briefly what was presented in four lectures. In this chapter the author compares fission with fusion and inertial fusion with magnetic confinement concepts. There is some confusion between diffusion and conduction processes and the Lawson $\eta\tau$ criteria and ignition are discussed in a rather misleading way. This chapter is just too brief and is, consequently, very superficial.

"Plasma Equilibrium in a Tokamak" (22 pages, 10 references) and "Stability of a Tokamak Discharge" (21 pages, 12 references) by F. Troyon from Ecole Polytechnique Fédérale, Lausanne, Switzerland are a short and thoughtful introduction to tokamak equilibrium and stability theory. Careful definitions are used and selected results from ERATO and PEST computational codes are presented. The present limits to tokamak operation are discussed including disruptions, beta limits, and resistive instabilities.

"Transport and Scaling Laws in a Magnetized Plasma" by A. Nocentini, Instituto di Meccanica, Università degli Studi P. le Europa, Trieste (59 pages, 17 references) introduces magnetic confinement principles by considering the physics of plasma in a straight cylindrical magnetic field. Then plasma transport in tokamak toroidal geometry is qualitatively described. Neoclassical and anomolous transport are discussed using simple qualitative arguments. Pfirsch-Schlutter results are quantitatively developed, and weakly collisional plasma results are sketched. Some discussion is given of anomolous transport and scaling laws.

"Plasma Heating in Toroidal Magnetic Confinement Systems" by R. Gravier, Fontenay-aux-Roses, France (57 pages, 24 references) discusses ohmic heating in tokamaks, and anomolous losses observed in tokamak [Fontenay-aux-Roses (TFR)] experiments are considered in some detail. Additional heating methods using neutral beams and electromagnetic waves are briefly discussed. Technologies employed by these supplementary heating methods are described.

"Plasma Wall Interaction in Tokamaks" by J. Bohdansky from Max-Planck Institute, Garching, Germany (34 pages, 18 references) describes the physics of particle reflection and re-emission from surfaces. Additional phenomena of arc spots, sputtering, desorption, blistering, and particle recycling are discussed briefly.

"Divertor Problems" by P. J. Harbour from Culham Laboratory, England (41 pages, 71 references) briefly states the purpose and the history of divertors. Descriptions of different types of divertors are presented. Some examples together with experimental results from current tokamaks using divertors are described. A note added in proof states that some of the conclusions in this chapter have been recently revised.

"Main Features of Cold-Blanket Systems" by B. Lehnert from the Royal Institute of Technology, Stockholm, Sweden (81 pages, 127 references) describes the main features and the present level of understanding of a cool gas blanket between a hot plasma and a solid wall. The importance of this subject to tokamak physics is uncertain.

"Control of Burn-Up Phase" by A. Sestero from Frascati, Italy (17 pages, 7 references) presents a brief discussion of the elements of feedback control of an unstable ignition point in a tokamak.

"Turbulent Plasma Behavior in Toroidal Systems" by R. Gravier from Fontenay-aux-Roses, France (37 pages, 15 references) is a short and interesting survey of instability phenomena observed in tokamaks. The TFR data are used to describe tearing instabilities, island formations, Mirnov oscillations, sawtooth oscillations, and disruptions. The word "turbulent" in the title of this chapter is somewhat misleading.

"Plasma Transport Calculations for Fusion Reactors" by D. F. Düchs from Garching, Germany (46 pages, 5 references) describes important physical effects predicted by large-scale computer codes developed for tokamaks. Selected results from INTOR studies are presented. Numerical techniques and computer time needed for these studies are briefly described.

This reviewer found this book very heterogeneous, ranging from some very good sections to rather poor. It contains no index, and the notation and units in formulas varied throughout the text. The editor apparently made no effort to correct many spelling and grammatical errors. Particularly frustrating in some chapters was the failure to distinguish between fundamental physics and empirically observed tokamak limitations. This book can be compared with *Plasma Physics for Nuclear Fusion* by Kenro Miyamoto, MIT Press, 1980. The purpose of each book is similar. In the reviewer's opinion the text by Miyamoto is much superior.

Robert A. Gross did his undergraduate study in engineering at the University of Pennsylvania and received his doctorate in applied physics from Harvard University. He then worked in the aerospace industry for six years, principally on research in high-temperature gas dynamics and supersonic combustion. In 1959 he was a senior National Science Foundation Fellow at the University of California, Berkeley and the Lawrence Livermore National Laboratory. In 1960 he was appointed professor at Columbia University where he founded its plasma physics laboratory. His research since then has been primarily concerned with the physics of very strong shock waves and the physics of high-beta tokamaks. He holds the Percy and Vida Hudson Chair of Applied Physics at Columbia University and in 1982 he was appointed Dean of the School of Engineering and Applied Science.

A Desirable Energy Future: A National Perspective

Authors	Robert S. Livingston, Truman D. Anderson, Theodore M. Besmann, Mitchell Olszewski, Alfred M. Perry, and Colin D. West
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Reviewer	William C. Gough

The goal of *A Desirable Energy Future: A National Perspective* is to develop an independent viewpoint to aid the planning of energy R&D. The authors did not attempt to predict the future based on theoretical and empirical data, for example, by use of large computer-based models. Rather, they assumed a desirable future and then examined what energy strategy could make that desirable future possible. The book is an outgrowth of the Oak Ridge National Laboratory (ORNL) National Energy Perspective project, that was carried out during the summer of 1979. The book is based on input from more than 20 background papers prepared by staff of the ORNL as well as from energy studies conducted from 1973 to 1981, which were examined for relevant data, analyses, and insights. The detailed analyses in the book are based primarily on 1978 energy production and consumption data.

The authors define *A Desirable Energy Future* as one with sustained economic growth and continued freedom of choice of lifestyles. Specifically, a per capita gross national product growth rate of ~2%/yr is considered adequate to maintain or improve our present level of amenities. The amenities "involve the continuation of personal freedom as embodied in the automobile and it means a continuation of established trends in housing."

The departure since 1979 from the historical energy growth trends in the United States was examined, and the major cause was attributed to a stagnant economy and a curtailment of consumer activity rather than to energy efficiency improvements. The authors, therefore, conclude that these recent trends do not alter the basic conclusions of their book since their objective was to define what the nation needs to do to actualize a desirable future while the current trends for the most part reflect negative effects.

The authors' approach the "energy crisis" as a set of energy problems that must be overcome, but stress that all energy problems are not equally urgent. For the United States, they establish two major classes of problems—the short term and the long term, i.e., beyond the year 2010. In the short term, the "most immediate and pressing problem is the vulnerability of the United States to the interruption of foreign oil supplies." A very acceptable solution to this problem, at least to the year 2020, is believed possible using relatively modest extrapolations of present technologies. Three methods of reducing oil imports are explored:

"1. produce more oil from domestic resources;

2. increase the efficiency of oil use (oil conservation); and

3. the substitution of other, preferred domestic, energy resources for oil."

The nontechnological approaches, which could contribute to solving the oil import problem by focusing public policy on economic or institutional systems, are also discussed.

The study concludes that "oil imports can be reduced to less than 20% of oil demand by the end of the century, and that this level is sufficiently low that a cutoff of supply from a significant oil-producing area of the world would not gravely affect the U.S." One essential ingredient of the plan is an "accelerated fuel substitution program, especially in the utility industry." However, the authors believe that "Without a major federal program, the shift away from oil and gas in electricity production will require 15 to 20 years." The study also concludes that improvements in transportation efficiency could be achieved by the year 2020 sufficient to assure that "individuals could drive their automobiles the same distance as today for half the fuel costs."

The authors attribute much of this country's current energy difficulties to a failure of our traditional social means for making and implementing energy decisions. They, therefore, devote a section to addressing ways to increase the effectiveness of our structures for making major energy decisions. However, this topic is of a sufficient magnitude that it would require another book to provide meaningful solutions.

In addressing the longer term problems, the authors clearly link our national interests to the worldwide energy situation. They point out that almost all (80%) of the increase in world energy use during the 20-yr period between 1956 and 1976 took place outside the United States. Since this book is exploring a desirable future, the authors hope "that during the next several decades much more attention will be devoted to improving the standard of living in the developing countries." They believe this is possible if there is a greatly expanded energy supply system so that the growing world population can be well fed and comfortable. To accomplish this, a transition must be made from the present situation in which growth in demand is met largely by natural oil and gas.

Global concerns are expected to become increasingly important in evaluating domestic energy policy. In fact, the authors believe that the economic and political linkage between the United States and other nations makes a purely national solution to our energy problems, especially the long-term ones, impossible. Predicting that the developing countries must continue to meet their growing energy demands with oil, the pressure on the world oil supply will result in price increases that would have severe impacts on their economies and cripple further development. Thus, the authors propose that the United States develop a policy to relieve the pressure on the international oil market by withdrawing as a large-scale buyer. "This action would not only establish a relationship with the rest of the world that would improve its well-being and contribute to international stability, it would also be an essential step toward alleviating our own political and economic vulnerability."

To resolve the long-term and global energy issues, the authors look to coal and uranium, and also the "light elements, in fusion reactors, and solar power." They believe that commercial fusion power units "that generate electricity at a competitive cost might appear by the year 2025." The discussion of fusion is quite limited in the book. The authors fail to mention any of the potential nonelectrical applications of fusion and their possible implications: fusion/fission, process heat, and industrial systems using photons or particles. Concerns on availability of lithium and helium seem overemphasized in relation to similar issues for other energy sources, the R&D time period involved, and the potential options available during that period.

Although the book deals primarily with the analysis of the energy system and with energy policy, the importance of energy R&D is stressed—both for lowering costs and reducing impacts. The authors emphasize that R&D efforts related to long-term issues should not be delayed. "Many decades are required to implement new technologies and to gain an understanding of their potential impacts; low R&D priority on long-term technologies and issues could doom us to perpetual energy crises in the future."

The authors believe that the ultimate goal of their recommended commitment of substantial resources for energy is for the United States to become an exporter of energy goods and technologies. This, they state, "will help maintain peace and stability in the world and will continue the tradition of the nation as a world leader in the marketplace." The implied message to those in the fusion program is an appeal to think in terms of a worldwide energy market and target the R&D to encompass the needs of such a market in terms of the size, nature, and application of fusion technology.

A Desirable Energy Future is a book of 262 pages with 87 tables and 40 figures. For those interested in obtaining an overall perspective on the elements of our "energy crisis," this book will prove very useful with its summary information and broad coverage of the subject. The authors should be commended for including an Appendix that outlines the assumptions made in the book, for example, in areas such as escalation and cost of fuels. There is also a useful listing of abbreviations and units. The writing is somewhat "laboratory report style" but quite readable. The most unforgivable sin that the authors committed was to include only a half-page table of contents and no index. This greatly reduces the usefulness of the book as a reference.

Bill Gough has 30 years of experience in the energy field ranging from basic research to applied energy technologies to commercialization activities. He is currently the U.S. Department of Energy (DOE) Site Manager [Stanford Linear Accelerator Center (SLAC)/Stanford Synchrotron Radiation Laboratory (SSRL)] responsible for the high-energy and nuclear physics work at the SLAC and the basic science research at the SSRL. Prior to this position, Bill was the director of DOE's Office of Program Assessment and Integration in San Francisco and the manager of the Electric Power Research Institute's fusion power program. He worked for the U.S. Atomic Energy Commission on nuclear power reactor programs and in research programs on controlled thermonuclear fusion and plasma physics. He was instrumental in establishing the fusion reactor technology effort. Bill is author of a Scientific American *article and has published in numerous journals, magazines, and books, including the* Environmental Engineer's Handbook. *He obtained his BS and MS degrees in electrical engineering from Princeton University and has studied the interaction of science and public policy during a sabbatical at Harvard University.*