

A Century of Oil, a Future of Options

Daniel M. Kammen

A generation of renewable energy technologies, now coupled with market mechanisms that make them viable alternatives to oil, has come of age in the past decade. At the same time, the politics of energy has returned to the center of the international stage. We have seen experiments with the deregulation of energy markets, as well as the California energy crisis, the Enron energy debacle, and massive grid failure and power out-

Energy at the Crossroads

Global Perspectives and Uncertainties

by Vaclav Smil

MIT Press, Cambridge, MA, 2003. 443 pp. \$34.95, £22.95. ISBN 0-262-19492-9.

ages in the northeast United States, Scandinavia, and Italy. Amidst these changes came the Gulf Wars and the 11 September 2001 attacks—events that highlighted the energy-security linkages that stem from American fossil fuel energy entanglements around the world. The costs of wind- and solar-generated electricity have fallen dramatically, high-efficiency hybrid vehicles are now making significant market inroads, and the use of fuel cells in vehicles and stationary power plants is now a very real possibility. A backdrop to these transformations has been the growing scientific awareness and now near-universal recognition of the reality of human-induced changes to global climate, largely as a result of fossil fuel combustion.

Into this fray steps Vaclav Smil, a prolific researcher and commentator on regional energy systems and the global energy economy. *Energy at the Crossroads*, his 18th book, is an informative and often personal account of our collective energy history, which draws on Smil's experience to put many of the trends in energy production and economics into perspective.

Smil starts by examining trends in both the supply mix and energy consumption over the last century. He provides a captivating account of the growth of the hydrocarbon economy and foreshadows his main theme of the need, yet difficulty, of altering this carbon-rich energy diet. He surveys coal, oil, and gas supplies as well as the reserves of hydrocarbon resources that are currently (al-

though perhaps only temporarily) seen as "noneconomic." The very large reserves of these nonconventional resources suggest that changes in our basic ideas about resource entitlements, the "good life," and our relation to the biosphere will be needed to motivate efforts to value and use our fossil fuel resources more wisely, in ways that do not degrade the planet.

Smil offers only a brief discussion of carbon sequestration, which its proponents claim could dramatically reduce the environmental impacts of fossil fuel use. Although I am wary about plans to sequester carbon underground or undersea (largely because cleaner energy options appear technically and economically more attractive), it is curious that a book about energy paths and choices neglects a topic that has received so much recent attention.

The sections on renewable energy options (biomass, wind, solar, hydropower, and geothermal energy) provide clear snapshots of these industries. Smil nicely highlights the question of technology takeoff. Although the global wind-energy industry has grown explosively at an annual rate of over 30% for almost a decade, wind power still plays only a small role in the global energy economy. In parts of northern Germany and Scandinavia, however, it now provides 25% of the electricity (and in selected months, up to 50%). The European Union hopes to obtain 10% of its electricity from wind by 2010. This dramatic rise—based on technological and economic innovations—is a striking example of rapid change in a seemingly staid energy industry. Smil rightly asks whether this growth is a harbinger of a transformed energy system or merely a minor sideshow to the hydrocarbon economy.

Other recent books present more detailed examinations of global hydrocarbon resources and their potential exhaustion (1) and the policies that have enabled the growth of renewable energy industries (2,

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NOTA BENE: AVIATION

Steps into the Sky

On 14 December 1903, in the dunes near Kitty Hawk, North Carolina, Orville and Wilbur Wright ran their "whopper flying machine" down a track placed on a slight incline and into the air. Wilbur was not used to the sensitive

elevator control, and the Flyer promptly pitched up, stalled, and within four seconds settled in the sand 18 meters from the end of the track. Three days later, with the launch rail on level ground, Orville piloted the Flyer on a 12-second, 37-meter flight into the brisk wind. Taking turns at the controls, the brothers completed three more, successively longer flights before noon, the last of which covered 262 meters in 59 seconds. These four controlled, powered, and sustained flights in a heavier-than-air machine would win the brothers recognition as the inventors and builders of the first successful airplane. The flights are seen by many as the birth of the aviation age, and their centennial is being celebrated in numerous ceremonies, exhibitions, books, and reenactments.

Tom Crouch and Peter Jakab, curators at the Smithsonian Institution's National Air and Space Museum (NASM), have each previously written well-received studies of Wilbur and Orville Wright (1, 2). In *The Wright Brothers and the Invention of the Aerial Age*, they offer a concise, accessible account of their subjects' lives and accomplishments. The book (portions of which were adapted from Crouch's earlier biography) is sponsored by the museum and supplements a new, identically titled exhibit there. The lively text is accompanied by abundant archival photographs, many of which are lavishly presented on full pages or two-page spreads.

Crouch and Jakab describe the Wrights' surprisingly rapid progress toward solving the crucial problems of lift, propulsion, and control. The brothers' success at Kitty Hawk capped a five-year effort in which they assimilated the nascent aerodynamic literature, experi-

The Wright Brothers and the Invention of the Aerial Age

by Tom D. Crouch and Peter L. Jakab

National Geographic Society, Washington, DC, 2003. 240 pp. \$35, C\$55, £25.50. ISBN 0-7922-6985-3.

Taking Flight Inventing the Aerial Age From Antiquity Through the First World War

by Richard P. Hallion

Oxford University Press, New York, 2003. 553 pp. \$35, £20. ISBN 0-19-516035-5.

CREDIT: SMITHSONIAN NATIONAL AIR AND SPACE MUSEUM

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3). Readers will find Smil's book useful for the comparative tours of each of these technologies and issues.

Smil devotes a chapter to the ongoing fascination, importance, and perils of fore-

casting. He notes that energy forecasts have not only been consistently wrong but have all too often been linear extrapolations of today's world into the future. He makes the important point that, in light of the upheavals that repeatedly impact the energy industry—such as the OPEC crisis, changing regulatory environments, the Asian economic downturn—normative, illustrative forecasts are particularly valuable. This point is well worth highlighting as we work to understand the true scope of human disruption of Earth's natural cycles and the central role our hydrocarbon diet plays in this story.

Smil prompts an important debate on the opportunities we have to shape our energy future. At several places, he comments specifically on the renewable energy-intensive, and highly energy-efficient, future described in normative models by Amory Lovins (4). Smil directly contrasts the Lovins view of economic and environmental coexistence—and, importantly, profit by doing good for the environment—with the neoclassical economic analyses of William Nordhaus (5) and other economists, who predict significant costs to the economy of the innovations required to create a clean en-

ergy system. Smil's final sections, on possible energy futures, make an excellent case for the need to reevaluate our patterns of consumption and to begin gradual shifts in the economy. What Smil has not focused on, however, are the recipes to translate these ideals into research and development strategies, incentives for current industries, social movements, or tools for policy-makers.

Energy at the Crossroads provides a highly accessible tour of the state of the energy world. Smil offers an important review of our options along with a well-reasoned call for action on what has become the paramount issue for humanity in the new century.

References

1. K. S. Deffeyes, *Hubbert's Peak: The Impending World Oil Shortage* (Princeton Univ. Press, Princeton, NJ, 2001).
2. H. Geller, *Energy Revolution: Policies for a Sustainable Future* (Island, Washington, DC, 2003).
3. P. Hoffman, *Tomorrow's Energy: Hydrogen, Fuel Cells, and the Prospects for a Cleaner Planet* (MIT Press, Cambridge, MA, 2001).
4. A. Lovins, *Soft Energy Paths: Towards a Durable Peace* (Friends of the Earth International, San Francisco, 1977).
5. W. D. Nordhaus, J. Boyer, *Warming the World: Economic Models of Global Warming* (MIT Press, Cambridge, MA, 2000).

mented with kites, tested designs in their homemade wind tunnel, and practiced piloting skills and their “wing-warping” banking technique with gliders. After spending an additional two years perfecting their design, they sought patent protection and buyers for their inventions. In 1908, they finally began to fly in public (ending skepticism about their success) and repeatedly broke records for distance, time aloft, and altitude. The following years saw the Wrights' engineering and flying activities eclipsed by business matters and patent litigation. Wilbur died in 1912; his brother survived as an elder statesman and honored pioneer of aviation until 1948. The authors conclude their book with an account of Orville's long-running feud with the Smithsonian Institution over the latter's declaration that the 1903 Great Aerodrome of Samuel Langley (a former head of the institution) was “capable” of flight. The disagreement led Orville to loan the 1903 Flyer to the Science Museum in London, where it remained until his death.

Instead of focusing on the Wright brothers, *Taking Flight* presents the invention of the airplane as the culmination of centuries of dreams and efforts. Richard Hallion, a founding curator at the NASM and formerly the U.S. Air Force historian, places the technological developments within the cultural, scientific, political, and military contexts of their times. His comprehensive and balanced account includes extensive citations to the records left by aviation pioneers as well as to previous histories. Hallion divides his narrative into seven historical phases. The earliest, dominated by myths and desires, included the invention of kites, rockets, and helicopter toys. Balloons and airships were the center of attention from the late 18th century to about 1900. Over the same interval, George Cayley's foundational aeronautics research was followed by a series of fruitless attempts at heavier-than-air flight. Four figures who stressed the importance of flight research with piloted gliders—the German Otto Lilienthal, the American Octave Chanute, and the Wright brothers—stand out in the 15-year period that saw the successful development of a practical air-

plane by 1905. Hallion devotes the second half of his book to covering the subsequent phases: the resurgence of European aeronautics, the maturation of flying and its acceptance by the military, and the important roles played by airplanes in the First World War.

In his introduction, Hallion presents six aspects of “common knowledge” about early flight that he believes false and summarizes alternative interpretations that are further developed within the book: Efforts to build the first airplane form only one strand of the quest for flight, and Europeans made important advances toward flight before the Scientific Revolution. The Wright brothers did not invent the airplane in isolation, nor did their foreign tours teach Europe's aviators how to fly. A highly unstable tail-first biplane, their Flyer highlighted the importance of controllability but did not inspire the planes that soon came to dominate world aviation. By the time of Wilbur's death, European innovations had already made the Wright company's designs hopelessly outdated. The European powers did not ignore the military potential of airships and airplanes during the arms race before the First World War, and in the war's first month aerial reconnaissance played a key role in the crucial battles of Tannenberg and the Marne.

Both of these books confirm the Wright brothers' preeminence among the pioneers of flight. But Hallion's account also offers convincing support for his conclusion “that had the Wrights never lived, the airplane would have been invented in Europe, in all likelihood France, by the year 1910.” It seems probable that many other technological breakthroughs are similarly characterized by a limited scope of contingency—an aspect worth remembering during celebrations of their anniversaries.

—SHERMAN J. SUTER

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The Future of Oil: Geology versus Technology. Jaromir Benes, Marcelle Chauvet, Ondra Kamenik, Michael Kumhof, Douglas Laxton, Susanna Mursula. and Jack Selody. © 2012 International Monetary Fund. IMF Working Paper Research Department The Future of Oil: Geology versus Technology. WP/12/109. Prepared by Jaromir Benes, Marcelle Chauvet, Ondra Kamenik, Michael Kumhof, Douglas Laxton, Susanna Mursula and Jack Selody. When learning futures options, on the other hand, traders new to any particular market (bonds, gold, soybeans, coffee or the S&Ps) need to get familiar not only with the option specifications but also with the product specifications of the underlying futures contract. These, however, are insignificant obstacles in today's environment, which offers so much information just a click away.