REVIEWS OF SCIENCE AND SOCIETY EDUCATIONAL RESOURCES

Brice Smith, *Insurmountable Risks: The Dangers of Using Nuclear Power to Combat Global Warming* (A Report of the Institute for Energy and Environmental Research), (RDR Books and IEER Press, Muskegon, MI, and Takoma Park, MD, 2006), 429 + vii pp., ISBN 1-57143-162-4, $19.95 (paperback)

First, in the interests of full disclosure, I am acquainted with Brice Smith and have worked with him at the Institute for Energy and Environmental Research (IEER) in Takoma Park, MD, where he was employed during the preparation of this book. There are literally dozens of books still in print on the subject of the advantages and/or disadvantages of nuclear power, but this is the most comprehensive and balanced a presentation on the subject I have found to date. I can say balanced in spite of the title, because the title, as one finds upon reading the book, is not a preliminary assumption but a conclusion based on the weight of evidence as presented in the book. Smith has assembled a very complete collection of the evidence both for and against the continued and expanded use of nuclear power, and analyzed both sides in depth. The results are, I believe, due to the weight of the evidence, which I, a former advocate for nuclear power, find compelling. The bibliography of works consulted contains nearly 550 entries, most of them primary sources.

Smith, following a brief introduction, analyzes the four major factors involved in assessing nuclear power -- costs, nuclear weapons proliferation, reactor safety, and disposal of nuclear waste products. Each gets its own chapter.

It is certainly true that nuclear power is a low emitter of greenhouse gases. Low, but not zero, if one takes into account such factors as the use of petroleum fuels during the construction of the plant and to process and transport the fuel to the plant and, ultimately, away from it after it has been used. But, as Smith shows in his comprehensive work, the ability to reduce greenhouse gases is not unique to nuclear power, and there are several alternatives that offer equal or greater promise to reduce greenhouse gas emissions while being less expensive, safer, and environmentally less damaging. It is also important to note that there is no source of energy available that is either completely safe or has no environmental impact. We are looking here for the best and safest sources of energy rather than the mythical perfect ones.

Two recent academic studies form the basis of his analysis of the costs of nuclear power compared to other forms of energy, both environmentally safer forms and the less safe, more traditional forms. They are the 2003 MIT study, *The Future of Nuclear Power*,[1] and the 2004 University of Chicago Study, *The Economic Future of Nuclear Power*.[2] Smith uses the results of these two studies, both prepared by advocates of nuclear power, to establish that the projected costs of new nuclear power plants will be substantially higher than currently employed technologies and at best comparable to more modern technologies, including wind, solar, and various carbon capture and sequestration processes using fossil fuels.

The MIT study calculates the necessary power plants for achieving the power capacity originally projected to exist by 2010 -- 1,000 Gigawatts of installed power -- and an alternative in which the nuclear power capacity grows in proportion to the projected energy demand growth in the world over the next 40 years -- 2,500 Gigawatts of installed power. The average size of nuclear power plants is about 1 Gigawatt, so the first alternative will require that by 2050 there will be 1000 1 GW nuclear plants in operation, and since all the plants presently in operation will have reached their design lifetime before 2050, this means 1,000 new plants in the next 40 years. A quick calculation shows that this requires the opening of one new nuclear plant somewhere in the world every 15 days for the next 40 years. If we accept the larger number as a goal, the rate of building increases to one every 6 days. This requirement is likely to be a technical, political and financial burden that the world will find difficult to bear.

In the next three chapters Smith delves into the issues in which most of the heat is generated and upon which the least light is shed in the current public debate: the link between nuclear power and the proliferation of nuclear weapons; the safety of nuclear power generation and estimates of the dangers of serious nuclear accidents; and finally the problem of safely and securely disposing of the waste products of the nuclear fuel cycle. Here Smith's analytic powers are at their best, as he digs into the literature, and, often using the words of the strongest proponents of nuclear power, shows the clay feet upon which the nuclear power statue has been erected. The link to proliferation is two-fold: most nuclear reactors require enriched uranium as fuel, and all reactors produce plutonium as a by-product. Once enrichment technology is acquired, its expansion to enable the creation of weapons-grade uranium (90% pure ^{235}U, or higher) is a matter of finding the space to build the enrichment facilities and the money to install them. And plutonium can be separated from the rest of the material in spent fuel rods chemically, which is considerably easier to do than the uranium enrichment process. It is true that most of the plutonium that can be recovered from spent reactor fuel is not weapons-grade plutonium – it is contaminated with amounts of ^{240}Pu and ^{241}Pu in excess of the allowable amounts in what is called "weapons-grade" plutonium (the production of which requires that the fuel be exposed in the reactor for a shorter period of time than is used in most power reactors); however, this does not prevent its use in nuclear weapons. It does, however, make it more difficult to use in weapons, since the lower grade material is more difficult to reliably detonate, due to the presence of the excess ^{241}Pu. So the possession of nuclear fuel processing or reprocessing facilities will enable any agency possessing the capability to, with more or less difficulty, produce the material required to construct a nuclear weapon. Every reactor design suffers from this problem, so the only way to verifiably prevent the diversion of nuclear fuel to a weapons program is for all of the fuel manufacturing and processing to be under the control of an international agency that can keep careful account of its stocks and control access to them. So far, the establishment of such an agency has proved to be an intractable problem.

Furthermore, in a world where a thousand or more nuclear plants are in operation, the amounts of fuel required will be enormous, and the processing of this fuel material will become a major industry, with all of the problems traditionally surrounding such industries, including safety and pollution, in addition to the nuclear-specific ones of radiation escaping into the environment, and the covert diversion of the tiny fraction of the fuel that would be needed to create a clandestine weapons program.

Advocates of nuclear power frequently assert that problems such as weapons proliferation are not "technical" problems, but "political" ones, and cite such issues as the need for international control of fuel manufacture and processing. Although, as Smith shows in his book, there are technical aspects to the proliferation issue as well as political, the tacit assumption of the nuclear power proponents is that the political problems are soluble, and once solved, the conditions will be right for a large expansion of nuclear power capacity. I think this assumption is false. The political problems are much more difficult than the technical problems, and to dismiss them as "political, and not technical," and therefore, presumably, more easily solvable is simply naïve.

As difficult as the political problems are, the technical ones are also difficult. Many safety issues will surround the construction of from 1,000 to 2,500 nuclear plants in the course of just 40 years, as will the problems of disposing of the waste fuel. These problems are no closer to solution now than they were 20 years ago, when the nuclear power industry was essentially brought to a halt by the Three Mile Island and Chernobyl accidents within a span of five years (1979 to 1984).

Smith points out the "creative" statistics that have been used by the power industry to justify the use of nuclear power, statistics that have wildly underestimated the probabilities of various types of accidents that could result in the release of dangerous amounts of radiation into the environment. Creative statistics have been used (by both sides in these arguments) to support what the various proponents consider constitutes "dangerous" radiation levels, as well. But even using the statistics proposed by the industry, he shows that, with up to 1,000 nuclear power plants in operation around the world, the probability of at least one accident of the seriousness of Three Mile Island or worse is in excess of 80%, and if the number of reactors in use grows to 2,500, the probability of at least one such accident approaches certainty and the probability of at least three such accidents is in excess of 50%. Given the disastrous effect of TMI on the US nuclear power industry, even though it did not release huge amounts of radioactivity into the nearby areas, it seems like folly to rely on a system that appears highly likely to succumb to the same fate again. That TMI had few serious environmental consequences appears to be the result, at least in part, of luck. The containment structure was not breached, but it was a close call. Five years later, Chernobyl showed just how serious it can be when things get really out of hand. I'm not saying here that TMI and Chernobyl are related, only pointing out that the line between a serious accident with catastrophic consequences and one without is a fine one indeed.

Finally, Smith takes up the issue of the safe disposal of the waste fuel and other radioactive materials involved in the production of the fuel. Although the amount of nuclear waste material in the world presently amounts to several thousand tons, there is as yet no repository for the safe, secure, long-term storage of this material anywhere in the world. In the US the efforts to find suitable storage has concentrated on the site at Yucca Mountain, Nevada, near the location of the underground nuclear test area. The decision to remove all other candidates from consideration was not a scientific one, but a political one, made in the US Senate, in apparent exasperation over the inability of the government to settle on a "most suitable" location. Although the timetable imposed by the Congress required the Department of Energy to have the Yucca Mountain facility in operation by 1999, it is not yet open and the most recent estimate of its opening date is by 2015 at the earliest, by which time, the total amount of spent fuel and other wastes scheduled to be interred there will exceed the design capacity of the facility. If we go on to build our share of the projected 1,000 to 2,500 new plants, by 2050, we will need three more facilities of the same capacity as Yucca Mountain to contain their waste products.

Although the transportation of fresh nuclear fuel and other radioactive materials and of nuclear wastes has been relatively trouble-free so far, if Yucca Mountain is ever opened the amount of potentially dangerous nuclear material on the highways and railroads will increase significantly, and with it the expectation that there will be an accident involving such material. There is also some evidence that the containers intended for shipping the nuclear materials have not been as rigorously designed as has been claimed, and that they may not be sturdy enough to withstand the shocks involved in a real accident at highway or rail speeds. This problem is compounded by fact that most of the nuclear power plants are in the region east of the Appalachians and hence much of the shipping of nuclear wastes will be over distances much greater than would be required if an eastern site had also been designated, as was originally intended.

Why, after 40 years of searching, examination, analysis and politics have we not been able to settle on a single site, or the two originally mandated? The answer, according to Smith, is a combination of politics and geology -- most of the suitable sites are located in areas where the political clout of the residents and their representatives has been sufficient to keep them from being seriously considered, and those in areas where local political influence is weaker are not geologically suitable. Yucca Mountain falls in the latter category. The more that we know about the geology and hydrology of the site, the less suitable it appears. As a result, DOE has mostly abandoned reliance on geology in favor of engineered solutions to the potential problems with Yucca Mountain. Smith quotes Allison Macfarlane, co-founder of the Yucca Mountain Project at MIT (p. 263):

> On siting a repository at Yucca Mountain, the DOE has painted itself into a corner that will be difficult to leave. After touting the natural geological features of the site to retain radioactive waste, the DOE has abandoned the geology for engineering design. It is now making its case for the site based not on the site itself -- the natural geologic features of Yucca Mountain -- but on the features that the DOE itself will build. . . .[Based on this] . . . the site as such, no longer matters.[3]

It has come to this because it is has become clear that the geology of the mountain is unsuitable for the repository. In order to keep it available, DOE has had to repeatedly lower its standards of safety for whatever material may find its way into the surrounding environment, most notably the ground water. About this, Smith has this to say (p. 272):

> At its most basic level, the case against Yucca Mountain boils down to the fact that it will not be likely to keep peak doses to an acceptably low level. In trying to overcome this fact, the EPA has relaxed the Safe Drinking Water Act standards at the site and has proposed the most lax radiation protection standard ever considered by a governmental body anywhere in the world.

But there are other problems with Yucca Mountain, not the least of which is its location on land still claimed by the Western Shoshone people, completing the cycle – the uranium that has fueled the reactors and produced the plutonium for our weapons program was mined mostly from land claimed by the Native peoples of the west, and using them as most of the miners, to the significant detriment of their health, and now that we are finished with it, we propose to put it back on Native land, only in a much more concentrated and dangerous form. This continues a pattern of abuse of Native peoples that has been in effect since the first settlers arrived in the new world. We are apparently a nation of slow learners.

At the head of the final chapter, Smith opens with the following quotation from the authors of *The Future of Nuclear Power*, as noted above, supporters of the use of nuclear power (p. 295):

> The potential impact on the public from safety or waste management failure and the link to nuclear explosives technology is unique to nuclear energy among energy supply options. These characteristics and the fact that nuclear energy is more costly, make it impossible today to make a credible case for nuclear power.[4]

This should be a suitable epitaph for the nuclear power industry.

I have two main criticisms of the book, and one minor one. First, this book has the potential to be an excellent reference work, containing much factual material that will be of value to those who need access to this data. However, a prime requisite for utility in this mode is a first-rate index. Alas, the book lacks such an index. I tried looking up several items that I was interested in and found only one of them via the index. The others I had to find by leafing through the book -- not the sort of required effort that would lead to its use as a reference. The second criticism is more of a wish. There is very little of the actual analysis that was done to yield the results shown in the book. I wish I could have seen how some of the numbers he cites were arrived at (while I expect that I could find that in the original documents cited in the book, I do not have ready access to all of them, so including at least a representative sample of the methodology would have been of great utility). I know that this would have made an already quite long work even longer, perhaps significantly longer, but I rather think it would have been worth it. And finally, this review was prepared from a pre-publication edition of the work, which contained quite a few typographical errors as well as a few clumsy or misleading phrases. Unfortunately, of the representative sample of those that I checked between the pre-publication copy and the final published version, all of them remained. I hope that at least the first and last of my criticisms can be corrected in future printings of the book.

- Hugh B. Haskell

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1. John Deutch and Ernest J. Moniz (co-chairs), *et.al.*, *The Future of Nuclear Power, An Interdisciplinary MIT Study* (2003), available on line at <http://web.mit.edu/nuclearpower/pdf/nuclearpowerfull.pdf>

2. George S. Tolley and Donald W. Jones (co-chairs), et.al., *The Economic Future of Nuclear Power, A study conducted at the University of Chicago* (2004), available on line at <http://www.ne.doe.gov/reports/NuclIndustrystudy.pdf#search=%22%22The%20Economic%2Future%20of%20Nuclear%20Power%22%2BUniversity%20of%20Chicago%22>.

3. Allison Macfarlane, "Underlying Yucca Mountain: The Interplay of Geology and Policy in Nuclear Waste Disposal," *Social Studies of Science*, **33**, 783 (2003).

4. *The Future of Nuclear Power*, p. 22.