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## **Energy at the Crossroads: Global Perspectives and Uncertainties**

by Vaclav Smil

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In his preface, Vaclav Smil calls this survey "Reflections on a Life of Energy Studies." Even for those of us who hadn't come across this expert author before, a quick glance at the Contents reveals a nearly encyclopedic treatise on all questions of human energy usage. This is a book of solid facts, not assumptions and intentions. The vast list of references gives the critical reader opportunity to check the veracity of the numbers and also the context in which they are cited.

So this is a good book. But is it worthwhile reading for a physicist, in particular for one who has dealt with some of these issues before? In answering that, let me be slightly facetious. As their attitude towards environmental and energy issues go, physicists tend to fall into three distinct categories:

First, dedicated scientists such as Archimedes or perhaps Steven Hawking, who are simply awed by the beauty of Nature. In comparison to Her grand design, human issues such as our individual survival seem trivial and boring.

Second, technological optimists such as Edward Teller, aware of and often competent with the most important environmental problems. For them, problems are there to be solved; we have mastered the ones we encountered in the past 5000 years and there is no reason why we shouldn't be able to master the present and future ones.

Third, political activists such as Amory Lovins, concerned scientists who analyze and boldly extrapolate present trends, and come to a simple conclusion: Unless human beings change their social behavior radically (in some way or another), humanity is inevitably doomed. They are either strongly engaged in activist programs to avoid such disastrous developments, or are at least sympathetic with people who do.

These three groups have little in common except that each group tends to be disdainful of the other two.

With this introduction, I can sum up my review of Smil's book rather simply: *Energy at the Crossroads* will annoy every one of those three groups, but be fascinating and enlightening to physicists (regardless of which of group they belong to) who have the stamina to carefully study these 400 pages. The reason for this seeming paradox is that there is hardly a single argument in this book to which Smil does not immediately give valid counterarguments. Thus, Smil convinces us that any unwavering stand one may take on energy questions is at least foolish, if not outright dangerous.

The subtitle *Global Perspectives and Uncertainties* already gives a hint that this will not be light "bedtime" reading. It is pedantic in stretches, giving meticulous reviews of what can seem to the superficial reader to be irrelevant details, such as the history of mining technology.

The book begins by describing long-term trends in global energy production, conversion, and consumption, starting essentially at the beginning of the 20th century. It describes in great detail the linkage of these variables to other economic and social data such as economy, quality of life, environment and, last but not least, war. In this approach, today's fundamental problem becomes clear immediately: During the past 100 years we have seen a dramatic dependence on fossil fuels, particularly in the developed countries, but increasingly in the third world as well. Can this go on indefinitely?

In moving from careful analysis of the past to a discussion of possible energy futures, Smil first inserts a sardonic but thought-provoking interlude: a chapter titled "Against Forecasting." This is arguably the most important part of the book. Smil makes clear that our ability to reliably project, even qualitatively, any aspect of human energy use for even 10 years ahead is, for all practical purposes, nil. As a simple example, the predictions of global total primary energy demand in year 2000 by the participants of the 1983 International Energy Workshop (including such institutions as the International Atomic Energy Agency, the World Bank, and the Oak Ridge Institute for Energy Analysis, along with several well-known academic specialists) differed by a factor of 3, overshooting or undershooting by as much as 60%! This is an unacceptably uncertain basis for serious policy decisions.

In Fig. 3.8, which gives these results, it can be noted that one individual predicted the actual value for 2000 correctly to within 3%: V. Smil. But instead of admiring the competence of the author, read what he himself says about this: Whereas the total number happened to be on the dot, Smil was as off the track as everybody else in the breakdown of this number in *types* of energy (coal, crude oil, natural gas, etc.). Thus, the correctness of the sum is actually somewhat fortuitous. There are many more such examples of seriously failing forecasts in this chapter, such as the optimism with which physics Nobel laureates such as Glenn Seaborg or Hans Bethe in the 1950s (and even as late as 1977) foresaw a world shaped by ubiquitous and inexpensive nuclear energy. But equally off the mark were many predictions regarding possible reductions in consumption. To this reviewer, who has been involved in some energy forecasting himself, this chapter is, indeed, delightfully entertaining bedside reading!

In the two ensuing chapters, Smil discusses fossil and nonfossil energies at length and in depth. In light of the recent U.S. ballyhoo about a revival of fission energy, fusion energy, and a future hydrogen economy, the sections on these options are, to say the least, sobering.

Having willingly followed Smil up to this point, the reader is, however, bound to have become somewhat impatient: Where is he leading us to? What are his own convictions? Aren't there necessary choices to be made? The answers to all three questions are in the last chapter on "Possible Futures," especially its last three sections: "What Really Matters," "What Does, and Does Not, Help," and "Realities and a Wish List." But once again, they are not easily deciphered. However, in contrast to the impression a superficial reader may have gained so far, Smil is far from entertaining an uninvolved, objectively detached stance. In order to enable readers to judge for themselves what Smil's 'own convictions' are, it is worthwhile quoting two passages from the last two sections:

[Through higher efficiencies] the global economy has been able to lower the energy intensity of its output by 0.7%/year during the past 30 years.... Conversely, today's global mean [annual consumption] of 58 GJ/capita [would have] required about 75 GJ during the early 1970s--and that rate was the French mean of the early 1960s and the Japanese mean of the late 1960s.

And so the answer is obvious: for more than 90% of people that will be alive in today's low-income countries in the year 2025 it would be an immense improvement to experience the quality of life that was reached in France and Japan during the 1960s....

Lowering the rich world's mean seems to be an utterly unrealistic proposition. But I will ask any European reader born before 1950 or shortly afterwards, and hence having good recollection of the 1960s, this simple question: What was so unbearable about life in that decade? What is so precious that we have gained through our much increased energy use that we seem to be unwilling even to contemplate a return to those levels of fuel and electricity consumption? How fascinating it would be to collect a truly representative sample of honest answers!

To begin with [the wish list], I would be overjoyed to see the worship of moderate growth coupled with an unwavering commitment to invest in smart, that is appropriately targeted, protection of biospheric goods and services. Two formidable obstacles are in the way: a disproportionate amount of our attention continues to go into increasing the supply rather than moderating the demand, and modern economists, zealous worshippers of growth, have no experience with running a steady-state economy, and an overwhelming majority of them would probably even refuse to think about its possible modalities. Yet there is little doubt that many of these moderating steps can be taken without materially affecting the high quality of life and at a very acceptable cost (or even with profit). I do not think I exaggerate when I see this to be primarily an issue of attitude rather than of a distinct and painful choice.

In summary, I will dare to rephrase Smil's conclusions more bluntly, in my own words: The future of energy production and consumption in the 21st century is fraught with many, extremely serious hazards, and *there are no simple, straightforward solutions* to any of these problems. But one conclusion is unavoidable: the only attitude we cannot afford is to neglect the problem.

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