

ARTICLE IN PRESS



ELSEVIER

Available online at www.sciencedirect.com

SCIENCE @ DIRECT®

Technological Forecasting & Social Change xx (2004) xxx–xxx

**Technological
Forecasting and
Social Change**

BOOK REVIEW

Energy at the Crossroads: Global Perspectives and Uncertainties

Vaclav Smil, The MIT Press

Cambridge, MA, 2003, 427 pp.

Victor Smil is a prolific writer when it comes to writing on energy, having written many books during the last 25 years or so; I believe this is his 18th book. All of his writings focus primarily on energy and environment. One would think that Smil would run out of ideas to write on after publishing so many books. However, this book is a good example of how well Smil thinks and writes on this very important subject. The book is even more important for the current times, with the price of oil hovering around \$45 per barrel, ever increasing appetite for energy by many nations and geopolitical uncertainties clouding the energy futures. It would not be very difficult to be quite pessimistic, and even an alarmist, considering the current climate in the energy markets. Smil, however, is neither. He does an excellent job of painting a believable view of energy situation.

What I like about this book is the author's clarity of writing, his deep understanding of history—how we have reached the present, discussing the many myths that confuse the general population concerning the role of energy in their daily lives and building balanced viewpoints about the energy futures by discarding popular approaches such as quantitative forecasting, in stead relying on understanding first and then suggesting what is possible in the future.

Smil has strong opinions and convictions; but they are well founded. Smil begins the book by stating: "I have always believed that books should be written for truly compelling reasons. So, why this book, and why now? The objective reason is simply the importance of its subject. . . It is the subjective reason for the book that I want to discuss here—the background that might help the reader understand my strong opinions. My goal in reviewing my long energy journey is to convince the reader that I have done my professional homework diligently and that my propensity to doubt and judge is not momentary whims or fashionable trends" (p. ix). One may not agree with everything that Smil has to say on the subject of energy; but it would be very difficult to argue that Smil has not done his homework. He is comprehensive in collecting facts and statistics and quite clear about why and how he develops his opinions, arguments and propositions.

The book consists of six chapters and an extensive list of references of 35 pages. The first chapter provides a fairly comprehensive discussion of long-term trends and achievements. The second chapter discusses linkages—linkages between energy and economy, energy and quality of life, energy and environment and yes, energy and war. The third chapter reviews and details the rather disappointing performance of energy forecasters in all areas, ranging from estimates of primary energy requirements to the role of conventional and new energy supply technologies. Next two chapters examine first the future

doi:10.1016/j.techfore.2004.09.001

of fossil fuels and then the prospects of non-fossil energy. The last chapter presents possible futures—what is possible, what really matters, what areas will help and will not, and a discussion of realities and the author's wish list.

Smil starts out by tracing the long-term trends and achievements of the 20th century (Chapter 1). Going back to 1880s, one can see the shift and growth of energy use, the rise of fossil fuels, advent and proliferation of electricity, impact of automobiles, profound shifts in manufacturing sector enabled by the use of fossil fuels and electricity, rise and decline of nuclear power and structural transformation of economies driven by ever increasing use of oil. Energy has become so ubiquitous that one only notices its absence whenever that happens. For example, few realize the dramatic dependence of modern civilization on such mundane items as electric motors: “Modern civilizations could retain all of its fuels and even have all its electricity but could not function without electric motors, new alphas (in baby incubators) and omegas (powering compressors in morgue coolers) of high-tech society. Consequently, it is hardly surprising that electric motors consume just over two-thirds of all electricity produced in the United States, and it is encouraging that they are doing with increasing efficiencies” (pp. 38, 39). Two trends in energy consumption are especially significant. First, the consumption has increased both on the aggregate and per capita basis. Second, a large disparity exists between affluent nations and poor nations. Further, the disparity also exists among different socio-economic groups within both the affluent and low-income nations. The culmination of such trends leads Smil to suggest that: “In spite of currently fashionable sentiment about the end of oil era, or an early demise of internal combustion engine, dominant energy systems during the first decades of the twenty-first century will not be radically different from those of the last generation” (p. 60).

Substantial work has been done on the linkages between energy and economy, energy and environment and energy and quality of life; relatively less has been written about the linkages between energy and war-energy as a basic necessity for conducting large-scale wars and energy as a cause for wars. Smil covers the familiar ground when discussing the linkages between energy and economy, focusing on energy intensities of economic production processes in various countries and how real costs of fossil fuels and electricity impact economic activities. For the quality of life, Smil considers indicators and proxies representative of the quality of life, focusing both on the physical well being as well as delivery of good-quality basic education and access to health care. Energy–environment linkages are of particular concern to Smil, as he believes that serious constraints on energy use and production stem from these linkages, especially when one considers the cumulative gradual changes such as acidification of ecosystems. On energy and war, one can foresee some dramatic and tragic possibilities. Uncertainties about the geopolitical situations combined with the declining availability of cheap conventional oil in countries outside the Middle East create some very horrific plausible scenarios. As Smil suggests: “Plausible scenarios span an uncomfortably wide range of possibilities, from a manageable transition toward more open and at least quasi-democratic regimes throughout the region thus far dominated by dynastic (Saudi Arabia), clerical (Iran), or military (Iraq) autocracies—all the way to visions of global Armageddon unleashed by the suicidal armies of the faithful against the infidels” (p.120).

Before looking at the prospects of fossil and non-fossil energy futures, Smil devotes considerable discussion on energy forecasting. He is quite critical of the energy forecasting school. Taking energy forecasts in each of the various categories (primary energy requirements, energy supply technologies that include conventional and synthetic oil, natural gas, electricity, nuclear and renewable technologies, energy prices and intensities and substitutions of energy resources), Smil shows the dismal record of

energy forecasters. Included are names such as IIASA and Cesare Marcetti, Amory Lovins, Seaborg, World Energy Conference, Meadows and others. Smil states: "One commonality is shared by virtually all of these forecasts: their retrospective examinations show a remarkable extent of individual and collective failure to predict both the broad trends and specific developments. Lack of imagination has been a common failure when appraising technical breakthroughs, but excessive faith in new techniques, particularly by people involved in their development and promotion, has been no less common when assessing future commercial diffusion of these innovations. With rare exceptions, medium- and long-range forecasts become largely worthless in a matter of years, often just a few months after their publications" (pp. 123, 124). Smil believes that only two ways of looking ahead are worthwhile: contingency scenarios that can prepare us for various outcomes and normative scenarios to guide our long-term paths.

Before discussing possible energy futures, Smil explores, in depth, the prospects for fossil fuels and non-fossil energy. In case of fossil fuels, three crucial questions are probed:

1. Is the decline of global crude oil production imminent?
2. How far can natural gas go?
3. What will be coal's role?

In case of oil, Smil provides a comprehensive discussion of mainly two schools of thought. The first one includes those who argue that the markets, through their pricing mechanisms, will determine the eventual fate of oil production and that one should not overly worry about the estimates of actual reserves of oil and how fast they are being depleted. The other includes those who argue about the imminent end of oil era with irreversible decline of global oil extraction during the early part of the 21st century. Of course, argument on both sides is about conventional oil, although any long-term outlook on oil must also consider the enormous resources of non-conventional oil in oil shale and tar sands. And, any forecasts of oil depletion must consider also the demand for oil which in itself is tainted by global uncertainties at the economic, technological, social and political levels. Furthermore, future oil consumption may be restricted by environmental impacts such as the necessity to reduce emissions of carbon dioxide. One can, thus, see that the question concerning oil depletion is quite complex and there are no easy answers. As Smil observes: "There is a large mass of oil, in conventional and non-conventional deposits, in the Earth's crust and although oil's contribution to total hydrocarbon supply will be declining (slowly until 2020, faster afterward), substantial amounts of crude oil will remain on the world market throughout the twenty first century. . . . There is *nothing inevitable* about any particular estimate of an imminent peak of global oil extraction; this event may, indeed, happen during the first decade of the new century, but it may come at any time from a few years to a few decades in the future." (p.210). Timing of this event will depend upon the quantity of unknown reserves and the demand for oil. As for natural gas and coal, Smil believes that natural gas will be the fastest growing component of the world's fossil fuel supply in decades ahead. This belief is founded on increasing substitution of natural gas for many uses, including electricity generation. The future of coal is less certain. Arguing that coal's future is not fundamentally a matter of resource availability or production but one of environmental acceptability. Smil suggests: "Perhaps only this much is certain. During the last quarter of the twentieth century coal use did not conform to the predictions of continuing rapid decline and the fuel still supplies nearly one-quarter of the world's primary commercial energy. Should it resume its pre-1974 rate of decline the fuel would provide only about 10% of the world's energy by 2025 and its share would

become insignificant before the year 2050” (p. 237). Smil argues that such a decline would have to be compensated by the increased use of natural gas.

Fossil fuels will not outlast human civilizations no matter what their actual longevity is. So, what comes after fossil fuels? Several alternate fuels come into play. These include hydro power, biomass-based energy supplies, electricity from wind, solar power, geothermal resources and of course nuclear. All of these alternate energy sources will contribute in a smaller degree to the global primary energy supply. However, the potential and actual contribution from each will vary from one place to another. Further, a major problem with all of these sources is their low power density, thus rendering them economically uncompetitive with some of the traditional fossil fuels. Besides, as the use of alternate technologies increases, their limitations and negative impacts also become more visible, as has been the case with the hydropower. Biomass fuels continue to be the most important source of heat in many countries, especially in low-income nations. For example, in some African regions, biomass provides more than 80% of their energy needs, especially for cooking and heating. Similarly, electricity generation from wind is a significant source of supply in countries such as Denmark.

And, what about the long-term future for nuclear fission as a significant source of energy supply? (Smil discounts nuclear fusion considering how little effort is being spent on it.) Smil’s answer is: “The best answer at the time of this writing (2002) is that it could—but most likely it will not”, for three reasons. First, no utility in the Western world, with the exception of France, is placing any major orders for nuclear plants. Second, many nations have legislated binding deadlines for abandoning nuclear power. Third, nuclear plants, currently being planned or under construction, will not add any significant additions to generating capacity. The only major driver that can push the increased use of nuclear power could be unacceptable situations that result from environmental events such as global warming from large-scale use of fossil fuels. However, this would be countered by the public’s mistrust of nuclear power and huge problems that need to be solved concerning nuclear waste disposal. Smil sums up the future of nuclear power thus: “And so the only certain conclusion is that a new nuclear era could be fueled comfortably for many generations to come either by deploying various breeder designs or by exploiting thorium, whose resources are much more plentiful (about fivefold) and also more accessible than those of uranium. But, for many reasons, we may never make any resolute decisions to follow either of these routes and nuclear generation of electricity may gradually fade out during the first half of the twenty-first century” (p. 316).

In the last chapter, Smil presents possible futures. No quantitative forecasts are offered, as Smil is not a fan of long-range forecasts of energy affairs. Perhaps, the best way to summarize his thinking on possible futures is by outlining his “set of fairly unexceptionable realities that will shape the future developments”. These include the following:

- The long established energy sources and conversion techniques will continue to dominate the markets during the first two decades of the 21st century.
- The duration of oil era may be determined more by the demand for fuel than by its availability. An early peak of oil extraction should not cause panic or regrets. Technical fixes such as coal liquefaction and extraction of oil shales will not be dominant. Natural gas, more efficient energy conversion techniques will ease the transition.
- It will take most of the 21st century to make a transition from fossil fuels to a system based largely on conversion of renewable energy.

- This transition will be governed more by concerns about global environmental change, and climate warming in particular, rather than any supply shortages.
- The concern and significant uncertainty about the eventual impact of climate change will be one of the key factors driving the energy decision-making during the 21st century.
- Several non-fossil conversion systems, particularly wind- and photovoltaic-generated electricity, will become much more important during the coming decades, both in absolute terms and as shares of relevant aggregates.
- The primary energy requirements at the global level will grow faster than the population growth during the first half of 21st century.
- Availability of useful energy will increase faster than the primary energy supply because of technological innovations and energy management improvements.
- Energy intensity of the global economic product will continue to fall but the quality of supply will rise as a result of increased consumption of natural gas and electricity.

Smil hopes that a radical change would occur in attitudes regarding the material consumption and the stewardship of the biosphere through moderation in the use of energy by all, but especially the wealthier nations. As he puts it: "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 key biosphere goods and services" (p. 369).

Overall, this book provides a hopeful, comprehensive and balanced view of energy landscape as seen at the present time. It contains a wealth of useful information, facts, figures, analyses, reflections, advice and prognosis for the future. As Smil sums it up at the end: "None of us knows what lies ahead. What we know is that our uses of energy that define and sustain our physical well-being and allow for an unprecedented exercise of our mental capacities will be the key ingredients in shaping that unknown future. . . As we were building the edifice of the first high-energy society many things got unraveled in the process but one key reality made the task easier: during the twentieth century we were largely on a comfortable, and fairly predictable, energy path of a mature fossil-fueled civilization. Things are different now: the world's energy use is at the epochal crossroads. The new century cannot be an energetic replica of the old one and reshaping the old practices and putting in place new energy foundations is bound to redefine our connection to the universe" (pp. 372, 373).

Only time will tell!

Kish Sharma
206 Turf View Drive,
Solana Beach, CA 92075, USA

1 September 2004