Global energy prospects

Choices, challenges and uncertainties for the not-so-distant future.

Hubbert's Peak: The Impending World Oil Shortage
by Kenneth S. Deffeyes
Princeton University Press: 2001. 285 pp. $24.95, £17.95

Megawatts and Megatons: A Turning Point in the Nuclear Age?
by Richard L. Garwin & Georges Charpak
Knopf: 2001. 384 pp. $30, £20.77

Tomorrow's Energy: Hydrogen, Fuel Cells and the Prospects for a Cleaner Planet
by Peter Hoffmann
MIT Press: 2001. 320 pp. $32.95, £22.50

Stuart Young

KARIM MOHSEN/GETTY IMAGES

An end to oil refineries? Calculations suggest a permanent downward trend in oil reserves by 2005.

We have heard the words 'energy crisis' repeatedly over the past 30 years, and, looking at the Middle East now, we can expect to hear them again. Yet the crisis, if it comes at all, will not arise from the drying-up of one production source or another, but will be caused by us, the energy consumers, if we do not make timely and efficient use of the alternatives to conventional sources such as oil. These three books carry this message about the (not so distant) future of global energy, although they do so from different viewpoints, dealing with oil, nuclear energy and hydrogen, respectively.

Hubbert's Peak contains some very practical information about the origin of oil, exploration for it and its production. On these matters, the geologist author Kenneth Deffeyes has written a most readable handbook which is well illustrated and has copious notes. But his book is more than that. We are introduced to the Hubbert of the title, a geologist who, in 1956, despite the scorn of others in the industry, predicted that US oil production would reach its peak, and then decline, soon after 1970. It did. Deffeyes explains how he has adapted Hubbert's statistical approach, with its elements of fact and hunch, to predict the turning-point in world oil production. Not, that is, the point when total oil reserves will be exhausted, but merely the first sign of a permanent downward trend. And, he expects, the beginning of consternation.

When will that be? About 2005 — possibly before — but not by any stretch of the figures as late as the end of this decade. So, if he is right we have, at most, two or three years in which to prepare for yet another price shock, and to accelerate our move away from oil as fuel. The strength of the book lies in its solid background and well-explained basis for that single prediction. Deffeyes has a light-hearted way of dealing with weighty matters, and his narrative is enlivened, although sometimes dislocated, by personal anecdotes. He completes his survey by mentioning some of the other energy sources that the world will be driven to use, but does so with less vigour than he applies to those matters directly concerning oil. The book will best be used as a practical and colourful adjunct to technical and economic studies of oil production.

Replacement of oil as a fuel for electricity generation will not be regretted. Crude oil is too valuable a commodity to be burnt on so large a scale, and by doing so we also add significantly to the global greenhouse effect. A return to greater reliance on coal seems inevitable, but only in the short term, for it faces even sterner criticism as a generator of greenhouse gases than does oil.

Nuclear energy almost completely avoids this main environmental danger of fossil fuels, but carries its own burden of risks and liabilities. Foremost is the perceived link between nuclear power generation and nuclear weapons. For many years, defenders of nuclear power have told us that this link is imagined or not relevant in practice, yet the widely held fear of nuclear power, extended to radiation hazards generally, has not gone away. We now have a book, *Megawatts and Megatons*, in which all aspects of the interaction between these two applications of nuclear energy are acknowledged and frankly examined, and the awesome global implications laid bare. The joint authors, Richard Garwin and Georges Charpak, are distinguished physicists who are highly qualified for this task. *Megawatts and Megatons* is largely based on their French-language work *Feux Follets et Champignons Nucléaires* (Odile Jacob, 1997) but includes some current allusions and data.

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Black alternative: if oil supplies dry up, there will be a short-term return to greater reliance on coal.

Garwin and Charpak cover a broad and dauntingly complex field, but the sequence of topics is logical and the text is carefully signposted throughout. In this jungle you

clarification *Nature*'s review by Horace Freeland Judson of James D. Watson's book *Genes, Girls and Gamow* (*Nature* **413,** 775–776; 2001) contains the statement, "Watson arrogates chief credit for messenger RNA to work he did at Harvard...". The reviewer stands by his comments. The reviewer has a right to his interpretation of Watson's account of his contribution to the discovery of mRNA, but *Nature* does not agree with, and dissociates itself from, the reviewer's statement. We regret the distress that this has caused. Editor, *Nature*.

know just where you are. The prose is faultless and a pleasure to read, even though the book is long and the amount of detail embodied in the text is vast. An admirable guiding principle can be discerned throughout — that the concerned reader should not be denied any detail, however small, if it might possibly affect their judgement on the contentious issues before them. This inevitably leads to some difficult passages, with which the reader with no knowledge of basic nuclear physics may struggle. Diehard opponents of nuclear power will no doubt say that, in proposing a safe path to its future use, Garwin and Charpak are partisan. No careful reader of this book could support that claim. The compilation is a full and fair contribution to understanding, and should be studied by everyone concerned with the problems of nuclear power.

Peter Hoffmann writes about the future for hydrogen and fuel cells in *Tomorrow's Energy*. As editor and publisher of *The Hydrogen & Fuel Cell Letter*, he has information on relevant development projects worldwide at his fingertips. In the eye of an enthusiast, hydrogen is the ideal fuel, for whether it is burnt in an engine for propulsion, or used in a fuel cell to generate electricity, the only emission is water. Yet the wider view reveals uncertainties, among them the question of effective generation of the gas. Hydrogen should perhaps be seen as a medium for transferring and storing energy, rather than a primary source.

Hoffmann's book is rich in references to small-scale developments, but poor in data presentation. In more than 250 pages of solid text there is not a single diagram, table or graph. Yet there are two dozen photographs, mainly of experimental vehicles, which add nothing to the technical understanding of the ventures they advertise. Science-based readers will feel deprived. ■

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Somewhere over the rainbow

The Rainbow Bridge: Rainbows in Art, Myth, and Science
by Raymond L. Lee Jr & Alistair B. Fraser
Pennsylvania State University Press: 2001. 408 pp. $65

Philip Ball

Faced with John Keats complaining about all charms flying at the touch of cold philosophy, we might be inclined to respond, "Oh, not that again!" But this book by meteorologists Raymond Lee and Alistair Fraser shows just how crude, prosaic and clumsy the art/science debate is apt to become, because the book is so much the opposite. Stunningly well informed about the art, science, philosophy and history of all eras since the Periclean Golden Age, unerringly elegant, flatteringly intelligent and beautifully illustrated, it is a masterful piece of accessible scholarship.

The authors have, of course, the perfect subject for bringing together not only art and science but myth, nature and anthropology. And Lee and Fraser refuse to peddle the simplistic device that celebrates Newton's matter-of-fact 'unweaving' of the rainbow and then shows how artists persisted in getting the rainbow wrong. Rather, we see how both art and science are represented by a multitude of voices, making their interplay more rich and complex than is commonly portrayed. I would not have expected the poet Wordsworth to spring to Newton's defence, for example, but here he is: "The beauty in form of a plant or an animal is not made less but more apparent as a whole by more accurate insight into its constituent properties and powers." The physicist Richard Feynman was unable to put it better over a century later.

And it is not hard to sympathize with the American painter Frederic Edwin Church in 1883: "I wish science would take a holiday for ten years so I could catch up." The book is a joy because of such things, whether you have ever marvelled at a rainbow or not.

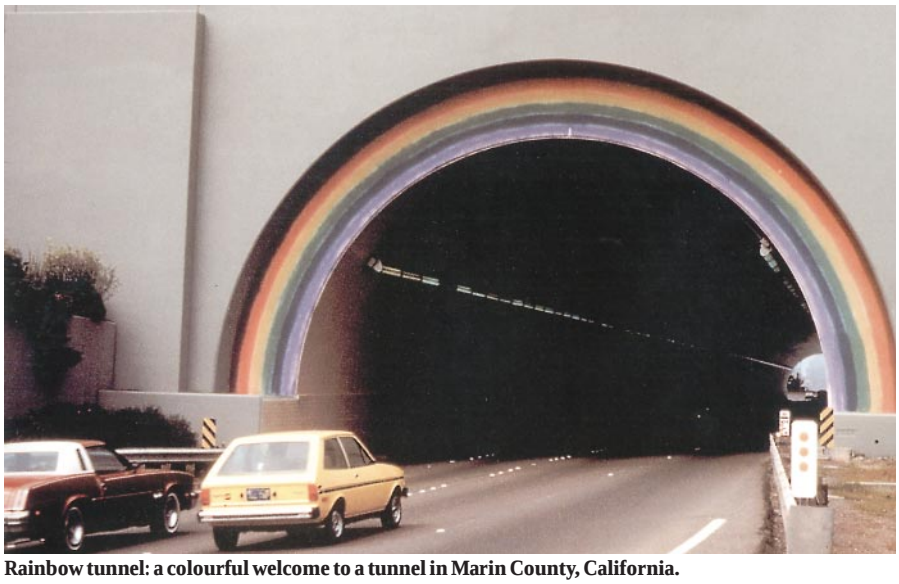
But who has not? The wonderful insight that emerges from the book is that, although we all imagine we know just what a rainbow looks like, painters of realistic landscapes reveal an astonishing variety of ways in which the rainbow is perceived. Rubens' version in *Rainbow Landscape* (*c.*1636) is way off beam, the painter making the classic mistake of representing it as a solid object that can be seen obliquely. The rainbow always faces the viewer in the plane, and moves when we move.

John Constable studied atmospheric phenomena in pedantic detail, yet his rainbow arching over *Salisbury Cathedral from the Meadows* (*c.*1831) is impossible, because the sunbeams show that the Sun is too high in the sky for the rainbow to be visible at all. In his defence, Constable was not averse to artistic licence, and probably considered it more important here to place the symbol of optimism over the storm-threatened church.

Impossible sunbeams also undermine Eric Sloane's rainbow in *Earth Flight Environment* (1976), for the beams should always be radii to the arch of the rainbow. We needn't get too indignant about Caspar David Friedrich's bizarre achromatic eyebrow rainbow from *c.*1810, apparently gracing a nighttime sky, for naturalism was probably never of much significance for this supremely Romantic painter, and a devotee of Goethe was unlikely to honour Newton's spectrum.

Lee and Fraser miss no opportunity to explore the rainbow's many subtleties, giving us plenty of colour theory, wave optics and cloud microphysics. They also present a thoughtful survey of the rainbow as an advertising icon. By placing a lottery's 'pot of gold' at the end of a rainbow, the advertisers are inadvertently reminding us just how unattainable it is. Of the rainbows of popular culture, the one most sadly omitted here is the magical arch that symbolically conjures a Technicolor Oz from a monochrome Kansas.

Rainbows are genuine miracles because they reveal, for a fleeting moment and in a structure that seems a mile high, one of nature's best-kept secrets — what light contains, the origin of colour. And the rainbow is truly a bridge, not just between art and science but between myth and reality, heaven and earth. Classical commentators such as Cicero were torn between explaining the rainbow as a natural phenomenon and celebrating it as an emblem of the gods. The Bifrost bridge spanned Midgard and Asgard in Norse mythology, and its shattering was a suitably dreadful image to herald the Twilight of the Gods. Not all cultures revered the rainbow: some considered it an evil omen, and that is surely what it looks like in Dürer's *Melencolia I* (1514), framing a fateful comet. To point at



Rainbow tunnel: a colourful welcome to a tunnel in Marin County, California.