the risk *after* Chernobyl, that is, after the learning process, and in reactors *other* than those of the Chernobyl type. The data we have amounts to one accident of the kind in 4,000 reactor years globally (not very relevant to Chernobyl-type reactors) or one in 80 reactor-years (not very relevant to non-Chernobyl reactors). It is abundantly clear that we will never be able to achieve certainty in assessing the risk of another Chernobyl accident; estimating the risk points the way to reducing it to insignificance. The Canadian nuclear safety manager must decide how relevant this 'non-western' and 'non-CANDU' event is to his own situation. The USSR safety managers have the somewhat different and more narrow problem of correcting the revealed weaknesses in the Chernobyl reactors and the way in which they were operated, similar to upgrading the hardware and the operation of NRX after its 1952 accident.

I concluded that these problems could only be dealt with by the use of the higher attributes of the human mind, that is, by bringing informed and disciplined judgment to bear. If we recognise this I consider that we can improve the application of judgment. We can operate on our own intellectual processes to some extent. The suggested discipline is to assemble our judgment into a quantitative working hypothesis.

Table: Safety Benefit / Detriment Comparisons.

	More advanced countries	*Less advanced countries*
Lower risk energy source (e.g., nuclear)	GLE 30 days LLE 0.37 days	GLE 200 days LLE 0.37 days
Higher risk energy source (e.g., coal)	GLE 29 days LLE 7.3 days	GLE 220 days LLE 7.3 days
None	GLE 0 LLE 0	GLE 0 LLE 0

GLE – Gain in life expectancy.
LLE – Loss in life expectancy.

One of the tables, reproduced here, from my NDP presentation implements this idea. It is intended to put the global impact of central station energy into the right logical and intellectual framework for decision making. It considers all important direct and indirect impacts and arrives at the total safety impact of each of the three realistic alternatives. The 'zero' option is an 'alternative,' to be considered equally with the other two; it is a clear departure from the general industrial development of the last two centuries. Any more narrow view would be literally reckless. It would raise the possibility, or probability, that in shying away from small risks we may expose ourselves to greater risks, or to loss of safety benefit, which is the same thing.

The numbers shown are a composite of my own work and that of Myers and his colleagues. To the best of my knowledge, they are the only attempts to make unbiased estimates which take both negative and positive safety contributions into account, and which are based as far as possible on real experience. They are disciplined, or try to be. The high safety benefit numbers are simply an attempt to apportion the great and sustained improvement of life expectancy in the modern world, which is hard fact, among the wealth-producing industrial activities which underlie it. The nuclear risk number takes Chernobyl into account.

The table indicates that the safety benefits to people from the production of energy in today's world far exceed the risks in both of the main categories considered. The present hassles between the regulatory bodies and the industry mainly boil down to arguments about increments of risk which are microscopic by comparison. For instance, it is my estimate that a faster second shutdown system for Pickering A would save about 0.000001 lives per reactor-year and would increase the expectation of life in Ontario by about a third of a second. By contrast, even the 0.35 day LLE figure for the total nuclear accident risk is the smallest figure in the table by a factor of 20.

What really matters, therefore, is whether or not the table is roughly right. Are Myers and I and our co-workers roughly right in our high assessment of safety benefits? Is the intermediate mortality figure for coal roughly right? And is the nuclear accident risk figure either roughly right or pessimistic? It is these questions which need to be answered by informed and responsible judgment. All the numbers are uncertain, but there is no 'conservative' escape route; we lose lives by eroding safety benefits just as readily as by underestimating risks.

The table should be dispassionately discussed in the scientific and professional community as part of our normal search for truth. Sadly, at this moment in the history of the human race, this is not likely to happen. If the numbers are accepted as roughly right, they show that human safety will best be furthered if both coal and nuclear energy are developed aggressively. They show that nuclear should displace coal to the greatest extent possible, so that a reduction in the cost of nuclear power could benefit safety even if the direct nuclear risk were increased somewhat as a consequence. In the present social climate, these are *unthinkable* thoughts. Experience shows that most scientists and engineers, like the vicar of Bray, will not take the risk of deviating far from strongly and widely held beliefs of the times. So the issues raised by my table will continue to be carefully ignored.

A final point about disasters of the Titanic / Chernobyl kind; their total effect on expectation of life in the world is negligible. In other words, they have virtually no effect on safety. Another unthinkable thought.

E. Siddall, P. Eng.

The Letter by E. Siddall raises a number of interesting topics. I would agree with many of his suggestions but would like to add some comments. The general area of risk management has attracted considerable scientific interest in recent years and is indeed an area which, in one form or other, accounts for the major proportion of our tax dollars. The question whether social effort would be more wisely spent in one direction or another is a continuing topic of discussion. Some other recent articles on risk management that readers might find of interest include a) B.N. Ames et al. ranking possible carcinogenic hazards. Science 236, April 1987: 271–279; b) M. Konner. Why the reckless survive. The Sciences N.Y. *Acad. Sci., May / June 1987: 2–4; c) T. Morsing. Risk philosophy and misunderstanding. Nuclear Europe 6–7, June / July 1987: 25–26; d) R. Wilson and E.A.C. Crouch. Risk assessment and comparisons: An introduction. 236, April 1987: 267–270. As usual, E. Siddall's contribution to this discussion is most interesting and thought-provoking.*

D.K. Myers