LETTERS

Energy: Calculating the Risks

My attention has been drawn to the 23 February issue of *Science* and the article "Risk with energy from conventional and nonconventional sources" by Herbert Inhaber (p. 718). I was commissioned by the Atomic Energy Control Board of Canada to review Inhaber's original report (*1*) after it had been sent out to be printed. My review was constructively critical and is available as AECB Report 1131, dated 27 March 1978.

My overall impression of Inhaber's work at the time was as follows:

> . . . the author did not challenge his own assumptions in the report as to how his conclusions may be altered. Nor were any alternative interpretations of the methodology presented. In this regard, the report may become subject to criticism, especially since the conclusions depict conventional energy systems to be less risky than the non-conventional ones. As this review will show, other interpretations of the methodology of risk accounting can lead to the opposite conclusion.

In the year since my review, Inhaber's report has been widely circulated and has been summarized, excerpted, and quoted as an authoritative study. But, is it really?

Before starting my review, I asked Inhaber to tell me how much effort went into the study. He replied that the report had been prepared during a 3-month period and required a total of 3 to 4 man-months of effort by Inhaber and a research assistant. Inhaber has published revised versions of his initial report, but the revisions have all been in the area of correcting data and calculations. There have been no additional revisions or improvements of his risk-accounting methodology.

There are several serious problems with Inhaber's methodology:

1) Inhaber includes *all* of the risks associated with materials acquisition, component fabrication, and on-site construction of energy facilities. This implies that every industry making or transporting anything connected with the facility would not be doing anything else if that facility was not built. I submit that only the *incremental* risks in constructing any energy system should be measured, not the gross.

2) Inhaber's "nonconventional" energy systems include an energy backup in the form of conventional energy. This might be acceptable if the risk contribution of the backup system were small in proportion to that of the nonconventional system. But is it? If one looks at figure 7 of Inhaber's original report (figure 4 of his article, one can readily see that, for wind, solar thermal, and solar photovoltaic, the energy backup systems contribute the majority of risk! Therefore, in view of the overwhelming risk contribution of conventional backup systems to the so-called nonconventional systems, Inhaber is not truly comparing conventional with nonconventional.

3) If one uses Inhaber's data as is, removal of the risks of creating an energy facility and the risk due to the backup system has the effect of *reversing* his conclusion. That is, nonconventional systems (which they now are because backup has been removed) are less risky than conventional systems. This demonstrates how *sensitive* Inhaber's methodology is to the validity of the assumptions upon which it is based.

The nuclear industry has made wholehearted reference to the Inhaber report as proof positive that nuclear energy systems are safer than nonconventional systems. There appears to be no questioning at all of Inhaber's surprising "pro-nuclear" conclusions. This can only serve to diminish the credibility of the nuclear industry.

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References

1. H. Inhaber, *Risk of Energy Production* (AECB 1119, Atomic Energy Control Board, Ottawa, Canada, 1978).

I found Inhaber's article to be surprisingly at odds with my own similar study (*1*) of electric energy systems. About half of his source material and the methodology he claimed as his own is taken from work I technically directed or had contracted at the Jet Propulsion Laboratory (JPL) (*1, 2*). Thus, I feel knowledgeable about the information and approach Inhaber used in his study.

When I received his late 1978 report (*3*), which the *Science* article summarizes, I found remarkable disagreement between results I obtained when I used the JPL study team data and the results Inhaber derived. For example, his estimates of total health risk (*4*) compared to those in the JPL final report were (i) a factor of about 15 greater for coal; (ii) a factor of about 100 greater for solar thermal electric; and (iii) a factor of about 100 greater for solar photovoltaic. However, his results were about the same for the health risk from a nuclear plant.

I notified him immediately, pointed out these enormous differences, and asked what the nature of the disagreement might be. He indicated that he had added a few things that were left out of the JPL analysis but did not identify even in a general way what these left-out factors might be. Since I had spent 3 years developing the data and had had the assistance of about 20 professionals, I expressed skepticism and advised him not to publish any further without checking his analysis. When I noticed his article about a year ago in *New Scientist* (*5*) without any substantial changes, I wrote to each member of the Canadian Atomic Energy Control Board warning them of potential inaccuracies in Inhaber's work. However, they continued to support him.

I believe the review process used by the scientific community in this case was inadequate. I am open to suggestions as to how this can be avoided in the future.

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References

1. R. Caputo, *An Initial Comparative Assessment of Orbital and Terrestrial Central Power Systems* (Report 900-780, Jet Propulsion Laboratory, Pasadena, Calif., March 1977).
2. K. R. Smith, J. Weyant, J. P. Holdren, *Evaluation of Conventional Power Plants* (Report ERG 75-5, Energy and Resources Program, Univ. of California Press, Berkeley, July 1975).
3. H. Inhaber, *Risk of Energy Production* (AECB 1119, Atomic Energy Control Board, Ottawa, Canada, 1978).
4. Total health risk in units of man-days lost per unit of electric energy generated (megawatts electric times the number of years) due to disease, accident, and death over the entire life cycle of the energy system.
5. H. Inhaber, *New Sci.* **78**, 444 (1978).

More correspondence concerning Inhaber's article will be published in a subsequent issue.—EDITOR

Fringe Benefits of Cataract Surgery

Persons facing lens removal because of cataracts frequently view their future with some alarm. To them and in particular to professional colleagues who have this problem, we say, "Cheer up. You'll have advantages you never expected." We hope that ophthalmologists will become aware of the morale value of informing their patients of the phenomena to be described and of the exciting new perceptual capabilities resulting therefrom.

Recently, after cataract surgery, one of us (D.D.) became acutely aware of these capabilities. His work requires the rapid examination of numerous, relatively small objects in museum exhibitions. When the object is behind the glass of a show case, the viewer often cannot get