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doi:10.1111/j.1467-8276.2005.00767_5.x Books Reviewed: 5 James J. Winebrake Smil, Vaclav. *Energy at the Crossroads*. Cambridge, MA: MIT Press, 2003, 427 pp.

This year, the United States will deplete essentially all its oil fields, producing a mere one million barrels per day (Mbpd). The country will rely almost solely on foreign imports extracted from nearly diminished oil fields. Coal will provide only a small fraction of U.S. energy needs, and natural gas and nuclear power will provide about 40%. Renewable power, most notably solar, will provide the United States with almost half of its energy needs.

Now back to reality. The Energy Information Administration predicts U.S. crude production to be about 5.6 Mbpd, with global production of over 26 billion barrels per year. Reserve to production (R/P) ratios are 30% higher than in 1980; and renewable energy provides the United States with less than 7% of its energy, with half of that coming from hydroelectric dams.

Long-range energy forecasts, such as the composite in the first paragraph derived from various forecasts from the late 1970s, are but one target for Smil's book, *Energy at the Crossroads*. With extensive data, common sense, and wit, Smil offers us an informative and even entertaining assessment of the past, present, and future of global energy use.

Smil begins his book by considering the importance of energy in modern society. His first chapter highlights the achievement of industrial civilization in converting millions of years of dead organic matter into the fossil fuels that power our world. Indeed, useful energy is attributed as one of the primary reasons that technical innovation, standards of living, and economic development over the past 100 years have outpaced that of the previous 10,000 years.

A further understanding of the link between energy use and economic growth is discussed in Chapter 2. Smil presents historical relationships between total primary energy supply (TPES) and gross domestic product (GDP), with a reasonable deconstruction of past doctrines that correlate energy intensity (energy/GDP), population growth, energy demand, and energy prices. Important to the forecasting debate, Smil suggests that even with increasing global populations, TPES does not have to necessarily increase over time.

The most entertaining part of the book is Chapter 3 (appropriately titled "Against Forecasting"). This chapter focuses on long-range energy forecasts, and expands upon much of what Smil has written about in previous work. He presents us with an extensive review of past forecasts, dating back decades. In one example that makes his point about the futility of forecasting, he cites a range of 1983 predictions of global primary commercial energy consumption for the year 2000. Predictions from so-called experts range from 5.33 billion tonnes of oil equivalent (Gtoe) to 15.24 Gtoe. Actual consumption in 2000 was about 9.2 Gtoe. Other forecasts that Smil lambastes include the

demand for electricity, energy prices and intensities, and energy substitution curves. What forecasts should we believe when they vary so remarkably and are driven by politically derived assumptions and the personal values of the forecasters? Smil suggests none.

After critiquing long-range forecasts, Smil presents his own view of the future. First, in Chapter 4, he discusses fossil fuels. He begins with a resource assessment, considering historic R/P ratios for oil and demonstrating that despite the alarmism of the 1970s, R/P ratios today are substantially higher than a few decades ago. He continues with the assessments of gas and coal and concludes that based on resource availability the transition to a non-fossil future may likely take the better part of a hundred years.

These arguments outline an important thesis of the book. Although not a cornucopian, Smil argues that *resource availability issues will not drive our transition to a sustainable energy future*. Instead he argues that the fragility of the biosphere will dictate the need for alternatives. Because important environmental services are quickly being compromised by fossil fuel-derived environmental impacts, human civilization will need to turn to alternatives not because of dwindling resources, but because our biosphere (and thus our existence) will demand it.

Enter Chapter 5, where non-fossil energy is the focus. This chapter provides a pragmatist's overview of solar, wind, hydro, biomass, geothermal, and ocean power. Smil discusses the potential, the problems, and the possibilities. His assessments are generally sound, blending a tempered optimism with a realist's perspective on the opportunities for renewable energy in the future. For example, in discussing the low power density of

biomass fuels he states: " [If] U.S. vehicles were to run solely on corn-derived ethanol the country would have to plant corn on an area 20% larger than is its total of currently cultivated cropland!" (p. 264).

Smil spends some time on the *fuel de jour*: hydrogen. He takes a balanced view of the so-called hydrogen economy, recognizing production, distribution, and storage as lingering problems. The development of a hydrogen infrastructure that can compete with other energy sources will be a daunting technical and economic task. In particular, in discussing hydrogen fuel cell vehicles, Smil recognizes what energy analysts have

dubbed the "chicken-or-egg" dilemma: " [M]anufacturers will not make and promote cars that people could not fuel easily but energy companies are not eager to invest into a new expensive infrastructure in the absence of any demand" (p. 307).

In Smil's final chapter, Chapter 6, he discusses possible energy futures, evaluating "what appears to be possible, both in technical and in social terms," and suggesting what he believes "to be desirable by outlining the key goals that are worth pursuing."

One of these "key goals" is the protection of our biosphere based on a foundation of "no-regrets policies." Although short on details for new policy initiatives, Smil calls upon policymakers to behave as "complexifying minimalists rather than as simplifying maximalists." Policymakers should consider many approaches to solving the sustainability question (complexifying minimalists), without tolerating "a priori ideological purity" that focuses on a single, "right" answer (simplifying maximalists).

Another approach that Smil suggests is a return to good, old-fashioned energy conservation "for the sake of the common good." He argues that annual consumption of

50 70 Gigajoules (GJ) per capita would allow our physical needs to be met along with "pursuits and opportunities of intellectual advancement with respect for individual freedom." Americans, who currently consume about 350 GJ/capita, might be shocked at such an estimate, but Smil states that France and Japan of the early 1960s were in this range, and asks "[W]hat was so unbearable about life in that decade?" I imagine readers can identify more than a few things.

Besides, where will we find the motivation to live with such restrictions? Can a democratic, market-based society ever have sufficient motivations to solve the biospheric problems that will haunt future generations? Can externalities, particularly ones whose costs may not appear for decades, ever be fully integrated into a market system? There are few examples on the scale that Smil sees as necessary. And as Smil readily admits, solutions will only be arrived at if we accept a paradigm of steady-state economics, contrary to the "zealous worship" of growth economics now practiced throughout the world.

Alas, the changing of consumer attitudes that Smil calls for is a bit naïve, though noble. Surely, we would like to think that our actions are partially motivated by concerns for future generations and the biosphere they will inherit, but how much can a free capitalist society avoid a tragedy of the largest commons we know? Are we, as Hardin cautioned 35 years ago, tragically doomed to destruction?

In sum, Smil provides an entertaining, thoughtful, and extremely well-researched book on energy pasts and energy futures. The reader will likely come away with a better appreciation of energy resource availability being secondary to the primacy of biospheric protection. The reader may also appreciate the coupling of sustainable energy use and Smil's grander vision of our future human condition, where all people are educated, healthy, fed, and free. However, the reader is still left to ponder the details of how to achieve the virtuous ends that Smil desires. Simply put, in the end are we willing to sacrifice for future generations? And can the pace of technical, social, and political change needed to address our biospheric problems match the heretofore unprecedented speed with which our biosphere is moving toward collapse?