Ens fusion technology

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OVERVIEW

EXPLORING THE COMPETITIVE POTENTIAL OF MAGNETIC FUSION ENERGY: THE INTERACTION OF ECONOMICS WITH SAFETY AND ENVIRONMENTAL CHARACTERISTICS

John P. Holdren
D. H. Berwald
Robert J. Budnitz
Jimmy G. Crocker
J. G. Delene
Ron D. Endicott
Mujid S. Kazimi
R. A. Krakowski
B. Grant Logan
Kenneth R. Schultz

John P. Holdren (top right) [SB, 1965, and SM, 1966, aeronautics and astronautics, Massachusetts Institute of Technology (MIT); PhD, aeronautics and astronautics/plasma physics, Stanford University, 1970] is professor of energy and resources at the University of California, Berkeley (UC, Berkeley), and faculty consultant in the Magnetic Fusion Energy Division of Lawrence Livermore National Laboratory (LLNL). His research interests include fusion reactor design to minimize radiological hazards, comparative assessment of the environmental and sociopolitical impacts of energy systems, and problems and prospects of nuclear arms control. **D. H. Berwald** (top left) [PhD, nuclear engineering, University of Michigan (UM), 1977] is manager of the Department of Systems Engineering, Energy Systems Operations at TRW Inc. His research interests include nuclear design and shielding analysis, fusion technology, advanced fission reactor fuel cycles, applications of advanced isotope separation technologies, and high-level waste disposal. **Robert J. Budnitz** (center right) (BA, physics, Yale, 1961; PhD, physics, Harvard, 1968) is president of Future Resources Associates, Inc., Berkeley, California, an engineering consulting firm. His research interests include nuclear fission reactor safety, radioactive waste management, and probabilistic risk assessment. He was formerly (1979–1980) Director of Research, U.S. Nuclear Regulatory Commission. **Jimmy G. Crocker** (center left) (BS, 1954, and MS, 1955, physics, Oklahoma State University) is manager of advanced nuclear programs for EG&G Idaho, Inc. at the Idaho National Engineering Laboratory. He previously was manager of the Fusion Safety Program. His current research interests include nuclear safety and treatment of brain tumors by boron neutron capture therapy. **J. G. Delene** (bottom right) (MS, nuclear science, UM, 1959) is a staff member in the Engineering Technology Division of Oak Ridge National Laboratory. He has made contributions to the reactor core physics of a variety of fission reactor concepts, to the dynamic modeling of nuclear power plants. His current interests include economic studies of fission, fossil, and fusion systems. **Ron D. Endicott** (bottom left) (BS,

electrical engineering, University of Kansas, 1973; MS, electrical engineering, New Jersey Institute of Technology, 1984) is a senior staff engineer in research and development at Public Service Electric and Gas Company. He has 13 years experience in the electric utility industry. During the past 8 years, his work has included studies of several fusion power plant conceptual designs. **Mujid S. Kazimi** (top right) (PhD, nuclear engineering, MIT) is associate professor of nuclear engineering at MIT. His research interests include thermal phenomena in fission reactor safety, advanced two-phase flow model development for reactor transient analysis, and fusion reactor safety. **R. A. Krakowski** (top left) (BS, chemical engineering, Ohio State University; PhD, nuclear engineering, University of California, 1967), after working on nuclear material problems at the Euratom Center of Research in Ispra, Italy, and teaching nuclear engineering at Ohio State University, joined the Los Alamos National Laboratory (LANL) in 1972 to work on material problems associated with space nuclear power. He presently heads a magnetic fusion systems study group at LANL responsible for alternative fusion concepts. **B. Grant Logan** (bottom right) [BS, physics, New Mexico State University; MS, nuclear engineering, UC, Berkeley; PhD, engineering science, UC, Berkeley] is a deputy associate director and the program leader for the Fusion Reactor Technology and Conceptual Design Program in the Magnetic Fusion Energy Division (M Division) at LLNL. His main interests are the design of magnetic fusion systems, including experiments, engineering test reactors, and advanced commercial power reactors. **Kenneth R. Schultz** (bottom left) (PhD, nuclear engineering sciences, University of Florida, 1971) is a manager of fusion development and technology at GA Technologies, Inc. He is responsible for the fusion nuclear technology aspects of several reactor design study projects for tokamak, mirror, and inertial confinement reactor applications, with emphasis on blanket engineering. He also is involved with several small blanket technology experiments.

PLASMA ENGINEERING

TOKAMAK FUSION TEST REACTOR CENTRAL IGNITION SCENARIOS

Martha H. Redi
Stewart J. Zweben
Glenn Bateman

Martha H. Redi (top) (BS, physics, Massachusetts Institute of Technology; PhD, physics, Rutgers University) has worked in applied physics at Princeton University since 1976. She has published papers in superconductivity theory, theoretical biophysics, oceanography, and plasma physics. Since joining the Princeton Plasma Physics Laboratory (PPPL) in 1982, she has been primarily interested in the computational modeling of tokamak transport. **Stewart J. Zweben** (center) (PhD, physics, Cornell University, 1977) is a physicist at PPPL, where his current interest is in alpha-particle measurements on the Tokamak Fusion Test Reactor. He studied turbulence and edge plasmas on tokamaks at the University of California, Los Angeles and the California Institute of Technology before coming to Princeton. **Glenn Bateman** (bottom) (PhD, Princeton University, 1970) is a research physicist at PPPL working on transport and instabilities in tokamaks.

DIFFUSION-DRIVEN STEADY STATES OF THE Z-PINCH

Bo Lehnert

Bo Lehnert (MS, electrical engineering, 1950, and PhD, magnetohydrodynamics, 1955, Royal Institute of Technology, Stockholm, Sweden; full professorship, plasma physics and fusion research, Swedish Natural Science Research Council, Stockholm, Sweden, 1977) has been head of the Fusion Research Unit of the Swedish Euratom Association since 1980. His research interests are plasma physics and its applications to thermonuclear fusion and to cosmical physics.

FUSION REACTORS

SYSTEM STUDIES OF COMPACT IGNITION TOKAMAKS

J. D. Galambos
D. T. Blackfield
Y-K. Martin Peng
R. Lowell Reid
Dennis J. Strickler
E. C. Selcow

J. D. Galambos (top right) (PhD, nuclear engineering, University of Illinois, 1983) is a member of the Computing and Telecommunications Division at Oak Ridge National Laboratory (ORNL) and works at the Fusion Engineering Design Center (FEDC). His interests include systems analysis of tokamaks, plasma edge modeling, and advanced fuel fusion. A photograph and a biography for **D. T. Blackfield** were not available at publication time. **Y-K. Martin Peng** (top left) (BS, electrical engineering, National Taiwan University, 1967; MS, 1971, and PhD, 1974, applied physics, Stanford University) is a member of the Fusion Energy Division at ORNL and is the plasma engineering manager of the FEDC. His research efforts include plasma engineering studies of the Compact Ignition Tokamak (CIT) and advanced tokamak reactor concepts and promotion of high beta spherical tori studies. **R. Lowell Reid** (bottom right) (BS, physics, University of Alabama, 1960; MS, mechanical engineering, University of Florida, 1969) is a member of the Plasma Engineering Branch of the FEDC. He is involved in computer modeling of fusion systems and in performing sensitivity analyses to define the performance, cost, and configuration of proposed fusion reactors. **Dennis J. Strickler** (bottom left) (MA, mathematics, University of Kentucky, 1973) is in the Computing and Telecommunications Division at ORNL. He is a member of the Plasma Engineering Branch of the FEDC and works in the areas of magnetohydrodynamic equilibrium and stability applied to tokamak plasma magnetics and poloidal field coil design. **E. C. Selcow** (photo not available) (BS, 1979; MS, 1981; and PhD, 1984, nuclear engineering, Columbia University, New York) is an employee of Grumman Corporation and is assigned to the FEDC. Her research activities include nuclear and plasma engineering modeling of tokamak reactor systems. She is responsible for the neutronic analyses at the FEDC and is currently working on the CIT. She is also involved in general neutronics method/code development at the FEDC.

MULTIPLEX TOKAMAK POWER PLANT

Ali E. Dabiri

Ali E. Dabiri (BS, engineering, Teheran Polytechnic, Iran, 1967; MS, 1969, and ScD, 1971, engineering, Massachusetts Institute of Technology) is a senior scientist at Science Applications International Corporation. He has worked on many aspects of fusion engineering issues including first-wall and blanket design

of alternative fusion fuel reactors. He is currently involved in compact fusion reactor studies. Past work includes gas/solid interactions, energy conservation, and energy systems.

BLANKET ENGINEERING

SELF-SHIELDING EFFECTS IN HETEROGENEOUS BLANKETS OF FUSION BREEDERS

Stefan Taczanowski

Stefan Taczanowski's (MS, technical nuclear physics; PhD, University of Mining and Metallurgy, Cracow, Poland, 1975) work in fast neutron activation analysis and gamma spectrometry earned him a PhD. Since then he has changed his field to unconventional nuclear energy. He worked at Kernforschungsanlage Jülich, Federal Republic of Germany (FRG) in 1977 and at Kernforschungszentrum Karlsruhe, FRG, from 1981 to 1984 as a guest scientist. His current interests cover—in addition to neutronics problems—parametric studies, statistical processing of experimental data, and fusile fuel cycle modeling.

SUBCOOLED WATER FLOW BOILING EXPERIMENTS UNDER UNIFORM HIGH HEAT FLUX CONDITIONS

Ronald D. Boyd

Ronald D. Boyd (BS, mechanical engineering, Tuskegee Institute, 1968; PhD, mechanical engineering, University of Michigan, 1976) is currently chairman of the Department of Mechanical Engineering at Prairie View A&M University. He is currently conducting research on high heat flux removal from fusion reactor, space cold plate, and electronic components. Additional fundamental research is being conducted on natural convection in enclosures and mixed convection. For the past 12 years, he has been a principal investigator and heat transfer consultant for the high heat flux materials and fusion component development, the liquid-metal fast breeder reactor spent-fuel transportation, the waste isolation pilot plant, and reactor safety programs. From 1968 to 1971, he was a research engineer at Los Alamos National Laboratory. His interests include theoretical and experimental (including optical) analyses of thermal transport processes.

OPTIMAL USE OF BERYLLIUM FOR FUSION REACTOR BLANKETS

Ulrich Fischer

Ulrich Fischer (Dipl.-Phys., Karlsruhe University, Federal Republic of Germany, 1979) is working at Kernforschungszentrum Karlsruhe, where he is engaged in neutron physics and nuclear data. Presently, his interests are focused on the neutronics of fusion reactor blankets.

A COMPARATIVE STUDY OF THERMAL NEUTRON FUSION BLANKET ARRANGEMENTS

Vijay R. Nargundkar
Mahadeva Srinivasan
Om Prakash Joneja

Vijay R. Nargundkar (right) (MSc, physics, Karnataka University, India, 1956; PhD, pulsed neutron studies, University of Bombay, India, 1966) has been working at Bhabha Atomic Research Centre (BARC) since 1957. He has worked in the field of fission physics at Atomic Energy of Canada, Ltd., Chalk River,

Canada (1961 and 1962), pulsed fast reactors at the Joint Institute for Nuclear Research, Dubna, Soviet Union (1972), and fusion blanket neutronics at the Institute for Reactor Development (IRD), Jülich, Federal Republic of Germany (FRG) (1977 and 1978). He has been the facility supervisor of the Purnima Critical Facility. His current interest is the theoretical and experimental studies of fusion blanket neutronics. **Mahadeva Srinivasan** (top) (BSc, physics, University of Madras, India, 1955; graduate, BARC Training School, 1958; MSc, 1966, and DSc, 1984, physics, University of Bombay, India) has been in charge of a critical experiments group at BARC since 1970. He has worked in the fields of fission physics at Atomic Energy of Canada, Ltd., pulsed fast reactors at the Joint Institute for Nuclear Research, Dubna, USSR, and fusion blanket neutronics at the IRD, Jülich, FRG. He has been the facility supervisor of the Purnima Critical Facility. **Om Prakash Joneja** (bottom) (MSc, Punjabi University, India, 1966; graduate, BARC Training School, India, 1967; PhD, physics, University of Bombay, India, 1976) has been actively working on fast neutron spectrometry and development of Monte Carlo codes. His present interest includes development of new experimental techniques for on-line measurement of tritium breeding in fusion blankets. He has worked at the IRD, Jülich, FRG, from 1972 to 1974 in the field of fast neutron spectrometry and from 1979 to 1980 on the $LiAlO_2$ blanket assembly for measuring tritium production.

SAFETY/ENVIRONMENTAL ASPECTS

RECYCLING AND SHALLOW LAND BURIAL AS GOALS FOR FUSION REACTOR MATERIALS DEVELOPMENT

Carlo Ponti

Carlo Ponti (degree, physics, University of Milano, Italy) worked for many years in the field of reactor physics and particularly in neutron transport and radiation shielding theory. Since 1976 he has been involved with the neutronics problems of tokamak fusion reactors. He is presently working in the area of safety and environmental impacts of fusion reactors, in collaboration with the Next European Torus team at Garching, Federal Republic of Germany.

DIVERTOR SYSTEMS

MODULAR PUMP LIMITER SYSTEMS FOR LARGE TOKAMAKS

Taner Uckan
C. Christopher Klepper
Peter K. Mioduszewski
Robert T. McGrath

Taner Uckan (top) (PhD, nuclear engineering, University of Michigan, 1975) is a staff member in the Fusion Energy Division at Oak Ridge National Laboratory (ORNL). His current research activities are in plasma/materials interactions, plasma edge diagnostics, pump limiters, and plasma confinement studies. He has worked in microwave development, Elmo Bumpy Torus experiments, and stellarator programs at ORNL and participated in tokamak experiments in the Federal Republic of Germany (FRG) (TEXTOR) and France (Tore Supra). **C. Christopher Klepper** (bottom) (PhD, physics, University of Texas-Austin,

1985) did his dissertation on a study of particle transport on the Texas Experimental Tokamak. Since then he has been a member of the research staff of the Fusion Energy Division of ORNL. There, his primary role is in the design and diagnostic instrumentation of a pump limiter for Tore Supra. This limiter is the contribution of the U.S. partners [ORNL and Sandia National Laboratories (SNL)] to the international collaboration on Tore Supra. **Peter K. Mioduszewski** (top) (BS, physics, University of Bonn, FRG, 1965; MS, physics, University of Marburg, FRG, 1969; PhD, physics, Technical University of Aachen, FRG, 1971) worked between 1972 and 1980 at Kernforschungsanlage Jülich, GmbH, on various problems of plasma/wall interactions. In 1980 he joined the Fusion Energy Division of ORNL. At present he is group leader of the Plasma Edge Physics Group at ORNL. Currently he is involved in studies on the Advanced Toroidal Facility at ORNL as well as in international collaborations on the Tore Supra and TEXTOR tokamak facilities. **Robert T. McGrath** (bottom) [BS, engineering physics, 1972; MS, physics, 1974; and MA, mathematics, 1975, The Pennsylvania State University (PSU); PhD, nuclear engineering, University of Michigan, 1980], whose graduate research on fusion-fission hybrid concepts led to the award for outstanding thesis research from the American Nuclear Society, Fusion Technology Division, served as assistant professor of nuclear engineering at PSU from 1980 to 1984. He spent summers as visiting research staff at the Fusion Power Program at Argonne National Laboratory. In 1984 he joined the Fusion Technology Division at SNL, where his main research interests are in plasma/wall interactions. There he provides analytical modeling of impurity generation and transport in the tokamak boundary and edge-plasma descriptions for power loading and particle exhaust for plasma interactive components and for the analysis of data obtained during the operation of these components.