The energy crisis: avoiding hasty decisions

The "energy crisis" is by now a familiar phrase to scientists, newscasters, politicians and the general public. Yet the energy crunch of the past two years has been determined by the economics, not the resources, of energy. These resources are not yet in short supply, but they have become less assured in the future and far more expensive. Although this may be crisis enough for a society such as our own, which is based on ample supplies of inexpensive energy, the real energy crisis comprises the set of decisions needed during the next several decades as the remainder of our hundred-million year old inheritance of fossil fuels is drawn down towards depletion. We, the scientific community, the United States and the world, are faced with the choice as to how and whether continued growth in energy supply can be maintained. The danger in the crisis lies in the possibility that critical choices will be made hastily, without an adequate consideration of alternatives, and on the basis of what is easiest in the present rather than what is best for the future.

Few people are as qualified to comment on the nature of those choices or their implication as is S. David Freeman, sometime engineer and lawyer with the TVA, assistant to the chairman of the Federal Power Commission, head of the President's energy policy staff and, most recently, director of the Energy Policy Project of the Ford Foundation. In *Energy: The New Era*, Freeman presents, in a single, readable volume, a sweeping survey of the historical development of our energy use, the causes of our present dilemmas and a view into the future. Written entirely in non-technical language, this book provides a much needed entry into the complex web of social, economic, political, environmental and technical factors that must be considered in the formation of a coherent energy policy for the next decade and beyond. No major issue escapes attention: the collision of energy and environmental policies; the implications of domestic and foreign policies; the debate over the quantity and recoverability of energy reserves; the pricing of energy, and the tangled web of government regulation, industry influence and economic pressures that affect both price and supply. All of these highly charged issues are dealt with concisely, clearly and in context. Despite the inevitable simplifications of a short, popular treatment of so many complex issues, no one who is contemplating research in this highly politicized arena can afford not to have read this book.

Energy, Ecology, and the Environment

R. Wilson, W. J. Jones
353 pp. Academic, New York, 1974. $4.95

Energy: The New Era

S. D. Freeman
386 pp. Walker, New York, 1974. $14.50 hardcover, $2.45 paperback

Fission, Fusion and the Energy Crisis

S. E. Hunt
164 pp. Pergamon, New York, 1974. $8.75 hardcover, $6.25 paperback

A Time to Choose: America's Energy Future (Report by the Energy Project of the Ford Foundation)

S. D. Freeman, *et al.*
511 pp. Ballinger, Cambridge, Mass., 1974. $10.95 hardcover, $3.95 paperback

Reviewed by Gene I. Rochlin

Among the policy options for the future that Freeman discusses are the two major methods for reducing energy consumption: leak-plugging—avoiding unnecessary waste of useful energy—and technical improvements by which a specific task can be performed with a smaller energy budget. In both cases there is no necessary connection between reduction in net energy use and output, whether that output is measured in terms of task performance or by an economic indicator such as GNP. In contrast, neither of the two technically oriented books reviewed, *Fission, Fusion and the Energy Crisis*, by S. E. Hunt and *Energy, Ecology, and the Environment*, by Richard Wilson and William J. Jones, seriously considers either of these possibilities. The focus of both is entirely on expanding energy supplies.

Hunt, who has long been associated with nuclear power in the United Kingdom, has written an excellent brief survey of nuclear fission and fusion power sources, very well illustrated and at a fairly low technical level. It appears to be aimed at a somewhat more sophisticated audience than the general public—perhaps at the knowledgeable bureaucrat or policy maker. Despite some inadequacies in definitions and some notational peculiarities, the book presents an adequate introduction to extant and future sources of nuclear power. Little is said, however, of potential risks. The only hazard adequately treated is that of iodine-131, and no mention is made of the possible dangers of nuclear wastes or the circulation of large quantities of fissionable material. Waste disposal is dismissed as having an "almost adequate solution," while better waste disposal techniques are seen as an economic rather than a technical problem. The interesting and informative comparative discussion of nuclear power policy in the US and the several countries of Europe makes the book well worth reading, but those looking for a reasonable estimate of comparative risks or an alternative to continuation of present patterns of energy growth will have to look elsewhere.

Unlike the other books reviewed here, *Energy, Ecology, and the Environment* is expressly intended as a text. It would be most suitable for liberal-arts or science-and-society survey courses, or as an auxiliary for introductory phys-

ics courses. Little mathematical and physical sophistication is necessary. Wilson and Jones deal with a broader set of issues than nuclear power alone. There is a thorough discussion of energy resources of all types and the environmental and thermal penalties that must be paid when they are converted for human use. Also included are such salient topics as water and air pollution, risk–benefit analysis, and the effects of radiation on life, as well as frequently neglected issues such as the trade-off between natural water cooling and cooling towers, and the mining and transportation of fuels. Particularly noteworthy are the often challenging and comprehensive problems at the ends of the chapters and the exemplary worksheets. These are used to impart the physicist's view of the world—the use of models and simple calculations to take a first cut at complex issues. This excellent presentation is unfortunately and inexplicably marred by the total lack of a index, as are Hunt's book and *A Time To Choose.*

There are a few minor errors such as the estimate of 53 K rather than 77 K for liquid-nitrogen temperature. More serious is the careless treatment of nuclear waste. On page 324 the authors state:

> "... the weight of the uranium fuel needed is 1 million times less than that of fossil fuels. The wastes produced will have proportionately less weight. Therefore ... we can guess that 100 tons of waste will be produced per year in the US in the year 2000. This seems very little ..."

This in disingenuous at best. Assuming the authors' estimate of 2×10^9 kW_t installed nuclear capacity in the year 2000 and an all-LWR reactor mix, AEC figures indicate about 50 000 metric tons of low-level solid wastes from the power plants, and about 3000 tons of high-level solids, 5000 tons of cladding hulls, and 30 000 tons of low-level solids from the reprocessing plants. A "back-of-the-envelope" calculation yields between 700 and 800 tons of fission products alone. Even if the rough number had been more accurately estimated, the reader would be better served if the thorough treatment accorded other issues had been extended to this case. This would not be so significant were it not for the not-uncommon implication that the dangers of a fission energy economy are minimal. Perhaps such authors would do well to reflect on the implications for the credibility of the US reactor program of the statement made by Hunt, who is certainly no opponent of nuclear power *per se:*

> "It would be ironic if, after our extreme and costly concern over the safety of UK designed reactor installation, we were to allow importation of light-water moderated reactors into this country even as a short-term expedient." (*Fission, Fusion and the Energy Crisis,* page 63)

Both Hunt and Wilson and Jones have implicitly assumed, as is the case in many recent books on energy and the energy crisis, that the primary contribution of scientists and engineers is to increase supply; that energy demand is an imperative to which we can only respond. *A Time To Choose: America's Energy Future,* the final report of the two-year Energy Policy Project of the Ford Foundation, suffers from no such restriction. The project staff went far beyond the definition of energy policy in terms of supply, increased efficiency and arbitrary targets for imported oil. By constructing three sweeping scenarios for the future use of energy in the US, they have developed a framework for the development of a coherent energy policy, one based on the ends, not the means, of supplying energy to society.

The three (unfortunately named) scenarios are not meant to exhaust the possibilities for energy policy, but to examine them. The "Historical Growth" model assumes a continued expansion of energy supply at the 1950–70 average rate of 3.4% per year to 187 quadrillion Btu in the year 2000—more than doubling the per capita use of energy. The "Technical Fix" scenario envisions a commitment to greater technical efficiency in the use of energy so that, without markedly altering patterns of use, the growth rate of supply can be reduced to 1.9%. Overall energy demand in the year 2000 is reduced to 124 quadrillion Btu, while both employment and GNP are altered only slightly. This still requires a $\frac{2}{3}$ increase in energy supply over the next twenty-five years which, given present estimates of fossil-fuel reserves, would require a considerable expansion of nuclear and other non-fossil-fueled energy sources. The third scenario, "Zero Energy Growth," aims at reducing the growth rate of energy to zero by 1990, but would still require an expansion of supply by a third to 100 quadrillion Btu. Although the GNP is reduced only slightly, and the employment rate is slightly higher than for "Historical Growth," the mix of jobs and services in the economy is redistributed (over several decades) into less energy-intensive sectors.

As the report points out, government policy is a determining factor in all of these scenarios. The critical issue is whether an appropriate policy choice can sever the apparent coupling between energy use and economic growth. There is obviously some correlation between energy consumption and well-being at low consumption levels. However, although both the GNP and energy use have roughly doubled since 1960, by how much has the standard of living increased? Sweden, for instance, a society as advanced as ours, uses 50% less energy per dollar of goods and services than we do. If we are committed not to size but to growth rate itself as an indicator of prosperity, then sooner or later we will be brought up short by natural limits. Exponential growth cannot continue indefinitely, and a carefully planned policy of reduction in energy use will certainly do no more "harm" than a collision with physical limits. The extensive list of technical opportunities for reductions in energy use, presented as part of an even longer list of necessary energy-related research and development, suggests that scientific and technical work can as easily respond to policy as determine it.

It is nearly impossible in such a short review to do justice to the breadth of the Energy Policy Project or the balance shown in the discussion of such sensitive issues as nuclear power, employment, or economic development. Much of the substantive work summarized in *A Time To Choose* is contained in the two dozen or so special reports and books commissioned by the project. The final report is an attempt to integrate employment, environmental protection, economics, and the demographic, political and social implications of energy use with the technical issues of energy supply and efficiency of use. As such, it is (despite occasional shallowness and political naiveté and the limitations of the simplified econometric model used) one of the seminal documents in this field. Its value is further enhanced by the inclusion of the comments of the Advisory Board, as they provide a nicely balanced summary of the criticism that has been leveled at the conclusions of the report.

The Energy Policy Project began in 1972, before the oil embargo and the OPEC cartel brought energy to the fore as a public issue. By the time the project was completed in 1974, much had changed. One can not help but be astonished at the rapidity with which re-

search and development in some of the areas suggested has been initiated. Much work is now being done on solar and geothermal power, and a beginning is being made on analyses of the relations between energy use, economics and quality-of-life. Yet, in the final words of the seventh and last informational bulletin issued by the Energy Policy Project staff, taken from *A Time To Choose:*

"... the scope of potential energy savings and the benefits of slower energy growth have not yet received their just due in the national energy debate."

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Spectrophysics

A. P. Thorne
402 pp. Halsted, New York, 1974
$19.75 hardcover, $11.95 paperback

This is a well-written book mostly about experimental methods of spectroscopy as seen from a university laboratory. It will be useful to graduate students who are to use the techniques in their experimental work and to physicists and engineers who apply them in part of their work. The emphasis is on determination of atomic and molecular structure. It will also be useful to workers who apply spectroscopic techniques in field measurements, but they will find they need to supplement the discussions of noise mechanisms, time and bandwidth. The range is very broad—from the ultraviolet to microwave spectroscopy and from echelles to Fourier-transform spectroscopy (but not Hadamard techniques). The treatment seems strongest in the ultraviolet and visible; descriptions of infrared sources and detectors are quite minimal and the concept of specific detectivity is not even mentioned. Modern infrared photon detectors are not usually limited by current noise. The noise-equivalent power of photoconductors is much less than that of thermal detectors, but the price of this performance is cooling and variation of responsivity with wavelength.

Most of the book is clearly written and lucid. There is, however, a long chapter at the beginning summarizing the quantum mechanics of atomic and molecular structure, which is written in the old tradition of Oxford and Cambridge textbooks, containing much densely packed truth in a form resistant to access by the reader unless he knows it already. Students are advised to skip those 65 pages in favor of a more deliberate book and go on to the excellent treatments of instruments, line parameters, and emission from gases, which can teach them both details and a perspective.

JOHN A. JAMIESON
Washington, D.C.

H. G. J. Moseley: The Life and Letters of an English Physicist

J. L. Heilbron
325 pp. U. of California Press, Berkeley, 1973. $15.00

It is a distinct pleasure to recommend this biography warmly to a broad spectrum of readers. The work is an example of a rarity: a book that is just what its purports to be—H. G. J. Moseley's life and letters.

In the first half John Heilbron deftly describes, with remarkable balance, the historical development of the various contexts in which we find Moseley and the meaning of both his work and the scientific context it changed. For example, in the first four chapters, he interweaves just enough illustration to make convincing his rather outrageous suggestion in the preface: "... it almost appears that the chief joint objective of British scientists and educational reformers of the nineteenth century was to smooth the path of Harry Moseley." Similarly, before we follow Moseley from the scientific backwater of Oxford to the physical laboratories of the University of Manchester, Heilbron makes us painfully aware of Moseley's limited options. The tradition of a lively interest in and support of physics at Manchester, cultivated for two decades by Arthur Schuster and later by Ernest Rutherford, was a godsend for Moseley.

There was stimulation and excitement enough for him during his three-year intimate involvement in this research community which, adroitly led by Rutherford, stood poised at the frontier of the new physics, confident of its point of view, choice of problems and methods of solution. Near the end of this stay, Moseley was able (in collaboration with C. G. Darwin) to play leapfrog with the Braggs on the latter's home field of x rays, when he focussed his forces on the elucidation of the transcending Manchester problem: the structure of the atom. His monumental investigation of the elements by means of x-ray spectra, begun at Manchester, was completed at Oxford, after he decided he had accomplished all that he had hoped for at Manchester. His choice of Oxford was not entirely free, however. He supposed that there was a lack of adequate research facilities on the continent, and he felt a prejudice against French and German researchers. These reasons kept him from working abroad and the choice to stay particularly at Oxford stems largely

MUSEUM OF THE HISTORY OF SCIENCE, OXFORD, UK

H. G. J. Moseley is shown here in the Balliol–Trinity Laboratory, approximately 1910. John Heilbron notes, "... it almost appears that the chief joint objective of British scientists and educational reformers of the nineteenth century was to smooth the path of Harry Moseley."