The study's full exposition is designed primarily for practitioners of the art of energy demand modeling. Others, including policy makers and students of energy problems, generally can omit the more technical portions and concentrate on the summary and comparison sections, which are concise but quite readable.

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Advances in Nuclear Science and Technology

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Eight topics covering a wide range of developments are reviewed in this eleventh volume of *Advances in Nuclear Science and Technology*, edited by Ernest J. Henley, Jeffrey Lewins, and Martin Becker. The topics are organized into three basic categories–science, technology, and the practicalities of nuclear power.

J. Walker and D. R. Weaver of the University of Birmingham review basic "Nuclear Physics Data for Reactor Kinetics," discussing the information available in five evaluated libraries (ENDF/B-IV, ENDL, UKNDL, KEDAK3, and SOKRATOR) as well as fission product, delayed neutron, and heavy element data. Various evaluations of absolute and relative group yields are compared. Recent experiments on delayed neutron spectra from thorium, uranium, and plutonium and the neutron spectra from single precursors are summarized. The major fuel nuclides and transactinium nuclides are reviewed with respect to accuracy, improvement requests, and calculational discrepancies due to group structure, data files, and coarse spatial representations in reactor calculations.

N. Pacilio, A. Colombio, R. Mosiello, F. Norelli, and V. M. Jorio, Comitato Nazionale per l'Energia Nucleare, review the stochastic theory form of reactor kinetic theory in "Analysis of Reactor Noise." A unified analytical theory for reactor noise is developed using the time-dependent differential equation in the state-generating function. Transforming this equation into a set of differential equations in the factorial moments or factorial cumulants of the state variable admits analytic solutions, especially in situations in which integrations of the generating function equation have been difficult or impossible. Numerous models are examined and explained in detail and the solutions (including limits) are developed under the ergodic hypothesis. A valuable compilation of over 20 experimental methods, observed probabilities, and formulas for data interpretation are included, and as well, a summary of the correspondence between the stochastic parameters and kinetic parameters is elucidated.

M. W. Jervis, Central Electricity Generating Board (CEGB), gives an update review of "On-line Computers in Nuclear Power Plants," as developed in both the U.K. and Canada. On-line computers supply a unique capability in power plant operation as part of the total control and instrumentation system. Policy formation basis, problem areas, and solution techniques are critically reviewed with reference to CEGB nuclear power plants. Computer functions and application classes are summarized and explained in considerable detail. Computer hardware and software systems and examples in the U.K. and Canadian operating plants are discussed. Cathode ray tube (CRT) displays in control room design and ergonomic factors are reviewed. Important aspects of reliability, obsolescence, replaceability, project management, and program and data security, as well as initial design licensing, modifications during the life of the plant, and the impact of future developments, are addressed. Considerable progress has occurred in CRT and alarm analysis. Continued investigation and improvement in operations research and reliability targets are recommended to establish the analysis-selection processes of significant and organized information through relatively few available channels for a more optimal operator response.

D. O. Pickman, J. H. Gittus, and K. M. Rose, United Kingdom Atomic Energy Agency, review the design of "Fuel for the SGHWR" (Steam Generating Heavy Water Reactor). Fuel design integrity criteria for the 36- and 60-rod distributions are examined. Operating experience on burnup, coolant flow and steam quality, fretting, dimensional changes, fuel/cladding gap, fission gas release, UO_2 swelling, corrosion and deposition, irradiated cladding mechanical properties, power cycling and ramps, and fuel defects is discussed. If logical design bases and performance predictions are to be maintained, then the development of performance model computer codes is imperative. The SEER-SLEUTH computer code modeling and validation of cladding and cladding fuel interaction are reviewed. Accident analysis of stagnation loss-of-coolant accidents (LOCAs), cladding diameter increase simulation using the Programmed Pressure and Temperature Fuel Rod testing rig, fuel behavior during irradiation, and measured pressure tube tests using the Bluster Blowdown rig are discussed. The transient modeling capabilities of the CANSWEL-1 and CANSWEL-2 (under development) computer codes are outlined and the reasonable comparisons obtained with test data relevant to LOCA and with simulated pressurized water reactor transients are reviewed. Future work on fuel cladding corrosion and incidence of defects is outlined.

M. Ishikawa and T. Inabe, Japan Atomic Energy Research Institute, describe the program of "The Nuclear Safety Research Reactor (NSRR) in Japan" related to reactivity-initiated accidents (RIA) of light water reactors (LWRs) and fast breeder reactors. The NSRR driver core is a TRIGA-Annular Core-Pulsed Reactor that generates very

rapid overpower transients ($100/s) to irradiate fuel rod clusters under realistic reactor conditions (temperature, pressure, flow rates, etc.). The main objectives are to investigate fuel failure thresholds and pressure boundary damage from fuel failure mechanical energy generation. The experimental research program aims, test fuel rods for the first phase, and program schedule are discussed. The results of 37 fuel failure tests (first phase) of single LWR fuel rods are reported with respect to general behavior, cladding surface temperatures, fuel failure mechanisms, wide-gapped fuel, and waterlogged fuel. Future plans include RIA experiments and core power mismatch accident experiments on unirradiated and irradiated fuel rods in technical collaboration with the U.S. Nuclear Regulatory Commission.

K. H. Puechl, Combustion-Engineering, Inc., reviews the "Practical Usage of Plutonium in Power Reactor Systems" with respect to breeding and recycling. Popular misconceptions about plutonium are examined, especially concerning maximum permissible body burden and lethal dose as well as "how easy it is to make a plutonium bomb." Plutonium properties are reviewed with major emphasis on plutonium utilization and radiological and nuclear properties. Recycle alternatives subject to technical constraints, radiological, economic, and safeguards considerations are discussed. It is observed that using accounting practices that attribute a sizable carrying charge to in-core fuel inventory results in accounting aberrations and precludes performing rational fuel life design for optimized resource conservation. Several fuel recycle approaches are described. The first, conventional cycle (conservative viewpoint), involves the minimum perturbation of the uranium fuel cycle. Blending options, plutonium reactivity value, fuel design, fabrication, and performance are outlined. The second approach described, plutonium burner, is based on using fuel with a high fissile content (70%) with the result of an extended fuel cycle and separative work savings; reactivity and materials considerations are included. Finally, the low concentration plutonium recycle approach is reviewed with emphasis on radiological considerations, fuel fabrication price, and plant design. The analysis concludes that the low concentration mixed oxide plutonium recycle would be more efficient from the standpoint of resource utilization than the conventional recycle.

P. R. Smith, of the University of London, surveys "Computer Assisted Learning in Nuclear Engineering" on digital computers with emphasis on projects at the Royal Naval College Greenwich (RNC), Queen Mary College (QMC), and Virginia Polytechnic Institute and State University (VPI). The education roles of the computer are delineated and defined for computer-assisted learning (CAL), computer-aided instruction, computer-aided design, and computer-managed learning. A review of computers in nuclear engineering education and the claims for CAL are given. The use of graphic display in CAL is described and illustrated with numerous current programs. The 67 U.K. CAL project packages include applications in aeronautical, chemical, electrical, electronic, mechanical, and nuclear engineering. Of the 34 nuclear engineering packages in use at QMC, 14 are briefly summarized and 1 is described in detail, illustrating usage and implementation. The CAL at VPI (developed under National Science Foundation support) is reviewed, and 16 modules on reactor statistics, fuel management, reactor dynamics, and thermal hydraulics are summarized. Considerations necessary for transferring and for implementation of CAL programs (FORTRAN) to other institutions are discussed. A qualitative evaluation of the CAL effectiveness at QMC indicates a very positive response and the "students find the CAL packages very motivating." The future attractive prospects of CAL for individualized learning are outlined.

M. J. McNelly, General Electric Company, reviews the concept of "Nuclear Energy Centers." After general background discussion of the issues, uncertainties, possible configurations, and alternatives of nuclear energy centers (NEC), the emphasis focuses on three significant problems: fuel cycle integration, modular construction, and heat rejection. Existing fuel cycle facilities and nuclear power plants are reviewed relative to location, status, and capability. The consequences of the delays in closing the fuel cycles (due to no reprocessing) are examined with respect to spent fuel buildup and estimated plutonium fabrication requirements. The rationale of NEC with integrated fuel facilities is presented and several fuel cycles (store-away, self-generated recycle, and plutonium burner recycle) are outlined. General characteristics of the plutonium burner energy centers and the use of the nuclear fuel resource and growth assumptions are compared for several planning scenarios. Standard design for NEC with six to eight units via modular construction is examined as a means to reduce total plant construction costs. Siting implication, water availability for cooling, and possible trends toward minimum water usage and the meteorological impact of evaporative towers are discussed.

The articles and reviews are adequately referenced, timely, and current with more than 40% of the 600 references being within approximately two years of the apparent literature cutoff dates. There are a few typos, none very serious.

The authors and editors are to be congratulated for their sound analysis and judgment in the review of physical and technical information presented in an interesting and clear manner. This volume has several articles of interest to every American Nuclear Society member.

Clarence E. Lee is a professor in the Department of Nuclear Engineering at Texas A&M University. He is currently doing research on analytical and numerical methods in diffusion and transport theory, charged particle transport, high temperature gas-cooled reactors (prismatic and pebble-bed), fission product migration, and fast reactor accident analysis.