Book Reviews

Nuclear Energy Technology. By Ronald Allen Knief, McGraw-Hill Book Company, New York (1981). 605 pp. $27.95.

Everything you wanted to know about nuclear technology—and much much more. Ronald Knief has covered, if not smothered, the subject of commercial nuclear power. It is all there; from nuclear physics and reactor core physics to risk assessment and Three Mile Island (TMI) with all bases touched in between. The exceptionally broad coverage implies some superficiality and dullness (it's a little like reading the Handbook of Chemistry and Physics), but it is enormously informative.

This is a reference, not a text, and it can profitably be consulted by any literate person. This is a source for facts, not a well-spring for understanding. The facts include (among others): Nuclear Physics, Reactor Physics, Reactor Kinetics, Fuel Management, Reprocessing and Waste Management, Thermal and Fast Reactors, Breeders and Convertors, Safety and Risk Assessment, TMI, the Regulatory Process, and Nuclear Safeguards. There is also a chapter on Nuclear Fusion.

The assertion above that this is not a text, but a reference, is of course based on personal opinion. It is contrary to the author's opinion and experience as outlined in his Preface. I suppose this difference in opinion reflects some sort of difference in pedagogical philosophy that deserves no further elaboration here.

Nuclear technology is viewed from the points of view of science, engineering, economics, politics, and sociology. The author is carefully nonopinionated and he provides thorough documentation. The book supplies a fine grist for all parties to the nuclear controversy. The recitation of facts is enlivened and enriched by many pictures, figures, graphs, and tables.

The author has performed a service in bringing this mass of material together between two covers. I anticipate appealing to it with some frequency in the future.

The book is organized into six chapters. The first of these is devoted to the introduction of concepts and terminology. The second is the most technical of all six. It provides a fast overview of the relevant nuclear physics and fission reactor core physics. Symbolic language is necessarily, but minimally, resorted to and I believe the bulk of its content can be appreciated by interested, but nontechnical, readers. Chapter 3 is devoted to the fission reactor fuel cycle—uranium processing, fuel assembly design and fabrication, reprocessing, wastes, and waste management. In Chap. 4, the principal types of commercial power reactors are described. These descriptions are rather complete; including details of core design, heat transfer systems, and steam generation. Chapter 5 deals with fission reactor safety and nuclear safeguards. The consequences of fission reactor accidents, the assessment of the risk of such accidents, the TMI accident, the regulatory process, and the safeguarding of special nuclear materials are discussed in considerable detail. Finally, Chap. 6 presents a summary of the current status of research aimed at the realization of controlled thermonuclear fusion as an energy resource. Both magnetic and inertial confinement systems are discussed.

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About the Reviewer: Dick Osborn has been a member of the faculty of the University of Michigan for nearly a quarter of a century and is now professor of nuclear engineering with special interests in nuclear and plasma physics. Following Dr. Osborn's graduate studies at Michigan State and at Case he was located at the Oak Ridge National Laboratory.

Economic and Environmental Impacts of a U.S. Nuclear Moratorium, 1985-2010. By Charles E. Whittle et al., The MIT Press, Cambridge, Massachusetts (1979). 381 pp. $22.50.

This book offers excellent insights into the potential economic and environmental impacts of a nuclear moratorium in the U.S. The bottom line of the authors' analysis is that these impacts are neither dramatic nor unbearable. This book is basically a defense of nuclear option by acknowledged nuclear proponents.

The book contains unusually rich technical information. It will be an excellent reference book for analyzing important economic and environmental impacts of alternative energy systems. The authors clearly recognize the need to develop a credible base scenario for any impact analysis. Thus, they make considerable effort to analyze the key factors for determining economic growth, which, in turn, affects the nation's energy needs. These detailed quantitative analyses are important features of the book, distinguishing it from other popular books such as Harvard Business School's *Energy Future* and the Resources for the Future's *Energy: The Next Twenty Years*. In this book, the authors developed their own economic and energy projections with rigorous quantitative analysis of important determinants and do not rely on other projections.

This book also makes a contribution in the realm of methodology. The study relies on an explicit and precise quantification of the impacts of a nuclear moratorium. To do so, the analysis deals with primarily quantifiable variables. Such an approach avoids, to the extent possible, making judgments on emotional, human, societal, and institutional factors. I prefer this approach because I know precisely how the authors draw their conclusions, with which I may or may not agree. Even though a U.S. nuclear moratorium may not be a probable scenario under the current political environment, the methodology can be applied to other situations dealing with important issues, such as a complete cutoff of imported oil.

The book is organized into two parts. Part One, consisting of four chapters, contains, in a summary format, discussions of essential analysis and results of the study. Part Two, consisting of eight chapters, presents the detailed analysis of each major topic such as the projected future course of economic growth, and the cost comparison between coal and nuclear power plants. These detailed analyses form the basis for the conclusions presented in Part One. For those who do not wish to go through the entire 381-page book, Part One (80 pages) gives the essential elements of methodology, analysis, and conclusions. However, without reading Part Two, one cannot fully appreciate the thoroughness of the data base and the technical information used in the study.

Briefly, the study presented in this book consists of three phases of analysis. The first phase developed the two basic economic and energy scenarios. The high and low gross national product (GNP) growth scenarios were based on detailed examination of the basic determining factors—population, labor force, productivity, and capital requirements. Based on these two economic growth scenarios, two energy demand projections were made. These projections were made on the basis of the relationships between energy demand and economic growth. Each of the major end-use sectors was analyzed with projected efficiencies of the various energy-use processes. Specific fuel demand projections then result from analyzing the technical strategies used for conservation and from a deliberate shift from oil and gas to coal and electricity. The projected total energy demand for 2010 is 118.3 quads in the low case and 158.8 quads in the high case. For comparison, the recent projections by the U.S. Department of Energy as contained in its Annual Report to Congress 1980 are 110.2 quads for the low (high-price) case, 117.6 quads for the mid-price case, and 123.2 quads for the high (low-price) case for 2010.

Throughout the book, I sense that the authors were conscious of the consistency of all computations. For example, in addition to energy demand projections, the authors developed future fuel price projections. Even though these price projections represent expert judgments, they are used along with the demand projections to compute the implicit price elasticities. The authors seem to be comfortable with the fact that the computed sectoral price elasticities are within the range of the estimates obtained from other studies. For further validation, a One-Sector Economic Growth Model was developed to check the consistency of the aggregate price elasticity implicit in the projected GNP and total energy demand.

The second phase of the study was to analyze the impacts of a nuclear moratorium. To perform the analysis, the energy supply assumptions were manipulated while energy demand projections remained unaffected. Specifically, it is assumed that nuclear reactors will expand from the planned 1985 capacity commitments (175 000 MW) to between 450 000 and 512 000 MW by the year 2000 for the two basic scenarios. In the moratorium case, the number of reactors are set at the scheduled 1985 level and all the additional needed nuclear capacity is simply shifted to coal. With this change in the energy supply mix, the study proceeds to analyze the economic and environmental impacts of a nuclear moratorium (or, more precisely, shifting from nuclear to coal). Major economic impacts analyzed in the study include future cost of electricity, regional impacts, the impacts on nuclear and coal industries, and international effects in terms of oil imports and foreign markets for nuclear reactors. Major environmental impacts include the global effects of increased levels of CO_2, reactor accidents, radioactivity, other emissions from coal plants, and land use impacts.

The third phase of the study was to analyze alternative long-range energy futures. To be specific, only solar and nuclear (breeders) options are contrasted and compared. Although this phase of the study is very interesting and insightful, the analysis of the asymptotic U.S. energy future has very little, if any, to do with a nuclear moratorium.

Several important findings are obtained from the study:

1. Nuclear power appears to be cheaper than fossil-fuel-generated power in most regions of the U.S. The estimated direct average cost per year of a nuclear moratorium lies in the vicinity of 1% of yearly GNP.
2. A nuclear moratorium may require 1 to 3 billion tons more coal to be mined per year in the period 2000 to 2010 than otherwise.
3. In the long run, atmospheric levels of CO_2 might lead to unacceptable changes in climate. However, a U.S. nuclear moratorium does not affect these levels significantly.
4. In the very long run, the society may have only solar energy and nuclear power (breeders) as its major energy options. Solar energy, especially as a stand-alone electric system, presently appears to be much more expensive than nuclear energy.

In order to make nuclear power more acceptable as the ultimate energy source, the authors suggest the following measures be taken:

1. The nuclear power plants should be confined to only a few sites (nuclear power parks).
2. Nuclear electricity generation and electrical distribution should be separated.
3. Security measures similar to those during wartime should be imposed on our nuclear plants.
4. The nuclear cadre should become more professional.

There are several deficiencies in the study. While many quantitative analyses were performed in the study, in numerous places the calculated figures cannot be easily interpreted as being either small or large. Consequently, it is highly subjective to use these calculated figures for making inferences on whether some impacts are critical or some technologies are acceptable. For example, it was calculated that in order to handle the High-Scenario asymptotic nuclear system of 1000 breeders, 1000 square miles is required to dispose of high-level wastes. The authors seem to accept this figure as favorable because, as was stated on p. 320, "1,000 square miles of high-level waste disposal area might be sufficient to take care of the entire nuclear energy system for tens of thousands of years." The 1000 square miles may appear to be small in comparison with the entire U.S. land area. But given the U.S. political system, a heated debate on where to locate the 1000 square miles would be inevitable and the outcome is by no means certain. In analyzing asymptotic U.S. energy futures, the authors considered only two alternatives—solar energy and fission breeders. Fusion is not considered because, as argued, the authors cannot state with assurance that it is feasible. In my view, it is too simplistic to dismiss the fusion option in the analysis.

Overall, the book is carefully done. It contributes significantly to the understanding of our energy problems and futures. I would highly recommend it as a valuable addition for your own library of energy literature.

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Thermohydraulics of Two-Phase Systems for Industrial Design and Nuclear Engineering. Edited by J. M. Delhaye, M. Giot, and M. L. Riethmuller, Hemisphere Publishing Corporation, Washington, D.C. (1981).

This volume is based on a lecture series at the von Karman Institute of Fluid Dynamics, Belgium, in 1978. Unavoidably, some of the contents have become outdated before its 1981 publication.

Volume I includes several basic aspects of pressurized water and liquid-metal fast breeder reactors (PWRs and LMFBRs) with chapters contributed by a number of authors.

Truly authoritative presentations by Y. Y. Hsu are given in Chap. 1, an overview of PWR and loss-of-coolant accident and emergency core cooling phenomena, Chap. 14 on boiling heat transfer, Chap. 15 on condensation heat transfer, and Chap. 19 on two-phase heat transfer computer modeling. The first three are areas of his personal research. The latter is a candid evaluation of various codes. Hsu has identified the need of in-core instrumentation and the need to improve the confidence in reactor safety margins via accurate modeling.

Definitive experiments on LMFBRs and their problems are reviewed in Chap. 2 by J. Costa. An effort on detailed modeling of the 19-pin voiding study carried out at his laboratory would be very useful, and, in fact, these experimental data can be used for validating the computer code. It would be a very desirable and timely subject to have some discussion in the areas of flow stratification and natural circulation.

Several of the chapters (Chaps. 3, 4, 5, 7, and 8) on formulation, based on first principles by J. M. Delhaye, have been published previously. Their relation to industrial design appears remote, and more work is needed to approximate these equations into a practical usable form. Furthermore, a clear delineation of relative merits and an authoritative recommendation of suitability of particular applications of the various averagings presented appear extremely useful and desirable. His excellent survey on flow regimes gives a systematic account of correlations suggested by various authors. On instrumentation, it appears desirable to clearly state that measurements by local attenuation of light or other beams (optical sensors) give linear or volumetric averages of densities or voids, while electrical probes, anemometers, and micro-thermometers give mass flow measurements or residence times. They give void fractions only when velocities of phases are equal. Overall, these chapters are very informative and provide a part of necessary background for multiphase flow and heat transfer.

Nucleation, friction factors, pressure drops, and critical flow are surveyed in Chaps. 6, 11, 13, and 18 by M. Giot. Their usefulness as a basic reference for engineering design is seen. Not many of the references given were published after 1974.

Regime transition in boiling heat transfer and two-phase flow instabilities and propagation phenomena are explained in Chaps. 16 and 17, written by G. Yadigaroglu. An important contribution is in identifying aspects that are not well understood, such as two-phase interaction laws and causes for oscillation of dryout points. Flow regime recognition and phenomenological approximation in the formulations are expected to continue to be a mode of computer modeling for some time to come.

D. Grand wrote chapters on pressure drops in rod bundles (Chap. 12) and two-phase calculations in LMFBRs (Chap. 20). Relating experimental pressure drop correlation to terms in the momentum equation appears useful. Two- and three-phase flow in LMFBRs at accident situations were illustrated via the SIMMER-1 code, including meltdown, but the accuracy of prediction is not known. Since modeling of sodium boiling is still in the early stage of development, much new information has been rapidly evolved since the publication of this volume.

The editors have made a good effort toward a coherent presentation. Gaps are there, and it is important to recognize that they exist. Accuracy of accident prediction has to be improved from both theoretical studies and experimental validations. Not only are the measurements challenging, but their limitations cannot be entirely eliminated. Further understanding of the physics of multiphase flow and improvements of mathematical procedures are very much needed if the formulations are to give correct modeling.

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About the Reviewer: William T. Sha is a senior scientist and manager of the Analytical Modeling Section, Components Technology Division, Argonne National Laboratory where he has been located since 1967. He is a noted developer of computational methods in the thermal-hydraulics area, and is solely or partially responsible for the development of many important computer codes, such as THUNDER, THINC, SAS, VENUS, THI3D, COMMIX, and BODYFIT. Dr. Sha's graduate training was at Columbia. He was engaged in reactor physics and heat transfer and fluid flow studies with Combustion Engineering and with Westinghouse Electric Corporation between the mid-fifties and the mid-sixties.

Structural Materials in Nuclear Power Systems. By J. T. A. Roberts. Plenum Press, New York (1981). 485 pp. $39.50.

The title of this book contains the phrase "Nuclear Power Systems" and the contents are faithful to the title. All previous books on nuclear materials have dealt almost exclusively with core materials, whereas the present monograph gives nearly equal weight to the balance of the plant. As one proceeds from the fuel element out to the turbine, the objects of concern become more massive and the materials phenomena that affect them change from principally physical to nearly exclusively chemical.

The introductory chapter gives an overview of the reactor systems (fission and fusion), their materials limitations, and the philosophy with which the latter are addressed. The