Book Reviews

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General Energetics: Energy in the Biosphere and Civilization

by VACLAV SMIL
Toronto: Wiley Interscience, 1991
pp.369

This is a fascinating book. At first glance it is an eclectic compilation of facts, figures and statistics on energy, energy densities, and power and power densities on our planet. It embraces solar radiation, winds and tides, photosynthesis by plants, food metabolism by living organisms and the human use of energy and fuels. While the author stands back from most of these facts, leaving it to readers to draw their own conclusions, his commentary shows him to be a humanist, deeply aware of the value of the human condition. It is this perspective which lifts the book from a dry catalogue of numbers to a stimulating and thought-provoking thesis.

It can also be a somewhat irritating book. The recitals of numbers reads, at times, like a scientific 'Believe it or not.' These facts and figures are compiled from a very wide study of the literature and are thus derivative. Few are the author's own. Careful readers might want to go back to the original references to be sure of the definitions and assumptions in the quoted statistics before using them in studies of their own. To be fair, however, a critical analysis of all this material would require a study ten times the size of this volume!

In the following synopsis, extracts or paraphrases from the book appear in italics. These have been chosen to illustrate the scope of the book and its style, thus illustrating both its virtues and the shortcomings mentioned above.

The opening chapter, 'The Universal Link: Energetics and Energy,' outlines the objectives of the book, setting itself, after a description of terrestrial energy fluxes and bioenergetics, to concentrate on the energetic limits and exploits of our species. It clearly sets itself apart from apocalyptic descriptions of 'energy crises.'

Chapter 2, 'Planetary Energetics: Atmosphere, Hydrosphere and Lithosphere,' describes solar energy fluxes, the energy of air and water in motion and the energy involved in earthquakes and soil erosion. Item (p.13): *There is a paradoxical contrast between the remarkable constancy of climate over 3 billion years*

of life complexification and a roughly 30% increase of solar luminosity. Can it be that the earth's climate is an almost intransitive system? This observation deserves more discussion. How sure are we of this? Surprisingly it is not even referred to in the later discussion of global warming.

Chapter 3, 'Photosynthesis: Energetics of Primary Production,' is necessarily a brief summary of a complex process. The section on the overall efficiency of photosynthesis has a number of intriguing facts (pp.50 and 57):

In spite of its prodigious photosynthesis an old growth Douglas Fir forest ... stores only 2% of its gross fixation.

With global average net primary productivity averaging only 15MJ/m^2 and with mean radiation reaching the earth's surface at 5GJ/m^2 the mean global efficiency would be about 0.3%.

Is this a small or large number? Considering how much radiation falls on rocks and desert it seems to be a large number indeed.

Chapter 4, 'Heterotrophic Conversions: Consumer Energetics,' describes the energetics of the animal kingdom. It includes this intriguing statistic: *The sun's power intensity averages 200nW/g but the daily metabolism of school children proceeds at a rate of 3mW/g* (p.62). A factor of 10^6! Clearly only a small part of the sun is producing fusion energy. One would like to know how this power density compares with that of projected fusion reactors.

Chapters 5, 6 and 7 discuss the nutritional needs of humans, the ways in which these needs were met by hunters and gatherers and, later, by solar farmers. Many fascinating facts here (pp.94,102,120,121):

The effective adaptation to heat, perspiration permitting a heat loss of 550 to 625W in extremely hardworking individuals, has been responsible for much of the economic, technical, and social transformation for mankind.

The high value of meat in foraging societies may be because of its fat content, not as a source of protein.

The energy requirements of irrigation lead traditional agricultures to do with as little water as possible.

Deep well bucket lifts may require three to four oxen putting in up to 1.6kW.

Chapter 8, 'Preindustrial Complexification,' describes prime movers and fuels in traditional societies. Item (p.134): *The building of the pyramids required an average net human power input of about 15MW during working hours.* There is an illustration of an Egyptian colossus drawn by 120 slaves with the sled runners being lubricated by water!

Chapter 9, 'Fossil Fuels: Heat and Prime Movers,' brings us to the contemporary scene. Much of the information here will be familiar to readers of *Energy Studies Review*. A salient point, discussed later, is that the current large use of coal, oil and gas is, in the scale of human history, a most recent phenomenon. It has occurred within the lifetimes of our parents or grandparents. At the same time there have been equally phenomenal increases, factors of 10 to 100, in the power, power/weight ratios and efficiencies of the engines which use these fuels.

Chapter 10, 'Fossil-Fuelled Civilization: Patterns, Trends, Costs,' describes the energy intensities and consumption patterns of contemporary societies. This chapter expounds the central thesis of the book (p.199). *While the share of non-fossil contributions will continue to rise, the bulk of consumption and growth will come from combustion of fossil fuels.*

Chapter 11, 'Energetics of Food: Modern Farming and Food Consumption,' shows how modern agriculture depends on energy subsidies. Fertilizer use has increased exponentially over the past few decades in the same manner as energy consumption. This is a worldwide trend. Energy subsidies are not restricted to the industrialized western cultures. China, for example, uses energy in agriculture to the same extent as the US (p.231). *China and Egypt with subsidies of 25GJ/ha approach those of European agricultures, 25-35GJ/ha.* This is the single most sobering statistic in the book.

Chapter 12, 'Environmental Implications: Necessities and Consequences,' has an impressive scope, embracing space, land use and heat rejection as well as the release of combustion products. The section on the metabolism of fossil-fuelled civilization likens food metabolism to energy use in its interference in biospheric cycles. Carbon dioxide emissions and global warming are but one example. *World-wide production of fertilizers, about 90Tg*

nitrogen, may equal as much as 50% of natural nitrogen fixation (p.260). This discussion underlines the root cause of our global concerns; there are so many people needing so much stuff.

Chapter 13, 'Energetic Correlates: Complexities of High-Energy Civilization,' is the core of the book. It is argued that, while energy is of inestimable value to humanity, there can still be too much of a good thing. Smil quotes David Rose (p.265) *"Energy itself is not the problem, but rather appears as an instrument for social purpose misunderstood and misused."* Smil argues that, while there is a strong correlation between per capita energy consumption and infant mortality, food availability, life expectancy and literacy, there is no clear justification for the existing consumption levels of the affluent industrialized nations, let alone for further increases.

Chapter 14, 'Grand Patterns: Energetic And Other Essentials,' summarizes Smil's thesis on the ways in which these challenges might be met (p.311): *Gradual transition from fossil-fuelled energetics to a civilization running on instantaneous solar flows — the most obvious solution — will be neither fast nor easy.* He has no panaceas and no apocalypse.

Readers will draw their own conclusions from this wide-ranging analysis. The very brief time scale of contemporary energy use appears in many sections. The global use of coal only surpassed that of wood about 100 years ago. The large scale energy subsidy of agriculture, on which 2/3 of the world population now depends, is a post 1950 phenomenon. Smil's data show that global population growth is fuelled by fossil energy subsidies to food production. Humanity seems to have escaped from the Malthusian trap of overrunning our food supply only to a find a future energy trap!

Smil is critical, even dismissive, of quick technical fixes to these problems. Fusion and hydrogen, together with soft energy paths, are dismissed in crisp paragraphs! They are not seen as matched to global needs, particularly in subsidizing food production for an expanding population.

Smil has, however, confidence in the human spirit and the ingenuity of humanity in facing these challenges. His hope is that *we will find the determination and intellect confirming the Linnaean designation of our species — sapiens* (p.316). His humanism is beautifully expressed in an entry in the Table in the Appendix (p.320), 'Power levels of ephemeral phenomena.' These entries range from 'Humming bird flight lasting 300 seconds at 0.7 watts' to 'Richter magnitude 8 earthquake lasting 30 seconds at 1.6×10^{15} Watts.' The entry reads: *CD player spinning Mozart's last symphony 2238 seconds 25 Watts.* A CD disc with white noise would also use 25 Watts! It is left to the reader to speculate on the negative entropy embodied in the Jupiter Symphony!

This book should be in all libraries. It is a book for browsing and reference, rather than reading. It will entertain and, at the same time, provoke thought.

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Le Pétrole

by JEAN-PIERRE ANGELIER
Paris: Economica (Collection Cyclope), 1990
pp.112

This small book (dimensions: 18 cm. by 10.5 cm.) provides a discussion of the institutions supporting the world petroleum industry that is accessible to the non-specialist. To no small degree, this is due to the clear writing style of the author: arguments are presented with a focus on their key aspects, and examples are used both to illustrate these fundamentals and also to relate them to real-world situations. This book is as easy to read as it is informative.

A short introduction (pp. 5-8) and a shorter conclusion (pp. 105-6) frame the core of the text, which can be grouped under three headings. In the first part (pp. 9-62 and 85-99), the author provides a discussion of the main institutional factors that have shaped the evolution of the world petroleum industry since the emergence of the Seven Sisters. The main argument presented here is that the at-

tempt at hegemony by the major oil companies ultimately proved unsuccessful: a lesson relearned by the Organization for Petroleum Exporting Countries (OPEC) a few decades later. Too many important factors (e.g., product taxes, structure of demand, availability of substitutes) are outside the control of the oil suppliers.

According to the author, what emerges from the decades of failed attempts at control by a few key players is a bipolar world oil market. At the international level, the upstream activities of exploration and production are separated from the downstream activities of refining and product sale by geography: most of the main sources of oil supply are located in countries where demand is insignificant. Further, on a global scale, upstream activities are concentrated in OPEC and a handful of other countries, while downstream activities are controlled to a large extent by privately-held companies with home bases in oil-importing countries. The market power of the actors in one pole, the author argues, serves to offset the exercise of market power by the other pole, à la John Kenneth Galbraith. The role of the world oil market with its spot, futures, and forward transactions, the argument goes, is thus to link these two poles of activity, thereby allowing the price of refined petroleum products to influence the price of crude oils.

The second part (pp. 62-76) provides a quick overview of the functioning of spot, forward, and futures oil markets. This is the part of the book that is least accessible to the non-specialist. Unfortunately, the discussion too often falls prey to jargon, and it seems likely that its teachings will be lost to the majority of readers.

Finally, in pp. 77-84 and 99-104, the author offers his forecast of the evolution of the world oil market over the next decade or so. He argues that the current characteristics of the world oil industry (bipolar with countervailing forces) are well-suited to a period of fairly stable prices: sharp price increases are thought to be unlikely, at least to the end of the decade.

As one might expect, the discussion of the ongoing process of penetration by upstream firms into downstream activities in producing countries and by agents of producing countries into the downstream activities of oil-importing countries is rather weak. It does not fit well with the author's view of countervailing forces, and its possible implications are relegated to a few paragraphs near the end of the book.

Another aspect of the book which is less desirable is the fact that it has already been surpassed by events. Such, however, is inevitably the fate of institutional expositions: as the institutions evolve, the discussion loses some of its relevance. We should not, however, forget that current institutions have roots in the past, and thus that works of the type provided by Angelier improve our understanding of the present by illuminating the past.

At a more technical level, I had problems with the author's habit of providing only (undefined) abbreviations of most units of measurement and of agencies and organizations. To the uninitiated, this is a barrier to understanding. There are also a few questionable inclusions in the first 20 pages or so; e.g., the suggestion that royalty rates are always 12.5% (p. 13), the argument that crude oil pipelines are generally less than 1000 kilometres long (p. 15 — a suggestion especially difficult for a Canadian to accept!). In addition, the brief discussion of cost conditions at the top of p. 12 is not very satisfactory: for example, it is not clear whether this is an illustrative example, and — if not — whether the amounts mentioned are in real or nominal terms and whether they are discounted or not.

Overall, this book provides a good introduction to the institutions and the functioning of the world oil market. Those wishing for a treatise on the economics of petroleum will have to look elsewhere after having read this accessible and clearly written book.

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