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ENERGY DIVISION
ANNUAL PROGRESS REPORT
for Period Ending September 30, 1988

Volume 2

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Contents

Abbreviations, Acronyms, and Initialisms

AACE	Athens Automation and Control Experiment
ADANS	Airlift Deployment Analysis System
ADM	action description memorandum
AFB	air force base
AHAM	Association of Home Appliance Manufacturers
AI	artificial intelligence
AID	U.S. Agency for International Development
APF	annual performance factor
AQM	Applied Quantitative Methods
ASE	Advanced System Engineering
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ATMS	Assumption-Based Truth Management System
AUB	Athens (Tennessee) Utilities Board
BER	Building Equipment Research
BPA	Bonneville Power Administration
CAP	Communication Alarm Processor
CCT	Clean Coal Technology
CERL	Construction Engineering Research Laboratory
CFC	chlorofluorocarbon
CGE	computable general equilibrium (model)
CHP	chemical heat pump
CO_2	carbon dioxide
CONUS	continental United States
COP	coefficient of performance
CSDP	Chemical Stockpile Disposal Program
CVSHP	continuously variable-speed air-to-air heat pump
DARE	Demand and Resource Evaluation
DO	dissolved oxygen
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DSG	dispersed storage and generation
DXGC	direct expansion ground coil
EA	environmental assessment
EC	Energy Concepts Company
ECIP	Energy Conservation Investment Program
ECO	energy conservation opportunity
ECOP	Energy Conservation Opportunity Program
ECUT	Energy Conversion and Utilization Technologies
EEAS	Energy and Economic Analysis Section
EIA	Energy Information Administration

EIS	environmental impact statement
EMCS	energy monitoring and control systems
EMP	electromagnetic pulse
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ERIP	Energy Related Inventions Program
FEMA	Federal Emergency Management Agency
FFE-2	second Federal Field Exercise
FGD	flue gas desulfurization
FHWA	Federal Highway Administration
FPEIS	final programmatic environmental impact statement
FRERP	Federal Radiological Emergency Response Plan
GAX	generator-absorber heat exchange
GOP	Government of Pakistan
HDL	Harry Diamond Laboratory
HEMP	high-altitude electromagnetic pulse
HFT	heat flux transducer
HGMS	high-gradient magnetic separation
HPS	high-pressure sodium
HRCP	Hood River Conservation Project
HTSC	high-temperature superconductor
HVAC	heating, ventilating, and air conditioning
IAAS	Integrated Analysis and Assessment Section
ICCB	Intergovernmental Consultation and Coordination Board
ICCT	Innovative Clean Coal Technology
ICS	Intelligent Cognitive Systems
IDIM	inverter-driven induction motor
IMEASY	Integrated Management and Economic Analysis System
INE	National Energy Institute (of Ecuador)
LEPC	local emergency planning committee
LP	linear programming (model)
M-G	motor-generator
MAC	Military Airlift Command
MCA	maximum credible accident
MCS	model conservation standards
MEC	Model Energy Code
MIT	Massachusetts Institute of Technology
MSC	Military Sealift Command
MTI	Mechanical Technology, Inc.
MTMC	Military Traffic Management Command
NAHB	National Association of Home Builders
NARM	nonazeotropic refrigerant mixture
NEPA	National Environmental Policy Act of 1969
NETPEM	Network Performance Evaluation Model
NO_x	nitrogen oxide
O&M	operation and maintenance
OEA	Office of Environmental Analysis
OPEC	Organization of Petroleum Exporting Countries
ORNL	Oak Ridge National Laboratory

OTS	Office of Transportation Systems
PC	personal computer
PEIA	programmatic environmental impact analysis
PEIS	programmatic environmental impact statement
PM-ECM	permanent-magnet electronically commutated motor
PRISM	Princeton Scorekeeping Method
PSTP	Power Systems Technology Program
PURPA	Public Utilities Regulatory Policies Act of 1978
PWMI	pulse-width modulated inverter
quad	quadrillion Btu
R&D	research and development
RCCP	Residential and Commercial Conservation Program
RECAP	Residential Energy Conservation Action Program
REDES	Regional Emission Database and Evaluation System
RH	remotely handled
RRAD	Red River Army Depot
RRC	Roof Research Center
RRPM	Regional Recruiting Potential Model
SAC	Strategic Air Command
SAIL	Scheduling Algorithm to Improve Lift
SARA	Superfund Amendments and Reauthorization Act
SFSD	steep front, short duration
SIR	savings-to-investment ratio
SO_2	sulfur dioxide
SPR	Strategic Petroleum Reserve
SRIC	short-rotation intensive culture
STRADS	Strategic Deployment System
SYSRAP	System Reconfiguration Analysis Program (AACE)
T/C	transmission/compressor
TE	thermoelectric
TOPS	Transportation Operational Personal Property Standard System
TORP	Transportation Operations Research and Planning
TRU	Transuranic Waste Program
TSRS	Transportation and Systems Research Section
TVA	Tennessee Valley Authority
UCG	Underground Coal Gasification
USAF	U.S. Air Force
USAID	U.S. Agency for International Development
USTRANSCOM	U.S. Transportation Command
VEMPS-II	vertically polarized electromagnetic pulse simulator
VHLL	very high-level language
VMT	vehicle miles of travel
VSI	voltage source inverter
VSP	vertical seismic profiling
WAP	Weatherization Assistance Program
WFO	Work for Others
WHPP	Waste Handling and Packaging Plant
WRF	Woodbridge Research Facility

Abstract

The goals and accomplishments of the Energy Division of Oak Ridge National Laboratory are described in this annual progress report for Fiscal Year (FY) 1988. The Energy Division is a multidisciplinary research organization committed to (1) increasing the knowledge and understanding of the way society makes choices in energy use and energy-using technologies, (2) improving society's understanding of the environmental implications of changes in energy technology, and (3) improving and developing new energy-efficient technologies. The Energy Division's programmatic activities focus on four major areas: (1) analysis and assessment, (2) transportation and decision systems research, (3) technology research and development for improving the efficiency of energy end-use technologies, and (4) electric power systems. The Division's total expenditures in FY 1988 were $44.3 million. The work is supported by the U.S. Department of Energy, U.S. Department of Defense, many other federal agencies, and some private organizations. Disciplines of the 139 staff members include engineering, social sciences, physical and life sciences, and mathematics and statistics.

Analysis and assessment activities cover a wide spectrum of topics ranging from energy use in developing countries to emergency planning for natural technological disasters. The methodologies used also are varied, ranging from econometric modeling to the development of techniques for subsurface imaging.

Transportation research concentrates on transportation operations research and planning, advanced computing applications for transportation networks, and analysis and modeling of transportation activity and energy use. Decision Systems research involves the development of computer-aided decision support systems and software, understanding decision making and designing tools to aid the decision process, artificial intelligence for expert systems, and machine learning.

Research on improving energy efficiency centers on building equipment, envelopes, and retrofits and industrial heat pumps. The building equipment area concentrates on thermally activated and electric-driven heat pumps for residential and commercial applications. Work is being conducted in the building envelopes area on walls, foundations, and roof structure materials and systems.

Research on electric power systems focuses on electric transmission and distribution systems. Emphasis is placed on automation of control, electromagnetic pulse effects, high-voltage transmission technologies, and new material applications.

Much of the information produced from the research work is valuable to other organizations as well as to the sponsors. Dissemination of this information, an important feature of research usage, was accomplished by involving the staff with professional and trade organizations; holding workshops; engaging private sector firms and universities in the research; interfacing with state and local governments; presenting the work at conferences; and publishing the results of the research in journals, reports, and conference proceedings.

Introduction and Executive Summary

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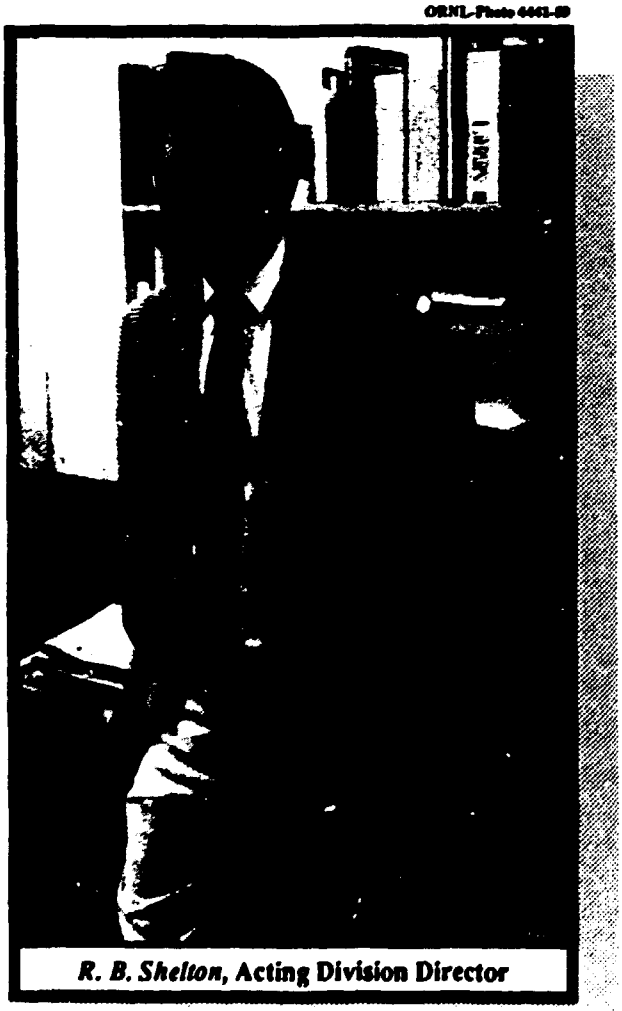
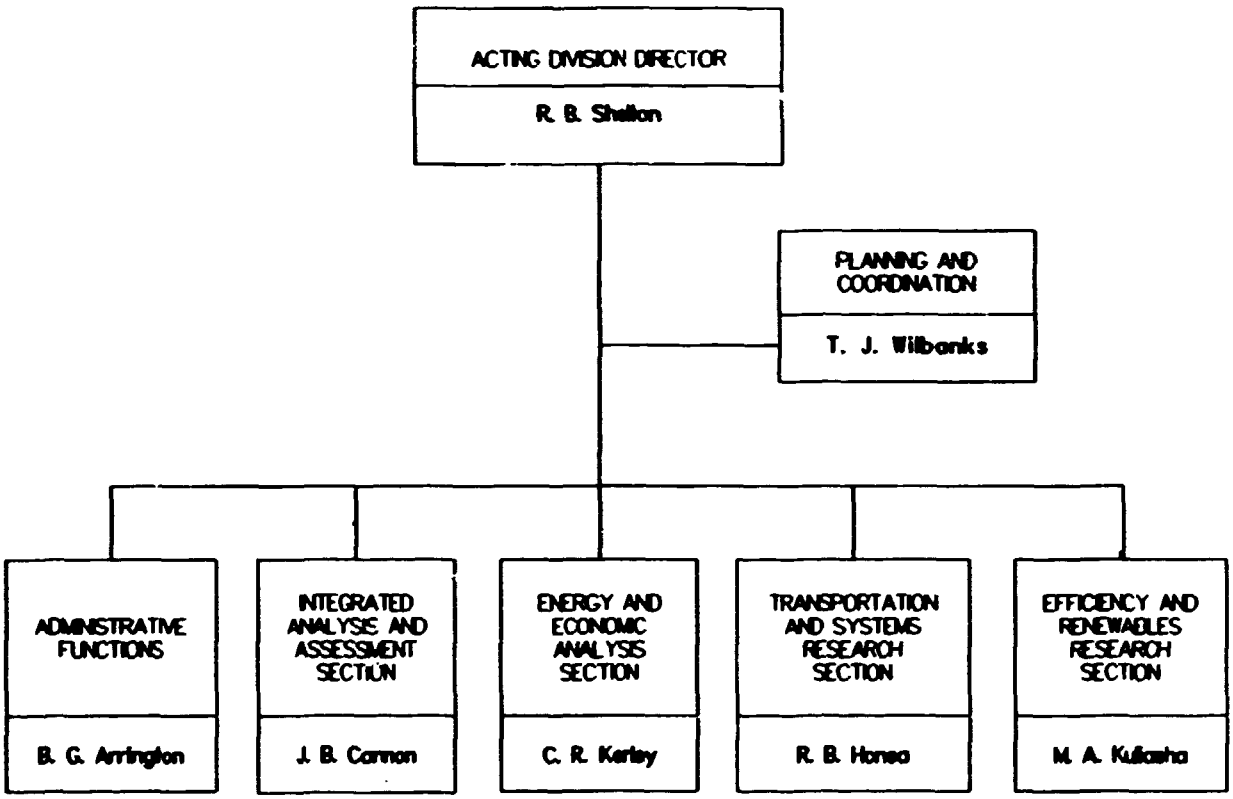


R. B. Shelton, Acting Division Director

ENERGY DIVISION



Introduction and Executive Summary 1

The Energy Division is a multidisciplinary research organization committed to (1) increasing knowledge and understanding of the way society makes choices in energy use and energy-using technologies, (2) improving society's understanding of the environmental implications of changes in energy technology, and (3) improving and developing new energy-efficient technologies. This report summarizes the major achievements of the Energy Division during FY 1988. While the summary of the Division's achievements is not meant to be exhaustive, it nevertheless represents a diverse set of accomplishments that reflect the major research and development (R&D) thrusts of the Division. A more detailed account of the Division's activities is embodied in the overviews of each section and in the abstracts of the publications by Division staff which are included in the complete version of this report.

W. Fulkerson spent most of the year leading a study for ORNL on the state of energy technology R&D. When he returned to the Energy Division as division director, R. B. Shelton, who had been serving as acting division director, assumed his new assignment as associate director of the Energy Division. Recently, Fulkerson was appointed acting

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W. Fulkerson, who spent most of the year leading a study on the state of energy technology R&D, has been appointed acting associate director of Advanced Energy Systems.

associate director of Advanced Energy Systems (see Fig. 1.1) and Shelton resumed his position as acting division director.

The Energy Division's programmatic activities have a number of crosscutting themes and can be characterized in four ways: (1) analysis and assessment, (2) transportation and decision systems research, (3) technology R&D focused on improving the efficiency of energy end-use technologies, and (4) electric power systems. Figure 1.2 summarizes the Division's expenditures by each of these categories and provides some indication of the relative importance of the categories in terms of their activity levels. The Division's total expenditures in FY 1988 amounted to $44.3 million. Roughly a third of the Division's expenditures was made in each of the areas of analysis and assessment and transportation and decision systems; a quarter of the expenditures was in the area of technology R&D; and less than 10% was accounted for by electric power systems.

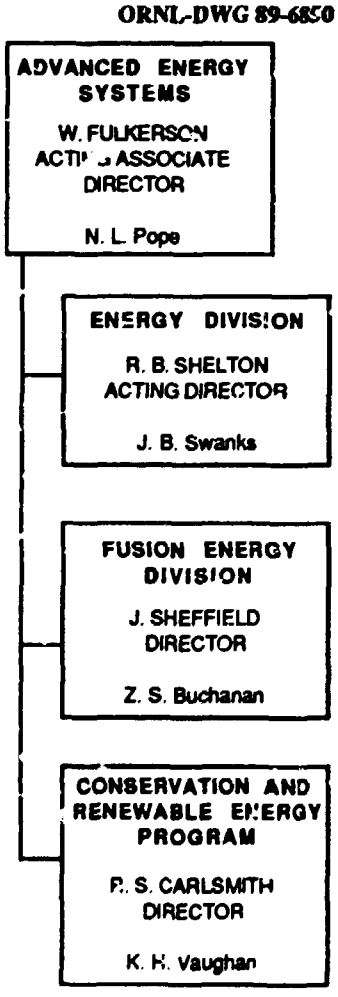

Fig. 1.1. Organizational Chart for Advanced Energy Systems.

The Energy Division's sponsorship is reflected in Fig. 1.3. Approximately one-half of the Division's expenditures is related to U.S. Department of Energy (DOE) activities, and the other half is spent on Work-for-Others (WFO) activities. The largest portion of the WFO expenditures, over 40% of the total budget, is for the U.S. Department of Defense, which includes the U.S. Army, U.S. Navy, U.S. Air Force, and Joint Agencies; the remaining 10% represents other WFO agencies, including the U.S. Agency for International Development, U.S. Federal Emergency Management Agency (FEMA), the U.S. Environmental Protection Agency, the U.S. Department of Transportation, and the Electric Power Research Institute.

The Division has a multidisciplinary technical staff (see Fig. 1.4) that encompasses nearly 140 professions, including engineers (36.1%), social scientists (31.4%), physical and life scientists (16.2%), and data systems personnel (16.2%). The Division is the home for the social sciences at the Oak Ridge National Laboratory (ORNL) and provides an important interdisciplinary environment for conducting research at the interface of social and technology issues and policies.

1.1 ANALYSIS AND ASSESSMENT

Analysis and assessment activities cover a wide spectrum of topics ranging from energy use in developing countries to emergency planning for natural and technological disasters. Likewise, the methodologies used are equally varied, ranging from econometric modeling to the development of techniques for subsurface imaging. The following is a summary of the major activities.

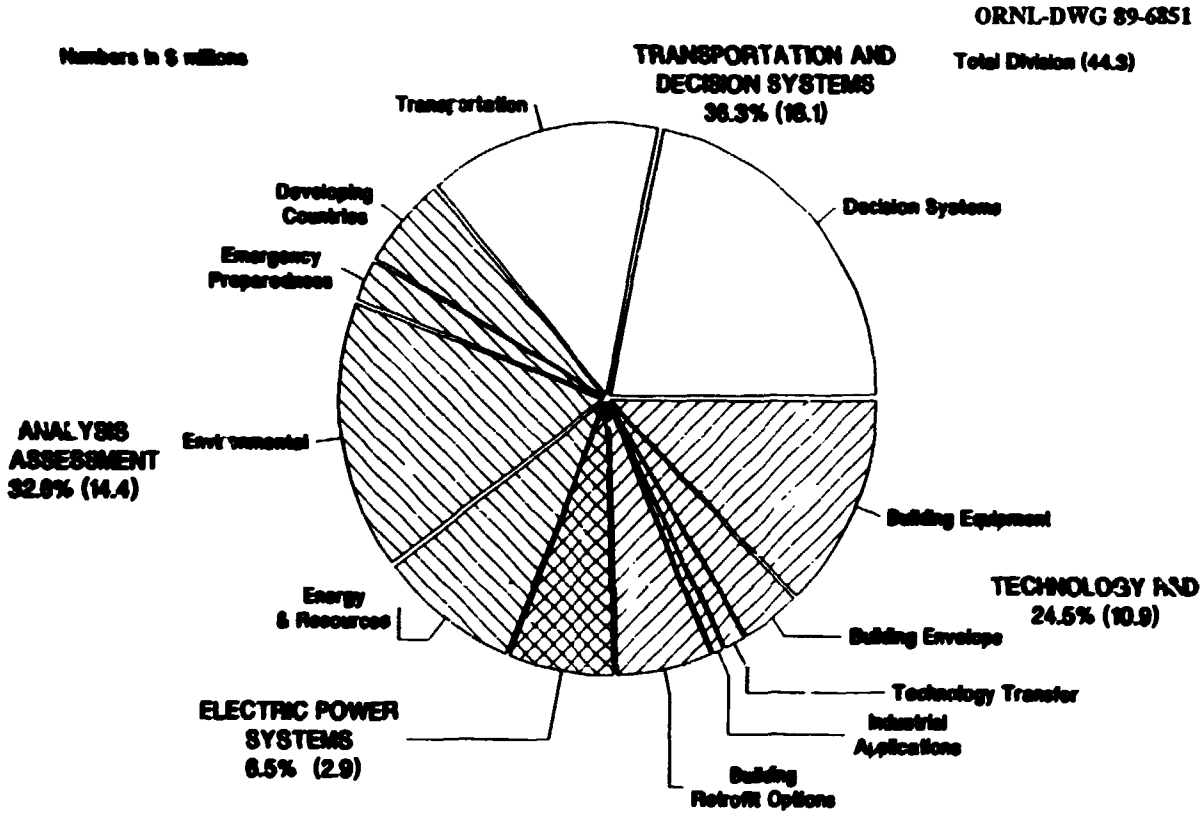

Fig. 1.2. Expenditures during FY 1988 by research area.

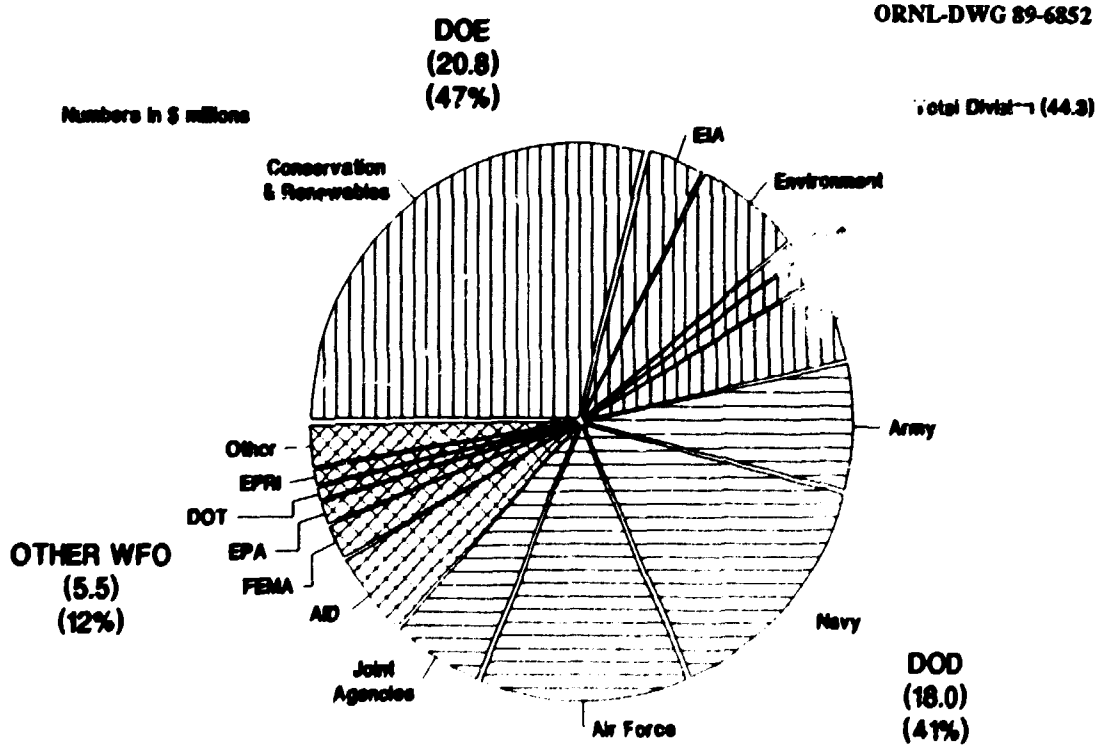

Fig. 1.3. Expenditures during FY 1988 by sponsor.

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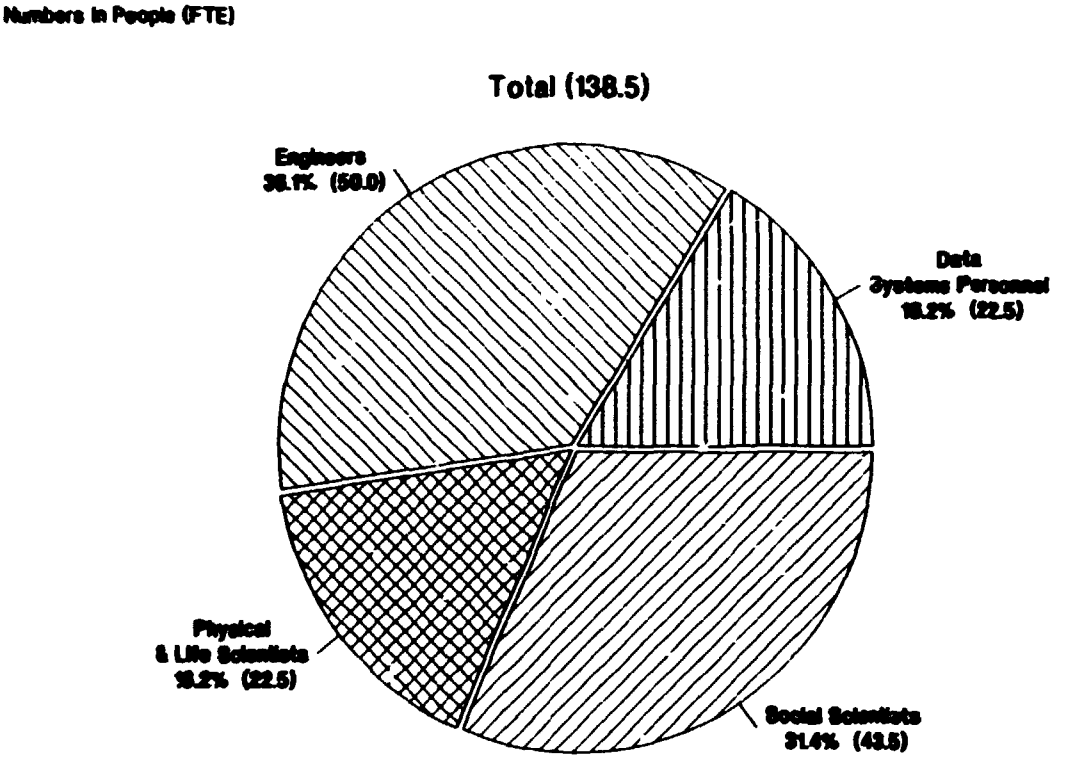


Fig. 1.4. Technical staff for FY 1988.

1.1.1 Energy and Resource Analysis

- Assessed the state of energy technology R&D. A major conclusion is that nonfossil energy sources are not yet ready to replace fossil fuels on a massive scale should concern about the changing greenhouse effect require such action. Hence, the current level of energy technology R&D investment, public and private, is inadequate to cope with this likely circumstance (Sect. 6.1.1).

- Developed an enhanced microcomputer uranium market model for the Energy Information Administration to consider policy scenarios under the free trade agreement between the United States and Canada. Domestic U.S. production estimates of uranium are presented in response to the introduction of a domestic production quota (Sect. 3.2.1).

- Undertook research showing the increased economic and institutional feasibility of recycling plastics as the costs of disposal escalate and as legislation and regulations to promote recycling are passed at various government levels. Findings indicated that not more than 25% of total plastic waste can be recycled into new products given current technological, economic, and institutional constraints (Sect. 3.2.2).

- Conducted a study combining techniques from economics and cognitive anthropology that analyzed the possibilities for cost-sharing arrangements between local jurisdictions and other governmental agencies to clean up hazardous waste sites. A three-stage research design was developed that allows decision makers to develop hypotheses about what types of cost-sharing packages will be either acceptable or unacceptable and then to test these

hypotheses in the field through interview and/or focus-group techniques (Sect. 3.2.2).

- Developed an energy impact model for the California Energy Commission to assess the economic substitutions and impact in each of 60 sectors from deployment of energy technology in various regions of California (Sect. 3.2.4).

- Assessed the results of field experiments with various biomass crops and reviewed how significant traits of biomass crop feedstocks affect conversion processes. In addition, research into new biomass energy technologies identified different types of risks and considered how the different classes of risk could be better assessed and managed by biomass program managers (Sect. 3.2.4).

- Evaluated estimated costs for the production of high-temperature heat exchangers containing advanced ceramic components. Results showed that heat exchangers in which the tube and headers are manufactured from silicon carbide cost 68% more than all-metallic heat exchangers (Sect. 3.2.4).

- Completed a study of the factors underlying consumer decision making and energy conservation investments. In the case of residential gas furnace purchases, results indicate that less than half of the purchases were based on economically rational motives (Sect. 3.2.4).

- Assessed the cost to electric utilities from alternative proposals for acid rain legislation. The results indicated that one of the eight utilities evaluated faces as much as a 39% cost increase in fuel, operations, and maintenance, with the average cost increase of the eight utilities being 15% (Sect. 3.2.4).

- Completed an assessment of the commercial progress of participants in the Energy-Related Inventions Program (ERIP). The study reported a total of $272 million in sales of ERIP technologies through 1986, which represents a 6-to-1 return in terms of sales-vs-program appropriations (Sect. 5.1.5).

1.1.2 Environmental Assessments

- Conducted research into the movement of groundwater in geologic formations, taking into consideration the sensitivity of flow to material properties, viscosity, and inertia. For a simple well-pumping experiment, it was found that the Darcy's law approximation led to a 12% error (Sect. 2.1.3.1).

- Developed a programmatic environmental impact analysis to support DOE's selection of projects proposed in the second round of the Clean Coal Technology (CCT) program. After estimating environmental parameters for national emissions from coal-fired utilities and industrial boilers, the analysis concluded that between 1985 and 2010, sulfur dioxide (SO_2) and nitrogen oxides (NO_x) would increase by 16 and 67%, respectively, without the implementation of the CCT program (Sect. 2.1.1.1).

- Completed an environmental impact statement (EIS) that evaluated the effects of retrofitting 19 dams for electricity production on the Upper Ohio River system. A recommendation was made for an alternative that produces 82% of the proposed power but with a lower probability of major environmental problems (Sect. 2.1.1.2).

- Prepared a final programmatic EIS that assessed the potential environmental impacts of the disposal of lethal chemical agents and munitions stored at eight military installations in the continental United States. On-site disposal was found to pose less risk than other alternatives that involved off-site movement of the stockpile (Sect. 2.1.1.3).

- Continued development of geophysical diffraction tomography techniques for subsurface imaging applications. In field

tests, the techniques have accurately imaged the size, shape, and position of buried pipes, rocks, soil types, and skeleton remains of the longest dinosaur ever found (Sect. 2.1.3).

- Completed an analysis of the effects of life extensions of power plants on the environment. The analysis revealed that life-extension measures are a cost-effective way to extend the operation of a plant an additional 30 to 60 years, although these extensions will increase emissions of SO_x and NO_x (Sect. 4.2.2).

1.1.3 Emergency Preparedness

- Conducted a survey to assess the status of public alert and notification systems for chemical emergencies in the United States and uncovered several problem areas in communications, plans and implementation procedures, and public responses to emergencies (Sect. 2.1.2.2).

- Undertook analysis of six instances of public participation in siting of nuclear and hazardous waste management facilities that defined more closely the uses and limits of the public participation process. Common factors found in the successful public participation case studies include adequacy and timeliness of information, in-house technical expertise, use of a citizen or expert task force to assess impacts and to negotiate conditions of acceptance, limited power sharing, interactive public participation, a responsive agency/developer, confidence of the task force in its own understanding of the impacts and technology, and modifications of the proposed plan to meet concerns of risk bearers (Sect. 2.1.4.2).

- Conducted a study employing two models used in planning crude oil acquisition, depletion, and size for the Strategic Petroleum Reserve. The study determined that the models could be used in a complementary fashion to evaluate risk and optimal fill and drawdown rates (Sect. 3.2.1).

- Conducted two studies to guide the federal government and states in distributing stored grains to the population in the event of a serious national food shortage. Because a serious disruption could result in 57% of the U.S. population having access to only 8% of stored grains, recommendations were made to improve access to these foodstocks before an emergency (Sect. 3.2.3).

- Constructed a computerized model system that provides FEMA with an interactive, integrative damage assessment capability to assess local, regional, and national direct economic capacity impact of large-scale natural and man-made disasters. Several hypothesized nuclear attack scenarios were analyzed to determine the amount of economic capacity destroyed (Sect. 3.2.3).

1.1.4 Developing-Country Analyses

- Evaluated a proposal to generate electric power from oil shale in Jordan. This project involved an economic, environmental, and technical assessment of the proposed circulating fluidized-bed technology. Results showed that a 50-MW plant was economically attractive only under very favorable conditions. Because of scale economies, a larger plant was more attractive economically but was subject to a wider range of uncertainties (Sects. 6.1.2 and 4.2.2).

- Assessed the market potential for (1) coal briquettes as a household fuel in Pakistan and (2) the Jiko-improved cookstove in Kenya. The findings indicated that a small number of coal briquetting plants of 50,000-tons/year capacity could be supported in Pakistan and that the Jiko-improved stove could reduce charcoal expenses by 15 to

40% and have a major impact in deforestation and balance-of-payments issues (Sects. 3.2.2 and 6.1.2).

- Developed an innovative approach to financing to encourage the use of photovoltaic cells in villages in the Dominican Republic that are not served by the central power grid. This financing approach may serve as a model for other small-scale technologies and other countries (Sect. 6.1.2).

1.2 ENERGY CONSERVATION TECHNOLOGIES

The Energy Division has major technology development programs in building equipment, envelopes, and retrofits and industrial heat pumps. Our building equipment research has concentrated on thermally activated and electric-driven heat pumps for residential and commercial applications. The building envelope research is concerned with walls, foundations, and roof structure materials and systems.

1.2.1 Heat Pumps

- Continued work on operational testing at Phillips Engineering Company on the generator-absorber heat exchanger absorption heat pump, where design improvements include a new absorber that shows promise for substantially reducing size and costs. In addition, an experimental gear-type solution pump with ceramic parts operated over 500 h with essentially no wear (Sect. 5.1.1.1).

- Introduced a variable-speed heat-pump-design model to the heating, ventilating, and air-conditioning industry and made agreements to integrate the model into an industry analytical design system. This model predicts the steady-state heating and cooling performance of an electrically driven, air-source heat pump that uses a variable-speed compressor to modulate system capacity (Sect. 5.1.1.3).

- Completed testing of a prototype heat pump (under subcontract with Energy Concepts Company) operating in both temperature-amplifying and heat-amplifying modes with a new absorption fluid (mixture of lithium, sodium, and potassium salts). Results showed that steam is produced by the fluid up to 400°F (Sect. 5.1.2).

- Completed an analysis of energy-use impacts due to chlorofluorocarbon (CFC) restrictions. Results showed that a phaseout of CFC-11 and -12 would cause energy-use increases ranging from 0.2 to 2.2 quads annually (Sect. 5.1.1.3).

- Changed the direction of the nonazeotropic refrigerant mixture (NARM) research from concentration on the capacity modulation aspect to investigation of ways to improve heat exchanger effectiveness. This decision was based on results from an experiment in which a significant increase in heat exchanger area was required to achieve an improvement in the steady-state cycle efficiency of vapor compression equipment using NARMs (Sect. 5.1.1.3).

1.2.2 Buildings

- Submitted a patent application naming an Energy Division staff member (Bob Edwards) as coinventor of the Smart House concept. Work on the project consisted primarily of the development of concepts and prototype equipment for the appliance control and communications subsystem (Sect. 4.2.2).

- Conducted tests of the thermal resistance of phenolic foam and expanded polystyrene roof insulations. Use of the PROPOR analytical technique showed agreement with steady-state data (Sect. 5.1.3).

- Published a Building Foundation Design Handbook that contained a compilation of the latest information on recommended practices for foundation design and installation ranging from radon protection to moisture reduction (Sect. 5.1.3).

- Provided testimony on recommended foundation insulation levels and thermal mass credits for the Council of American Building Officials Model Energy Code. The ORNL recommendations were adopted into the code, which is cited frequently in local building codes (Sect. 5.1.3).

- Developed a *Decision Guide for Roof Slope Selection* for the Air Force Engineering and Services Center to provide Air Force design personnel with a method, based on life-cycle costing, to address typical design questions concerning roof slope (Sect. 5.1.8).

1.3 ELECTRICAL POWER SYSTEMS

Our research on electric power systems is focused specifically on electric transmission and distribution systems. Emphasis is placed on automation of control, electromagnetic pulse effects, high-voltage transmission technologies, and new material applications.

- Designed a unique axial gap superconducting motor (based on an earlier permanent magnet design developed by the Applied Technology Division) that uses power electronics for commutation and speed control and that will remove a general dynamics problem existing in current superconducting motor designs (Sect. 5.1.7).

- Conducted an assessment of the energy applications of high-temperature superconductivity. The assessment covered the areas of motors, power electronics, transportation, lighting, electromagnetic pumping, electromagnetic heat pumping, materials fabrication, materials production, and magnetic separation technologies (Sect. 5.1.7).

1.4 TRANSPORTATION AND DECISION SYSTEMS

Transportation research concentrates on transportation operations research and planning, advanced computing applications for transportation networks, and analysis and modeling of transportation activity and energy use. Decision systems research involves (1) the development of computer-aided decision support systems and software, (2) understanding the decision-making process and designing tools to aid the process, (3) artificial intelligence for expert systems, and (4) machine learning.

- Completed prototype computer software for greatly improved global routing and scheduling of Military Air Command aircraft for the Airlift Deployment Analysis System. An important development was a prototype insertion heuristic that, unlike previous insertion heuristics, can handle thousands of airlift missions (Sect. 4.1.1).

- Developed a prototype large-scale transportation planning system to be used in scheduling the movement of U.S. armed forces equipment and personnel from their military bases to airports and seaports for deployment overseas (Sect. 4.1.1).

- Developed a strategic airlift and sealift selection and routing algorithm for the U.S. Transport Command (USTRANSCOM) that schedules military lift capabilities against intercontinental cargo and personnel to be moved during large-scale military deployments (Sect. 4.1.1).

- Supplied the Network Performance Evaluation Model, which estimates the energy, travel time, and emissions impacts of different types of dedicated car- and vanpools and bus lanes, to 30 different

planning organizations in the United States (Sect. 4.1.2).

- Developed a prototype expert system used to process alarms and diagnose operational problems from Bonneville's microwave communication system. The microwave system relays data from several power systems to a central facility. Actual and potential problems are signaled, and the appropriate solution is returned (Sect. 4.2.2).

- Continued work on automated knowledge elicitation, with two particular systems advanced during the year. Research in the first system consisted of managing dynamic knowledge bases and developing the capability to identify redundant and inconsistent pieces of knowledge. The other elicitation system collects data from experts and others to determine the types of rules used to process uncertainties. Work on these systems suggests that the methods used to represent and manipulate uncertainty in expert systems show little resemblance to how people actually think and deal with uncertainty (Sect. 4.3).

- Produced a report on fuel economy and market-share trends of cars and light trucks for the period from 1976 through the first half of 1988 and constructed an interactive microcomputer system to manage the 13 years of data on individual light-duty vehicle models (Sect. 4.1.2).

1.5 RESEARCH UTILIZATION

David Greene began a one-year assignment to provide advice and technical assistance on alternative fuels for the transportation sector to the Office of Policy Integration, DOE Headquarters.

A Technology Policy Center was established as a focus for research on public policy issues in the development, transfer, and societal acceptance of technology. The Center is investigating the commercial development of high-temperature superconductivity and the potential market for U.S. energy technologies in less-developed countries. A workshop on energy technology and policy is being planned for fall 1989.

An industry advisory group was organized in cooperation with the Association of Home Appliance Manufacturers to review activities related to CFC substitutes in the refrigerator/freezer research area.

The Smart House has been featured in numerous national forums, and the work conducted at ORNL has been transferred to many different manufacturers in the private sector.

A nationwide search was conducted to find a licensee to further develop the dual-loop triple-effect absorption chiller cycle. The Trane Company was selected as licensee, and the Gas Research Institute agreed to co-sponsor the project.

A new program was started last year to assist state regulatory commissions and electric utilities to assess alternative resources to meet electric energy service needs. Eric Hirst spent a year at an electric utility documenting their planning activities. The work has expanded into reviewing DOE's Least-Cost Utility Planning Program, treating uncertainty in utility planning, and examining the role of energy-efficiency programs for new buildings in reducing load-growth uncertainties for utilities.

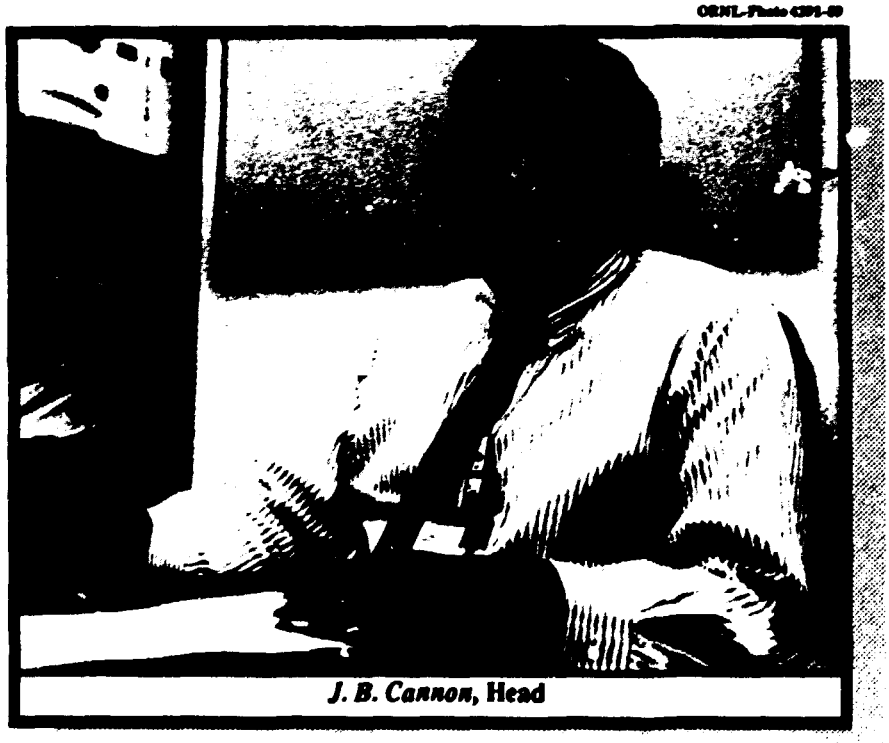
A technology transfer plan was developed for DOE's Residential and Commercial Conservation Program. An assessment of DOE's Office of Transportation Systems' technology transfer program was completed. Work began on analyzing the technology transfer strategies of DOE's Office of Conservation.

ORNL will be providing the U.S. support for the newly organized International Energy Agency's Center for the Analysis and Dissemination of Demonstrated Energy Technologies.

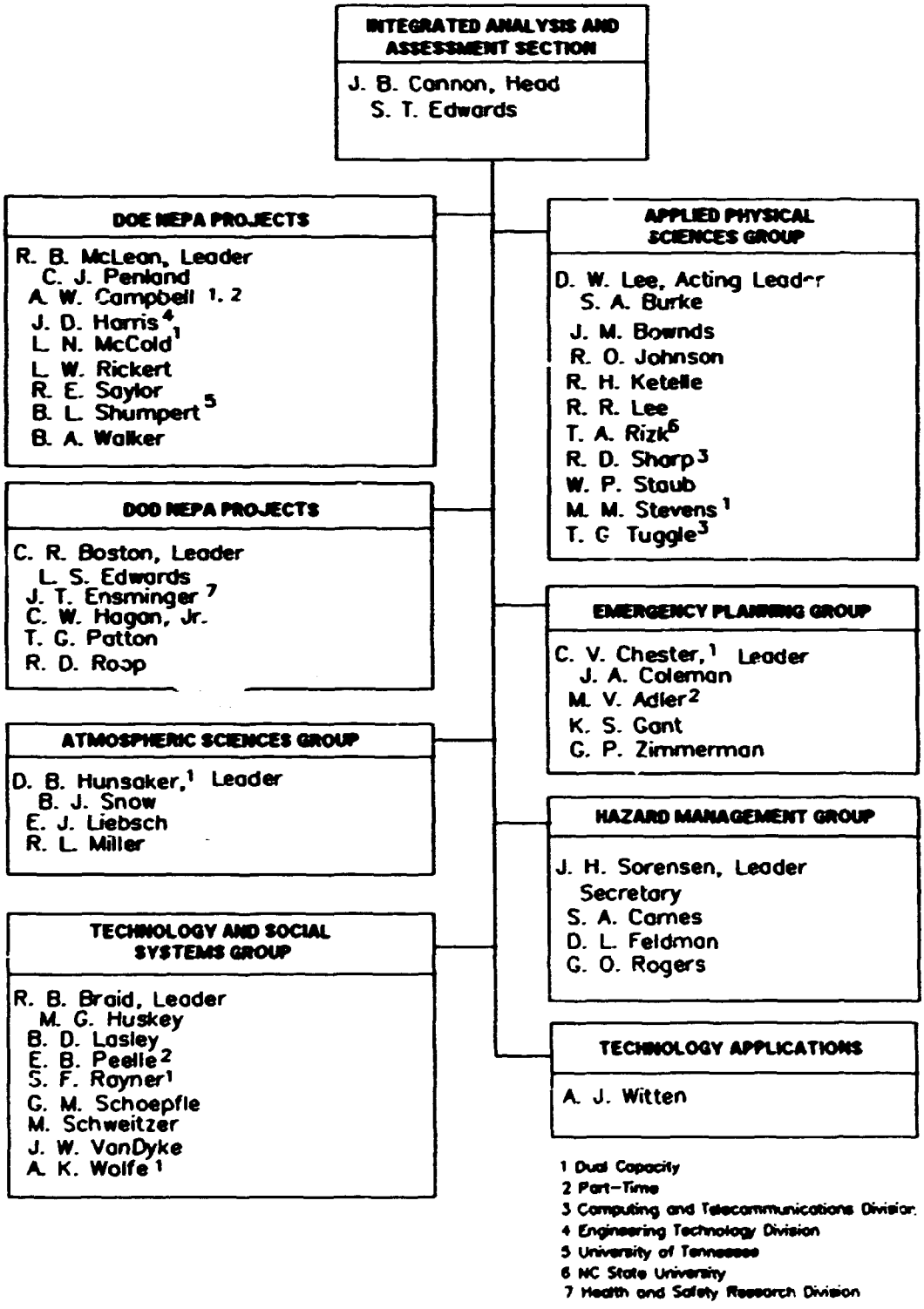
Information produced from research efforts is valuable to other organizations as well as to the sponsors. Dissemination of this information is an important feature of research utilization. During FY 1988, the Energy Division staff published 100 articles in technical

and scientific journals; 80 papers were printed in proceedings from technical conferences; 120 reports were published by ORNL and other sponsors; 2 books and 10 book chapters were published; and 15 EISs and environmental assessments were issued. The Division organized 16 workshops and symposia and hosted numerous visitors from other research organizations, universities, and industries.

Integrated Analysis and Assessment 2



J. B. Cannon, Head


INTEGRATED ANALYSIS AND ASSESSMENT SECTION
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C. J. Penland
A. W. Campbell 1, 2
J. D. Harris 4
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R. E. Saylor
B. L. Shumpert 5
B. A. Walker
DOD NEPA PROJECTS
C. R. Boston, Leader
L. S. Edwards
J. T. Ensminger 7
C. W. Hagan, Jr.
T. G. Patton
R. D. Roop
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2 Part-Time
3 Computing and Telecommunications Division
4 Engineering Technology Division
5 University of Tennessee
6 NC State University
7 Health and Safety Research Division

Integrated Analysis and Assessment Section 2

2.1 OVERVIEW

The Integrated Analysis and Assessment Section (IAAS) has overall responsibility at ORNL for assisting federal agencies with the preparation of environmental assessments (EAs) and environmental impact statements (EISs) required by the National Environmental Policy Act (NEPA). This interdisciplinary activity is a major long-term ORNL program that involves other sections within the Division and several other research divisions as well–namely Environmental Sciences, Health and Safety Research, Health and Environmental Protection, and Chemical Technology. We also perform research in the physical and social sciences. Primarily as a result of past NEPA activities, we have acquired expertise in such areas as emergency preparedness, low-level radioactive waste management, site characterization methodologies for waste disposal facilities, contaminant transport modeling in atmospheric and aqueous systems, public acceptance of hazardous technologies, institutional mechanisms for managing complex technologies, socioeconomic impacts of technological change on communities, and global environmental decision making. Our work in the global environmental decision making area is a collaborative effort with the Transportation and Systems Research Section and is summarized in Sect. 4.2.1 of this report.

2.1.1 NEPA Projects

As in past years, NEPA projects constituted a large fraction of our FY 1988 work load. Table 2.1 provides a complete listing of projects undertaken. Our sponsors include DOE, the Federal Energy Regulatory Commission, the Nuclear Regulatory Commission, and the U.S. Department of Defense (DOD). In terms of the number of projects, our NEPA work load was dominated by DOD projects. A brief summary of three prominent projects is provided here.

2.1.1.1 Environmental Impact Analysis for the Innovative Clean Coal Technology Program

The DOE Clean Coal Technology (CCT) program involves a five-year series of competitions to select advanced pollution control and power generating technologies that can use coal more cleanly and efficiently than present technologies can. Applicants from the private sector selected to be in the program can receive matching federal funds for as much as half of a project's anticipated costs. We prepared a programmatic environmental impact analysis (PEIA) to support DOE's selection of projects from the second round of CCT solicitations.

Two alternatives were evaluated in the PEIA: (1) the no-action alternative, which assumed that the Innovative Clean Coal Technology (ICCT) program was not implemented and that conventional coal-fired technologies with flue gas desulfurization (FGD) controls to meet New Source Performance Standards would continue to be used; and (2) the proposed action, which assumed that the ICCT projects were selected and funded and that successfully demonstrated technology would undergo widespread commercialization by the year 2010. Under the

Table 2.1. List of FY 1988 NEPA projects

	Proposed action/task	Document	Status
	Department of Energy		
1.	Renovation of production facilities and cleanup of contaminated areas at the Feed Materials Production Center, Fernald, Ohio	Environmental impact statement (EIS)	Significant progress made on preparation of the preliminary draft EIS
2.	Restart of the ORNL High Flux Isotope Reactor, Oak Ridge, Tennessee	Environmental impact analysis (EIA)	Draft completed
3.	Sale of Parcel A on Oak Ridge Reservation to City of Oak Ridge for resale to developer	Action description memorandum (ADM)	Final ADM completed for sale of initial 50 acres; Draft ADM completed for sale of remaining 690 acres
4.	Use of the Oak Ridge K-25 Centrifuge facilities by *AIChemIE* for isotope separation	ADM	Draft completed
5.	Construction and operation of the Argonne National Laboratory 7-GeV synchrotron	Environmental assessment (EA)	Draft completed (Ref. 1)
6.	Transportation of ORNL contact-handled transuranic waste to the Waste Isolation Pilot Plant near Carlsbad, New Mexico	EA	Draft completed
7.	Site characterization study for the ORNL Waste Handling Pilot Plant for remote-handled transuranic waste	Environmental report	Draft completed (Ref. 2)
8.	Environmental implications of Innovative Clean Coal Technology demonstrations associated with second-round solicitation of the DOE Clean Coal Program	Programmatic environmental analysis	Final completed (Ref. 3)
9.	NEPA follow-up study of DOE loan guarantee fuel ethanol plants located in Indiana, Tennessee, and Louisiana	Environmental impact appraisal	Draft completed
10.	Strategic Petroleum Reserve, Decommissioning of the Sulphur Mines Site, Louisiana, and Texas	EA	Work initiated
10a.	Remedial action at the DOE Kansas City Plant, Kansas City, Missouri	EA	Work initiated

Table 2.1. (continued)

	Proposed action/task	Document	Status
	Federal Energy Regulatory Commission		
11.	Hydroelectric projects in the El Portal River, Mariposa County, California	EIS	Draft EIS issued. The El Portal River was later designated "wild and scenic," thus precluding the proposed developments (Ref. 4)
12.	Hydroelectric project in the upper Ohio River in Ohio, Pennsylvania, and West Virginia	EIS	Draft and Final EISs issued (Ref. 5)
13.	Nationwide analysis of Public Utility Regulatory Policies Act of 1978 benefits at new dams and diversions as required by the Electric Consumer Protection Act, Sect. 8(d)	EIA	Final report issued (Ref. 6)
14.	Rule-making governing independent power producers and the bidding process	Environmental report	Final report issued
	Nuclear Regulatory Commission		
15.	Standard review plan for evaluating the environmental impacts of fuel fabrication and UF_6 conversion facilities	Technical memorandum	Draft completed
	Department of Defense - Army		
16.	Disposal of chemical agents and munitions stored in Indiana, Maryland, Kentucky, Alabama, Arkansas, Colorado, Utah, and Oregon	EIS	Final Programmatic EIS issued (Ref. 7)
17.	Disposal of unitary chemical munitions and agents stored at Tooele Army Depot, Tooele, Utah	Phase I-environmental report	Final report completed (Ref. 8)
18.	Disposal of unitary chemical munitions and agents stored at Tooele Army Depot, Tooele, Utah	Phase II-EIS	Work initiated
	Department of Defense - Air Force		
19.	Development of procedures for assessing environmental impacts of Air Force low-altitude flying operations	Generic EIS	Work on preliminary draft generic EIS continued

Table 2.1. (continued)

	Proposed action/task	Document	Status
20.	Development of an air-to-surface weapons range in the southeastern United States	EIS	Site screening study and site characterization report completed
21.	Cumulative impact assessment for rail garrison peacekeepers	(Classified) EIS	Preliminary draft completed
22.	Development of an electromagnetic pulse surveillance facility at Tinker Air Force Base (AFB), Oklahoma	EA	Final completed (Ref. 9)
23.	Development of an Air Force regional communication facility in the Northeast (New Jersey)	EA	Final completed (Ref. 10)
24.	Development of a contingency training facility at Tyndall AFB, Florida	EA	Draft completed
25.	Basing of 16 E-6A aircraft at Tinker AFB, Oklahoma	EA	Final completed (Ref. 11)
26.	Establishment of a military operations area near Tyndall AFB, Florida	EA	Draft completed
27.	Development of a regional hazardous waste incinerator for the Air Logistics Centers (Georgia, Utah, California, Oklahoma, and Texas)	Environmental scoping report	Draft completed
28.	Development of land use (air installation compatible use zone) study for Kelly AFB, San Antonio, Texas	Environmental report	Draft completed
29.	Development of hazardous waste staging facility at Kelly AFB, San Antonio, Texas	EA	Draft completed
30.	Static testing of the Titan IV solid rocket motor at Edwards AFB, California	EA	EA issued (Ref. 12)
31.	Launch program at Cape Canaveral Air Force Station, Florida, using the Atlas II vehicle	EA	Draft completed
32.	Construction and operation of a hypergolic facility at Vandenberg AFB, California	EA	Draft completed

Table 2.1. (continued)

	Proposed action/task	Document	Status
33.	Strategic Defense Initiative experiments involving laser tests at remote locations (Ascension Island, Antigua, Wake Island, and Maui)	EA	Work Initiated

References are as follows:

1. *Environmental Assessment of the Proposed 7-GeV Advanced Photon Source,* DOE/OR-899, Oak Ridge National Laboratory, Oak Ridge, Tenn., September 1988. R. B. McLean, E. Ricci, R. L. Kroodsma, R. L. Miller, W. P. Staub, J. P. Witherspoon, and M. Swihart.

2. *Site Characterization Report for the Proposed Transuranic Waste Handling and Packaging Plant, Oak Ridge National Laboratory,* U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, Tenn., September 1988. A. W. Campbell, G. F. Cada, R. H. Ketelle, R. L. Kroodsma, R. R. Lee, and L. R. Pounds.

3. *Programmatic EIA for the Innovative Clean Coal Technology Program,* DOE/PEIA-0002, Office of Fossil Energy, DOE, September 1988. R. M. Reed, C. C. Coutant, N. E. Hinkle, D. B. Hunsaker, Jr., G. Marland, L. N. McCold, R. L. Miller, L. W. Rickert, M. S. Salk, J. A. Watts, J. W. Webb, A. K. Wolfe, J. T. Stone.

4. *Draft EIS El Portal Project, FERC No. 3581, California,* FERC/DEIS-0049, Federal Energy Regulatory Commission Office of Hydropower Licensing, November 1987. R. M. Reed, J. J. Beauchamp, J. M. Bownds, D. M. Evans, G. M. Kondolf, S. F. Railsback, R. D. Sharp, B. J. Shumpert, W. P. Staub, E. Szarleta, J. W. Webb and T. Wright.

5. *Final EIS, Hydroelectric Development in the Upper Ohio River Basin,* FERC Docket No. EL85-19-114, Ohio, Pennsylvania, and W. Virginia," FERC Office of Hydropower Licensing, FERC/FEIS-0051, September 1988. J. M. Bownds, S. Y. Chang, C. C. Coutant, B. D. Holcomb, F. C. Kornegay, S. F. Railsback, R. M. Reed, M. J. Sale, B. L.Shumpert, M. M. Stevens, M. M. Swihart, J. A. Watts, J. W. Webb.

6. *Final Staff Report, Evaluating Environmental and Economic Effects, PURPA Benefits at New Dams and Diversions, Docket No. EL87-9,* Federal Energy Regulatory Commission, July 1988. L. J. Allison, P. W. Brown, G. F. Cada, R. L. Graham, C. T. Hunsaker, F. C. Kornegay, F. E. Latham, S. F. Railsback, M. J. Ringo, M. J. Sale, B. L. Shumpert, M. M. Swihart, and J. W. Webb.

7. *Final Programmatic Environmental Impact Statement,* Program Executive Officer - Program Manager for Chemical Demilitarization, Chemical Stockpile Disposal Program, January 1988. S. A. Carnes, K. R. Ambrose, J. E. Breck, P. R. Coleman, J. B. Cannon, C. V. Chester, F. D. Copenhaver, D. L. Feldman, G. F. Flanagan, W. Fulkerson, R. L. Graham, G. D. Griffin, W. H. Hermes, E. L. Hillsman, F. C. Kornegay, K. H. Lin, R. L. Miller, N. B. Munro, G. O. Rogers, L. L. Sigal, M. B. Sears, J. H. Sorensen, W. P. Staub, V. R. Tolbert, L. C. Waters, A. P. Watson.

8. *Final Phase I Environmental Report for Tooele Army Depot, Tooele, Utah,* Program Executive Officer-Program Manager for Chemcial Demilitarization, Chemical Stockpile Disposal Program, September 9, 1988, G. P. Zimmerman, C. R. Boston.

9. *Environmental Assessment for the Electromagnetic Pulse Surveillance Facility at Tinker Air Force Base, Oklahoma,* Department of the Air Force, July 1988. P. E. Aldrich, C. E. Easterly, R. L. Kroodsma, and L. W. Rickert.

10. *Draft Environmental Assessment for the Proposed Northeast Regional Communications Facility and the Federal Aviation Administration Barnegat Project,* Department of the Air Force, August 1988. C. E. Easterly, D. M. Evans, R. L. Kroodsma, R. L. Miller, S. F. Railsback, S. F. Rayner, L. W. Rickert, W. P. Staub, and A. J. Witten.

11. *Environmental Assessment for the Navy TACAMo Squadrons at Tinker Air Force Base, Oklahoma,* Department of the Air Force, August 1988. R. L. Kroodsma, C. E. Easterly, F. C. Kornegay, D. W. Lee, L. W. Rickert, and G. Hart

12. *Environmental Assessment, Titan IV Solid Rocket Motor Upgrade Testing at Edwards Air Force Base, California,* Department of the Air Force, May 1988. C. E. Easterly, D. M. Evans, E. J. Liebach, K. H. McCorkle, R. M. Reed, D. S. Shriner, and J. W. Webb.

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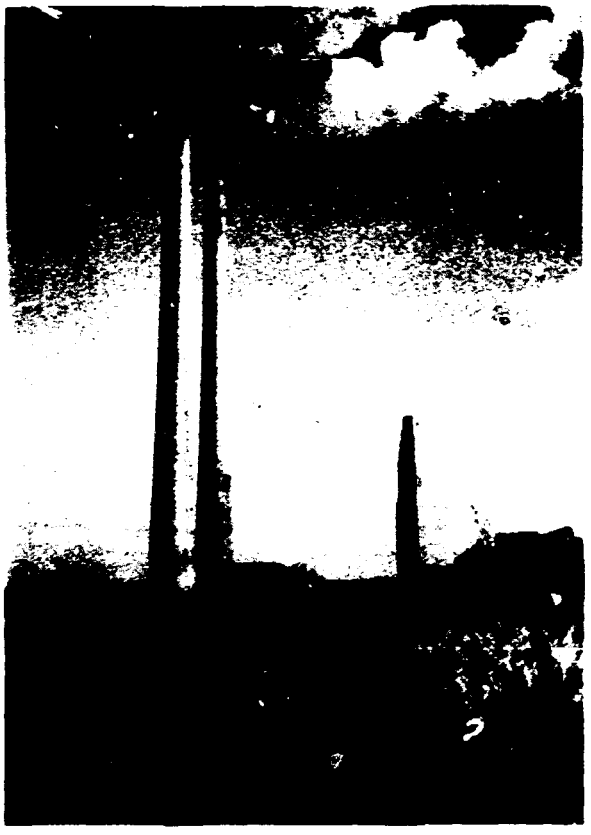

Advanced clean coal technologies are being examined for potential repowering or refitting of existing fossil-fired power plants.

proposed action alternative, changes to three environmental parameters of concern [sulfur dioxide (SO_2), nitrogen oxides (NO_x), and solid waste] were estimated as a result of the maximum commercialization by the year 2010 of 19 generic innovative clean coal technologies (see Table 2.2).

The results of the analysis showed that under the no-action alternative, if no new emission regulations were promulgated, national emissions from coal-fired utilities and industrial boilers for SO_2 and NO_x would increase by 16% and 67%, respectively, between 1985 and 2010. The major increase in SO_2 and NO_x would occur in the southwestern quadrant of the United States. With respect to acidic deposition, there would likely be continued impacts on water chemistry from atmospheric deposition of sulfur and nitrogen compounds under the no-action alternative. The northeastern quadrant would be the region of the United States most affected by continued production of acidic precursors. Carbon dioxide (CO_2) emissions would likely increase under the no-action alternative between the years 1985 and 2010 as a function of the amount of coal burned. Solid waste generated under the no-action alternative would include approximately 4340 acres/year of FGD sludge and 2710 acres/year of ash. This compares to current land disposal requirements estimated to be 570 acres/year for FGD wastes disposal and 1440 acres/year for ash disposal.

Under the proposed action alternative, commercialization of innovative clean coal technologies would have a substantial beneficial effect on air quality in the year 2010, as shown in Table 2.2. Commercialization of the technologies would result in decreases in atmospheric emissions of SO_2 and, to a lesser extent, NO_x. These reductions in SO_2 and NO_x emissions could contribute to an amelioration of current impacts of acidic deposition on surface waters. Any reduction of acidification would be greatest in the northeastern quadrant of the United States and in southeastern Canada.

2.1.1.2 EIS for hydroelectric development in the Upper Ohio River Basin

An EIS was completed that evaluated the effects of retrofitting 19 dams for electricity

Table 2.2. Emissions projection for innovative clean coal technologies[a]

Technology	Applicable market (quads)	Environmental consequences – 2010 (% change in national emissions)[b] SO_2	NO_x	Solid waste
Circulating fluidized bed	27.4	-26%	-7%	+13%
Pressurized fluidized bed	27.4	-44%	-20%	+18%
Fuel cells	27.4	-29%	-22%	-16%
Integrated gasifier combined cycle	27.4	-34%	-23%	-7%
Advanced slagging combustor	29.5	-45%	-10%	+26%
Limestone injection multistage burner	12.9	-30%	-11%	+20%
Low NO_x burner	28.7	0	-21%	0
Spray dryer	29.5	-56%	-20%	+35%
Reburning	30.8	-10%	-23%	-17%
Sorbent injection	12.9	-33%	0	+27%
Selective catalytic reduction	21.3	0	-22%	0
Direct liquefaction	29.5	-25%	-12%	+7%
Indirect liquefaction	29.5	-60%	-10%	+10%
Coal-oil coprocessing	29.5	-25%	-10%	-24%
Ultrafine coal cleaning, medium sulfur	4.5	-21%	0	+14
Ultrafine coal cleaning, high sulfur	0.4	-2%	0	<1%
Advanced flotation, high sulfur	0.4	<1%	0	<1%
Advanced physical, medium sulfur	4.5	-21%	0	+14%
Advanced chemical, medium sulfur	9.9	-24%	0	+32%

[a]Maximum commercialization of each technology within the applicable market was assumed. Technology mixes were not considered.

[b]Changes are measured relative to total national emissions in the no-action alternative.

production on the Upper Ohio River system. Public meetings and agency working sessions were held to discuss such issues as water quality [(mainly related to temperature and dissolved oxygen (DO) content], recreational fisheries, fish protection devices, river navigation, and wetlands utilization. Both cumulative and site-specific concerns were addressed, as well as non-target resources such as aesthetics, socioeconomics, and archaeological resources. The four alternatives evaluated included (1) production of all proposed power with little environmental protection, (2) operation according to DO standards, (3) operation to prevent water quality degradation, and (4) operation that accounts for the protection of all resources. We recommended the fourth alternative, which entails production of 82% of the proposed power but has a low probability of causing major environmental problems (Fig. 2.1). We also recommended mitigation, emphasizing protection of wetlands, fish habitat, and dissolved oxygen levels below the dams.

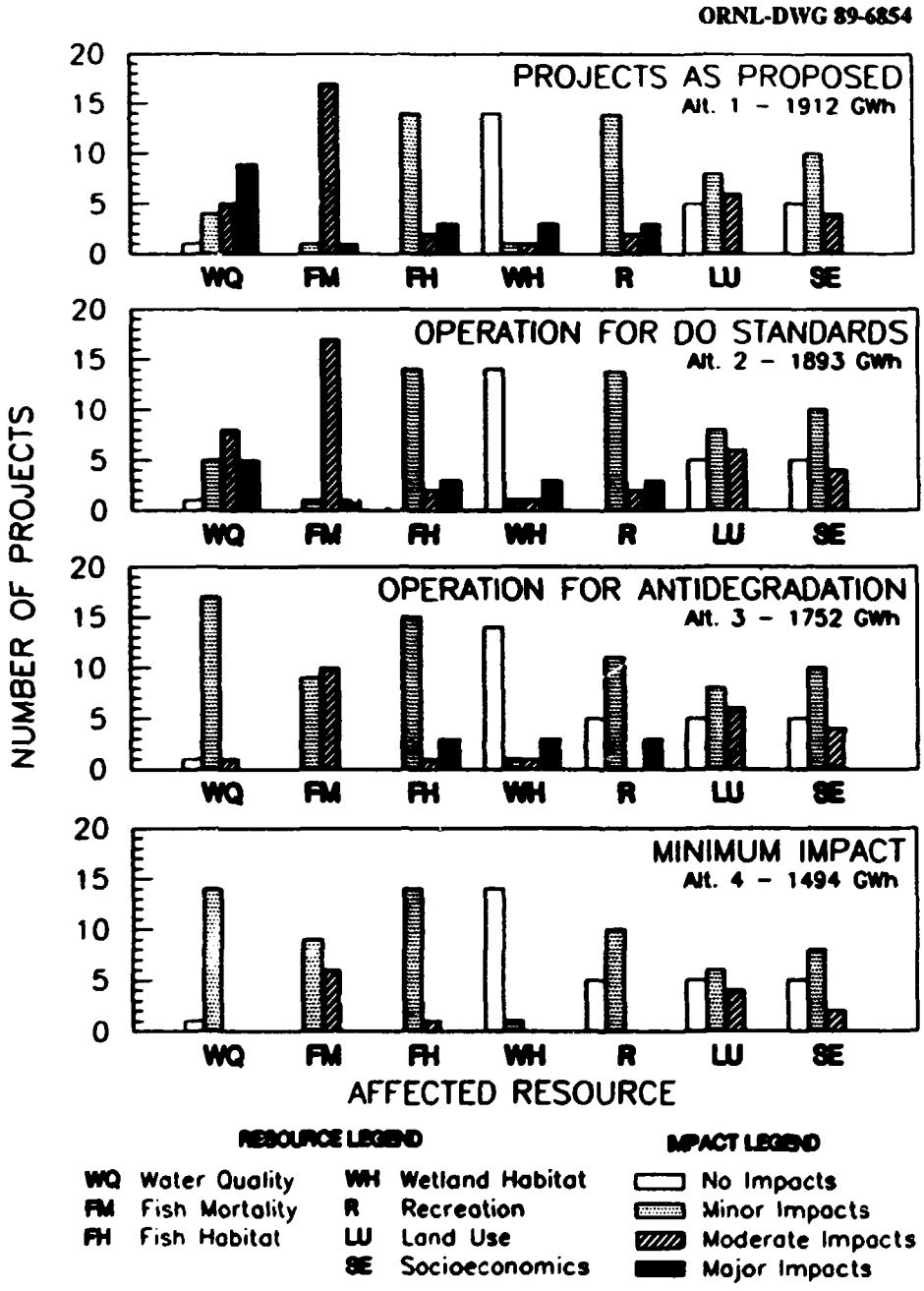

Fig. 2.1. Summary of impacts of the four alternatives for hydroelectric development in the upper Ohio River Basin.

2.1.1.3 Chemical Stockpile Disposal Program *Final Programmatic Environmental* Impact Statement

We provided technical support to the U.S. Army by preparing a final programmatic environmental impact statement (FPEIS) that assessed the potential environmental impacts of alternative approaches to disposing of the lethal chemical agents and munitions stored at eight installations in the continental United States (CONUS). Consistent with a

Congressional directive, the principal focus of the FPEIS was analysis and comparison of on-site disposal of the stocks at their present storage locations; rail relocation of the stocks to regional disposal centers for destruction; and rail relocation of the stocks to a national disposal center for destruction. Other alternatives were also considered, including, for example, air, truck, and barge transport modes and destruction technologies such as incineration and cryofracture. We concluded that the CONUS stockpile could be destroyed in a safe, environmentally acceptable manner and that the risk of catastrophic accidents would be relatively low for all programmatic alternatives. On-site disposal was found to pose less risk to the public and the environment than alternatives involving off-site movement of the stockpile and was therefore selected as the best choice (see Table 2.3). In its Record of Decision, the Department of the Army selected the on-site disposal alternative and committed to a NEPA review of implementing the programmatic decision at each of the eight storage installations where the respective stocks would be destroyed.

2.1.2 Emergency Preparedness

The Division's research in the emergency preparedness area is centered in the IAAS. This work is directed at improving society's ability to cope with natural and technological hazards and large-scale technological disasters such as a nuclear war. The thrust of our work this past year dealt with (1) development and exercise of federal plans for responding to radiological emergencies and (2) evaluating human response to technological risks at the individual and the organizational levels. Specifically, we continued to provide assistance to DOE's Office of Safety Policy and Standards in drafting emergency planning orders and planning, executing, and evaluating large emergency response exercises involving DOE and other federal, state, and local agencies. DOE federal response plans are being improved as a result of these activities. We also performed a study for the U.S. Environmental Protection Agency evaluating alert and notification systems for chemical emergencies, and we initiated a major program for the Army to enhance emergency

Table 2.3. Comparison of programmatic alternatives for destruction of chemical munitions and agents stored in the continental United States[a]

Alternatives	Probability of one or more fatalities	Maximum fatalities	Expected fatalities	Person-years at risk	Expected plume area (km^2)
Continued storage	8	17	479	61	96
On-site disposal	1	1	1	1	1
Regional disposal	6	8	10	2	4
National disposal	11	8	32	2	8
Partial relocation	12	4	27	1.3	14

[a]These measures are indicators of the risk and of catastrophic accidents involving releases of lethal agent with off-site consequences. Values have been normalized with respect to the on-site disposal alternative.

preparedness at sites where lethal unitary chemical munitions and agents will be destroyed. These studies are summarized in Sects. 2.1.2.1 and 2.1.2.2.

2.1.2.1 Response to radiological accidents: planning and exercises

The Federal Radiological Emergency Response Plan describes the roles of federal agencies when responding to a radiological accident in support of the state. In FY 1989, we assisted with two large interagency exercises. The evaluation was completed for the second Federal Field Exercise, a June 1987 exercise based on a nuclear power plant accident. The lessons learned from this exercise are being incorporated into the federal plan. We also assisted with the planning, execution, and evaluation of Compass Rose, a May 1988 exercise based on a terrorist attack on a nuclear weapons shipment (Fig. 2.2). In addition to the exercise activities, we have been involved in revision of the federal plan, preparation of DOE emergency planning orders, development of operating procedures for the Federal Radiological Monitoring and Assessment Center, and preparations for the reentry of one of the U.S.S.R.'s reactor-powered satellites.

2.1.2.2 Alert and notification systems for chemical emergencies

ORNL conducted a survey to assess the status of public alert and notification systems

ORNL-Photo 4361-88

Fig. 2.2. Photograph of participants in the Federal Radiological Monitoring and Assessment Center during the Compass Rose Exercise. The participants are plotting contamination levels resulting from the hypothetical terrorist accident.

for chemical emergencies in the United States. This survey supported a much larger EPA study, required by Title III of the 1986 Superfund Amendments and Reauthorization Act, of current emergency systems for chemical accidents, including technologies for preventing, monitoring, and detecting accidents and alerting the public. The survey consisted of a sample size of 277 local emergency planning organizations. Responses were received from 60% of the sample. We found that communities do not know the types of information needed to make good decisions in a chemical accident (too much reliance is placed on making warning and protective action decisions in crisis settings without prior planning about how that process would occur). Furthermore, communications linkages (from both hardware and human standpoints) between facilities and communities are largely unreliable and inadequate, and plans and implementation procedures at the facility and in the community are weak or nonexistent in many cases and require greater attention. Many existing alert and notification systems would work to provide a precautionary alert over a period of several hours but would fail to provide a timely warning in an accident in which hazardous materials are suddenly released. The response of the public to a warning, particularly in the absence of preemergency information programs, is still uncertain and potentially problematic.[1]

2.1.3 Waste Management and Physical Sciences

The Section's activities in the radioactive waste management area and related research in the physical sciences have experienced significant growth in the past few years. Our work is focused on the development of the geophysical diffraction tomography technique for subsurface imaging applications (Fig. 2.3), development of site characterization methodologies for waste disposal facilities, development of waste management strategies, and contaminant transport modeling in atmospheric and aqueous systems. Our geohydrologists are often called upon to perform site screening and characterization studies for new waste disposal facilities. Specifically, for the Low-Level Waste Disposal Development and Demonstration Program, we characterized the geologic and hydrologic systems of a site in Bear Creek Valley of the Oak Ridge Reservation that is under consideration for disposal of low-level radioactive waste.[2] We also examined management of waste from the Y-12 Plant with uranium contamination levels sufficiently low that the waste would be regulated without regard to its radioactivity content. We found that such wastes could be managed as sanitary/industrial waste and disposed of in a sanitary landfill, resulting in both a significant cost savings and extension of the life span of existing radioactive waste disposal facilities. A brief summary of our work in the groundwater transport area is provided in Sect. 2.1.3.1.

2.1.3.1 Groundwater hydrodynamics

The movement of groundwater in geologic materials is classically modeled with Darcy's Law as the equation of motion. Darcy's Law has been so commonly used, with success in many applications, that it is regarded as essentially a fundamental law of physics. However, we have investigated the fundamentals of groundwater hydrodynamics and the implicit assumptions incorporated into Darcy's Law using the Theory of Mixtures.[3] The basic equations of motion can be reduced to Darcy's Law by assuming that the motion of the solid, the inertia of the fluid, and the viscosity of the fluid can be neglected. Additionally, the stress in the fluid must be assumed to be the result of pressure alone, and the effect of the interaction of the solid with the fluid must be linearly dependent on the relative velocity of the fluid. These restrictive assumptions cannot be expected to be valid for all applications of groundwater movement in geologic materials.

The significance of neglecting viscosity and inertia on the motion of groundwater was

ORNL-Photo 2952-88

Fig. 2.3. Geophysical diffraction tomography technique for subsurface imaging applications.

investigated for the classical Theis problem of radial flow into a well in a confined horizontal aquifer. We found that with simplifying assumptions the presence of viscosity and inertia resulted in a reduction of 12% in the flow and lag in the response of the aquifer to pumping.

Further investigations into the sensitivity of the flow to material properties and the effects of other restrictive assumptions are being pursued. The results obtained thus far indicate that Darcy's Law has significant limitations in providing an accurate description of groundwater motion.

2.1.3.2 Leaky aquifer research

We continued investigations of Darcian multilayered flow with a leaky interface. The work established that certain restricting, ad hoc assumptions on the nature of the flow are unnecessary and, in many realistic settings, simply incorrect. It was found that the principal use of such assumptions is due to a previous desire to simplify the mathematics in the modeling. The research effort succeeded in showing how more advanced mathematical techniques may be applied to this type of model with the result that the modeler may now analytically examine important trade-offs between physical parameters, such as pumping rates and hydraulic conductivity.

The work, originally motivated by an observation that suggested a nonintuitive rotation in the flow, established that rigorous adherence to the original equations of motion, without the typical *a posteriori* assumptions, does indeed support a weak rotation of groundwater flow. These analytically computed results were duplicated independently by using a common finite element computer code. The potential impact this more rigorous modeling may have on predicting contaminant transport through multiple aquifer systems has not been studied.

2.1.3.3 Validation of groundwater contaminant transport model

We conducted a groundwater dye tracer field experiment (see Fig. 2.4) to demonstrate the predictive accuracy of groundwater contaminant transport modeling in the saturated zone of a 600-m² area within a surrounding larger site in Bear Creek Valley of the Oak Ridge Reservation. The site is being characterized for low-level waste disposal.[4] The validity of the model output was judged

Fig. 2.4. Groundwater dye tracer field experiment.

on the basis of the accuracy with which the model prediction matched the tracer behavior in the far-field portion of the test.

Modeling assumed steady state aquifer conditions, which were not met during the tracer test because of lack of significant rainfall for a period of weeks to months after tracer injection. The initial dye migration rates observed in the tracer test were consistent with the model-predicted rates; however, lack of rainfall resulted in water table decline and aquifer gradient reduction with an accompanying unanticipated slowdown of tracer movement. This observation indicates that short-term and seasonal variations in aquifer conditions strongly influence local, shallow-zone groundwater flow.

Despite the higher-than-average density of aquifer characterization tests performed, the initial modeling efforts inaccurately predicted the tracer migration direction. The site hydrologic test interpretation, and therefore the initial model grid, assumed that groundwater flow at the site was controlled by the hydraulic gradient determined from an initial well array. The site characterization testing scale and the dominantly hydrologic, rather than geologic, interpretation of the test data are considered to have led to the inaccurate model predictions.[4]

The results of the tracer test are consistent with the larger-scale conceptual model that has evolved for the Bear Creek Valley site. The results of the site characterization and

modeling efforts indicate that flow in the shallow aquifer is controlled by geologic features ~1 m thick, which are not accommodated by conventional numerical models.

Successful model use on such a site depends on defining the resolution required for any application, followed by field testing and model grid definition at compatible scales. Where high resolution is required, very detailed tests and fine model grids will be required. The groundwater tracer test demonstrated the strong control of geologic conditions on groundwater flow. The use of tracer tests to characterize sites and verify model results provides the highest level of resolution of groundwater flow characteristics.

2.1.4 Technology and Social Systems

Research in the area of technology and social systems is directed at understanding the institutional mechanisms by which society manages technologies. It is critical that the full range of potential impacts of technology on society be understood so that appropriate institutional responses can be implemented to guide development of technology. For society, it is vital that those institutions reflect a high level of public trust, operate according to procedures to which society has given its consent, and provide for an equitable distribution of cost and risk liabilities in implementing the technology. To further these research objectives, several projects were undertaken, two of which are summarized here.

2.1.4.1 Development of an Intergovernmental Consultation and Coordination Board for the Army Chemical Stockpile Disposal Program

An analysis of public participation mechanisms in programs characterized by perceived high risk and public opposition was conducted in order to evaluate the Intergovernmental Consultation and Coordination Boards (ICCBs) established for mitigating public concerns in the U.S. Army's Chemical Stockpile Disposal Program. Drawing upon the guidelines of American democratic theory and the lessons of nuclear waste disposal and other programs, a framework was developed for ICCB evaluation. Analysis of public concerns expressed at scoping meetings and other hearings revealed additional problems likely to be encountered in the operation of these boards for enhancing trust toward the Army by state and local governments, tribal nations, and the general public.

The major findings of this study are that ICCB success in mitigating public concerns hinges upon single agency management, early involvement of the public, small-group information sharing opportunities, and consideration of issues through mediation, negotiation, and routes of appeal to a programmatic ICCB. Moreover, the goals and functions of these boards should be elucidated as maintaining citizen concurrence and providing public input, not alleviating all disagreements.[5]

2.1.4.2 Public participation process for siting hazardous facilities

Because the keys to public acceptance in siting of nuclear and hazardous waste management facilities are not well understood, we undertook analysis of six instances of public participation in siting, five of which were judged to be successful.[6] Our intent was to define more closely the uses and limits to public participation. Success was broadly defined as any outcome that reduces conflict between the interested parties and the agency or proponents and that results in a legitimate and lasting decision. The cases included the locally and state monitored retrievable storage siting efforts in Tennessee and the two hazardous waste assessment/siting efforts in North Carolina, as well as the Hanford Defense Waste Citizens Forum and the New Mexico Waste Isolation Pilot Plant.

Common factors found in the successful public participation case studies include adequate and timely information, in-house technical expertise, use of a citizen or expert task force to assess impacts and negotiate conditions of acceptance, limited power sharing, a responsive agency/developer, confidence of the task force in its own understanding of the impacts and technology, and modification of the proposed plan to meet risk-bearer concerns. In addition, involvement in meaningful public participation is one of the few ways of changing opinion, increasing trust, and possibly opening the way for negotiations.

The limits to public participation include recognition of public participation as a double-edged sword in which poorly focused or mismanaged public participation can result in worsening public acceptance. The role of public participation in addressing the loss of trust of the public in institutions was found to be important, though limited. Public participation cannot overcome conflicts caused by different public participation goals among interested parties and promoters, inadequate compensation, or lack of responsiveness of the promoter, nor can it counteract use of the usually unsuccessful "decide, announce, and defend" strategy.

The role of public participation in public acceptance of siting of noxious facilities is essential but not sufficient by itself to achieve consensus and to reach lasting decisions. Successful siting involves public participation and some combination of incentives, compensation, power sharing, accountability, addressing uncertainty and lack of trust, and a net positive benefit vs impact balance.

2.2 RESEARCH UTILIZATION

Work performed by the Integrated Analysis and Assessment Section and applied research results are valuable not only to our sponsors but also to other organizations. The members of the Section present papers at conferences and professional meetings and report results to our program sponsors. While the use of the research carried out by the Section can best be characterized in terms of information transfer, we also participate in technology transfer.

A large potion of our work involves the preparation of NEPA documents in support of a sponsor's need to inform the public of the environmental consequences of a major federal action. The analyses contained in such documents transfer significant information to the public as well as to the scientific community. The non-NEPA portion of our work, such as work for FEMA, is also used to transfer technical information. In particular, the work on emergency preparedness and evacuation planning is of great value not only to our sponsors but also to the scientific community. That ORNL is becoming a center of expertise in these areas is an accepted fact.

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2.4 ABSTRACTS OF PUBLICATIONS

[2.4.1]

IMPLICATIONS OF THE ZION FEDERAL FIELD EXERCISE FOR THE FEDERAL RADIOLOGICAL EMERGENCY RESPONSE PLAN

M. V. Adler K. S. Gant
B. H. Weiss* W. F. Wolff**

[Abstract of *Health Phys.* 54 (Suppl. 1), 538 (1988)]

The second Federal Field Exercise (FFE-2), held in June 1987 at the Zion Power Station, provided another opportunity to evaluate the Federal Radiological Emergency Response Plan (FRERP). Over 1000 players from state agencies in Illinois and Wisconsin; Lake County, Illinois; Kenosha County, Wisconsin; Commonwealth Edison; and 12 federal agencies participated in the three-day exercise. FRERP again proved to be a workable guide for organizing and coordinating federal response. The federal agencies were able to provide the needed assistance and work with the states to set priorities for the use of federal resources. Both the exercise and the preexercise planning made the participants more aware of some of the problems that might arise during a multiagency response to a large accident. The large field exercise provided an opportunity for a more complex and more realistic response than that normally found during routine regulatory exercises.

Research sponsored by U.S. Department of Energy Office of Nuclear Safety.
*U.S. Nuclear Regulatory Commission.
**U.S. Department of Energy.

[2.4.2]

LESSONS LEARNED FROM THE SECOND FEDERAL RADIOLOGICAL EMERGENCY RESPONSE PLAN FIELD EXERCISE (FFE-2)

M. V. Adler K. S. Gant
B. H. Weiss* W. F. Wolff**
V. Adler†

(Abstract of p. 14-4 in *Proc. ANS Top. Meet. Emerg. Respon.–Plann., Technol., Implementation*, Charleston, S.C., Sept. 26-28, Savannah River Laboratory, Aiken, S.C., September 1988)

The FFE-2, held in 1987 at the Zion Nuclear Power Station, provided a large-scale, multiagency field test of the Federal Radiological Emergency Response Plan (FRERP). FRERP provided workable guidance for coordinating the federal response efforts and effectively supplementing the states' resources. Needs for more training for responders and clarification in portions of the response were identified.

Research sponsored by U.S. Department of Energy Office of Nuclear Safety.
*U.S. Nuclear Regulatory Commission.
**U.S. Department of Energy.
†Federal Emergency Management Agency.

[2.4.3]

COMMUNITY COORDINATION PLAN FOR BASING THE B-2 BOMBER AT WHITEMAN AIR FORCE BASE, MISSOURI

R. B. Braid F. C. Kornegay*
B. D. Lasley P. Sage**
J. P. Fichera** P. Lufkin**
L. Taylor**

(Abstract of ORNL/TM-10542, Oak Ridge National Laboratory, November 1987)

The U.S. Air Force Strategic Air Command (SAC) intend to deploy B-2 bombers at Whiteman Air Force Base (AFB), Missouri, in the early 1990s. Establishment of the B-2 unit at Whiteman will constitute a substantial expansion of SAC activities at the base and the return of the first permanently assigned fixed-wing aircraft in 25 years. The most significant consequences to the region should be in the economic benefits to the area in the form of new primary and secondary jobs and the sales of products and services to Whiteman AFB and base employees. Some short-term adverse impacts to housing, schools, and roads appear to be possible, but timely cooperative planning and mitigation by SAC and local communities should be effective in reducing substantially the degree of these impacts.

Research sponsored by the U.S. Air Force, Strategic Air Command.
*Environmental Compliance Division.
**URS Corporation, Santa Barbara, Calif.

[2.4.4]

SURVEY RESEARCH AS AN INTEGRAL COMPONENT OF STRATEGIC AIR COMMAND SOCIAL IMPACT ASSESSMENT

R. B. Braid A. K. Wolfe

[Abstract of *Environ. Profess.* 10, 243-56 (1988)]

The Strategic Air Command (SAC) operates approximately 70 low-level routes throughout the United States for purposes of training and maintaining the operational readiness of its air crews. Little information exists regarding the impacts to people that might be attributed to bombers flying as low as 400 to 500 ft above ground level. To improve its National Environmental Policy Act documentation, SAC sponsored exploratory social survey research at Oak Ridge National Laboratory to establish the nature and extent of impacts to people living under two of SAC's low-level routes. Almost half the respondents were indifferent to the flights, one-third supported SAC's activities, and one-sixth opposed them. Men and older people were more supportive of the flights than women and younger people. Survey research also elicited topics of concern. Safety was mentioned most often, followed by noise and startle effects. Discovering the issues of particular concern to affected people prompted SAC to move the location of one route in several areas, thus mitigating adverse effects through avoidance.

Research sponsored by the U.S. Air Force, Strategic Air Command.

[2.4.5]

DISPOSAL OF OAK RIDGE NATIONAL LABORATORY REMOTELY HANDLED TRANSURANIC WASTE: A STRATEGY FOR NEPA COMPLIANCE

A. W. Campbell

(Abstract of ORNL/TM-10802, Oak Ridge National Laboratory, May 1988)

To assist the Oak Ridge National Laboratory Transuranic (TRU) Waste Program in planning for a new remotely handled (RH) TRU Waste Handling and Packaging Plant (WHPP), feasible options for achieving compliance with the National Environmental Policy Act of 1969 (NEPA) were identified and analyzed with regard to implementation. An integrated evaluation of environmental regulations, future TRU waste management activities, and potential environmental impacts was conducted to recommend the most timely, cost-effective strategy for preparing NEPA documentation for the disposal of RH TRU wastes. The relationship of WHPP project milestones and the environmental review process were the focus of the analysis. Consideration of potential environmental issues associated with construction and operation of the WHPP indicated that preparation of an environmental assessment would likely be the first step toward NEPA compliance.

[2.4.6]

TECHNICAL OPTIONS FOR PROTECTING CIVILIANS FROM TOXIC VAPORS AND GASES

C. V. Chester

(Abstract of ORNL/TM-10423, Oak Ridge National Laboratory, May 1988)

Costs and quantitative estimates of effectiveness of general technical options for protecting civilians in place against very toxic vapors are provided and compared with possible hazards. Useful protection can be obtained by taking refuge in enclosed spaces if the leak rate is low, cloud passage is quick, and it is possible to tell when the cloud has passed. Charcoal filters and masks are available in the United States and abroad that give good protection if there is some system to warn people to use the protective equipment. The most cost-effective method of protection found is a mouthpiece respirator that costs less than $14 and can be donned in seconds. Protection for a single room in a residence by a charcoal filter and blower can be obtained for under $1000. In cool weather, the population of a mass shelter can be provided with a charcoal-filtered air supply (of 3 cfm per person) for about $10/person.

Research sponsored by the Office of Program Manager for Chemical Munitions, Aberdeen Proving Grounds, Md.

[2.4.7]

INTERGOVERNMENTAL CONSULTATION AND COORDINATION AND EMERGENCY RESPONSE: THE RELATIONSHIP BETWEEN ICCB AND SARA TITLE III IN THE U.S. ARMY'S CHEMICAL STOCKPILE DISPOSAL PROGRAM

D. L. Feldman

(Summary of ORNL/TM-10973, Oak Ridge National Laboratory, September 1988)

The relationship between Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) and the Intergovernmental Consultation and Coordination Board (ICCB) in the U.S. Army's Chemical Stockpile Disposal Program (CSDP) is examined from four perspectives: (1) the current status and likely future direction of SARA implementation in the eight CSDP continental U.S. sites; (2) the applicability of SARA to the CSDP; (3) the effect of SARA information management upon the ICCB; and (4) challenges posed by SARA in the areas of public participation and intergovernmental relations. The structure and concerns of state emergency regulatory commissions and local emergency planning committees (LEPCs) varies. The status of state "right-to-know" laws predating SARA also varies, and financial and public participation concerns related to emergency planning and intergovernmental consultation and coordination for each state were also different. SARA grants considerable discretion to state and local governments in

developing emergency plans. Title III requires that LEPCs include relevant state and local officials, police, fire, civil defense, public health, environmental affairs, transportation personnel, and members of the mass media and designated community groups. Interest in serving on LEPCs varies by public awareness of hazardous materials issues.

Research sponsored by the U.S. Department of the Army.

[2.4.8]

DATA PACKAGE FOR THE LOW-LEVEL WASTE DISPOSAL DEVELOPMENT AND DEMONSTRATION PROGRAM ENVIRONMENTAL IMPACT STATEMENT

R. H. Ketelle R. R. Lee

(Abstract of ORNL/TM-10939, Oak Ridge Nztional Laboratory, September 1988)

This data package was required to support an environmental impact statement to evaluate the effects of future disposal of low-level waste at four sites on the Oak Ridge Reservation. Current waste disposal facilities are exceeding their capacities, and increasingly stringent disposal requirements dictate the need for sites and new waste disposal technologies. The Low-Level Waste Disposal Development and Demonstration Program has developed a strategy for low-level waste disposal built around a dose-based approach. This approach emphasizes contamination pathways including surface and groundwater and worker safety. This strategy dictates the types of data needed for this data package. The data package provides information on geology, soils, groundwater, surface water and ecological characterization of the Oak Ridge Reservation to evaluate alternative technologies and alternative sites.

Research sponsored by the U.S. Department of Energy, Oak Ridge Operations, Office of Research and Waste Management.

[2.4.9]

IDENTIFICATION OF SITES FOR THE LOW-LEVEL WASTE DISPOSAL DEVELOPMENT AND DEMONSTRATION PROGRAM

R. H. Ketelle D. W. Lee

(Abstract of ORNL/TM-10221, Oak Ridge National Laboratory, April 1988)

This report presents the results of site selection studies for potential low-level radioactive waste disposal sites on the Oak Ridge Reservation. The West Chestnut site was judged to be best suited for deployment of the shallow land burial technology. The Central Bear Creek Valley site was ranked most favorable for deployment of the above-grade disposal technology.

[2.4.10]

LOW-LEVEL RADIOACTIVE WASTE DISPOSAL AT A HUMID SITE

D. W. Lee

(Abstract of pp. 661-69 in *Proc. 1988 Joint CSCE-ASCE Natl. Conf. Environ. Eng.*, Vancouver, Canada, July 1988)

Waste management in humid environments poses a continuing challenge because of the potential contamination of groundwater in the long term. Short-term needs for waste disposal, regulatory uncertainty, and unique site and waste characteristics have led to the development of a site-specific waste classification and management system proposed for the Oak Ridge Reservation. The overlying principle of protection of public health and safety is used to define waste classes compatible with generated waste types, disposal sites and technologies, and treatment technologies.

Research sponsored by the U.S. Department of Energy Defense Waste Program.

[2.4.11]

GEOLOGY OF THE WEST BEAR CREEK SITE

R. R. Lee R. H. Ketelle

(Abstract of ORNL/TM-10887, Oak Ridge National Laboratory, January 1989)

A geological study was conducted at the proposed "tumulus" low-level waste disposal site in west Bear Creek Valley to describe the geologic characteristics of the site and to provide a foundation for concurrent geohydrologic studies. Results of this study indicate that the site is underlain by generally uniform dipping strata of the Cambrian Conasauga Group. Detailed examination of the lithologic features of a portion of the Conasauga at the site indicate that direct application of regional stratigraphic nomenclature requires minor modification. Analysis of intermediate-scale (meter-scale) structural features leads to the development of two conceptual models. The first model relates the character of these features to lithologic homogeneity and bedding thickness. The second model describes two styles of intermediate-scale structural deformation: one that occurs within lithologically correlative intervals and is continuous across the site and another that is stratigraphically localized. Both styles of structural deformation contribute to minor formational thickness variations.

[2.4.12]

CONTAMINANT TRANSPORT MODEL VALIDATION: THE OAK RIDGE RESERVATION

R. R. Lee R. H. Ketelle

(Abstract of ORNL/TM-10972, Oak Ridge National Laboratory, September 1988)

This report is a comprehensive summary of the contaminant transport model validation experiment. The early tracer migration rate was very close to the rate predicted from site analysis. A diminished rate of migration later in the test is suspected to be related to changing environmental conditions. The direction of tracer migration, however, differed from the direction predicted from site analysis. A plume less than 3 m wide was observed at a 245 degree azimuth, parallel to geologic strike. The finite element model selected to conduct the model validation failed to accurately simulate field observations in the far-field. The sophisticated data acquisition techniques employed in site testing and the use of standard techniques for data interpretation accurately predicted the early tracer migration rate. The scale at which site data were acquired, however, was incapable of resolving the geological influences on flow, and the interpretation of those data did not adequately consider the natural site conditions. The absence of steady state conditions may be related to fluctuations in the annual precipitation cycle and to episodic precipitation events. Modeling must account for this transient flow system and for natural conditions in the complex geologic setting at Oak Ridge.

[2.4.13]

SUBSURFACE GEOLOGY OF THE CHICKAMAUGA GROUP AT OAK RIDGE NATIONAL LABORATORY

R. R. Lee R. H. Ketelle

(Abstract of ORNL/TM-10749, Oak Ridge National Laboratory, May 1988)

Analysis of rock core and geophysical log data acquired from five core holes in the Oak Ridge National Laboratory (ORNL) Main Plant Area indicates that the Middle Ordovician Chickamauga Group is a lithologically diverse rock unit. Subdivision of the Chickamauga into nongenetic rock units is consistent with the position of major lithologic breaks identified in both core and geophysical logs; the placement of these units is in close agreement with their placement in previous work. Lithologic variability and interfingering occurs commonly within units, and comparison of correlative intervals from adjacent core holes suggests that lateral variability also occurs commonly. Small- to intermediate-scale structural features, typical of rocks elsewhere on the Oak Ridge Reservation, are absent in the Chickamauga at ORNL. Although numerous high-angle fractures are identified, characteristic structural features in the Chickamauga are ubiquitous bedding plane fractures and polished bedding plane partings with slickensides. This style of internal structural

deformation is attributed to the mechanical behavior of the strongly interbedded Chickamauga lithologies during Appalachian Orogeny deformation.

[2.4.14]

SITE SUITABILITY STUDY FOR THE PROPOSED VEMPS-II VERTICALLY POLARIZED ELECTROMAGNETIC PULSE SIMULATOR

L. N. McCold R. D. Roop
K. H. McCorkle* J. W. Van Dyke
J. W. Webb**

(Abstract of ORNL/TM-10697, Oak Ridge National Laboratory, February 1988)

The U.S. Army's Harry Diamond Laboratory (HDL) is planning to build and operate a vertically polarized electromagnetic pulse simulator (VEMPS-II). Construction is proposed at HDL's Woodbridge Research Facility (WRF) because it is headquarters for HDL's electromagnetic effects research and testing activities. The authors characterized and compared three potential sites with the Army's preferred location for the facility. Although construction and operation of VEMPS-II may be possible at all of the sites considered, the significantly lower cost at the proposed site at WRF appears to be a decisive factor favoring this site. None of the alternative sites show an overriding advantage for any of the other criteria considered.

Research sponsored by the United States Army, Harry Diamond Laboratories, Woodbridge Research Facility, Woodbridge, Va.
*The University of Tennessee.
**Environmental Sciences Division.

[2.4.15]

FIELD TEST EVALUATION OF CONSERVATION RETROFITS OF LOW-INCOME, SINGLE-FAMILY BUILDINGS IN WISCONSIN: AUDIT FIELD TEST IMPLEMENTATION AND RESULTS

L. N. McCold J. A. Schlegel*
L. O'Leary* D. C. Hewitt**

(Abstract of ORNL/CON-228/P2, Oak Ridge National Laboratory, June 1988)

This report describes the field test of a retrofit audit performed during the winter of 1985-86 in four South Central Wisconsin counties. The purpose of the field test was to measure the energy savings and cost effectiveness of the audit-directed retrofit program for optimizing the program's benefit-to-cost ratio. The purpose of this report is to describe the methods and results of the field test. Actual retrofit costs were close to expected costs. Overall measured annual energy savings averaged 15 therms/$100 retrofit invested. Houses that received wall insulation or a condensing furnace did slightly better, and the houses that

received only minor retrofits did poorly. When estimated program costs were included, average annual savings dropped to about 13 therms/$100. The uncertainty associated with the energy savings means that these comparisons of savings and costs also have large uncertainties.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Wisconsin Energy Conservation Corp.
**Portland Energy Office.

[2.4.16]

BEYOND THE NIMBY IMPASSE II: PUBLIC PARTICIPATION IN AN AGE OF DISTRUST

E. B. Peelle

(Abstract of pp. 575-82 in *Proc. Spectrum 88, Int. Meet. Nucl. Hazard. Waste Manage.*, Richland, Wash., September 1988)

Using a broad definition of public participation, we review the key factors in the general siting milieu as well as the thickets of public participation-public involvement. Six public participation case studies are analyzed for problems and common factors contributing to their success or failure. The uses as well as the limits of public participation in complex nuclear and hazardous waste management and siting processes are considered. We conclude that carefully structured public participation efforts including some form of power sharing offer the best (and sometimes the only) hope of devising legitimate and durable decisions.

[2.4.17]

CULTURE AND THE COMMON MANAGEMENT OF GLOBAL RISKS

L. P. Gerlach* S. Rayner

[Abstract of *Practic. Anthropol.* 10(3), 15-18 (1988)]

The reactor fire at Chernobyl highlighted a problem for all nations: that of managing common technological hazards and common resources in the absence of global government. In addition to radiological catastrophe, the greenhouse effect, acid rain, desertification, groundwater quality, pesticide pollution, and environmental consequences of oceanic exploitation are prominent examples of transnational risks. Traditionally, the solutions to transnational problems have been sought through intergovernmental treaties. This report examines the new institutional forms emerging to tackle the transnational problems of anthropogenic climate change due to the greenhouse effect. Institutional innovations will be required to deal with problems of interregional and international distributive justice that will arise in either preventing or adapting to anthropogenic climate change. Furthermore,

it is argued that these institutional innovations are likely to emphasize the role of extra-governmental organizations linking various constituencies within and between nation-states.

Research sponsored by the U.S. Department of Energy.
*Department of Anthropology, University of Minnesota, Minneapolis, Minn.

[2.4.18]

ACCIDENT ANALYSIS OF RAILWAY TRANSPORTATION OF LOW-LEVEL RADIOACTIVE AND HAZARDOUS CHEMICAL WASTES–APPLICATION OF THE "MAXIMUM CREDIBLE ACCIDENT" CONCEPT

E. Ricci R. B. McLean

(Abstract of ORNL-6477, Oak Ridge National Laboratory, September 1988)

The maximum credible accident (MCA) approach to accident analysis places an upper bound on the potential adverse effects of a proposed action by using conservative but simplifying assumptions. This report presents a guide for the preparation of transportation accident analyses based on the use of the MCA concept. The example is the analysis of the environmental impact of the potential derailment of a train transporting a large shipment of wastes. The shipment is assumed to be contaminated with polychlorinated biphenyls and low-level radioactivities of uranium and technetium. The train is assumed to plunge into a river used as a source of drinking water. The conclusions from the example accident analysis are based on the calculation of the number of foreseeable premature cancer deaths that might result as a consequence of this accident.

Research sponsored by the U.S. Department of Energy Office of Nuclear Energy.

[2.4.19]

ENERGY CONSERVATION FOR LOW-INCOME HOUSEHOLDS: A STUDY OF THE ORGANIZATION AND OUTCOMES OF WEATHERIZATION ASSISTANCE PROGRAMS

M. Schweitzer

[Abstract of *Energy Syst. Pol.* 12, 101-17 (1988)]

The U.S. Department of Energy's (DOE's) Weatherization Assistance Program funds local agencies to provide weatherization services to low-income households. This paper describes the most salient features of this program and similar weatherization efforts, examines relationships between organization and program outcomes, and presents recommendations for improvements to weatherization programs and related activities. Locally controlled factors found to be significantly related to program performance include the amount of the weatherization director's time spent on program administration, the use of established client selection criteria, the frequency of evaluation of local goal attainment,

and the type of weatherization crews used. Factors controlled at state or federal levels that are related to program performance include delays in state reimbursements of local agency expenditures and local flexibility in the choice of weatherization measures.

Research sponsored by the U.S. Department of Energy Office of State and Local Assistance Programs.

[2.4.20]

EVALUATION OF WARNING AND PROTECTIVE ACTION IMPLEMENTATION TIMES FOR CHEMICAL WEAPONS ACCIDENTS

J. H. Sorensen

(Abstract of ORNL/TM-10437, Oak Ridge National Laboratory, March 1988)

This preliminary evaluation of warning systems and protective action options for off-site emergency planning for chemical weapons accidents concentrates on the timing of warning and protective action implementation. The evaluation concludes that (1) a specialized warning system using tone alert radios, automatic telephone dialing systems, sirens, or a combination thereof is desirable within 10 km; (2) a rapid means of respiratory protection and expedient sheltering are the actions that could be most rapidly implemented within 10 km of a release point; (3) populations at distances greater than 10 km should have time to evacuate without specialized warning systems except in institutional facilities; and (4) the detection and warning decision times are critical elements in determining the feasibility of population protection. A 5- to 15-minute organizational response is needed to provide warning to potentially threatened populations. Even an expedient organizational response, however, would not provide 100% ensurance that everyone will have time to learn of the accident and take action.

Research sponsored by the Office of Program Executive Officer, Program Manager for Chemical Munitions, Aberdeen Proving Ground, Md.

[2.4.21]

REVIEW OF PUBLIC ALERT SYSTEMS FOR EMERGENCIES AT FIXED CHEMICAL FACILITIES

J. H. Sorensen G. O. Rogers
W. F. Clevenger*

(Abstract of ORNL/TM-10825, Oak Ridge National Laboratory, July 1988)

TITLE III of the 1986 Superfund Amendments and Reauthorization Act (SARA) requires communities that have facilities that store or use hazardous chemicals to develop emergency response plans for chemical accidents. Facilities are required to disclose information to the communities. Five major findings emerged from the study: (1) communities do not know what information about a chemical accident is needed to

make correct decisions, and too much reliance is placed on making warning and protective action decisions in a crisis setting without prior planning; (2) communications linkages from both a hardware and a human standpoint between facilities and communities are largely unreliable and inadequate; (3) plans and implementation procedures at both the facility and in the community are weak or nonexistent in many cases and require greater attention; (4) many existing systems would work to provide a precautionary alert over several hours but would fail to provide a timely warning in a sudden accident; and (5) the response of the public, particularly in the absence of preemergency information programs, is still uncertain and potentially problematic.

Research sponsored by the U.S. Environmental Protection Agency and the Federal Emergency Management Agency.
*The University of Tennessee, Knoxville.

[2.4.22]

EMERGENCY PLANNING FOR NUCLEAR ACCIDENTS: CONTENTIONS AND ISSUES

J. H. Sorensen B. M. Vogt*

[Abstract of *J. Wash. Acad. Sci.* 78(2), 210-25 (1987)]

This paper identifies and discusses issues concerning emergency planning for nuclear power plants. The critical point for changes made in planning requirements was the Three Mile Island accident. Current plans, as a result of these changes are far too complex, bureaucratic, and rigid to permit flexibility in managing emergencies. Many of the issues in nuclear power plant emergency planning are derived from behavioral intent surveys. Research based on these methods, which concludes that people will behave in certain ways in an emergency, is largely invalid and should not be the basis for developing emergency plans. The basis for plans must be developed on existing knowledge, not on speculative or inaccurate assumptions. Recommendations are proposed to revise radiological emergency planning, redevelop policy positions, and rely more on local and state governments.

Research sponsored by the Federal Emergency Management Agency.
*The University of Tennessee.

[2.4.23]

VIBRATIONAL IMPACTS OF HUSH HOUSE OPERATION

A. J. Witten

[Abstract of pp. 94-100 in *Proc. Joint ASCE-CSCE Natl. Conf. Environ. Eng.* (July 1988)]

The U.S. Air Force (USAF) is required to test turboprop and turbojet engines before or after maintenance or repair and prior to installation on aircraft. The most modern USAF facility for conducting engine diagnostic tests is the hush house, a hangar-like structure designed to isolate the noise from the surrounding environment. One type of hush house,

the T-10, is of particular concern because of vibrational impacts to surrounding structures induced by subaudible sound (infrasound) emitted during operation. This report describes a predictive method for assessing vibration-driven structural impacts.

Research sponsored by the U.S. Air Force

[2.4.24]

INVESTIGATION OF AEROACOUSTIC MECHANISMS BY REMOTE THERMAL IMAGING

A. J. Witten G. E. Courville

[Abstract of *Proc. Thermosense X–Int. Conf. Therm. Infrared Sens. Diagn. Control* 934, 207-14 (April 1988)]

A hush house is a hangar-like structure designed to isolate the noise from aircraft engine operations during diagnostic testing. While they suppress audible noise, they emit subaudible acoustic energy, which has caused structural vibrations in nearby facilities. It was hypothesized that the low-frequency acoustic waves are a result of acoustic Cherenkov radiation. This radiation is in the form of a coherent wave produced by the engine exhaust gas flow. The speed of sound in the exhaust gas is quite high as a result of its elevated temperature. Therefore, the gas flow is sonic or subsonic relative to its own sound speed but is supersonic relative to sound speed in the surrounding cooler air and, as a result, produces acoustic Cherenkov radiation. To confirm this hypothesis, thermographic surveys were conducted to image the thermal structure of the engine exhaust gas within the hush house. In the near-field, these images revealed that the exhaust gases did not behave like a high Reynolds number turbulent jet, but rather, the transition to turbulence is delayed by a suppression in growth of the self-excited instability wave as a result of acoustic Cherenkov radiation.

Research sponsored by the U.S. Air Force.

[2.4.25]

A HARDWARE/SOFTWARE SYSTEM FOR IMPLEMENTING GEOPHYSICAL DIFFRACTION TOMOGRAPHY

A. J. Witten W. C. King*

[Abstract of *Proc. SPIE Conf. Hybrid Image Signal Process.* 939, 64-70 (April 1988)]

Geophysical diffraction tomography is a technique for high resolution, quantitative imaging of subsurface cross sections. The method is based upon an imaging process known as filtered backpropagation, which is a generalization of the inverse straight ray tracing process referred to as backprojection. In backpropagation, an image of spatial variations in refractive index is formed by backpropagating data received along an array of detectors, by means of the reduced wave equation, from the array into the support volume of the host

medium. This report describes a microprocessor-based data acquisition system specifically designed and fabricated for geophysical diffraction tomography, discusses signal processing algorithms that are implemented on the system, and presents results of several field studies.

Research sponsored by the U.S. Army, Toxic and Hazardous Materials Agency.
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[2.4.26]

GEOPHYSICAL IMAGING WITH ARBITRARY SOURCE ILLUMINATION

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[Abstract of *IEEE Trans. Geosci. Remote Sens.* 26(4), 409-19 (1988)]

Geophysical diffraction tomography is a generalization of the conventional backprojection algorithm of X-ray tomography accounting for the diffraction effects that result from longer wavelength seismic or electromagnetic waves necessary for geophysical remote sensing. This report presents an algorithm for a configuration in which a finite number of sources of arbitrary character are distributed along one line and a finite number of receivers are distributed along a line having an arbitrary orientation with respect to the source line. The two-dimensional form of the algorithm is implemented for cylindrical beam (a point source in two dimensions) illumination. Numerical experiments are performed to investigate a range of source-receiver configurations. It is found that parallel source and receiver arrays, a cross-borehole configuration, provides better image quality than orthogonal arrays [an offset vertical seismic profiling (VSP) configuration]. However, the offset VSP configuration may be the most practical.

Research sponsored by the U.S. Army, Toxic and Hazardous Materials Agency.
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[2.4.27]

ULTRASONIC IMAGING WITH A FIXED INSTRUMENT CONFIGURATION

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[Abstract of *Appl. Phys. Lett.* 53(1), 16-18 (1988)]

Diffraction tomography is a technique based on an inversion of the reduced wave equation, which has been proposed for high-resolution ultrasonic imaging. While this approach has been considered for diagnostic medical applications, it has, until recently, been limited by the speed of data acquisition associated with instrument motions. This report presen s the results of an experimental study directed toward demonstrating tomography using a fixed instrument configuration. Remote sensing with acoustic waves has been used in geophysical exploration, nondestructive testing and evaluation, underwater applications,

and diagnostic medicine. Acoustic methods in medicine are routinely employed as a result of the nonionizing nature of acoustic energy, the inherent differences in the mechanical properties of soft tissues and the availability ultrasonic instrumentation. Current medical ultrasound instruments employ pulse-echo techniques, similar to naval sonar, to identify size, position, transmission, and reflection characteristics of internal structures. While the use of clinical ultrasound has become routine, it is qualitative relying heavily on interpretation of echo amplitude and arrival time.

Research sponsored by the U.S. Department of Energy.
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[2.4.28]

RISK COMMUNICATION: WHO'S EDUCATING WHOM?

A. K. Wolfe

[Abstract of *Pract. Anthropol.* 10(3-4), 13-14 (1988)]

Risk communication most often is viewed as a formal process in which experts or officials educate members of the public about probabilistic risk assessments. This narrow, one-way approach often fails to convince people that the technology in question truly is safe, partly because probabilities of harm may not be the primary issue of public interest. This paper argues that more effective risk communication can be achieved by learning the concerns of affected people and by addressing those issues in a more responsive, interactive process. Social impact assessments of Air Force low-altitude military overflights are used to illustrate these points. The emphasis on noise is analogous to the emphasis on probabilistic assessments of risk. While it may be the only issue raised by professionals, it may not be the primary issue of concern to the people overflown and it certainly is not the only item about which people may be upset. The paper concludes that the social impact assessment process, particularly through data collected from field interviews, can help facilitate effective and interactive communication between sponsors of a technology and people affected by that technology.

Research sponsored by the U.S. Air Force.

[2.4.29]

ANTHROPOLOGY AND THE NATIONAL ENVIRONMENTAL POLICY ACT: IS AN ANTHROPOLOGICAL PERSPECTIVE WARRANTED?

A. K. Wolfe R. B. Braid, Jr.

(Abstract of a paper presented at the *Soc. Appl. Anthropol. Ann. Meet.*, Tampa, Fla., Apr. 21-23, 1988)

The National Environmental Policy Act (NEPA) has been interpreted inconsistently, sometimes deemphasizing affected peoples' perceptions of and responses to proposed actions. This paper argues that these perspectives are important in NEPA research to meet both the letter and spirit of the law. A field survey research method, developed to incorporate such perspectives, has been used to assess the impacts of particular technological activities on people living in widely scattered rural areas. This report discusses the development of this field method and concludes by noting its contribution to the NEPA process.

Research sponsored by the U.S. Air Force.

2.5. ABSTRACTS OF ENVIRONMENTAL ASSESSMENTS AND ENVIRONMENTAL IMPACT STATEMENTS

[2.5.1]

ENVIRONMENTAL ASSESSMENT FOR TITAN IV SOLID ROCKET MOTOR UPGRADE TESTING AT EDWARDS AIR FORCE BASE, CALIFORNIA

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E. J. Liebsch K. H. McCorkle**
R. M. Reed† D. S. Shriner†
J. W. Webb†

(Summary of report, May 1988)

To ensure access to space with greater payload capacities and without manned systems, the U.S. Air Force plans the continued use of Titan solid-propellant rocket motors and proposes to test-fire five Titan IV solid rocket motors at Edwards Air Force Base, California. The project would have minimal impacts in the areas of surface water, aquatic and terrestrial ecology, land use, noise, and socioeconomics. Short-term, near-by air quality impacts were identified. A protective clear zone of about 1 mile would be established around the test stand, and testing would occur only if the wind direction were such that the exhaust cloud would not proceed over housing areas. Thorough real-time dispersion monitoring, data analysis, and refinement of the rocket exhaust dispersion model would be conducted to determine whether conditions would allow an easing of the wind restrictions

for test firings. Essential test personnel would be located in a protected concrete bunker near the test stand. Real-time monitoring of bunker air supply, test area exhaust cloud, and deposition would be performed in conjunction with downwind cloud monitoring.

Research sponsored by the Department of the Air Force.
*Health and Safety Research Division.
**The University of Tennessee.
†Environmental Sciences Division.

[2.5.2]

ENVIRONMENTAL IMPACT STATEMENT, HYDROELECTRIC DEVELOPMENT IN THE UPPER OHIO RIVER BASIN

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M. M. Swihart** J. A. Watts*
J. W. Webb

(Summary of FERC/FEIS-0051, Federal Energy Regulatory Commission, September 1988)

This environmental impact statement is an evaluation of the effects of retrofitting 19 dams for electricity production on the Upper Ohio River system. Public meetings and agency working sessions were held to air such issues as water quality [mainly temperature and dissolved oxygen (DO)], recreational fisheries, fish protection devices, river navigation, and wetlands use. Both cumulative and site-specific concerns were addressed as well as nontarget resources such as aesthetics, socioeconomics, and archeological resources. The alternatives evaluated included (1) production of all proposed power with little environmental protection, (2) operation according to DO standards, (3) operation to prevent water quality degradation, and (4) operation that accounts for the protection of all resources. The fourth alternative produces 82% of the proposed power, has a low probability of major environmental problems, and is recommended with mitigation emphasizing protection of wetlands, fish habitat, and dissolved oxygen levels below the dams.

Research sponsored by the Federal Energy Regulatory Commission.
*Environmental Sciences Division.
**Subcontractor, The University of Tennessee.
†Environmental Compliance and Health Protection Division.

[2.5.3]

FINAL STAFF REPORT EVALUATING ENVIRONMENTAL AND ECONOMIC EFFECTS, PURPA BENEFITS AT NEW DAMS AND DIVERSIONS

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F. C. Kornegay

(Summary of Docket NO. EL87-9, Federal Energy Regulatory Commission, July 1988)

Under the Public Utilities Regulatory Policies Act (PURPA), certain small-scale hydroelectric facilities at existing dams and those requiring construction of new dams or diversions are afforded financial and other incentives to stimulate development of such facilities. We evaluated the effects of PURPA on 1,746 projects with a combined capacity of 14,605 MW across the country. Predictions of economic and financial viability and ecological acceptability were made. Three alternatives were evaluated: (1) No PURPA benefits to projects requiring new dams and diversions, (2) PURPA benefits without environmental constraints found in Section 210(j) of PURPA, and (3) PURPA benefits with the environmental constraints. We concluded that under alternative 1, about 16 new hydropower dams or diversions (216 MW) are viable; under alternative 2, about 100 projects (1,740 MW) are viable; and under alternative 3, about 50 projects (690 MW) could be built. Therefore, PURPA benefits would stimulate development. The environmental constraints imposed by Section 210(j) of PURPA would not result in significant adverse ecological effects, especially on fisheries.

Research sponsored by the Federal Energy Regulatory Commission.
*Environmental Sciences Division.
**ELI, Inc., Concord, N.H.
†Subcontractor, The University of Tennessee.
‡Health and Safety Research Division.

[2.5.4]

CHEMICAL STOCKPILE DISPOSAL PROGRAM, FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

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K. R. Ambrose**
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(Abstract of report, January 1988)

This report was prepared in compliance with the National Environmental Policy Act (NEPA) to assess the health and environmental impacts of destroying the nation's stockpile of lethal unitary chemical (nerve and blister) agents stored at eight Army installations in the continental United States. The Army conducted in-depth studies on risk, transportation, and emergency preparedness and funded studies by citizen groups. On-site disposal posed less risk of human health impacts than alternatives involving off-site movement of the stockpile. The Record of Decision supported the Army's preferred alternative for on-site disposal at each site. The Army has requested the assistance of Oak Ridge National Laboratory in preparing the site-specific NEPA documents for each site.

Research sponsored by the Department of the Army.
*Environmental Sciences Division.
**Health and Safety Research Division.
†Biology Division.
‡Computing and Telecommunications Division.
††Environmental Compliance and Health Protection Division.
§Engineering Physics Division.
¶Chemical Technology Division.
#Engineering Organization.

[2.5.5]

FINAL ENVIRONMENTAL ASSESSMENT UNDERGROUND COAL GASIFICATION CLEAN FUELS PROOF-OF-CONCEPT PROJECT

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R. D. Roop
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J. W. Van Dyke

(Summary of DOE/EA-0342, U.S. Department of Energy, January 1988)

Oak Ridge National Laboratory provided technical support to the U.S. Department of Energy's Morgantown Energy Technology Center in preparing an environmental assessment for the Underground Coal Gasification (UCG) Project, located in Carbon County, Wyoming. The objective is to demonstrate the economic viability and environmental acceptability of the UCG process in commercial operation by converting UCG-produced synthesis gas to marketable ammonia and urea products. The project would have minimal impacts on surface water, land use, air and noise quality, aquatic ecology, and socioeconomics. Potential concerns for impacts on groundwater, surface subsidence, and the hawk habitat could be mitigated to below significant levels. Measures to minimize impacts on groundwater resources include careful siting of burn modules and monitor wells and groundwater restoration, if necessary. Surface subsidence could be mitigated by regrading the escarpments to a lower-angle slope and restoring natural drainage. Measures to reduce impacts on ferruginous hawks include initiating construction before the breeding season begins, restricting hunting in the area, and providing artificial nests.

*Environmental Sciences Division.

[2.5.6]

PROGRAMMATIC ENVIRONMENTAL IMPACT ANALYSIS, INNOVATIVE CLEAN COAL TECHNOLOGY

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S. Zukor

(Summary of DOE/PEIA-0002, U.S. Department of Energy, September 1988)

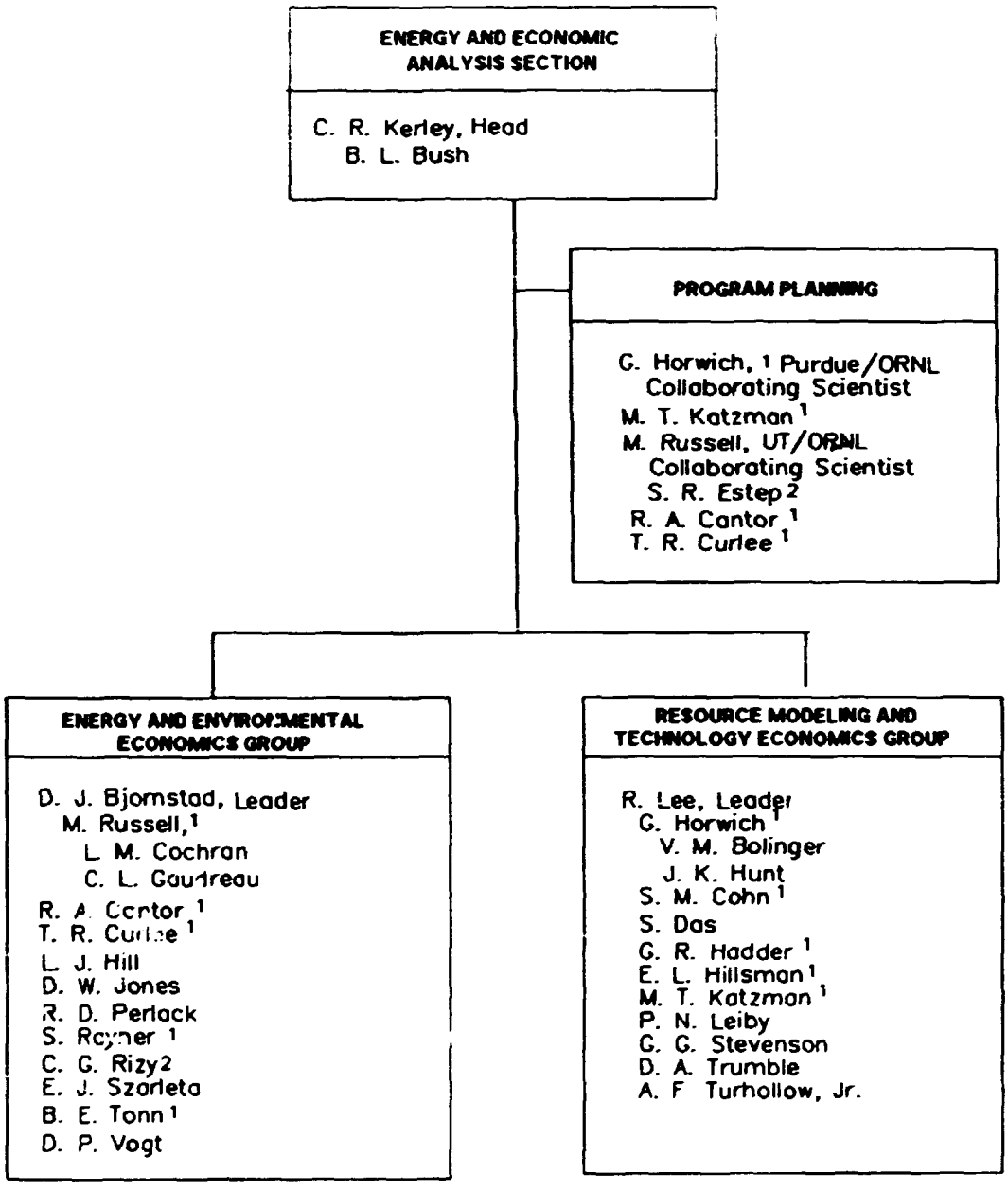
Oak Ridge National Laboratory assisted in preparing a programmatic environmental impact analysis (PEIA) for the Innovative Clean Coal Technology (ICCT) program. The PEIA was to address only the impacts associated with 19 innovative clean coal technologies

for the year 2010. The analysis was based on output from the Regional Emission Database and Evaluation System (REDES) model developed by Argonne National Laboratory for ICCT. The model expressed differences in the amounts of sulfur dioxide, nitrogen oxide, and solid wastes production forecast for 2010 for each technology, with maximum market penetration, in comparison with 1985. Atmospheric emissions and resultant effects of acidic deposition would be reduced with ICCT. The amount of solid waste was generally predicted to increase, but for some technologies, decreases could occur. The amount of carbon dioxide (CO_2) produced was generally similar to that of conventional technologies because CO_2 emissions are not controlled and are basically a function of the amount of coal burned. However, because some of the innovative clean coal technologies are more efficient than conventional technologies, some reduction in CO_2 emissions could occur.

Research sponsored by the U.S. Department of Energy Office of Clean Coal Technologies.
*Technology and Management Services, Inc.
**Environmental Sciences Division.

Energy and Economic Analysis Section 3

C. R. Kerley, Head



1 Dual Capacity
2 Part-Time

Energy and Economic Analysis Section 3

3.1 OVERVIEW

The Energy and Economic Analysis Section (EEAS) is a multidisciplinary organization that focuses principally on economics. The staff is supported by a collaborating scientist program with The University of Tennessee and Purdue University. During FY 1988, two distinguished scientists, Milton Russell, former chief of policy at the U.S. Environmental Protection Agency (EPA) now at The University of Tennessee, and George Horwich, Purdue University's Burton Morgan Professor for the Study of Private Enterprise, conducted research on energy and environmental issues while in residence at ORNL. The Section maintains an independent research agenda and actively supports research programs in other Energy Division sections and ORNL divisions. Research work is published in refereed journals and ORNL reports and is otherwise disseminated to the scientific community and to the public through staff participation in scientific conferences and workshops.

EEAS's integrated economics research program is a leader in contributing to a better understanding of energy use and resource application in the U.S. and world economies. The Section's objective is to conduct high-quality economic analysis that focuses on technology assessment and adoption; financing alternatives; and productivity improvements that enhance long-term economic growth, efficient energy use, and environmental quality. The challenge is to contribute economic analysis to identify growth planning options that are based on careful analysis of societal decision making and risk acceptance. An important component of our work is the support of federal programs on energy security and emergency management.

3.2 RESEARCH PROGRAM

The Section's research agenda is made up of four broad categories of projects: (1) productivity and energy security; (2) energy and environment; (3) emergency management and risk acceptance; and (4) modeling and technology.

3.2.1 Productivity and Energy Security

Productivity and energy security projects include privatization studies and productivity gain-sharing assessments for the U.S. Department of Defense (DOD) and energy security studies for DOE. Studies in privatization have assisted the U.S. Air Force in developing policies and procedures that facilitate the effective use of the private sector to deliver facilities and services. As privatization procedures are refined and implemented, the military services will provide location, land, and unique markets to which entrepreneurs can apply capital, focused efficiency techniques, and experience to increase productivity and reduce energy and other operating costs at DOD facilities.[1] Gain-sharing programs have been assessed for the U.S. Navy as a way to encourage cost-saving and productivity-enhancing behavior. Under gain sharing, measures of dollar savings are calculated, and a fraction of savings, often half, is returned to the production teams responsible

for the savings. This provides a direct link between compensation and worker behavior and serves as a forum for management to communicate goals, and progress toward goals, to workers. Many Navy operations are "client oriented," making gain sharing a potentially beneficial program. However, other characteristics of Navy applications create a unique challenge for gain-sharing research because of the mixing of civilian and service personnel and the demands of preparedness goals.

Energy security research was conducted for the DOE Office of Planning and Financial Management, Petroleum Reserves. Two models were used in planning crude oil acquisition, depletion, and size for the Strategic Petroleum Reserve (SPR). Figure 3.1 is a computer output from one of the models, the Teisberg Model. Five scenarios are assumed for the oil market (a slack market, in which there is excess oil production capacity; a normal state; or a disruption of 4, 6, or 10 million barrels/d), and transitions from one scenario to another are described in terms of probabilities. The optimal oil acquisition rate (a negative acquisition rate in Fig. 3.1 means drawdown) depends on the year, the condition of the oil market, the probabilities of changes in the market conditions, and the size of the stockpile in that year. Optimal drawdown rates are not necessarily at the maximum possible, although they should be greater if the market disruption is larger. Also, it is desirable to fill the SPR as quickly as possible when in a normal market—at least to a certain point, after which further filling should occur only during slack markets. Comparisons between the

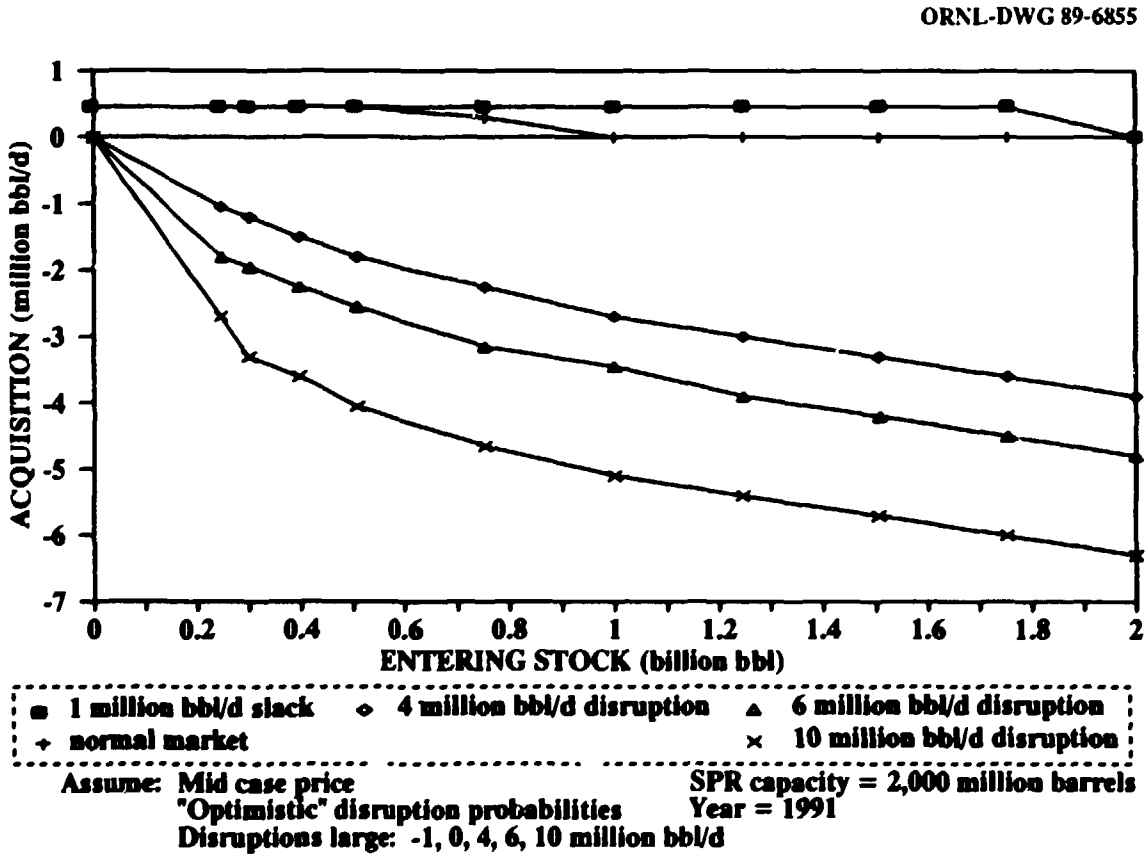


Fig. 3.1. Teisberg optimal acquisition rates in 1991 with a maximum possible disruption of 10 million barrels/day.

Teisberg Model and the Hogan-Leiby approach, which uses a model of the world oil market within a risk analysis framework, suggested that the two could be used in a complementary fashion to evaluate risk and optimal fill and drawdown rates, respectively.[2]

The SPR and other options for mitigating the impacts of oil supply disruptions were addressed in a study for the Navy on the availability and quality of jet and distillate fuels. Figure 3.2 summarizes oil supply and demand in six regions in the world under three oil market scenarios: (1) business as usual, (2) one-quarter year into a major political disruption in the Persian Gulf, and (3) a major disruption combined with military mobilization. Supply from the Organization of Petroleum Exporting Countries (OPEC) decreases dramatically during the disruptions, but oil from the strategic stockpiles in the United States and Japan helps to offset the reduction in OPEC supply.[3] In general, as the price increases during a disruption, the supply of oil from nondisrupted regions increases and the demand for oil decreases.

In other energy security research, a microcomputer uranium market model was enhanced for DOE's Energy Information Administration (EIA) to consider policy scenarios under the free trade agreement between the United States and Canada.[4] An example of the analysis is illustrated in Fig. 3.3, in which U.S. production of uranium is expected to increase significantly for the first few years after a domestic production quota is introduced. Although eligible for trade under the agreement, most Canadian uranium is already committed for delivery to Canadian and

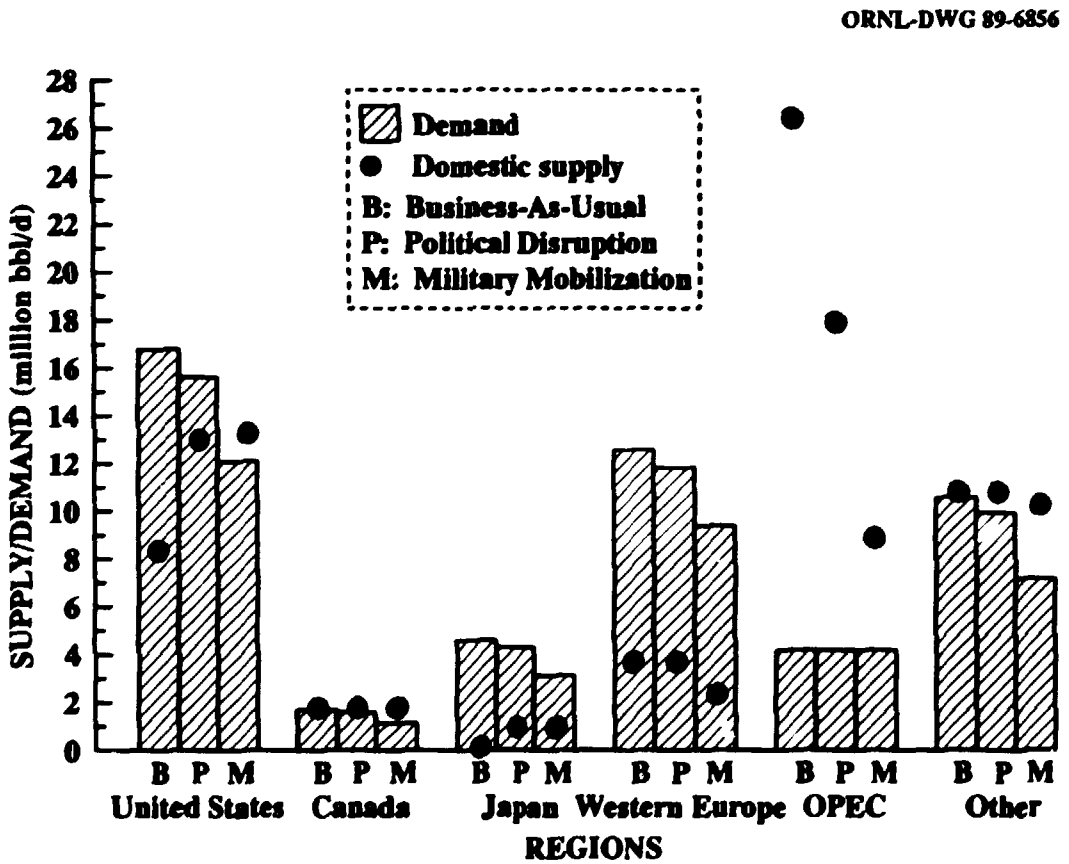


Fig. 3.2. Regional total world petroleum supply and demand in 1995 scenarios.
Source: NMFFS OMS and DIS Models.

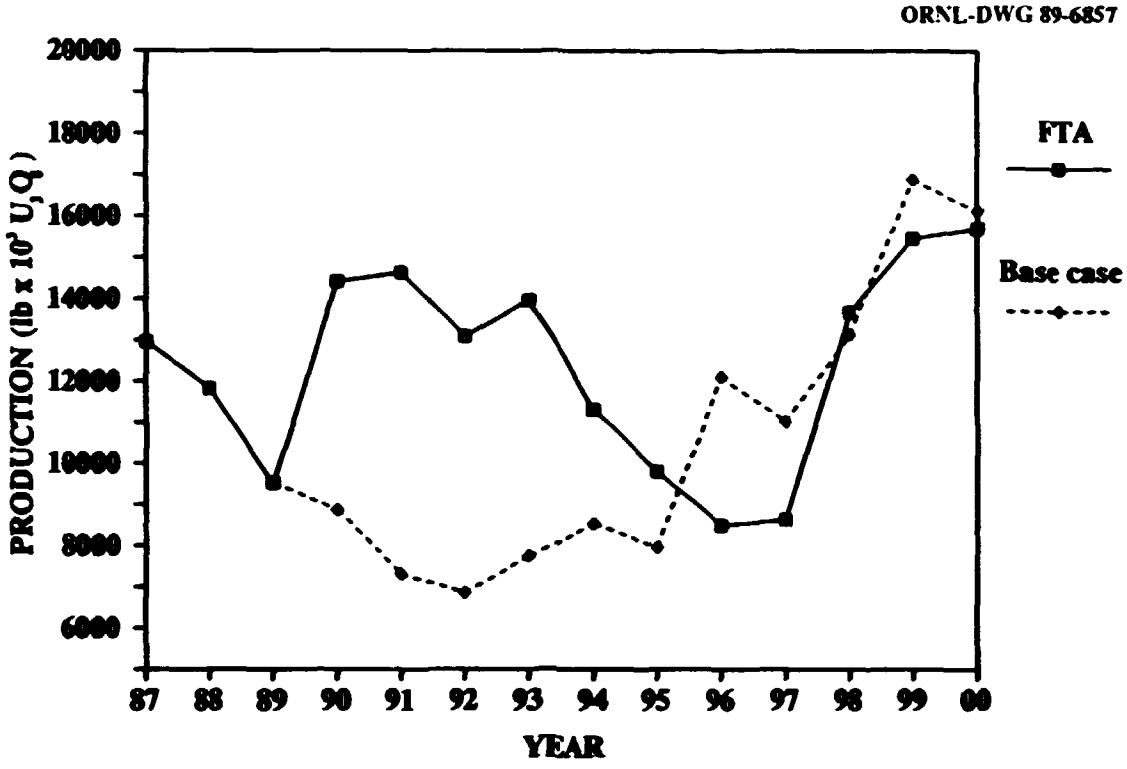


Fig. 3.3. U.S. uranium production (lb × 10^3 U_3O_8) with 62.5% quota on domestic production and with a free trade agreement (FTA) in place, compared with the business-as-usual case without the quota.

foreign utilities. The Section's support of EIA's uranium industry viability study was enhanced by the use of the Uranium Resource Assessment Data System, developed by ORNL, to estimate the uranium resources in the United States as of 1987.

3.2.2 Energy and Environment

Projects in this category include economic analysis of plastic recycle, acid rain legislation, ozone pollution abatement, Superfund cost sharing, forest preservation, world CO_2 reduction, and international energy development. Our work in plastics recycling was sponsored by DOE's Energy Conversion and Utilization Technologies (ECUT) program.[5] The work updated and disseminated our findings that not more than 25% of total plastic waste can realistically be recycled into new products, given current technological, economic, and institutional constraints. Staff participation on two national advisory panels on plastics recycling and disposal has focused attention on the economic and institutional feasibility of recycling plastics by conversion to new products, by manufacturing basic chemicals and fuels, and by burning to retrieve heat energy. Recent findings indicate that plastics recycling is becoming more economically and institutionally feasible. Recent federal actions to reauthorize the Resource Conservation and Recovery Act and the Clean Air Act may have direct implications for plastics recycling.

An environment-related economic study for the Bureau of Mines focused on the increased cost to electric utilities that would result from alternative proposals for acid rain legislation. Table 3.1 summarizes the estimated percentage cost increases for fuel and operations and

ORNL-Photo 4354-89

ORNL researchers have focused attention on the economic and institutional feasibility of recycling plastics.

Table 3.1. Cost comparison among proposed acid rain legislation

Company	Percentage cost increase from base year*				
	H.R. 4567	S.2203	S.300	S.316	S.321
Duke	5.1	16.8	19.3	10.3	10.3
Ohio	26.9	39.4	30.8	29.4	30.6
Potomac	18.3	27.9	27.9	18.3	22.0
South Carolina Public	0.0	10.0	10.2	0.0	5.7
Southern Indiana	16.4	19.4	19.4	16.4	16.4
Texas	0.0	2.6	2.6	0.0	0.0
Associated	17.5	22.5	17.5	17.5	17.5
Big Rivers*	7.9	15.0	13.3	7.9	13.3

*Percentage increase in cost between the base case and legislation scenarios.

maintenance. The results indicate that Ohio Power would generally face the largest increases in costs (e.g., as much as 39.4% of its fuel, operations, and maintenance costs), and that proposal S.2203 would result in the largest cost increases for most of the utilities.[6]

An environmental economics project is in progress for EPA to analyze the possibilities for cost-sharing arrangements among local jurisdictions and other governmental agencies to clean up hazardous waste sites. In at least one case study, the analysis explores the trade-offs a local jurisdiction must consider in selecting among alternative policy proposals affecting the cleanup remedy, cost sharing, and sharing of authority over the management of the cleanup efforts. Combining techniques from economics and cognitive anthropology, we are identifying acceptable policy proposals and using preference information to explain proposal acceptance.

Paralleling the environmental studies, the Section is involved with the international economics of energy use and economic development in Third World countries. EEAS staff have contributed to the efforts of the Office of Energy of the Agency for International Development (AID) and to the open literature on energy and economic development. For example, an assessment of the market potential for coal briquettes as a household fuel in Pakistan, similar to a study conducted in Haiti in 1985–86, was completed this year. Pakistan's penetrable residential market for coal briquettes, estimated to be about a half-million tons of briquettes per year replacing firewood, is sufficiently large to support one or more plants producing 50,000 tons per year.[7] Other projects included an assessment of the Jiko-improved cookstove in Kenya. The Jiko cookstove reduces charcoal expenses by 15–40%. The apparent commercial success of that stove, estimated at 17% penetration of the Nairobi market, and the importance of household energy demand in both deforestation and balance-of-payments issues, has generated much interest among other development agencies and scholars studying the topic.

A principal focus in the AID energy work has been how to implement energy price reform. An article in *Natural Resources Forum*[8] emphasizes a balanced, politically realistic set of simultaneous and related actions including time-phased price reform, efficiency improvement, and energy sector organizational

ORNL-Photo 4360-89

In a case study for EPA, interviews were set up to determine people's opinions about cleaning up hazardous waste sites.

reform. This work has influenced how practitioners and students think about energy price reform, as well as price reform in general. The Section has contributed to efforts in assessing supply areas for fuelwood in Zaire and conducting a prefeasibility study for a 400-MW oil-shale-fired power plant in Jordan. Studies on energy for rural development, both renewable and conventional, have been instrumental in developing a coherent rural energy strategy for the AID Office of Energy.

3.2.3 Emergency Management and Risk Acceptance

Projects in this category evaluate (1) industrial impact assessment and mobilization capabilities in national disasters and emergencies, (2) the analysis of dam safety and risk, and (3) the uses of experimental economics for risk acceptance evaluation.

During the year, several emergency preparedness activities were completed for the Federal Emergency Management Agency (FEMA). EEAS staff prepared two planning reports to guide the federal government and states, respectively, in distributing stored grains to the population in the event of a serious national food shortage. A serious transportation disruption would result in 57% of the U.S. population having access to only 8% of stored grains. Our analysis included the use of action planning and response strategies, such as moving grains before an emergency, to improve access to these basic foodstocks.[9] In other work, a new multiple-user version of the prototype Integrated Management and Economic Analysis System (IMEASY) was delivered to FEMA. This computerized model system provides FEMA with an interactive, integrative damage-assessment capability to assess local, regional, and national direct economic capacity impacts of large-scale natural or man-made disasters.

In flood hazard assessment, studies were completed for the U.S. Army Corps of Engineers. A survey design was developed to obtain information on economic damages and on the response of households and businesses to flood warnings. Draft reports were completed on sources of data for estimating the value of household contents that would be subject to flooding, and on depth-damage functions that describe the relationship between economic damages and the extent of flooding. A primer was written on flood threat recognition, warning, and response systems.

In other risk analysis research, the EEAS staff worked closely with individuals in the disciplines of sociology, psychology, engineering, law, and anthropology to develop interdisciplinary approaches to nontypical risk questions. Risk acceptance is a major policy issue in the areas of nuclear power, hazardous waste, chemical manufacturing, and biotechnology; the study of risk acceptance is complicated by competing paradigms of societal risk analysis. Experimental economics approaches were evaluated as a potential tool to test the underlying assumptions of three competing risk acceptance models. Four major conceptual obstacles to applying the experimental economics approach to risk acceptance questions were identified. These were experimental economics assumptions regarding rationality over choices, preferences of individuals and society, institutional rules, and elicitation techniques. Considering applications of each assumption as described in the experimental economics literature, the evaluation included suggestions about how each might be modified to address comparisons of risk acceptance models; however, we concluded that risk acceptance experiments will need extensive pretesting.[10]

3.2.4 Modeling and Technology

Projects and activities in this category include model development and expert review, manpower studies, and new technology development and transfer. A major EEAS activity is the management of the EIA program at ORNL. This project provides expert reviewers to assess and recommend improvements to EIA studies, procedures, and models. During the past year, EIA initiated a series of new forecasting program models,

resident on personal computers (PCs), that were reviewed through the project. A second activity examined the appropriateness of using experimental economics to assist EIA in studying proposed regulatory actions. The Experimental Economics Laboratory of the University of Arizona was used to explore the use of experimental economics in studying the deregulation of pipelines. We are evaluating the results of this work and exploring the possibility of organizing a small but similar laboratory at ORNL for follow-on energy and risk research.

A 60-sector input-output energy impact model derived from the Bureau of Labor Statistics' national forecasts to the year 2010 was developed for the California Energy Commission. The PC-based, menu-driven model has DOS-assessed software capabilities, such as LOTUS, for data updating and scenario creation. The model is used by the Commission to assess the economic substitutions and impacts in each of the 60 sectors resulting from deployment of energy technology units in various regions of California.[11]

Another major focus was on models used for management of military manpower and resources. A study completed for the Navy Personnel Research and Development Center developed software to examine the performance of time-series models that were applied in an automated fashion to the problem of predicting the rate at which naval officers will leave the service.[12] Hundreds of forecasting models were calibrated for individual officer communities. The software allows for calibration of autoregressive, integrated moving-average models; loss rate models, relative to the total inventory of officers; or transfer function models. Using both mean-absolute-error and mean-square-error statistical criteria, we concluded that applying the loss rate against an officer inventory (instead of forecasting loss numbers) is the recommended method of forecasting 1–2 years ahead. Automated estimation of model parameters provided results that were superior to those from exponential smoothing and other forecasting approaches.

A second manpower evaluation model is the Regional Recruiting Potential Model (RRPM), developed for the Army National Guard. The model assesses the ability of a county (or group of counties) to support a new or increased level of Guard membership. The empirical content of the model is based on a two-step procedure. The first step projects the potential membership for a county based on economic and demographic characteristics, assuming the Guard units are within the county. The second step estimates the share of potential members who would still join if the new unit were located in another county. The general willingness to travel declines relatively rapidly, with 80% of Guard members in the United States traveling less than 30 miles to their units. Use of the RRPM modeling system by the Guard Bureau has created interest in the individual state organizations and has led to further developments in providing similar analysis capability for the state recruiting offices.[13]

The Section's technology assessment activities include participation in a technology policy center and assessments within three branches of new technologies: (1) biomass technologies, (2) materials technologies, and (3) conceptual studies.

A technology policy center has been established by a seed grant from ORNL as a focus for research on public policy issues in the development, transfer, and societal acceptance of technology. The center has been evaluating a DOE initiative to accelerate the commercial development of superconductivity through improved collaboration between industry and national laboratories. Researchers from the center are beginning a study of the potential market niche for American energy technologies in less-developed countries. A workshop on a least-cost, high-efficiency world energy future is planned for fall 1989, to be followed by a symposium in spring 1990.

Biomass technology research in association with the Environmental Sciences Division at ORNL continued in support of DOE's Herbaceous Energy Crops and Short Rotation Woody Crops programs. Work is this area includes defining the current financial and

technological status of herbaceous and short-rotation woody crops for energy production.[14] Efforts centered around the assessment of field experiments with various biomass crops and the review of how significant traits of biomass feedstocks affect conversion processes. Because many new biomass energy technologies involve extraordinary risks, our research identified different types of risks and considered how these could be better assessed and managed by biomass program managers. Overcoming or mitigating commercialization risks is as important to a successful commercialization strategy as technical research in achieving cost reduction.[15]

Several activities fall into the area of materials technologies: plastics recycling, microwave sintering of ceramics, ceramic heat exchangers, ceramic engines, and inorganic and biomass-based plastics. A draft report was completed on the estimated cost of producing advanced ceramic components using microwave sintering. Cost was found to be sensitive to total yield but not particularly sensitive to energy inputs, which were estimated to contribute only about 2% of the total cost of production.[16]

A study was completed for DOE's Office of Industrial Programs that estimated the cost of producing high-temperature heat exchangers in which key components are manufactured from ceramics. Heat exchangers in which the tubes and headers are manufactured from silicon carbide cost significantly more than comparably sized all-metallic heat exchangers–about 68% more for a typically sized unit. Unit costs were estimated to be very sensitive to changes in production volumes, powder cost, capital cost, and total yield.[17]

A study was completed for DOE's ECUT program that addresses the economic viability of plastics based on inorganic and biomass materials. Biomass and inorganic plastics are estimated to cost significantly more than conventional plastics. Significant technological improvements will be required to compensate for the disadvantages these alternative polymers face in terms of raw materials and intermediate products. Further, the study found that arguments for these alternative resins based on reduced environmental degradation and promoting oil security are questionable.[18]

A different thrust of the technology research related to energy conservation and environmental impacts. A study was completed for DOE on the factors underlying consumer decision making and energy conservation investments in the case of residential gas furnace purchases.[19] Figure 3.4 summarizes some of the results of the study and indicates that economically rational motives were sufficient to account for 56 (along the main diagonal of Fig. 3.4) of the 118 decisions made by households on their purchases of low-, medium-, or high-efficiency furnaces. The model tended to underpredict the efficiency ratings of furnaces purchased by the 48 households (located in the lower left portion off the main diagonal). In 42 cases, the model prediction was for a low-efficiency furnace purchase when actual purchases were 18 medium-efficiency and 24 high-efficiency furnaces. In six cases, the prediction was for medium efficiency when the actual purchase was high efficiency. Factors that explain why purchases were not predicted by the model include cost, efficiency, house value effects, and concern for energy conservation.

3.3 RESEARCH UTILIZATION

Most EEAS research projects contribute directly to planning, policy, and analysis activities of public agencies. The research is predominantly focused on sponsors' needs and normal avenue of use. For example, the Teisberg and Hogan-Leiby model studies are used by DOE to assist in SPR planning activities. Information and analysis developed for EIA support its data and information activities, including the Secretary of Energy's report to Congress on the uranium industry. Studies on energy conservation and impacts are used by DOE, the U.S. Department of the Interior, and other agencies to understand energy retrofit decisions. Studies for the Navy and Military Airlift Command are to be used in

ORNL-DWG 89-6858

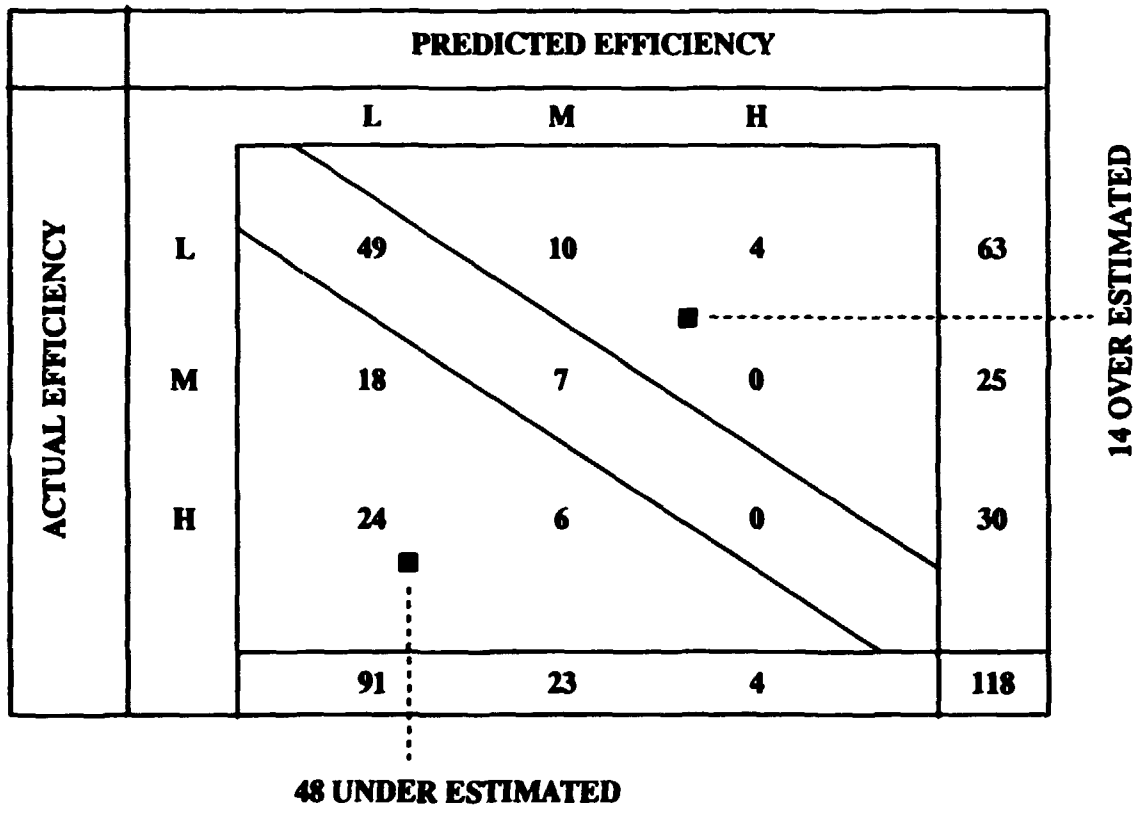


Fig. 3.4 Economic-man model predictive content.

selecting the appropriate computer systems for improving manpower and resource management. The results of the flood hazard assessment for the Corps of Engineers are to be used by the Corps' district offices for their assessments of alternative flood control projects. Other agencies that use our research results in program planning and analysis include FEMA, the Bonneville Power Administration, EPA, the Department of the Air Force, the Department of the Navy, and AID.

These primary uses of our project research are important to individual sponsor's needs, but the use of our research is not limited to those purposes alone. The EEAS research agenda has been structured to contribute to broader national and world policy issues that are important to the scientific community and to other agencies that benefit from DOE research, including EPA, AID, and DOD. Some important scientific problems for which our research is being used to arrive at policy responses include world CO_2 increase and ozone problems, infrastructure modernization for energy efficiency in the government sector, hazardous waste management, and energy for development in Third World nations. Many of these problems are interrelated, and our mix of research projects for DOE and Work-for-Others sponsors, conducted in a laboratory environment, provides a forum by which the many technical and social aspects of individual problems emerge and become incorporated into solutions for more general energy and environmental problems.

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3.5 ABSTRACTS OF PUBLICATIONS

[3.5.1]

THE ROLE OF LIABILITY PREFERENCES IN SOCIETAL TECHNOLOGY CHOICES: RESULTS OF A PILOT STUDY

R. A. Cantor S. Rayner
R. B. Braid

(Abstract of *Risk Assess. Manage.*, ed. L. Lave, Plenum Press, New York, 1987)

In a recent paper, Steve Rayner argued that resolving the question, "How safe is safe enough?" is less important in making societal technology choices than "How fair is safe enough?" Adopting the fairness question as the concern of risk management would imply that the process of technology choice should recognize explicitly the preferred principles different parties hold with respect to obtaining consent from those in the relevant institutions. This paper discusses a recent empirical pilot study that explored the fairness hypothesis in the context of nuclear power. For this type of societal technology choice, violation of preferred principles may be a major source of the conflict between different

constituencies. Additionally, the study contributes towards the development of a new approach in risk management that combines the cultural model of risk perceptions with the decision-theoretic approaches found in economics and psychology.

Research sponsored by the Office of Assistant Secretary for Nuclear Energy, U.S. Department of Energy.

[3.5.2]

THE ECONOMIC FEASIBILITY OF PLASTICS RECYCLING

T. R. Curlee

(Abstract of a paper presented at the Proceedings of the Recyclingplas II Conference, Washington, D.C., 1987; in *Business Opportunities in Recycling Plastic Wastes*, Technomic Publishing, Lancaster, Pa., 1987)

This paper addresses numerous factors that collectively determine the economic feasibility of technologies to recycle plastic wastes. A major point of the paper is its distinction between an assessment of feasibility based on only the expected direct costs and revenues associated with a technology and a more complete assessment that also considers relevant institutional and technological constraints. Evidence from markets where plastics recycling as a segregated waste has thus far been successful suggests that success has come not so much from technical fixes to the problem but rather from favorable institutional and economic conditions. If the past is an indication of the future, we can expect that plastics recycling outside the municipal waste stream will grow during the coming decade in selected markets where economic and institutional constraints are minimal. For those plastics that cannot be segregated easily from other materials in the municipal waste stream, tertiary and quaternary processes that can accommodate various combustible wastes will continue to be adopted.

Research sponsored by the U.S. Department of Energy.

[3.5.3]

OIL SUPPLY DISRUPTIONS AND MODELING METHODOLOGIES: THE ROLE OF LP MODELS

T. R. Curlee A. F. Turhollow, Jr.
S. Das

[Abstract of *Energy Econ.* 10(2), 147-54 (1988)]

This paper has three main objectives. First, an argument is made that oil vulnerability is not a problem of the past but remains a significant concern for all oil-consuming countries, especially in 1990 and beyond. Second, it is suggested that the severity of past disruptions can be attributed, in part, to physical and institutional constraints that prevented the oil market from reacting quickly to what were relatively minor supply disruptions. The

currently changing structure of the world oil market, in particular the evolving sales agreements under which an increasing percentage of world oil is traded and the vertical integration of major Organization of Petroleum Exporting Countries members into areas such as refining, could decrease the ability of the market to adjust smoothly to future disruptions. Third, it is suggested that linear programming (LP) models offer unique capabilities in assessing the degree to which the world and domestic oil markets could adjust to short-term supply disruptions, given constraints on transportation, trade, and refining possibilities imposed by the physical structures of those market sectors or by control of those sectors by increasingly powerful producing countries. The assessment of this flexibility will help pinpoint areas needing attention and also indirectly contribute to the evaluation of short-run demand elasticities for world oil. The U.S. Department of Energy's Petroleum Allocation Model is used as an example of one LP model that can address such issues.

Research sponsored by the U.S. Department of Energy.

[3.5.4]

CERAMIC HEAT EXCHANGERS: COST ESTIMATES USING A PROCESS-COST APPROACH

S. Das T. R. Curlee
R. A. Whitaker*

[Abstract of *Ceram. Bul.* 67(10), 1684-89 (1988); ORNL/TM-10684, Oak Ridge National Laboratory, August 1988]

This paper presents the results of a study to estimate the cost of ceramic recuperators and examine the sensitivity of recuperator cost to changes in key technical and economic parameters. The focus of the work is on high-temperature recuperators of the fixed-head, tube-and-shell type in which the tubes and headers are replaced by silicon carbide. Both extrusion and slip-casting technologies are considered for the production of ceramic tubes. Slip casting is assumed to be the method used to produce the ceramic headers. Sensitivity analyses on the cost of ceramic tubes suggest several conclusions. First, tube cost is sensitive to production volumes at low levels (i.e., fewer than 20,000 tubes per year) but flattens out at higher production levels. Second, tube cost is quite sensitive to powder cost, given that materials contribute between about 55 and 60% of the total cost of a tube in the base case. Third, the cost of capital equipment can have a significant impact on tube cost, especially in the case of extrusion, which is more capital intensive than slip casting. Fourth, improvements in total yield can substantially reduce the cost of a tube. Finally, neither slip casting nor extrusion appears to be the clear winner in terms of producing ceramic tubes at the least cost.

Research sponsored by the U.S. Department of Energy Office of Industrial Programs.
*The University of Tennessee, Knoxville.

[3.5.5]

PETROLEUM AVAILABILITY IN DISRUPTED MARKETS

S. Das G. R. Hadder
R. Lee R. M. Davis

[Abstract of *Res. Policy* 14(3), 173-79 (1988)]

Econometric and linear programming models are used to evaluate petroleum availability during 90-d scenarios representing severe disruptions of 11 million bbl/d of crude oil from the Persian Gulf region, the associated effects of the Strategic Petroleum Reserve, International Energy Agency sharing agreements, increased fuel demand required to mobilize U.S. military forces, and other important issues. Results for the different scenarios in 1990 are presented for world crude oil demand, crude oil supplied to the United States, and U.S. output of refined product categories. The disruption scenario impacts on worldwide demand were substantial. Using Strategic Petroleum Reserves and international oil sharing, the global demand for oil fell by 9.3% relative to business-as-usual. With production of U.S. military fuels confined to U.S. refineries, the decrease in global demand was also 9.3% relative to business-as-usual, but the U.S. civilian sector was more dependent on imports of refined products. The loss of Venezuelan exports combined with increased military demand for fuel decreased the global demand for oil by 12.1%. The increase in military fuel demand was at the expense of the civilian sector, thus exacerbating the impact of this disruption on civilian fuel consumption.

Research sponsored by the U.S. Department of the Navy.

[3.5.6]

NAVY MOBILITY FUELS FORECASTING SYSTEM PHASE IV REPORT

S. Das G. R. Hadder
P. N. Leiby R. Lee
R. M. Davis

(Abstract of ORNL-6517, Oak Ridge National Laboratory, September 1988)

Oak Ridge National Laboratory (ORNL) has assisted the U.S. Department of the Navy in developing and testing a methodology for forecasting mobility fuel availability, quality, and relative price and in evaluating options to increase fuel supplies during world oil disruptions. The Navy Mobility Fuels Forecasting System, enhanced by ORNL review of data on world oil reserves, production and prices, trends in oil quality, and changes in refinery technology, was used to examine possibilities in a business-as-usual scenario and two hypothetical scenarios involving disruptions, in 1995, in crude oil production resulting from (1) political disruption in the Persian Gulf and (2) U.S. military mobilization in the Persian Gulf. The scenario studies found that (1) a steep decline occurs in JP-5 fuel production for

the disruption scenarios; (2) with adjustments of the jet fuel price differential, refiners appear able to satisfy military demand for JP-5 in disruption scenarios but with substantial cost increases; (3) the sulfur content of JP-5 is predicted to rise substantially and the production of military diesel fuels is limited in most cases by sulfur content; (4) military fuel availability can be increased through either the price mechanism and/or property modifications, but such strategies to increase production of one military fuel could lead to a decrease in another; (5) with the refining capacity and crude oil and product slates projected for 1995, it is technically possible to satisfy the postulated scenario requirements for military fuels JP-4, JP-5, DF-A, DF-2, F-76, and F-77.

Research sponsored by the U.S. Department of the Navy.

[3.5.7]

A NON-TRADITIONAL METHODOLOGY FOR FLOOD STAGE-DAMAGE CALCULATIONS

S. Das R. M. Lee

[Abstract of *Am. Water Resour. Bul.* 24(8), 1263-72 (1988)]

This paper presents a new methodology to calculate economic losses from hypothetical extreme flood events such as the Probable Maximum Flood. The methodology uses economic data compiled from already-available secondary sources such as U.S. Census data on magnetic tapes, using microcomputer and other electronic media. Estimates of land elevations are obtained from topographic maps, and flood elevations are estimated using, for example, a dam breach and flood routing (DAMBRK) model. The calculations are performed at a disaggregate spatial scale, by various land use and industrial classification categories. The basic area units are city blocks (for urbanized areas), enumeration districts, and Census tracts. Depth-damage functions, which provide an estimate of damages as a proportion of the existing value of the structure, are estimated statistically. Computer software (called DAMAGE) is used to combine the economic, flood elevation, and depth-damage information to compute economic losses for different possible flood stages and for different inflow events. Two case studies are presented as illustrations of the method. The results show that the methodology is a cost-effective way of estimating economic damages under alternative flood conditions.

Research sponsored by the U.S. Army Corps of Engineers.

[3.5.8]

AN ANALYSIS OF THE IMPACT OF RESIDENTIAL RETROFITS ON INDOOR TEMPERATURE CHOICE

T. M. Dinan

(Abstract of ORNL/CON-236, Oak Ridge National Laboratory, October 1987)

The objective of this study was to determine whether or not households choose higher winter indoor temperature levels after their houses have been made more energy efficient. A theoretical model for explaining household temperature choice is developed, with a household production function approach. A means model, fixed-effects model, and random-effects model are used to sort out the observed variation in the pooled cross-section/time-series data set of monitored indoor temperature levels. This analysis reveals that the Hood River Conservation Project residential retrofits resulted in a statistically significant increase in indoor temperature levels. With the average level of increase in efficiency among the sample homes, these results imply a 0.6°F average increase among the sample homes. The average level of takeback among low-income households is 0.9°F, as opposed to the 0.6°F increase observed in the sample as a whole. Homes that used electricity as their sole heating fuel had significantly lower levels of takeback, averaging 0.3°F.

Research sponsored by the U.S. Department of Energy and the Bonneville Power Authority.

[3.5.9]

IMPLEMENTING ENERGY PRICE REFORM IN DEVELOPING COUNTRIES

L. J. Hill

[Abstract of *Nat. Resour. Forum* 12(1), 57-67 (1988)]

One of the most significant energy problems in many developing countries is that energy prices do not reflect the true cost of providing energy. This paper suggests a commercial energy price reform program for countries in which energy price levels are far from "correct." In view of the economic and sociopolitical realities in developing countries, it is argued that energy price reform is more likely to occur if it takes shape as a balanced, politically realistic set of simultaneous and related actions. Besides a time-phased price reform, these actions include demand- and supply-side efficiency improvements and energy sector organizational reform.

Research sponsored by the U.S. Agency for International Development.

[3.5.10]

MODELING THE MACROECONOMY/ENERGY ECONOMY RELATIONSHIP IN DEVELOPING COUNTRIES: THE CASE OF LIBERIA

L. J. Hill

(Abstract of *J. Dev. Areas* 22(1), 71-84 (1987))

One of the ways in which developing countries can ameliorate liquidity problems is to develop internal energy resources to offset the payments problems associated with importing petroleum. Developing internal energy resources requires an assessment of energy options to provide decision makers with a menu of feasible alternatives from which to choose. An important component in assessing energy alternatives is an estimate of future energy demand. The purpose of this paper is to describe the construction and simulation results of a modeling system used to simulate energy demand by sector and fuel type in Liberia, West Africa, between 1982 and 2000 under four scenarios. The scenarios provide a plausible bound on both domestic and international conditions that may impinge on Liberia's economic performance over the simulation period. The methodology used to simulate Liberian sectoral energy demand involves the recursive interaction of a macroeconomic model and energy demand equations estimated by sector and fuel type.

Research sponsored by the U.S. Agency for International Development as part of a joint USAID/Government of Liberia energy assessment.

[3.5.11]

PUBLIC POWER IN THE U.S. ELECTRIC UTILITY INDUSTRY: REGULATORY ISSUES AND COMPARATIVE FINANCIAL INDICATORS ACROSS OWNERSHIP TYPES

L. J. Hill

(Abstract of ORNL/TM-10497, Oak Ridge National Laboratory, January 1988)

The U.S. electric utility industry consists of (1) investor-owned utilities; (2) rural electric cooperatives (distribution and power supply cooperatives); (3) federal power projects (the Tennessee Valley Authority and five federal power marketing agencies with the supply sources); and (4) state/municipal systems (state projects, county projects, public utility districts, municipally owned electric systems, and joint action agencies). In 1984, public power–defined as the latter three ownership types–accounted for 23.4% of total generating capacity and 24.0% of total end-use sales in the industry. The average price of end-use

electricity across all customer classes obtained by investor-owned utilities in 1984 was 6.53¢/kWh, while the corresponding price for publicly owned systems was 5.28¢/kWh. Several operating and regulatory/legislative characteristics account for this difference in average price. Differences include (1) the nature and extent of federal and state regulations and (2) financial considerations such as sources and cost of capital, taxation, and the treatment of construction work in progress for rate making. In 1984, the average long-term interest rate for investor-owned systems was 9.67% compared with 7.00%, 8.20%, and 7.76% for state/municipal systems, cooperatives, and federal projects, respectiveiy. In general, publicly owned utilities are exempt from federal taxation; however, with the exception of the five federal power marketing agencies, the utilities either are subject to sub-Federal taxation or make in-lieu-of-tax payments. In 1984, total tax payments attributable to electric operations accounted for 15.41% of the total electric operating revenues of investor-owned electric utilities. For state/municipal systems and rural electric cooperatives, the corresponding percentages were 4.89 and 2.03, respectively.

Research sponsored by the Energy Information Administration.

[3.5.12]

ENERGY REQUIREMENTS FOR RURAL DEVELOPMENT

D. W. Jones

(Abstract of ORNL-6468, Oak Ridge National Laboratory, June 1988)

In traditional agriculture, fuel use is almost nonexistent. As a nation develops and its agricultural sector develops and mechanizes, other sectors grow at relatively more rapid rates, reducing agriculture's share of national income. As a result, more developed and mechanized agricultural sectors claim roughly the same, or even smaller, shares of national energy consumption. Farm mechanization, irrigation, commercial fertilizer use, and the introduction of high-yielding varieties of seeds are the major elements of farm modernization that increase energy use. The actual quantities of energy used in each of these activities are quite location specific. Fuel cost shares of farm equipment operation have been estimated to be between 25 and 45% of total equipment operating cost, although conditions of fuel availability, spare parts, and maintenance appear to be as important to successful mechanization as low fuel prices. Farm mechanization is highly dependent on road infrastructure. The release of former farm residents to urban locations, where they require delivery of their food, accompanies farm mechanization. A rough estimate of the magnitude of the associated increased fuel use is 10% of the embodied energy in the food moved.

Research sponsored by the U.S. Department of Energy and the U.S. Agency for International Development.

[3.5.13]

ENERGY USE AND FUEL SUBSTITUTION IN ECONOMIC DEVELOPMENT: WHAT HAPPENED IN DEVELOPED COUNTRIES AND WHAT MIGHT BE EXPECTED IN DEVELOPING COUNTRIES

D. W. Jones

(Abstract of ORNL-6433, Oak Ridge National Laboratory, August 1988)

This paper begins with a reexamination of developed countries' historical experiences with structural changes in energy sources and uses, in aggregate terms, and where possible, on sector- and fuel-specific bases. It then draws together comparable evidence on developing countries in an effort to assess similarities and differences in situations and experiences. Particular attention is paid to evidence of fuel substitution in the household sector. A major difference between the experiences of the industrialized and developing countries is that in the former, the mechanization and energization of transportation parallelled or followed the mechanization and energization of industry, while the reverse generally is the case in today's developing countries. High energy intensity, low productivity transportation sectors may place serious constraints on the macroeconomies of developing countries. Similarly, residential, relative to industrial, electrification has proceeded more rapidly in today's developing countries than it did in the industrialized countries, with detrimental financial and system reliability results. The household sectors of the industrialized countries used energy primarily for space heating, while those of the developing use energy mostly for cooking. Fuel substitutions and technological changes in heating systems assisted in the shift in energy consumption from the residential to the industrial sector in the industrialized countries. Fuel substitution can assist in that shift in the developing countries, but how much technological change in cooking systems can contribute is unclear. Substitution between traditional and modern fuels in the household sector, historically in the industrialized countries and presently in the developing countries, and the continued substantial claim of the household sector on modern fuels in the industrialized countries, require the inclusion of traditional fuels in meaningful measures of aggregate energy intensity such as energy-GNP ratios.

Research sponsored by the U.S. Department of Energy and the U.S. Agency for International Development.

[3.5.14]

MONOPSONY AND PLANT LOCATION IN A THüNEN LAND USE MODEL

D. W. Jones

(Abstract of *J. Reg. Sci.* 28(3), 317-27 (1988)

Previous work has developed a method for studying non-infinitesimal operational units, called "plantations," with the Thünen model. In that model, increasing returns to scale generate large operational units, but the potential market power conferred by the scale economies is sidestepped as an issue. This work introduces finite supply elasticities and

examines their locational impacts. The profit-maximizing monopsonistic plantation is smaller, and the shipment distance for its processed output is shorter than that for a comparable competitive plantation. This approach does not involve spatial competition strategies.

Research sponsored by the U.S. Department of Energy and the U.S. Agency for International Development.

[3.5.15]

SOME SIMPLE ECONOMICS OF IMPROVED COOKSTOVE PROGRAMS IN DEVELOPING COUNTRIES

D. W. Jones

[Abstract of *Resour. Energy* 10(3), 247-64 (1988)]

More efficient cookstoves have been introduced in developing countries by development agencies to retard deforestation and to improve the welfare of low-income consumers. Studies of the economics of cookstove programs have been limited to financial analyses of stove costs and an input-output study of a single country. This paper examines the consequences of the implicit income effect of a 25 to 50% improvement in fuel efficiency of household cookstoves. A model is constructed to examine the spending pattern of resources saved from reduced fuel expenditures and the consequences of fuel price reductions caused by reductions in aggregate demand. It is found that, with parameter values typical of low-income developing countries, roughly 50% of technical fuel savings from stove efficiency improvements are lost through increased fuel use induced by income and price effects. Even when the income elasticity of demand for the fuel is zero and own-price elasticity is one-half, with a unitary supply elasticity, 28% of the initial technical savings will be lost through increased consumption.

Research sponsored by the U.S. Department of Energy.

[3.5.16]

INTERNATIONAL CONSIDERATIONS ASSOCIATED WITH ECONOMIC PLANNING FOR RECOVERY FROM A GENERALIZED DISASTER

D. W. Jones L. J. Hill

(Abstract of ORNL-6434, Oak Ridge National Laboratory, August 1988)

This report addresses international economic considerations in planning for recovery from a generalized disaster, including the geographical dispersion of economic activity and the importance of the U.S. dollar in international trade. Although the report addresses several specific disaster scenarios and appropriate policy responses in reaction to them, a number of important general policy guidelines were discussed. First, international

cooperation and coordination are of paramount importance in restoring the effective functioning of the international monetary system. Second, a policy of fixed exchange rates in the aftermath of an international disaster is ill-advised. Third, except for commodities crucial to national defense, a domestic import and export controls cannot be justified. Fourth, the extent of real trade reduction during a conflict has widespread financial and real repercussions. The United States probably could withstand real trade disruptions during a conflict more successfully than many of its current trading partners. Finally, multinational enterprises might be important institutions in recovery from both real and monetary standpoints, acting as the international conduit for capital flows, trade flows, and, in more serious disasters, price signals and international monetary and financial reconstruction.

Research sponsored by the U.S. Department of Energy and the U.S. Federal Emergency Management Agency.

[3.5.17]

ENERGY REQUIREMENTS OF DEVELOPMENT PROJECTS

D. W. Jones G. S. Samuels, Jr.

(Abstract of ORNL-6298, Oak Ridge National Laboratory, January 1988)

This report focuses on the energy requirements of pumped irrigation and cement plants as examples of the energy operating requirements of large development projects. On the basis of conservative assumptions about the nearness of the water table to the surface and the efficiency of operating pumping systems, using pumped irrigation to increase the arable land area of the countries studied by 5% would require an energy equivalent between 4.5 and 8.5% of 1980 energy imports (commercial energy consumption) of four of the countries studied. Somalia and Chad would require 15 and 22% of their 1980 oil import partly because of relatively large, marginally arable land areas and partly because of low energy imports. The introduction of one or (at most) two moderate-sized cement plants into five West African countries and Sudan requires from 12 to 40% of those countries' 1980 national commercial energy consumption for the operation. These calculations assume high levels of maintenance and developed country standards of fuel-efficient operation; therefore, actual fuel requirements are likely to be higher. The countries studied have few or no domestic fuel supply options other than imports.

Research sponsored by the U.S. Agency for International Development.

[3.5.18]

THE IMPACTS OF INADEQUATE ELECTRICITY SUPPLY IN DEVELOPING COUNTRIES

D. W. Jones A. P. Sanghvi*
E. L. Hillsman

(Abstract of ORNL-6436, Oak Ridge National Laboratory, August 1988)

Many developing countries are experiencing growth in demand for electricity that exceeds their ability to increase generation capacity. Unreliable electricity supplies and unserved demands are consequences. Costs of low-quality electricity supply, or unreliable supplies, in manufacturing sectors alone, have been estimated to be as high of 1.8% of gross national product in Pakistan and India in the early 1980s. Losses in the commercial sector and agriculture and consumer surplus losses in households would raise the loss estimates. Continued expansion of generation capacity is unlikely to be a viable option. Expansion costs during the 1985-94 period have been estimated at $520 billion in 1985 prices. This amount does not appear to be available in world capital markets, and rearrangement of national development expenditures to accommodate further power sector spending is already constrained by the fact that the power sector typically claims 25 to 40% of government capital expenditures.

Research sponsored by the U.S. Department of Energy and the U.S. Agency for International Development.
*Hagler, Bailly & Company, Washington, D.C.

[3.5.19]

ENERGY AND AGRICULTURE IN THE HAITIAN ECONOMY: A COMPUTABLE GENERAL EQUILIBRIUM MODEL

D. W. Jones M. T. C. Wu*
S. Das S. M. Cohn

(Abstract of ORNL-6294, Oak Ridge National Laboratory, February 1988)

This report documents a computable general equilibrium (CGE) model of the economy of Haiti and emphasizes energy use in agriculture. CGE models compare favorably with econometric models for developing countries in terms of their ability to take advantage of available data. The model of Haiti contains ten production sectors: manufacturing, services, transportation, electricity, rice, coffee, sugar cane, sugar refining, general agriculture, and fuelwood and charcoal. All production functions use functional forms that permit factor substitution. Consumption is specified for three income categories of consumers and a government sector with a linear expenditure system of demand equations. The economy exports four categories of products and six categories of imports. Balanced trade and capital accounts are required for equilibrium. Total sectoral allocations of land, labor, and capital are constrained to equal the quantities of these inputs in the Haitian economy as of the early 1980s. The series of subroutines used in the solution procedure

have been implemented on an IBM AT with a math coprocessor chip, but can be used on the IBM PC or XT with some sacrifice in speed. The model can be used to study the consequences of fiscal and trade policies and sectorally oriented productivity improvement policies. Guidance is offered regarding how to use the model to study economic growth and technological change. Limitations of the model are also pointed out as well as user strategies which can decrease the number of or work around some of those limitations.

Research sponsored by the U.S. Agency for International Development.
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[3.5.20]

FINAL EVALUATION OF USAID ALTERNATIVE ENERGY SOURCES PROJECT IN ECUADOR

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(Abstract of ORNL-6361, Oak Ridge National Laboratory October 1987)

This report describes the results of the Alternative Energy Sources Project carried out under the direction of Ecuador's National Energy Institute (INE) between 1981 and 1986 with funds provided to the government of Ecuador by the U.S. Agency for International Development/Quito. The project's goals were (1) to encourage more rational use of energy resources to improve Ecuador's ability to meet the energy needs of its population and (2) to better address the energy needs of lower income Ecuadorian families, particularly those in rural areas. INE developed credible programs in two major areas: energy policy studies and nonconventional energy demonstrations/energy conservation. INE has developed technical competence in the following areas: small hydro plants; solar domestic water heaters; family-sized biogas digestors; passive solar architecture; low-temperature, low-enthalpy geothermal energy; energy-efficient metal cookstoves; and industrial energy conservation. Several general lessons emerge. (1) In an institution-building project, USAID should anticipate an array of delays, institutional fluctuations, and administrative hiatuses. Work plans and schedules should be kept flexible and encouragement should be given consistently. (2) New institutions gain credibility only over time and by the high quality of their work; credibility cannot be conferred by edict. (3) The actual progress of a project, particularly an institution-building project, should not be judged by spending patterns; alternative indicators of project achievement need to be devised. (4) It is important for a new institution to use accounting procedures which are consistent with those of donor agencies; many delays can be avoided by such prior coordination.

Research sponsored by the U.S. Agency for International Development.
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[3.5.21]

MID-TERM EVALUATION OF USAID SUDAN ENERGY PLANNING AND MANAGEMENT PROJECT (650-0059)

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(Abstract of ORNL-6421, Oak Ridge National Laboratory, June 1988)

In 1984, the U.S. Agency for International Development's (AID's) mission in Sudan implemented the Energy Planning and Management Project to strengthen several key institutions in the energy sector of Sudan. One component of the project focused on improving management, billing and collection, pricing, purchasing and stores, and vehicle operation and maintenance in the National Electricity Corporation. The other major component was devoted to strengthening the capability of the National Energy Administration to conduct national energy planning studies. Oak Ridge National Laboratory, at the request of the Sudan Mission and the Office of Energy of AID, fielded a team in January 1987 to evaluate the progress of the project and make recommendations for the remainder of the project's implementation. The evaluation team spent three weeks in Sudan studying files and documents, interviewing personnel associated, or otherwise familiar, with the project's implementation, and examining equipment in the field which was purchased and/or installed with project funding. Evidence was found that the project had apparently been instrumental in increasing the reliability of the Blue Nile Grid from a low of 74% in 1983 to 94% at the time of the evaluation. The effort to improve the National Electricity Corporation's billing and collection system were already showing positive results at the time of the evaluation, and promised to be of major importance for the utility and the nation. The project contractors at the National Energy Administration had strengthened the computing system there, but had less tangible success in interjecting new routines into that agency than had the contractor for the other component. The political events surrounding and following the overthrow of the Nimieri government in Sudan in 1985 caused major implementation problems for the Energy Planning and Management Project, including evacuation of all American personnel for over six months in 1986. A major drought coincided with these events and reoriented the attention of the AID Mission in Sudan, also contributing to implementation problems for the project.

Research sponsored by the U.S. Agency for International Development.
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†U.S. Agency for International Development, Nairobi, Kenya.

[3.5.22]

FROM HORSE CARTS TO MINIMILLS

M. T. Katzman*

[Abstract of *Public Interest*, 92, 121-35 (Summer 1988)]

The scrap metal recycling industry has played a major role in supplying raw materials to the steel and aluminum industries and in reducing the volume of hazardous waste. The evolution of the scrap metal recycling industry, its potential for forward integration into minimill production, and barriers to vitality are discussed. Particular attention is paid to the effect of Superfund cleanup liabilities on the willingness of scrap processors to handle automobiles, heavy appliances, and transformers. On October 7, 1988, this article was cited approvingly by the U.S. Court of Appeals for the District of Columbia in deciding *Hazardous Waste Treatment Council et al. v. U.S. Environmental Protection Agency*. The Court held that while the author's assertion that Superfund liability can reduce the willingness to recycle, thus worsening the waste disposal problem, Congress does not allow EPA discretion to offset counterproductive consequences of the public policies it enacts.

Research sponsored by the U.S. Department of Energy Office of Industrial Programs.
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[3.5.23]

COMPARATIVE EVALUATION OF TECHNOLOGIES

R. D. Perlack

(Abstract of Chap. 24, pp. 225-36 in *Rural Energy Planning-Asian and Pacific Experiences*, ed. K. V. Ramani, Asian and Pacific Development Centre, Kuala Lumpur, Malaysia, Weng Fatt Press, Kuala Lumpur, Malaysia, 1988)

Fuelwood is the principal energy source, especially in rural homes, for cooking and heating. To replace scarce fuelwood, rural homes use traditional fuels such as agricultural residues or animal wastes; some rural households use commercial energy such as kerosen for cooking and lighting. Because these substitute fuels are also becoming scarce, a need exists for developing new technologies to increase end-use efficiencies and fuelwood supplies. Important solutions rest in improving electrical appliances and planting fast-growing trees for energy fuel. Nontraditional technologies and energy sources must be economical and efficient to develop, produce, and use. The energy supplies developed must be chosen on the basis of location (i.e., whether hydropower, biomass, or other resources are available).

Research sponsored by the U.S. Department of Energy and the U.S. Agency for International Development.

[3.5.24]

WOOD ENERGY PLANTATION ECONOMICS IN THE GREAT PLAINS

R. D. Perlack W. A. Geyer*

[Abstract of *J. Energy Eng.* 113(3), 92-101 (1987)]

Short-rotation intensive culture (SRIC) is a method of producing wood energy feedstocks that is potentially competitive with conventional wood sources in eastern Kansas. Silver maple is used as a representative energy species to examine alternative cutting cycles and planting densities. The sensitivity of discounted average cost is also evaluated with respect to changes in biomass productivity and to changes in production and harvesting costs. The results show that SRIC wood feedstocks can be grown, harvested, and delivered at costs approaching $50/dry tonne. This cost is nearly competitive with prices of delivered wood chips from conventional forest sources in eastern Kansas.

Research sponsored by the U.S. Department of Energy.
*U.S. Department of Energy.

[3.5.25]

COST OBJECTIVE OVERVIEW FOR SHORT ROTATION WOODY CROPS

R. D. Perlack J. W. Ranney*

(Abstract of *Proc. Int. Workshop Econ. Eval. Short-Rotation Biomass Energy Syst.*, International Energy Agency and North Center Forest Experiment Station, Duluth, Minn., 1988)

The costs of short-rotation intensive culture (SRIC) feedstocks are evaluated under state-of-the-art conditions and under two sets of assumptions about anticipated advances in the technology. The results indicate that delivered SRIC feedstock costs using available technology are likely to range between $3.00 and $4.10/GJ, depending on the region where grown. On the basis of estimates of technological advances in genetics, cultural management, and harvesting, delivered costs could be lowered to under $2.00/GJ by the year 2000.

Research sponsored by the U.S. Department of Energy Biofuels and Municipal Waste TEchnology Division, as part of their Short Rotation Woody Crops Program managed by Oak Ridge National Laboratory.
*Environmental Sciences Division.

[3.5.26]

A COMPARISON OF DECENTRALIZED MINIGRIDS AND DISPERSED DIESELS FOR IRRIGATION PUMPING IN SAHELIAN AFRICA

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S. Schweitzer*

[Abstract from *Nat. Resour. Forum* 12(3), 235-42 (1988)]

A key ingredient in the expansion of agricultural output in many developing countries is the availability of reliable and cost-effective energy supplies for irrigation. Such supplies are also fundamental to any strategy to stimulate rural economic development. This paper compares the costs of water pumping through the use of commonly used, small diesel-driven pumpsets vs a decentralized generator connected to a small electrified grid. An example representative of irrigated cropping systems found in the Senegal River Basin is used to compare costs. The results show that pumping costs from a decentralized power supply and minigrid are roughly comparable to those of direct-drive diesel pumpsets. Further, excess capacity would be available to provide power for small industries and other rural needs. In many sparsely populated rural locations where low-capacity factors make central grid extension uneconomic, a minigrid with a guaranteed load of irrigation pumping can be an attractive alternative for providing power for rural development.

Research sponsored by the U.S. Agency for International Development.
*International Energy Agency, U.S. Mission to the Organization for Economic Cooperation and Development, Paris.

[3.5.27]

ECONOMICS OF SHORT-ROTATION INTENSIVE CULTURE FOR THE PRODUCTION OF WOOD ENERGY FEEDSTOCKS

R. D. Perlack J. W. Ranney*

[Abstract of *Energy* 12(12), 1217-26 (1987)]

The economics of short-rotation intensive culture (SRIC) for the production of wood energy feedstocks in six regions of the United States are evaluated for present conditions under two sets of assumptions about anticipated advances in technology. The results show that delivered SRIC feedstock costs using available technology are likely to range between $3.00 and $4.10/GJ. On the bases of estimates of technological advances in tree breeding and selection, cultural management, and harvesting, delivered costs could be lowered to under $2.00/GJ. Advances in genetics, cultural management, and harvesting needed to reduce SRIC costs are technically attainable by the year 2000.

Research sponsored by the U.S. Department of Energy Biofuels and Municipal Waste Technology Division.
*Environmental Sciences Division.

[3.5.28]

OZONE POLLUTION: THE HARD CHOICES

M. Russell*

[Abstract of ORNL/TM-10909, Oak Ridge National Laboratory, September 1988; *Science* 241, 1275-76 (September 1988)].

This paper examines tropospheric ozone pollution and alternative approaches for dealing with it. Its underlying message is that the U.S. Congress should not act on any of the measures now before it to amend the Clean Air Act with regard to ozone. The paper examines the origins and health and environmental effects of ozone pollution and describes the magnitude of the current problem. This report summarizes what would be required to attain the current Clean Air Act goals and determines that they may be unattainable in practice in some locations. It concludes that the Clean Air Act is flawed and that a public debate should be encouraged on fundamental changes in its goals and framework.

Research sponsored by the U.S. Department of Energy.
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[3.5.29]

TROPOSPHERIC OZONE AND VEHICULAR EMISSIONS

M. Russell*

(Abstract of ORNL/TM-10908, Oak Ridge National Laboratory, September 1988)

This paper examines changes in the transportation system as a means of reducing tropospheric ozone in the South Coast Air Basin of California. It takes this issue as a paradigm for the broader national situation where there are environmental risks for which no plausible or acceptable remedies exist. Its underlying thesis is that the cruel choices this prospect offers should be faced openly and public debate fostered. This report summarizes the origins and the health risks of ozone, the current and prospective levels of control required to avoid them, the prospective contribution of transportation controls, and the information required to put the issue in a social benefits and social costs framework for decision. It contrasts this approach with that found in the Clean Air Act and in the amendments now before the U.S. Congress. On the narrow issue, the paper concludes that changes in the transportation system could be a significant part of a control strategy, but could not be sufficient in themselves to allow Los Angeles to meet the ozone standard. More broadly, the ozone standard in Southern California cannot be met by the turn of the century without sacrifices of an order not willingly accepted by a free society except perhaps in war time. Whether it can be met in the following decades remains uncertain. Moreover, there is the question of whether the cost would be worth bearing. The paper suggests that information is available or can be gathered to address the ozone issue from the social

benefits and social costs viewpoint. While this approach has advantages, the choice of whether or not to use it is one that depends at base on individual values.

Research sponsored by the U.S. Department of Energy.
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[3.5.30]

COAL BRIQUETTING IN PAKISTAN: A MARKET AND BUSINESS ASSESSMENT

G. G. Stevenson T. D. Wilson*

(Abstract of ORNL-6427, Oak Ridge National Laboratory, April 1988)

Firewood and charcoal use in Pakistan has led to extensive deforestation. Kerosene use depletes the country's foreign exchange earnings. Substituting coal briquettes from indigenous coal for these fuels in residential, commercial, institutional, and light-industrial cooking and heating uses could help alleviate these problems. Equally important, coal briquettes present a potentially interesting business opportunity for the Government of Pakistani (GOP) and foreign private investors. Our objectives were (1) to evaluate the potential financial success of an unsubsidized, private sector coal briquetting venture in Pakistan, based on financial competitiveness in market niches, market size, and consumer acceptance; (2) to examine private sector interest and potential business arrangements; (3) to examine potential effects of government policies on such an undertaking; and (4) to make recommendations to the private sector, the U.S. Agency for International Development (USAID), and GOP on further work. Our results show that coal briquettes potentially can compete against firewood in some markets, particularly in certain urban areas of Punjab and most urban markets of the North-West Frontier Province (of Pakistan). Salt Range or Makerwal coal would be used for these briquettes. Coal briquettes will also compete against charcoal and kerosene in many areas of Pakistan. The most promising briquette is a coal/biomass mixture not requiring carbonization. A limited opportunity may also exist for a carbonized briquette using Makerwal coal. Smoky briquettes for space heating also are competitive in certain areas, but market size is limiting. We recommend a private sector initiative to plan a coal briquetting venture based on a particular coal, process, and market to prove financial viability. This initiative should be supported by USAID/GOP with tax concessions and assistance in briquette formula development, market testing, a detailed engineering study, and possibly building a plant on a cost-sharing basis.

Research sponsored by the U.S. Agency for International Development.
*JDS Group, Inc., Cambridge, Mass.

[3.5.31]

SECOND-YEAR GROWTH AND PRODUCTIVITY FOR POTENTIAL HERBACEOUS ENERGY CROPS IN THE SOUTHEAST AND MIDWEST/LAKE STATES

A. F. Turhollow, Jr.

(Abstract of ORNL/TM-10626, Oak Ridge National Laboratory, July 1988)

The results of the second year of the lignocellulosic energy crop screening projects in the Southeast and Midwest/Lake States of the Herbaceous Energy Crops Program are summarized. Most species being screened are grasses, both annual and perennials, and legumes. Establishment of perennial crops was completed during the second year. Yields were quite variable, ranging from zero for flatpea at a drought-stricken site in Virginia to as high as 31.9 Mg/ha for a sweet sorghum-rye double crop at a site in Indiana. The yield data collected–along with agronomic input, machinery, and labor requirements–will be combined in the future to help select the best species for further development as energy crops.

Research sponsored by the U.S. Department of Energy Biofuels and Municipal Waste Technology Division.

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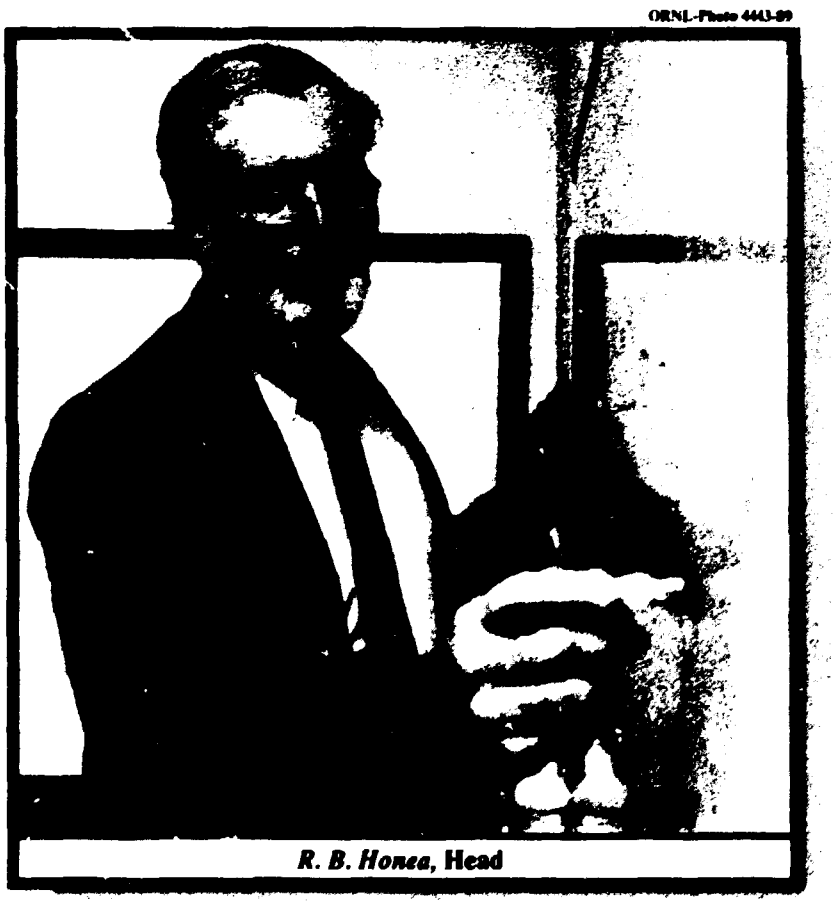

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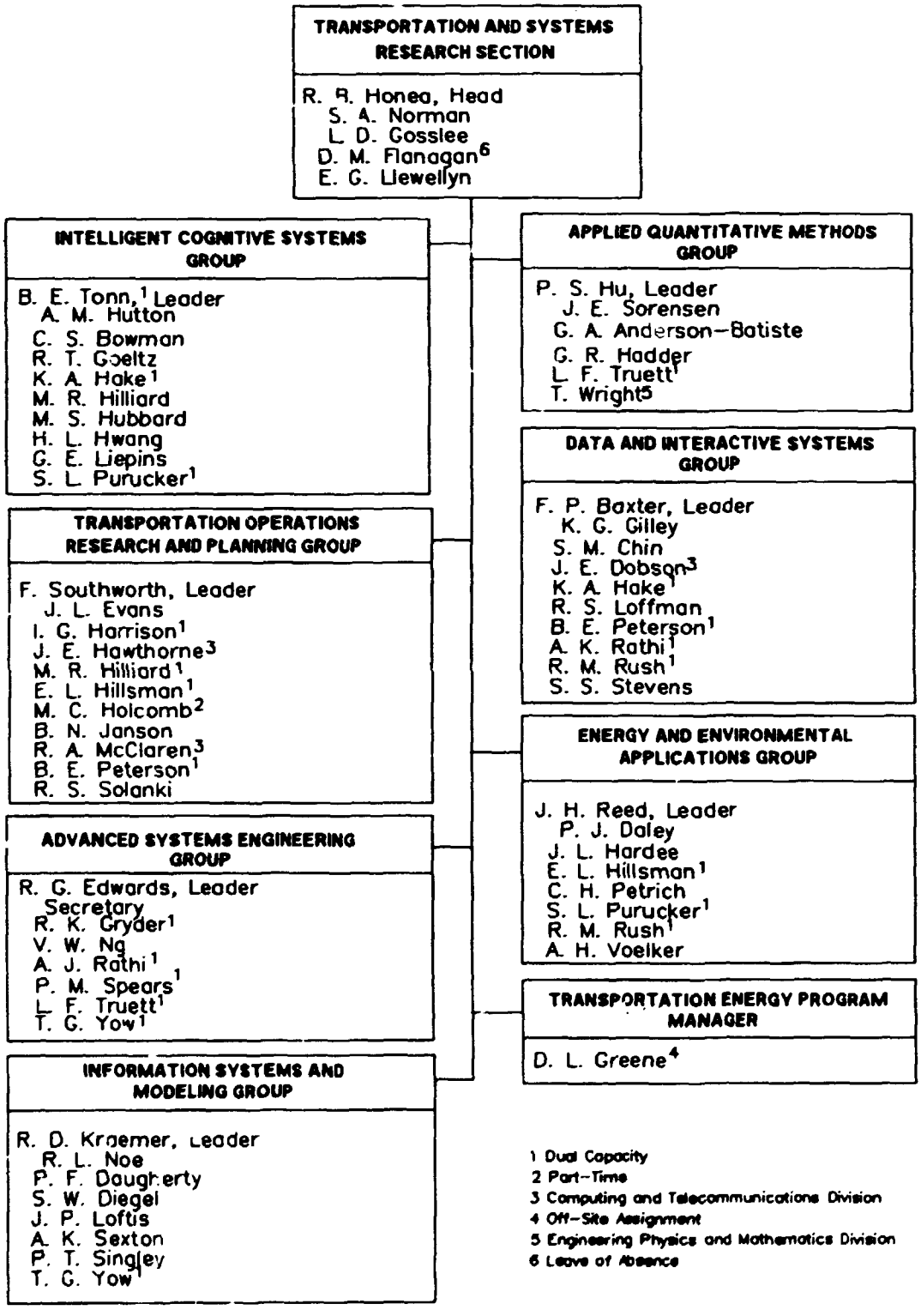
R. B. Honea, Head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Transportation and Systems Research Section 4

In September 1988, tasks of the Decision Systems Research Section were combined with the Transportation Research Program to form the new Transportation and Systems Research Section (TSRS). The Integrated Utility planning work of Eric Hirst and the Conservation Evaluation and Technology Transfer Programs, managed by Marilyn Brown (which had been part of the Decision Systems Research Section), were combined with similar programs in the Efficiency and Renewables Research Section. This section covers the work of only TSRS.

Combining the various transportation research tasks with those related to decision research has provided an effective organizational focus for the new section. Much of the research now being done in the section can be related directly to either transportation research or the decision and information requirements associated with transportation problems. In addition, the development of other decision systems is still an important part of the section's efforts; TSRS groups have also concentrated on research in the areas of environment, energy distribution, and artificial intelligence.

4.1 TRANSPORTATION

The section's transportation research advanced along several fronts during the past year. Within the wide range of specific projects, TSRS transportation-related research and development pursued several broad themes of practical and theoretical knowledge in the field, including energy use in transportation; approaches toward more effective routing of transportation networks on a large scale; and routing, scheduling, and other transportation concerns for the U.S. military.

4.1.1 Military Deployment and Scheduling

A significant portion of the section's transportation work in the past year was devoted to improving the efficiency of military deployment, scheduling, and transportation coordination. This work included the development of improved tracking systems, improved decision-modeling systems, advanced expert systems, more-efficient methods of database management, and other support tools for the military's decision systems. The following paragraphs briefly describe a few of the section's projects in this area.

The Airlift Deployment Analysis System (ADANS) being developed for the U.S. Military Airlift Command (MAC) has required both basic and applied research to develop improved global airlift routing and scheduling algorithms. The same project also required research and development to provide the data and information architecture necessary to drive a large decision support system. This multilayer data architecture eventually will employ both advanced expert systems and high-speed communications capabilities.

One of the most important developments resulting from the ADANS project has been a prototype insertion heuristic for the global routing and scheduling of MAC aircraft. Developed by Rajendra Solanki, Charles Bowman, and Frank Southworth of the Transportation Operations Research and Planning (TORP) group, this algorithm provides a very flexible approach to vehicle scheduling. In related work for MAC, TORP

researchers applied a mixed-integer program to a routing and scheduling heuristic, allowing more cost-efficient allocation of military and commercially leased aircraft.

Also, TSRS undertook work on a variety of research and development projects concerned with the very core of modern military success: the quick, efficient movement of troops and material on a regional, national, and global level. For example, the Strategic Deployment System (STRADS) for the Military Traffic Management Command (MTMC) required that ORNL analysts design a large-scale transportation planning system to be used in scheduling the movement of U.S. armed forces equipment and personnel from their military bases to airports and seaports for deployment overseas; the system is now being prototyped on microcomputers. The work on STRADS is being done by the section's Information Systems and Modeling group, headed by Ron Kraemer.

In a related project, the efforts of members of the Advanced System Engineering (ASE) group, headed by Bob Edwards, and the Intelligent Cognitive Systems (ICS) group, headed by Bruce Tonn, resulted in the completion of the Interim TC-ACCIS–a decision support system–in 26 major U.S. Forces Command facilities, with software installation assistance from the staff of The University of Tennessee. This system facilitates management of unit movement information by local transportation officers and provides a means of electronic exchange of transportation data between local facilities and MTMC.

The TORP group's Scheduling Algorithm to Improve Lift (SAIL) project involves the development of a ship-scheduling algorithm to support the Military Sealift Command's (MSC's) deployment-planning activities. During 1988, the prototype software was installed on the U.S. Navy's new IBM 3090 computing system in Washington, D.C., and tests were begun. Several efficiencies in the mathematical programming solution algorithm were then incorporated. Members of the TORP group have been working with staff from the Computing and Telecommunications Division, headed by Bob McLaren, on the SAIL project for TSRS.

The ASE group, headed by Bob Edwards, played a crucial role in the further development of projects such as SAIL and STRADS through its work on the Deployment Analysis Prototype. The prototype is the "front end" of complex, state-of-the-art scheduling systems because it provides designers and users with the opportunity of feasibility testing for a particular situation.

The ASE staff undertook three significant studies for the U.S. Transportation Command (USTRANSCOM). These studies provided a survey of the automated deployment systems–those in existence now and those in development–at MTMC, MSC, and MAC and evaluated opportunities for improving intercommand operations and consistency among the systems surveyed.

Also for USTRANSCOM, TORP researchers have developed a strategic airlift and sealift selection and routing algorithm that schedules intercontinental movements of personnel and cargo during large-scale military deployments. The heuristic attained accuracy within 3% of the optimal solution provided by previous formulations of the same problem and did so in a fraction of the previous computer time.

In 1988, TSRS completed a major project dealing with military personal property–the Transportation Operational Personal Property Standard System (TOPS). As a multiservice project for MTMC Headquarters, TOPS is a fully integrated information management system that is able to track the movement of the personal property of the U.S. armed forces personnel. The TOPS team has finished designing the database and prototyping most of the systems functions.

4.1.2 The Broader Range of Transportation Projects

The transportation work of TSRS was in no way limited to military deployment and scheduling. Many projects were undertaken on

behalf of a variety of government entities other than military. The results of some of the work being done by the TSRS for the military have proven to be beneficial in the civilian sector as well.

A prime example of civilian adaptation of the research and development provided for the military is the convoy routing and scheduling model developed by TORP. The National Highway Planning Network, developed by Bruce Peterson of TORP, provides a database for a wide variety of highway transportation uses for approximately 379,000 miles of roadway. This database was applied by the U.S. Army Forces Command and Army National Guard in exercises in nine states. Later, it was adopted by the Federal Highway Administration (FHWA) as a unified database for use in its planning and monitoring activities.

In related work for FHWA, Frank Southworth, Bruce Peterson, and Bruce Janson of TORP redesigned much of the Highway Traffic Forecasting System to allow statistical and econometric analyses of the distribution of trucks in different weight classifications, truck use on different types of highways, and the impact that such distribution has on the nation's increasingly congested highway system.

TSRS researchers also disseminated ORNL's Network Performance Evaluation Model (NETPEM), which is used in the analysis of High Occupancy Vehicle facilities. NETPEM estimates the energy, travel time, and emissions impacts of different types of dedicated carpools, vanpools, and bus lanes, and has now been acquired by 30 planning organizations around the country. In another project, TORP's Bruce Peterson assisted DOE's Office of Conservation and Radioactive Waste Management in developing a multistage simulation program replicating the packaging and transportation of spent fuel from reactor site to repository. In work for the Federal Emergency Management Agency, ORNL's Real-Time Traffic Monitoring and Analysis System was linked to telemetrically accessed roadside traffic counters in Atlanta and the Tampa Bay area.

The Applied Quantitative Methods (AQM) group, headed by Pat Hu, examined fuel economy and market-share trends of cars and light trucks for the time period between 1976 and the first half of 1988. An interactive

ORNL-Photo 4359-89

The Applied Quantitative Methods group examined fuel economy and market-share trends of cars and light trucks.

microcomputer system to manage 13 years of data on individual light-duty vehicle models and their characteristics was studied. The system was installed on a personal computer in DOE headquarters to ensure quick turnaround results.

The Section's Transportation Energy Programs group also explored energy use in transportation. A study by Greene and Liu examined the increase in the surplus of fuel resulting from changes in the ways in which cars are made. The study strongly suggested that the value to consumers of gains in surplus fuels has been balanced by the increased retail price of the more fuel efficient cars. Another important study in this area by TSRS[1] examined the trends of the changing world energy markets and the possible outcomes of these trends through the year 2020.

The group also developed a methodology to expand sampled data from the Nationwide Truck Activity and Commodity Survey precisely to the sampled population and to adjust biases in estimating 1989 truck activities using a 1987 sample frame.

4.2 ENVIRONMENT AND ENERGY

TSRS also carried out extensive work in the areas of environment and energy. The variety of projects under this heading are in two main categories: global climatic change and energy distribution.

4.2.1 Global Climatic Change

One of the most crucial problems addressed by TSRS is the issue of global climatic change.

With support of the staff of the Integrated Analysis and Assessment Section and the Energy and Economic Analysis Section, TSRS has developed a research program in global environmental management and policy. This effort is led by Steve Rayner, who is also the program coordinator for all global climate change work for the Division. The principal focus of 1988 activity was on the problems of environmental decision making at the global and regional levels and at the local level as it affects transboundary environmental issues.

Energy Division staff have collaborated with researchers from major academic institutions and research centers to develop a distinctive perspective on problems such as defining global common resources (i.e., the atmosphere and the oceans) and stimulating human management of those resources at global, regional, national, and local levels. This perspective emphasizes the importance of consensus among decentralized, diverse stakeholders in an information-intensive world order rather than the traditional formal agreements among nation-states. It is in the interaction among these groups and, in turn, their interaction with the nation-states that true global consensus can be found.

Through various environmental solutions introduced in small, incremental steps, learning from trial and error is facilitated. A next major step is to investigate which intersections in the resulting knowledge flow provide the most useful information for policy makers.

Dissemination of this perspective in the research community has been achieved by publications and staff participation in national and international meetings and conferences. The program leader participated in a national planning committee of the Social Science Research Council to develop a national agenda for research into the human dimensions of global change.

Our principal achievements in TSRS during the past year include the preparation of two draft reports concerning global climate changes. Other activities included an assessment of the energy sector related to greenhouse gases and problems of environmental decision making and enforcement in the Union of Soviet Socialist Republics. This assessment was prepared for the DOE Office of Environmental Analysis (OEA), which supported much of the program's activity during the year. Another important activity was the completion of plans for a workshop on the problems arising from defining and managing the global commons. The workshop, sponsored by the Energy

Division of ORNL and The University of Tennessee, is scheduled for the summer of 1989 in Knoxville.

Other TSRS efforts related to climate change include collaboration with other ORNL divisions to provide support for decision making through the modeling of possible climate-impact scenarios. For example, TSRS researchers collaborated with the Geographic Data Section of the Computing and Telecommunications Division to assess the danger to various coastlines in the world (chiefly in the United States and Australia) if the greenhouse effect were to produce a rise in sea levels. The results were summarized on maps (Figs. 4.1 and 4.2) showing the potential

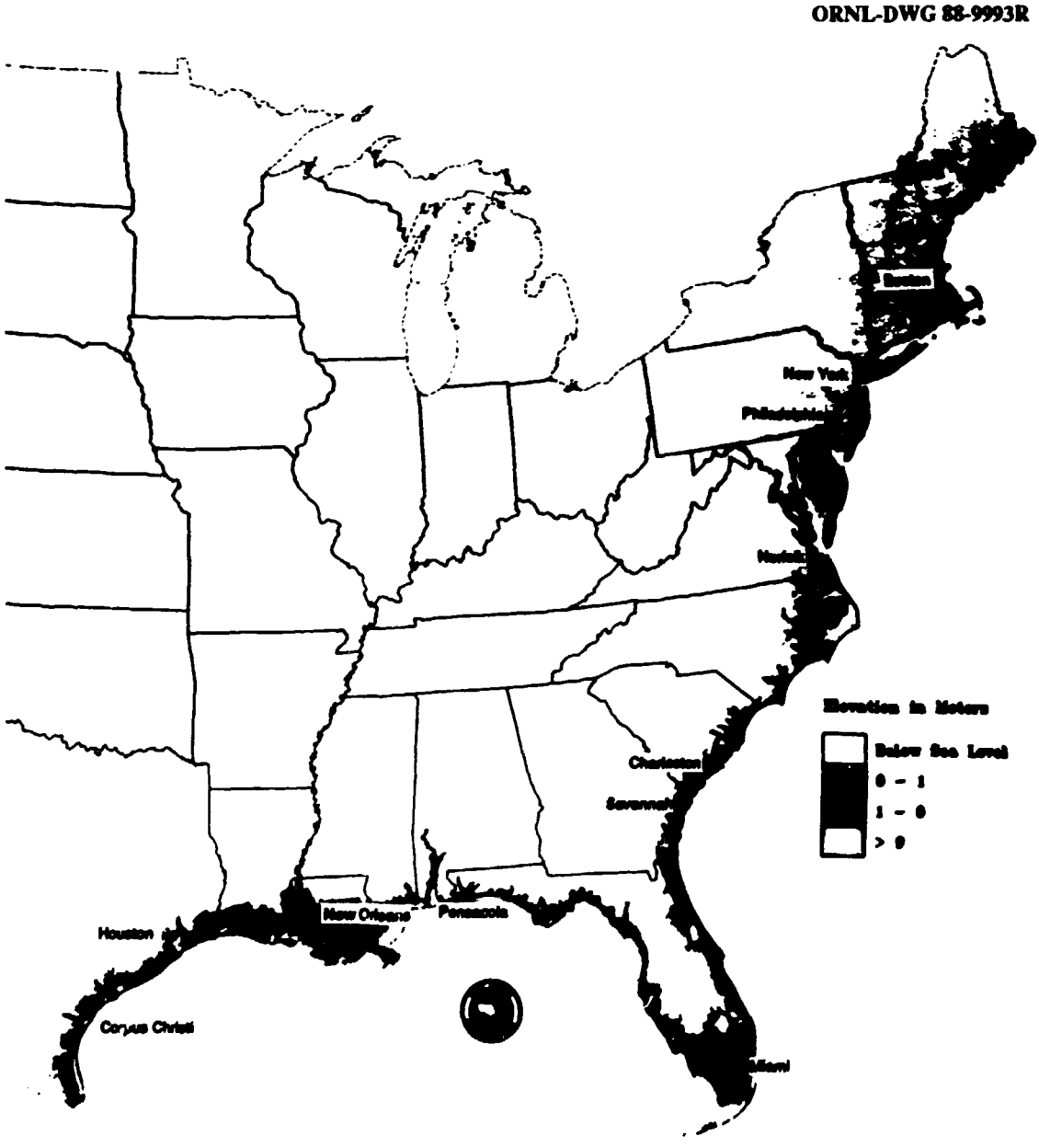


Fig. 4.1. Areas along the Eastern Seaboard of the United States and in the Gulf of Mexico that would be threatened by a rise in sea level of from one to nine meters Such a rise could result from the warming of the earth's surface (the "greenhouse effect") and would affect millions of people in several densely populated areas.

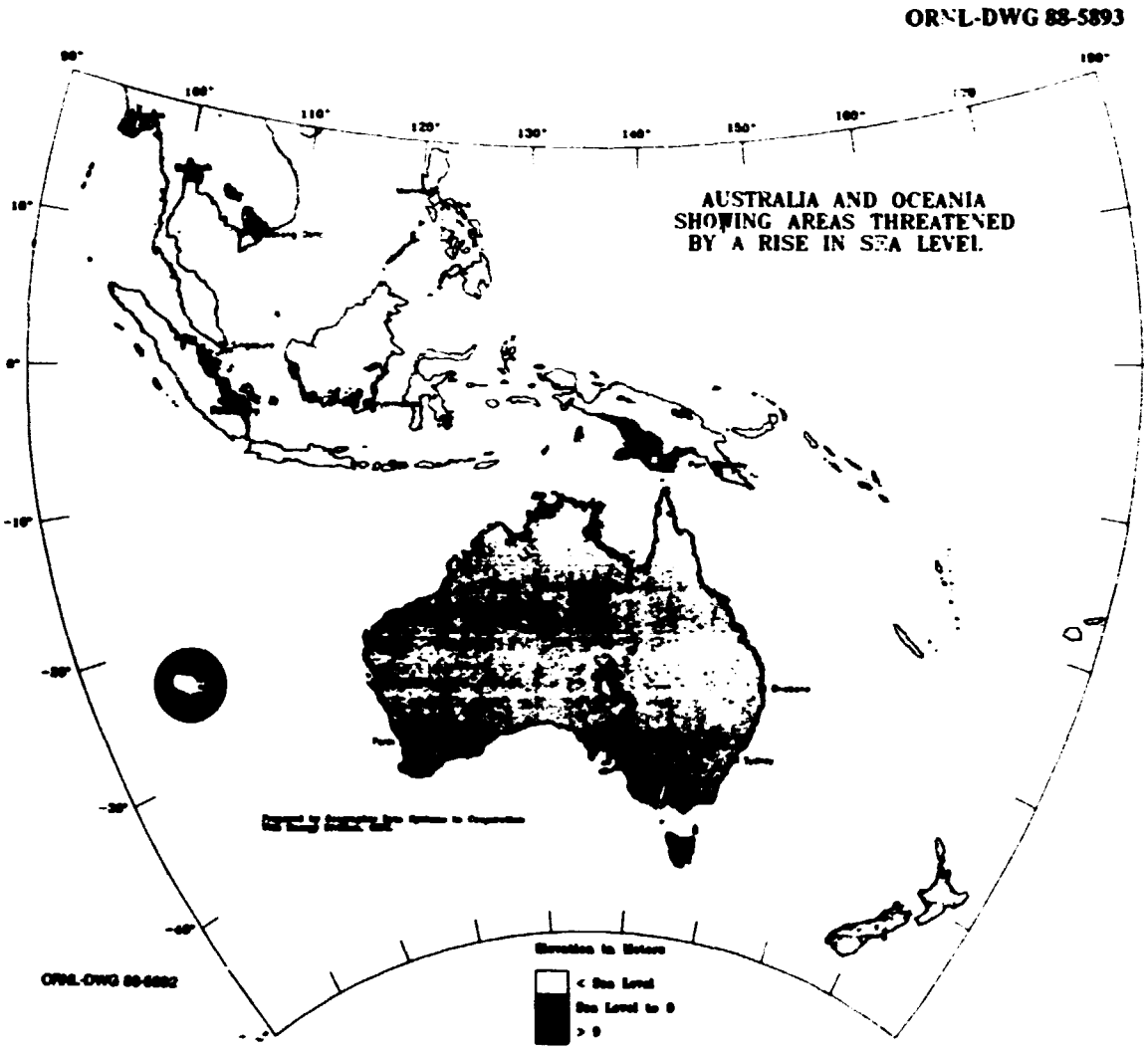


Fig. 4.2. Areas of Australia and Oceania threatened by a rise in sea level resulting from the warming of the earth's surface (the "greenhouse effect"). Many heavily populated cities would be endangered.

effects from inundation (although not erosion) at levels ranging from 1 to 9 m (the latter as a worst-case scenario). These projections came from a study of the long-term global effects from increased levels of carbon dioxide (CO_2) in the atmosphere. One major concern has focused on thermal expansion of the oceans and possible melting around the polar ice caps due to possible earth-surface warming caused by increased CO_2 levels, triggered by such events as increased fossil fuel combustion, major forest clearing, industrial fuel production, and volcanic activity.

Research continues toward finding ways to provide industrial and regional environmental impact assessment capability to OEA staff within a personal computer environment. These efforts are aimed at developing more timely, cost-efficient computer tools to be used by OEA in data analysis, storage, and documentation.

4.2.2 Energy Distribution

The distribution of energy (chiefly, electrical power) and the development of decision systems to direct and aid that distribution remained one of the section's chief areas of focus in the past year. TSRS projects in this

area ranged from energy distribution on statewide and regional levels to projects involving the day-to-day lives of people in individual homes.

Members of the ASE group continued their productive involvement with the Smart House Project for the National Association of Home Builders (NAHB). The 1988 work on the project consisted primarily of the development of concepts and prototype equipment for the appliance control and communications subsystem. ASE assisted in defining and testing the Time-Division Multiplexing protocol used in the subsystem. Work later in the year resulted in the construction of prototype test equipment to be used in the testing necessary to confirm compliance with the one-in-a-billion error-rate specification of the subsystem. In December 1987, NAHB submitted a patent application naming Bob Edwards of the ASE group as coinventor of the Smart House concept.

The Smart House will employ high-tech sensors, integrated circuitry, and computer intelligence to monitor and regulate a home's electrical and energy systems and to provide time-saving conveniences to the resident. The TSRS Smart House research continues to push the limits of current technology. One significant research area concerns the capabilities of systems within the Smart House to communicate with each other and, in some cases, to compensate for breakdowns in other systems. Facilitating this type of exchange of functions between systems (e.g., between a security system and a centralized heating system) represents an extremely difficult and innovative technological task.

Also important is the efficient distribution of electrical power on a vast scale. In 1988, Bruce Tonn, Rick Goeltz, and Steve Purucker launched an initiative to develop a body of research involving power distribution studies. A major project of the ICS group is the development of a Communication Alarm Processor (CAP) for the Bonneville Power Administration (BPA). Part of the significance of the CAP project is how it merges theoretical research with practical application, using specific, problem-solving work to advance the general knowledge in a given field [in this case, the field of artificial intelligence (AI)]. CAP is a prototype expert system used to process alarms from BPA's microwave communication system, which relays data from several power systems in four states to a central operations control facility. Problems and potential problems are signaled, and the

ORNL-Photo 2425-89

Prototype test equipment was constructed to confirm compliance of a subsystem for the Smart House Project.

appropriate solution is sent from the central facility.

As the power system as a whole grows more complex and automated, the need for such an expert system to help process the flood of information becomes more crucial. CAPS is now being field-tested and will receive real-time data, diagnose operational problems, archive alarm information, and support analysis aimed at improving equipment maintenance. Because the human operators of the system often must make split-second decisions based on the data they receive, TSRS staff have also concentrated their efforts on human interaction with the system to ensure the highest possible levels of operator confidence in the data. The practical work done here on human–expert system interaction will have wider applications in the field of AI.

For the Athens Automated Power Distribution Study, the Energy and Environmental Applications group (headed by John Reed and in conjunction with the Efficiency and Renewables Research Section) completed follow-up experiments confirming that the startup of individual end-use appliances such as air conditioners can be observed at the feeder level by using high-speed monitoring, thus providing a greater depth of data detail than before. In addition, models were developed that can predict hourly residential air-conditioning loads by using outdoor temperature data and thermal time constraints derived from audit data.

TSRS researchers also examined issues such as pollution emissions and power plant life extension. Researchers in the ICS group analyzed the ways that utility managers make decisions on extending the lives of aging electricity-generating plants and the environmental effects of these extension efforts. This study is particularly important in light of both uncertainties and regulatory difficulties involved in constructing new plants as well as concerns over possible shortfalls in electricity generation in the future. The study focused on pollution resulting from power production and how life extension of power plants would affect the pollution situation. After data about plant size, age, fuel type, heat rates, and capacity factors were analyzed, the study concluded that life-extension measures most likely will be used more frequently in the future as financial, environmental, regulatory, and competitive pressures cause utilities to seek alternatives to the large-scale production of new generating plants. However, it also was found that power plant life extension (one of the few viable options for electricity generation remaining to utilities) will increase pollution–specifically, emissions of sulfur oxides (SO_x) and nitrogen oxide (NO_x).

Another important project, which combined elements of military deployment, energy distribution, and decision making, was the work done by the AQM group on the U.S. Navy's Forecasting Mobility Fuels Availability and Suitability Project, headed by Jerry Hadder. One of the most significant results of this research was a comprehensive report on trends and possibilities for jet fuel availability under three different world-situation scenarios: (1) business as usual; (2) political disruption; and (3) military mobilization by U.S. armed forces. The section's work on the project provided the required reliable means of forecasting the availability of fuel.

An assessment of proposed oil shale use for power production in Jordan was near completion in 1988. Carl Petrich directed the study that examined both economic and environmental concerns in determining the feasibility of 20- and 50-MW demonstration units and a 400-MW commercial-scale plant. ORNL's portion of the study concentrated on four areas: (1) assessment of the projected need for power in Jordan, (2) environmental aspects of the proposed plants, (3) engineering feasibility of using Jordanian oil shale in a circulating fluidized-bed combustor, and (4) economic feasibility of the plants and the proposed mining operations. From a strictly technical perspective, this early assessment found that Jordanian shale could be exploited successfully. The economic situation is less clear; if the need for such plants can be demonstrated, it is possible that international lenders could fund the project.

4.3 ARTIFICIAL INTELLIGENCE

In addition to work on transportation and energy and environment issues, TSRS continued its innovative research in the field of AI. This work is by no means isolated from the other areas of the Section's research, however, because the use of AI (particularly expert systems) is at the heart of many of the Section's projects involving transportation, energy distribution, and environmental issues.

Work undertaken in 1988 by the ICS group will have a wide-ranging effect on the field of AI. Researchers focused on the practical applications of advanced genetic algorithms and in the past year have produced methodologies for using the genetic algorithm in mulitobjective problems and identified ways to improve the efficiency of classifier machine learning. In the ADANS project for MAC, the researchers showed how a genetic algorithm can assist in discovering appropriate parameters for a complex, multiobjective scheduling algorithm. Initial experiments indicate that a collection of good parameter sets can be found. The techniques learned in this process are now being applied to a lake acidification data set to compare machine learning techniques with standard statistical techniques for data analysis and pattern recognition.

Also in 1988, work continued on Automated Knowledge Elicitation. Two systems in particular were advanced during the year. In the Acquiring and Reasoning About Knowledge system, a research effort led by Bruce Tonn has been conducted in developing an Assumption-Based Truth Maintenance System (ATMS) to manage dynamic knowledge bases. ATMS is augmented with the capability to identify redundant and inconsistent pieces of knowledge.

The other elicitation system is the Likelihood Elicitation System, which collects data from experts and others to help determine what kinds of rules they use to process uncertainties. Analyses of the data have indicated that, in practice, individuals do not follow the rules suggested by traditional probability theory or by the theory of certainty factors. The work done by ICS suggests that the methods used to represent and manipulate uncertainty in expert systems bear little resemblance to how people actually think and deal with uncertainty. This year, work progressed on synthesizing AI concepts of uncertainty by developing methods for nonstatistically judging mathematical models of human behavior.

4.4 RESEARCH UTILIZATION

One of the most obvious and high-profile of the TSRS efforts in this past year was the NAHB Smart House project, co-invented by Bob Edwards (see Sect. 4.2.2). The work done on Smart House was almost immediately transferred to wide use among a broad range of manufacturers in the private sector. Smart House has been featured in a variety of national forums, including numerous articles in technological and trade journals and in the mass media. In many of these stories, in print and on television, the role of TSRS in the development of Smart House was singled out for elaboration. Other stories dealt more generally with the Smart House concept. In all of these cases, the usage of the TSRS research was in clear evidence for a large audience. The Smart House concept is expected to dominate the general philosophy behind instrumentation in home construction well into the next century; therefore, it is likely that TSRS research in this area will continue to grow exponentially in ever-increasing applications throughout a broad and varied range of the national economy.

Another example of broader usage of TSRS research is the work done by Bruce Peterson of TORP. Although the National Highway Planning Network (see Sect. 4.1.2) was undertaken for the U.S. Army Forces Command and Army National Guard, in 1988 FHWA adopted the network as the unified database it will use in many of its planning and monitoring activities. The TSRS-developed database is the most extensive in existence.

FHWA will use the network for, among other things, tracking the routing of spent fuels, convoy scheduling, forecasting the flow of the nation's freight, and planning alternative routes for heavy trucks. Through its use by FHWA, the network will clearly have a growing, continuing impact on both the public and private sectors.

In another transportation-related project, NETPEM for the analysis of High Occupancy Vehicle facilities (see Sect. 4.1.2) has been acquired by 30 planning organizations around the country.

One of the most important means of research utilization is the dissemination of research results through the traditional methods of outreach (e.g., ORNL reports, journal articles, books, and conference proceedings). Such activity continued on a large scale within the Section in 1988. Almost every publication of TSRS researchers contains information of either a practical or theoretical nature that will be applied to problems other than those posed by the original sponsors. Examples are numerous and varied, ranging from the mention of the work on genetic algorithms by the Section's Mike Hilliard and Gunar Liepins in *Technology Review* to the work of Bruce Tonn, Rick Goeltz, and Steve Purucker on a communications alarm processor (the paper will be presented by Purucker at an international conference in Stockholm). Information dissemination represents one of the most pervasive and effective means of broader application of the Section's research.

4.5 REFERENCES

1. D. L. Greene, D. Sperling, and B. McNutt, "Transportation Energy to the Year 2020," *A Look Ahead: Year 2020*, pp. 207-31, Special Report 220 Transportation Research Board, National Research Council, Washington, D.C., 1988.

4.6 ABSTRACTS OF PUBLICATIONS

[4.6.1]

AN INVESTIGATION OF VERY HIGH-LEVEL LANGUAGES AND THEIR IMPLEMENTATION ON A FORTH LANGUAGE MICROPROCESSOR

H. G. Arnold W. B. Dress*
R. S. Loffman

(Abstract of ORNL/TM-10616, Oak Ridge National Laboratory, November 1987)

The potential for using a Forth language microprocessor to implement very high-level languages (VHLLs) in artificial intelligence research was investigated by surveying the current state of the art of VHLLs, by benchmarking several computers and microcomputers against a customized Forth language microprocessor, and by extrapolating the results to draw conclusions about implementing expert systems on the Forth language microprocessor. It was found that there is little agreement among researchers and developers as to just what a VHLL really is and what it should do. However, the results of this research indicate that yet another language will be of no immediate benefit to the data managmeent and decision

support communities. What would be of use is machine intelligence that would eliminate the need for a specific language. To this end, our results indicate a need to shift the emphasis of research from the VHLL and expert systems arena to that of pattern recognition and data retrieval consistent with user interfaces for support systems.

Research sponsored by the U.S. Department of Energy.
*Instrumentation and Controls Division.

[4.6.2]

OPTIONS FOR IMPROVING COMPUTING AND DATA SYSTEM SUPPORT FOR HQ USTRANSCOM DEVELOPMENT PLANNING

R. G. Edwards

(Abstract of ORNL/TM-10913, Oak Ridge National Laboratory, August 1988)

This report, part of a series to be produced in the course of ORNL studies for the U.S. Transportation Command (USTRANSCOM), presents options for improving automation support for HQ USTRANSCOM deployment planning. The study covers methods for improving data concepts used in deployment databases, makes recommendations for extending the life of the joint deployment system, and offers alternatives for integrating HQ USTRANSCOM planning support with other deployment systems.

Research sponsored by the U.S. Department of the Air Force, U.S. Transportation Command

[4.6.3]

OPPORTUNITIES FOR INTEGRATING DELIBERATE AND TIME-SENSITIVE JOINT DEPLOYMENT PLANNING IN USTRANSCOM COMPONENT COMMANDS

R. G. Edwards

(Abstract of ORNL/TM-10818, Oak Ridge National Laboratory, May 1988)

This report presents three possibilities for integrating deliberate and time-sensitive planning functions for the U.S. Transportation Command (USTRANSCOM). Two proposals recommended for use by the Military Traffic Management Command (MTMC) and the Military Sealift Command (MSC) build on cooperative planning initiatives already in progress in the two commands. A unique application of relative probabilistic measures is a key element in a proposal for improving MTMC/MSC airlift planning.

Research sponsored by the U.S. Department of the Air Force, U.S. Transportation Command.

[4.6.4]

ADVANCES IN AUTOMOBILE TECHNOLOGY AND THE MARKET FOR FUEL EFFICIENCY, 1978-1985

D. L. Greene

[Abstract of *Transp. Res. Rec.* 1155, 18-27 (1987)]

The Corporate Average Fuel Economy standards for automobiles and light trucks were intended to improve energy efficiency, primarily through technological improvements. While it is not clear how much of the impetus for manufacturers to improve fuel economy should be attributed to the Corporate Average Fuel Economy, analysis of light-duty vehicle sales and characteristics since the Corporate Average Fuel Economy went into effect in 1978 do indicate that technological improvements are responsible for about one-half of the 40% increase in automobile fuel economy between 1978 and 1985. Size/class shifts are responsible for only 10% of the total gain. The 1978-85 market for automotive efficiency reflects interactions of demand shifts, regulation, and technological change. An attempt is made to measure the technical improvements in automotive fuel efficiency by estimating stochastic frontier cost functions for automotive fuel economy in 1978 and 1985.

Research sponsored by the U.S. Department of Energy Office of Policy Integration Planning and Analysis.

[4.6.5]

MODELING OPERATING WEIGHT AND AXLE WEIGHT DISTRIBUTIONS FOR HIGHWAY VEHICLES

D. L. Greene J. C. Liang*

(Abstract of ORNL-6437, Oak Ridge National Laboratory, July 1988)

A method and model were created for estimating truck axle weight distributions on U.S. highways. A personal-computer–based FORTRAN model, AXLEWGTS, was written that permits the calculation of axle weight spectra by vehicle configuration, registered weight, highway class, and state given vehicle travel and other assumptions. The effort was hampered by the absence of valid registered weight data among most truck weight information.

Research sponsored by the U.S. Department of Transportation Office of Program and Policy Planning.
*Rensselaer Polytechnic Institute, Troy, New York.

[4.6.6]

AUTOMOTIVE FUEL ECONOMY IMPROVEMENTS AND CONSUMERS' SURPLUS

D. L. Greene J. T. Liu*

[Abstract of *Transp. Res.* 22A(3), 203-18 (1988)]

The change in consumers' surplus resulting from the alteration of automobile characteristics to achieve greater fuel economy is estimated. Measures of surplus change based on random utility models of consumer choice are calculated from data on the characteristics of makes and models from 1978 to 1985. Random utility models with constant and random coefficients are used. Although highly dependent on assumed attribute values, the results suggest that consumer surplus gains have been roughly equal in magnitude to the increased retail price of more efficient cars.

Research sponsored by the U.S. Department of Energy Office of Policy Integration.
*Vanderbilt University, Nashville, Tenn.

[4.6.7]

REFINERY INVESTMENT AND NAVAL FUEL PRODUCTION

G. R. Hadder S. Das
R. M. Davis*

[Abstract of *Energy* 13(1), 45-56 (1988)]

Survey data and linear programming techniques have been combined to forecast probable domestic refinery configurations and the production of Navy and other fuels for the years 1990 and 1995. The forecasts suggest that Gulf and West Coast refinery investments could be used largely for the support of motor gasoline production. Future refinery configurations affect the availability of Navy mobility fuels. To maintain current fuel-supply levels, it appears that the military will have to pay more for Navy jet fuel relative to the price of civilian jet fuel. The quality of Navy jet fuel is projected to be stable during the forecast period. The Navy's marine diesel fuel is forecast to be in good supply. However, the low-temperature fluidity of the fuel is expected to deteriorate.

Research sponsored by the U.S. Navy Energy and Natural Resources Technology Division, Office of Naval Research.
*Central Management.

[4.6.8]

NAVY JET FUEL PRODUCTION DURING A MILITARY MOBILIZATION SCENARIO

G. R. Hadder S. Das
R. M. Lee R. M. Davis*

[Abstract from *Energy* 13(7), 537-42, (1988)]

Refinery linear programming models have been used to estimate the regional production of U.S. Navy jet fuel for a military mobilization scenario based on a substantial loss of Persian Gulf crude oil production and the loss of all Venezuelan petroleum exports. In the scenario, the demand for all U.S. military fuels is assumed to have tripled. The effects of these scenario conditions are mitigated by the use of Strategic Petroleum Reserves and by the sharing agreements of the International Energy Agency. The analysis suggests that, without market overrides, Navy jet fuel requirements might not be met in the strategically important U.S. West Coast and foreign Pacific regions.

Research sponsored by the U.S. Navy Energy and Natural Resources R&D Division, Office of Naval Research.
*Central Management.

[4.6.9]

BUILD-1: A DISAGGREGATE MODEL OF THE U.S. ELECTRIC UTILITY INDUSTRY

E. L. Hillsman D. R. Alvic**
R. L. Church*

[Abstract from *Eur. J. Oper. Res.* 35, 30-44 (1988)]

This paper presents a linear programming model of the U.S. electric utility industry that represents each of the nation's 300 electric utilities and the options each has for meeting demand for electric energy. The model has been designed to estimate how the utility industry would respond to changes in policy or energy markets, especially in the current period of slow growth in demand and limited opportunities for expansion. By estimating the use, upgrade, retrofit, and retirement of individual generating facilities with known geographical coordinates, the model provides the geographically detailed results needed by models of pollutant transport and other regional environmental impacts.

Research sponsored by the U.S. Department of Energy Office of Energy Analysis.
*University of Southern California.
**The University of Tennessee, Knoxville.

[4.6.10]

LIGHT-DUTY VEHICLE MPG AND MARKET SHARES REPORT: FIRST SIX MONTHS OF MODEL YEAR 1988

P. S. Hu L. S. Williams*

(Abstract of ORNL-6496, Oak Ridge National Laboratory, August 1988)

This report presents the estimated sales-weighted fuel economies, sales, and market shares of automobiles and light trucks on a make and model basis, from 1976 to the first six months of model year 1988. This is the first time that data for model years 1976, 1977, and 1987 have been published in the report series vehicle. Among the results of this extensive analysis, it was found that sales-weighted fuel economy for the entire automobile fleet increased to 28.5 mpg for the first six months of 1988, up 0.3 mpg from model year 1987. Domestic cars showed greater improvement (0.3 mpg) than did foreign imports (0.1 mpg). The main reason for the gains in both areas was the sales shifts toward size classes that had improvements in fuel economy over the previous year. Another significant result of this report showed that the gap between the sales-weighted fuel economies of the domestics and the imports has narrowed from 9.2 mpg in model year 1976 to 2.9 mpg for the first six months of model year 1988.

Research sponsored by the U.S. Department of Energy Office of Transportation Systems.
*The University of Tennessee, Knoxville.

[4.6.11]

ANALYSIS OF THE PRINCETON SCOREKEEPING METHOD USING END-USE DATA FROM THE HOOD RIVER CONSERVATION PROJECT

H. L. Hwang

(Abstract of ORNL/CON-270, Oak Ridge National Laboratory, March 1989)

The Princeton Scorekeeping Method (PRISM), which is widely used in energy conservation studies, produces weather-adjusted estimates of energy consumption that enable researchers to evaluate and monitor changes in energy consumption over time. While clearly valuable in most areas, the accuracy of the method has been questioned concerning estimates of space heating. This report analyzes extensive PRISM data from the Hood River Conservation Project and concludes that PRISM's performance, while generally consistent during the years studied, overestimates space heating electricity use by an average of 19%. This report demonstrates a simple regression model that shows attractive potential for adjusting PRISM estimates.

Research sponsored by the U.S. Department of Energy Bonneville Power Administration.

[4.6.12]

USING AI IN THE PREPARATION OF BUDGET SUBMISSIONS

H. L. Hwang J. D. Morris*
M. L. Emrich*

(Abstract of pp. 81-86 in *Proc. Second Int. Symp. Methodol. Intell. Sys.*, November 1987)

This paper describes an automated budget preparation system that was developed using an expert system shell. Capabilities, operating environment, and limitations of the tool are discussed. Specific features of the budget preparation system are detailed.

Research sponsored by the U.S. Department of the Navy Naval Sea System Command.
*Data Systems Research and Development Division.

[4.6.13]

CANDIDATE EVALUATION SYSTEM: DOCUMENTATION OF THE DATA BASE AND APPLICATION SOFTWARE FOR THE PROTOTYPE EXPERT SYSTEM SUPPORT

R. S. Loffman

(Abstract of ORNL/CSD/TM-264, Oak Ridge National Laboratory, June 1988)

The U.S. Department of the Army established the Candidate Evaluation System Development Project, Project Management Office to analyze the current procedure for filling Army civilian jobs and to develop improved automated procedures to meet this need. The Army Civilian Personnel Center (now the Civilian Information Directorate) tasked Oak Ridge National Laboratory to provide technical support, research, and development to the Project Management Office and deliver a prototype of a Candidate Evaluation System that would run on the minicomputer hardware and software being delivered to personnel offices located throughout the world. This report (1) discusses the background of the project, including constraints and requirements; (2) describes the data base design and program code developed to implement the prototype; (3) documents known limitations of the prototype; and (4) contains recommendations to be considered in future development. The objective of this report is to document the prototype software systems for use by Army programmers/analysts who will maintain or further develop the prototype software.

Research sponsored by the U.S. Department of the Army, Civilian Information Directorate.

[4.6.14]

LESSONS LEARNED FROM ROUTING MILITARY CONVOYS

B. E. Peterson S. M. Chin

[Abstract of *Proc. Appl. Geog. Conf.* 10, 124-29 (September 1987)]

We discuss some of the design aspects of the Mobilization Automated Support System that illustrate the nature of these compromises and our experiences with users that have influenced choices. This discussion centers on three dichotomies in system design: (1) optimality vs. practicality, (2) flexibility vs. rigidity, and (3) visual vs. verbal communication. Our experience shows why these approaches are in tension, the advantages of each, and that many design questions can be placed on these dimensions.

Research sponsored by the U.S. Department of the Army Forces Command.

[4.6.15]

EXPERT SYSTEMS AND POWER SYSTEM PLANNING IN DEVELOPING COUNTRIES

S. L. Purucker

(Abstract of pp. 551-55 in *Proc., Trans. SOUTHEASTCON '88*, Knoxville, Tenn., September 1988)

This paper outlines an expert systems approach for least-cost planning in developing countries. It presents the results of the capacitor planning prototype expert system, which evaluates the installation of capacitors and the value of reducing losses. A load flow is used to examine loss reduction. It includes an economic module to identify savings. The solution is constrained by limiting investment and the number of installations. The prototype was tested using the standard 30-bus Institute of Electrical and Electronics Engineers, Inc., load flow.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distributions.

[4.6.16]

POWER PLANT LIFE EXTENSION AND POLLUTION EMISSIONS

S. L. Purucker

(Abstract of ORNL/TM-10942, Oak Ridge National Laboratory, September 1988)

The U.S. Department of Energy's Office of Environmental Analysis asked Oak Ridge National Laboratory to assess the extent to which utilities are planning to extend the life of existing power plants and to determine the environmental consequences of these efforts. Given future power demands and the uncertainties associated with new construction, it is expected that utility interest in power plant life extension activities will increase, as will SO_x and NO_x emission pollution. Several utilities have conducted life extension studies of specific plants. As yet, there has been only limited construction activity. Extending the life of power plants without the introduction of emission controls will result in continued production of SO_x and NO_x at current levels.

Research sponsored by the U.S. Department of Energy Office of Environmental Analysis.

[4.6.17]

ANALYSIS OF WATER HEATER DATA FROM ATHENS LOAD CONTROL EXPERIMENT

J. H. Reed J. C. Thompson*
R. P. Broadwater* A. Chandrasekaran*

(Abstract of pp. 1232-38 in *Proc. IEEE Trans. Power Delivery*, Power Engineering Review, July 1988, Portland, Oreg.)

This paper describes water heater load control experiments on the Athens Utilities Board distribution system in Athens, Tennessee. Data from experimental days are compared with data from days of normal operation to assess the effects of the control experiments. Plots are presented to describe water heater operation. Water heater models are used to estimate water usage. Results indicate that water heater control reduces energy demand but may have adverse effects on daily load patterns. Analysis shows also that the operation of load control receivers deteriorates as the duration of the control period is increased. Methods used to improve data integrity are presented. The results are based on the filtered data set, and the problems of identifying the associated time skew in the data and the timing-out of load control receivers are addressed.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
*Tennessee Technological University.

[4.6.18]

LOAD CONTROL EXPERIMENTS WITH HEAT PUMPS DURING THE WINTER

J. H. Reed R. P. Broadwater*
A. Chandrasekaran*

(Abstract of *IEEE/PES 1988 Winter Meet.*, IEEE Paper No. 88 WM 094-5, New York, February 1988)

The Athens Automation and Control Experiment is a hardware- and software-oriented research and development project installed on the Athens Utilities Board's distribution system in Athens, Tennessee. The purposes of the experiment are to automate the distribution system and to develop and implement control strategies that improve the efficiency and controllability of the system. The focus of this paper is on load control experiments performed on heat pumps during the winter. The data indicate that load control of heat pumps can result in a higher energy use for the heat pumps because of the operation of the auxiliary heat.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
*Tennessee Technological University.

[4.6.19]

PATTERNS OF ELECTRIC WATER HEATER USE AND THE EFFECTS OF WATER HEATER LOAD CONTROL ON CUSTOMERS

J. H. Reed R. P. Broadwater*
A. Chandrasekaran* J. C. Thompson*

(Abstract of pp. 11.114-11.126 in *Proc. ACEEE Summer Study*, Pacific Grove, Calif., August 1988 (1988))

This paper reports on the analysis of the water heater load control experiments conducted as part of the Athens Automation and Control Experiment (AACE). The analysis is based on data from end-use monitoring devices and survey data. Thirty-six water heaters were monitored during the winter months of 1986-87. Water heaters were turned off for periods of 2, 3, and 4 h during the morning and evening peaks. The winter peak diversified water heater load was about 1050 W and occurred at 7:00 a.m. A smaller and broader peak of about 750 W occurred in the evening. The expected demand reduction from load control ranged from 700-920 W per unit; however, because of reliability problems, the actual reductions fell in the range of 375-500 W per unit. The highest diversified water heater peak following restoration of control was approximately 2 kW. The effects of control at the system level were no longer apparent 2 h after control was restored. Fewer than 5% of the customers complained to the utility about load control operations. The analysis of hot water consumption also showed that 80% of the customers would have

sufficient hot water for an entire day if they had 120-gal water heaters, which suggests that storage water heating might be a viable alternative to direct control of water heaters.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
*Tennessee Technological University.

[4.6.20]

MONITORING LOAD CONTROL AT THE FEEDER LEVEL USING HIGH SPEED MONITORING EQUIPMENT

J. H. Reed W. R. Nelson
G. R. Wetherington* E. R. Broadaway*

(Abstract of a paper published in *IEEE/PES 1988 Winter Meet.*, IEEE Paper No. 88 WM 095-2, New York, February 1988)

Traditional techniques for monitoring load control often have proven ineffective or costly. This paper describes the use of a high-speed data acquisition system (50 samples per second) to monitor load control. The system has proven extremely effective in evaluating the impact of load control. A method for detecting appliance starts within the high-speed data is described and given a preliminary test. This high-speed monitoring technology promises to be relatively inexpensive, to be highly reliable, and to provide real time information that may be used by the system operator to make decisions about load control actions.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
*Instrumentation and Controls Division.

[4.6.21]

DISAGGREGATION WITHIN NATIONAL HIGHWAY VEHICLE MILES OF TRAVEL AND FUEL USE FORECASTS IN THE UNITED STATES

F. Southworth B. E. Peterson

(Abstract of Chap. 10 in *Spatial Energy Analysis*, L. Lundquist, L. G. Mattson, and E. A. Erickson, eds. Gower Publishing, Aldershot, England, 1988)

We reviewed recent efforts to understand and quantify the variability in current nationwide fuel use and vehicle miles of travel (VMT) and the relationship between these two variables as an aid to medium- and long-range (10- to 30-year) highway transportation energy planning. VMT-generated estimates of fuel use are of particular interest because planning data associated with VMT provide the best source of information on spatial, demographic, and socioeconomic breakdowns also of interest to energy-policy analysts. In all cases, innovation in the modeling of fuel use and VMT is motivated by a lack of

sufficient quality in the available data. As a contribution to the state of the art in VMT and subsequent fuel-use forecasting, a multidimensional, log-linear modeling approach is described that makes full use of the currently available VMT information and may be used to provide VMT (and, by implication, fuel use) forecasts broken down by, among others, vehicle class, highway type, and state.

Research sponsored by the U.S. Department of Energy Office of Transportation.

[4.6.22]

A METHOD FOR THE NONSTATISTICAL ASSESSMENT OF BEHAVIORALLY BASED POLICY MODELS

B. E. Tonn

[Abstract of a paper published in *Environ.Plann.* 20, 669-79 (1988)]

Advanced computer technology, sophisticated econometric computer software, and the increasing availability of disaggregated data have facilitated the development and use of statistically estimated mathematical models of human behavior for planning and policy analysis. This paper presents a method to subjectively judge the quality of such models and illustrates how the results of the method can be used with statistical measures of model quality as indicators of the predictive abilities of the models. Ideas are drawn from the artificial-intelligence literature that discusses how to represent and manipulate subjective judgments. Five models related to household energy use behavior are subjectively assessed, statistically estimated, and used to predict future behavior. In four of the five cases, the subjective assessments, in combination with the statistical measures, correctly indicate the quality of a model's predictive accuracy.

Research sponsored by the U.S. Department of Energy Bonneville Power Administration.

[4.6.23]

UNCERTAINTY, RISK, AND FUTURE GENERATIONS: PLANNING THEORY TOPICS FOR THE CHALLENGING 1990s

B. E. Tonn

(Abstract of a chapter published in *Planning Theory for the 1990s*, Robert Burchell, ed., Rutgers University Press, 1988)

This chapter presents 16 questions that entail large uncertainties, present potentially enormous risks, and could affect future generations. Planning theorists should begin to explore several topics during the next decade, including problems such as global climatic change, toxic waste, soil erosion, groundwater contamination, and genetic extinctions.

Sponsored by the U.S. Department of Energy.

[4.6.24]

PEOPLE VERSUS PROBABILITY

B. E. Tonn R. T. Goeltz

(Abstract of ORNL/TM-10898, Oak Ridge National Laboratory, August 1988)

This research explores how subjects combine estimates of uncertainty in probabilistic and evidential contexts. Two major computer programs written in Common Lisp asked subjects questions about the likelihoods and conjunctions of independent events. The results suggest that in the probabilistic context the best model to describe individual decision making is not the product rule but a minimum rule and that models varied as the magnitude of the likelihoods varied. In the evidential context, subjects appeared to use a maximum rule, although some evidence supports the use of the certainty factor rule. Subjects had difficulty in combining contradictory evidence.

Research sponsored by the U.S. Department of the Navy Naval Sea System Command and the U.S. Department of Energy.

[4.6.25]

MONITORED WOOD USE IN HOOD RIVER HOMES: SAVING ENERGY OR SAVING ELECTRICITY?

B. E. Tonn D. L. White

[Abstract of *Energy Build.* 13, 63-72 (1988)]

This paper analyzes wood use for space heating in the 320 Hood River Conservation Project (HRCP) participant homes that were submetered for electricity use, indoor temperature, and wood heat output (100 homes). Analysis of survey data indicates that wood users tend to live in larger homes and have larger families and larger incomes. Analysis of household reports of wood use and of submetered wood use data indicates that the former are unreliable. HRCP energy conservation investments saved much more energy associated with wood than with electricity in wood-using homes. Investments in wood-using homes were the most cost-efficient at saving energy but the least cost-efficient in saving electricity.

Research sponsored by the U.S. Department of Energy Bonneville Power Administration.

[4.6.26]

PATTERNS OF RESIDENTIAL WOOD AND ELECTRICITY USE: RESULTS FROM THE HOOD RIVER CONSERVATION PROJECT

B. E. Tonn D. L. White

[Abstract of a paper published in *Energy* 13(6), 485-97 (1988)]

In this article, Tonn and White identify significantly different daily patterns of wood and electricity use among 100 houses that contained both wood-heat output and electricity-use submeters installed as part of the Hood River Conservation Project. Patterns include low-wood/high-electricity, high-wood/low-electricity, and low-wood/low-electricity profiles. Profiles are not differentiable by day of the week but differ widely as outdoor temperatures drop. Small houses tend to use high-electricity/low-wood patterns whereas low-electricity/high-wood patterns are used by larger households and houses.

Research sponsored by the U.S. Department of Energy Bonneville Power Administration.

[4.6.27]

ENERGY SAVINGS DUE TO MODEL CONSERVATION STANDARDS IN MULTIFAMILY BUILDINGS

B. E. Tonn D. L. White
C. Currier*

(Abstract of pp. 2.180-2.194 in *Proc. 1988 ACEEE Summer Study. Energy Effic. Build.*, American Council for an Energy Efficient Economy, Washington, D.C., August 1988)

Over the course of several years, the Bonneville Power Administration and utilities in the U.S. Pacific Northwest have invested significant amounts of money in retrofitting existing dwellings with energy conservation measures. In 1983, region-wide model conservation standards (MCS) were developed to guide the construction of energy-efficient dwellings to preclude the more costly retrofitting process. This paper evaluates energy savings attributable to MCS in the multifamily sector. The savings per square foot range from 15-25%, depending on the modeling approach.

Research sponsored by the U.S. Department of Energy Bonneville Power Administration Office of Energy Resources
*Tacoma Public Utilities, Tacoma, Wash.

[4.6.28]

STANDARDS AND CONVENTIONS FOR THE TOPS USER INTERFACE

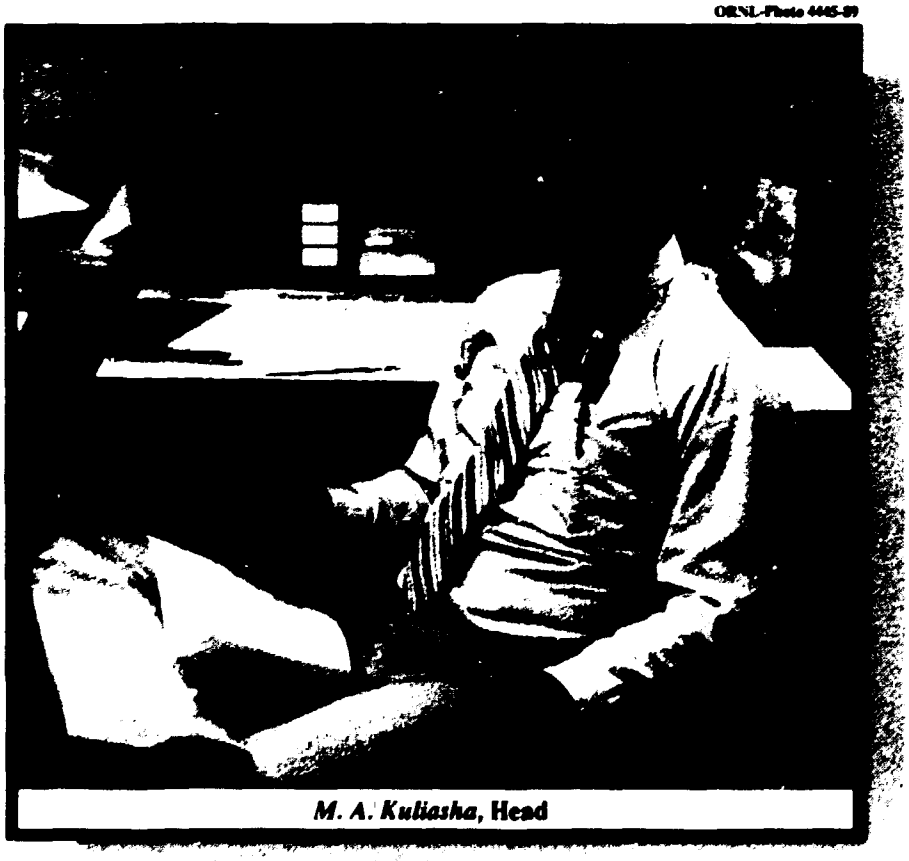
L. F. Truett, S. W. Diegel, J. P. Loftis, P. T. Singley, P. M. Spears, S. S. Stevens, T. G. Yow, P. Meszaros**, K. Kraemer*, E. Wilkinson-Singley†

(Abstract of ORNL/TM-10546, Oak Ridge National Laboratory, August 1988)

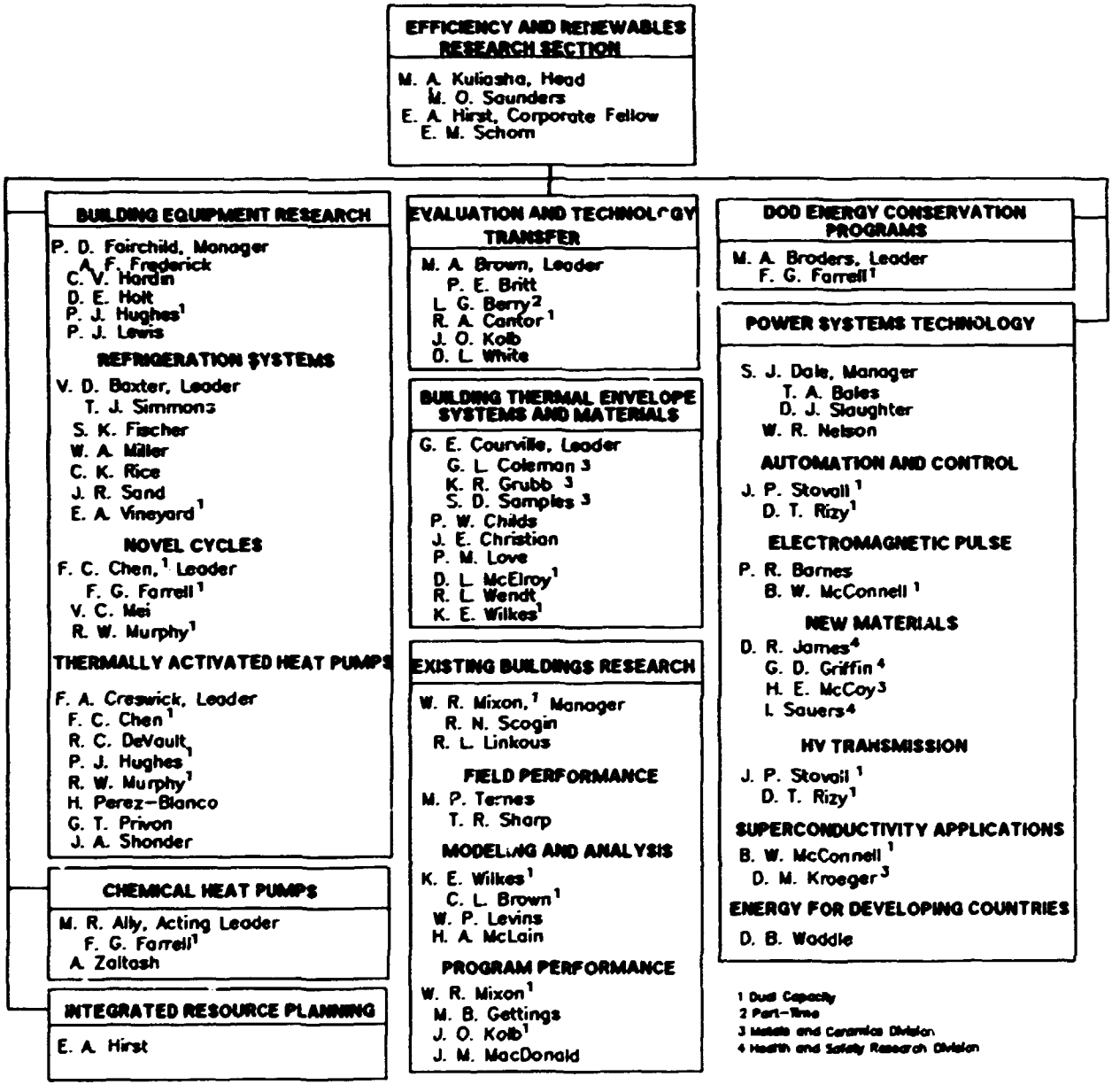
The Transportation Operational Personal Property Standard System (TOPS) is an automated information management system to help administer the personal property transportation program for the U.S. Department of Defense. The standards presented in this report are written to ensure that the user interface for TOPS is consistent among modules, easy for the user to understand, and efficient to use. The standards provide guidance in the design of screens; the programming of function keys; and the implementation of user instructions, error messages, and help files.

Research sponsored by the U.S. Department of Defense Military Traffic Management Command.
*ORACLE Corporation.
**Computing and Telecommunications Division.
†Microtext Technical Communications.

Efficiency and Renewables Research 5



M. A. Kuliasha, Head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J. P. Stovall[1]
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B. W. McConnell[1]
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Efficiency and Renewables Research Section 5

5.1 OVERVIEW

The Efficiency and Renewables Research Section conducts research to improve the efficiency of energy end-use and delivery technologies. The major research areas within the Section encompass energy use in buildings and the transmission, distribution, and use of electric energy. Buildings research includes heating, ventilating, and air conditioning (HVAC) systems; building envelopes and materials; and measures to improve the energy efficiency of existing buildings. Additional work areas within the Section include chemical heat pumps for industrial applications, work for various sponsors evaluating energy conservation programs, research on the technology transfer process, and a new program in integrated resource planning for electric utilities.

5.1.1 Building Equipment Research Program

The Building Equipment Research (BER) program at ORNL, sponsored by the DOE Office of Buildings and Community Systems, has had as its primary emphasis equipment used for space heating and cooling and for providing refrigeration and water heating in residential and commercial buildings. The research pursued in the BER program falls under three activity areas: thermally activated heat pumps, novel cycles, and refrigeration systems.

5.1.1.1 Thermally activated heat pumps

Work at Phillips Engineering Company on the generator-absorber heat exchange (GAX) absorption heat pump for residential applications included construction and successful testing of an outdoor trial unit. Also, a new absorber design shows promise for substantially reduced absorber size and costs, and an experimental gear-type solution pump with ceramic gears and shafts operated over 5000 h with essentially no wear.

United Technologies Carrier neared completion of laboratory testing of the upper loop of their dual-loop absorption heat pump concept. Performance objectives were met and economic studies indicated predictable consumer paybacks within 2 to 3 years in northern-climate commercial building applications. Similarly, The Trane Company completed laboratory testing of its GAX absorption heat pump that is intended for commercial building applications. Economic studies predicted a 1-1/2 year payback in northern climates.

Martin Marietta Energy Systems, Inc., was granted a patent waiver by DOE on a dual-loop triple-effect absorption chiller cycle conceived at ORNL. This next-generation cycle represents a major advancement in cooling performance with a predicted coefficient of performance (COP) of 1.6, which is more than 50% better than current state-of-the-art absorption chiller technology. A nationwide search was conducted in conjunction with ORNL's Office of Technology Applications to find a licensee to further develop the technology. The Trane Company was selected as the licensee, and the Gas Research Institute agreed to co-sponsor the project.

Supporting studies in absorption technology included completion of a worldwide survey of

technical data on absorption fluids by the Institute of Gas Technology[1] and installation and initial operation of an ammonia-water absorber heat and mass transfer test loop at ORNL. A view of the apparatus is shown in Fig. 5.1. Also in 1988, ORNL hosted the Third International Absorption Experts' Meeting.

ORNL's work on Stirling engine-driven heat pumps is concentrated on free-piston Stirling engine-driven heat pumps, with the main effort now focused on a novel magnetically coupled

ORNL-Photo 5381-88

Fig. 5.1. Absorber heat and mass transfer test loop.

transmission/compressor (T/C) development. The magnetic coupling concept promises simplicity, better reliability, and better manufacturability than the hydraulic coupling that had been previously developed under the program. Proof-of-concept tests with this magnetic T/C concept test rig were successfully completed by Sunpower (Fig. 5.2). A preliminary engine-compressor design study was carried out, and an initial estimate of manufacturing cost was judged to be favorable.

The Mark I engine-T/C design developed by Mechanical Technology, Inc., has been improved steadily.[24] The hydraulic coupling has been replaced by a new "dry" T/C design that also uses a magnetic coupling. Based on the dry transmission, a modified system design, Mark II, was completed and a value engineering analysis for the design was performed by a major engine manufacturer, Deere & Co. Substantial component cost reductions and competitive system cost estimates were obtained.

A study by the Massachusetts Institute of Technology[5] (MIT) in support of Stirling engine technology development has resulted in an improved understanding of heat transfer in cylinders and of heat exchangers with fluctuating pressure and flow direction. The work should be useful in Stirling engine simulation and design. A complex-variable correlation has been developed that predicts heat transfer with reasonable success.

Efforts on the free-piston linear internal-combustion engine-compressor development were concerned primarily with the segmented-bellows-type refrigerant seal. The seal performed very well in long-term, multiunit, engine-only durability tests. However, an early failure was experienced in the first test of the seal under refrigerant load in an operating engine-compressor assembly. Work is continuing to evaluate the acceptability of the seal under actual operating conditions.

5.1.1.2 Novel cycles

Novel refrigeration cycle concepts investigated or tested during the year included the superconducting magnetic heat pump

ORNL-Photo 4552-89

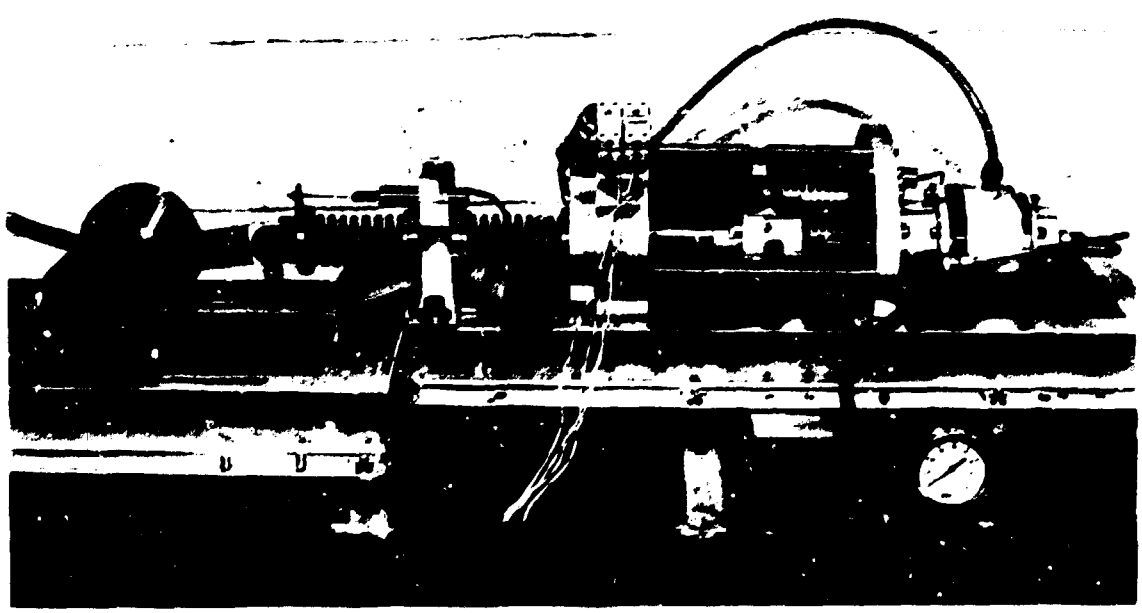


Fig. 5.2. Magnetic transmission/compressor test apparatus.

concept and the electric motor-driven Stirling refrigeration cycle. In addition, flow studies explored a novel ejector heat pump concept.

Laboratory tests were performed to examine the performance of an existing electric motor-driven Stirling cooler that uses helium as the working fluid. Results of the tests have shown that the cooler achieved a maximum thermal efficiency of 18% of the corresponding Carnot efficiency compared with approximately 25% for conventional vapor-compression refrigeration technology. This achievement is viewed as a promising initial indication of the potential of this nonchlorofluorocarbon technology.

5.1.1.3 Refrigeration systems

An important milestone was achieved in capacity modulation research with the completion of the first distribution version of the ORNL variable-speed heat pump design model.[6]

Nonazeotropic refrigerant mixtures (NARMs) have been identified as a means to improve thermodynamic cycle efficiency in vapor compression equipment and as an alternative capacity modulation option. An experimental scoping study at ORNL showed significant capacity modulation potential through NARM composition control using a single-speed compressor.[7] Steady-state cycle efficiency improvement potential was demonstrated last year, although a significant increase in heat exchanger size was required.[8] This improvement prompted a change in the direction of the ORNL NARM activity from concentration on the capacity modulation aspect to investigation of means to improve heat exchanger effectiveness with NARMs. Alternative heat transfer surfaces will be fitted to the ORNL test rig, and the most promising NARM-component refrigerants are to be identified (Fig. 5.3).[9]

Work in the chlorofluorocarbons (CFC) alternatives area continued at a low funding level. An analysis of energy use impacts was completed for a wide range of alternative technologies and severities of CFC restrictions.[10] Study results showed that the energy-use increase would range from 0.2 to 2.2 quads annually, assuming current R22 (HCFC-22) uses were not regulated.

ORNL-Photo 4357-89

A test rig is used to examine system performance of a nonazeotropic refrigerant mixture in a residential heat pump.

ORNL-Photo 8758-87

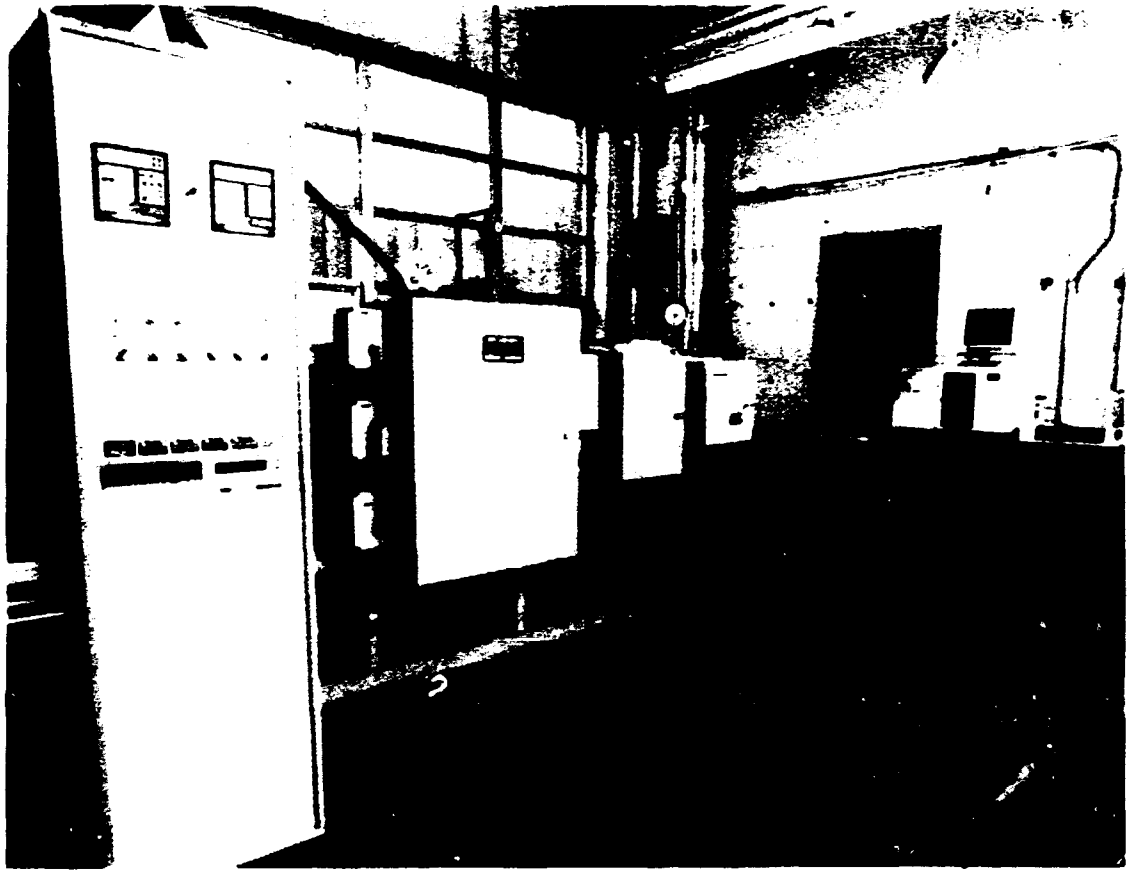


Fig. 5.3. Nonazeotropic refrigerant mixtures breadboard heat pump.

5.1.2 Industrial Chemical Heat Pumps

The Chemical Heat Pump (CHP) program at ORNL is part of DOE's Office of Industrial Programs that encompasses various sorption and CHP hardware concepts. Significant accomplishments within the last year include the completion of a study of the properties of liquid-vapor ternary mixtures,[11] design of a fixed-bed solid-vapor system computer simulation model,[12] simulation studies of absorption heat pumps using aqueous lithium bromide and ternary nitrate mixtures,[13,14] and corrosion tests measuring the rate of stress corrosion cracking of an aqueous nitrate mixture for five commonly used heat exchanger materials.[15]

Energy Concepts Company of Annapolis, Maryland, is testing a new absorption fluid that is an aqueous mixture of lithium, sodium, and potassium salts. Initial testing of a prototype heat pump operating in both temperature-amplifying and heat-amplifying modes showed that steam can be produced by the fluid at temperatures up to about 400°F.[16]

A new project was initiated with Rocky Research of Boulder City, Nevada, to develop a high-temperature solid-vapor heat pump system.

5.1.3 Building Thermal Envelope Systems and Materials

The Building Thermal Envelope Systems and Materials Program, sponsored by the Building Systems Division of the Office of Buildings and Community Systems of DOE, includes research

in the areas of walls, roofs, foundations, and building materials.

The Large Scale Climate Simulator, a major new experimental facility for the program, became operational during the year. This device consists of two large environmental chambers (simulating outdoor and indoor conditions) separated by a test platform for roof systems. Both low-slope (commercial) and pitched (residential) roofing systems up to 3.7 m x 3.7 m can be tested. Results of an early experiment to measure the thermal resistance of various roof insulations over the range of temperatures are shown in Fig. 5.4.

Involved was a series of measurements of the thermal resistance (per inch of thickness) of the materials (phenolic foam and expanded polystyrene insulations) with constant temperature differences across the samples (labeled steady state) and the use of the PROPOR technique to analyze a single dynamic test in which the temperature difference was varied over the range indicated. Agreement between the methods is good, and both methods yield results consistent with steady-state data available from the literature at a single value of temperature (Fig. 5.4). Note the significant difference in thermal resistance per inch for the two materials, due primarily to the fact that the phenolic foam has low thermal conductivity CFC-11 gas trapped in its closed-cell structure while the expanded polystyrene has air. An increase in thermal resistance with decreasing temperature is to be

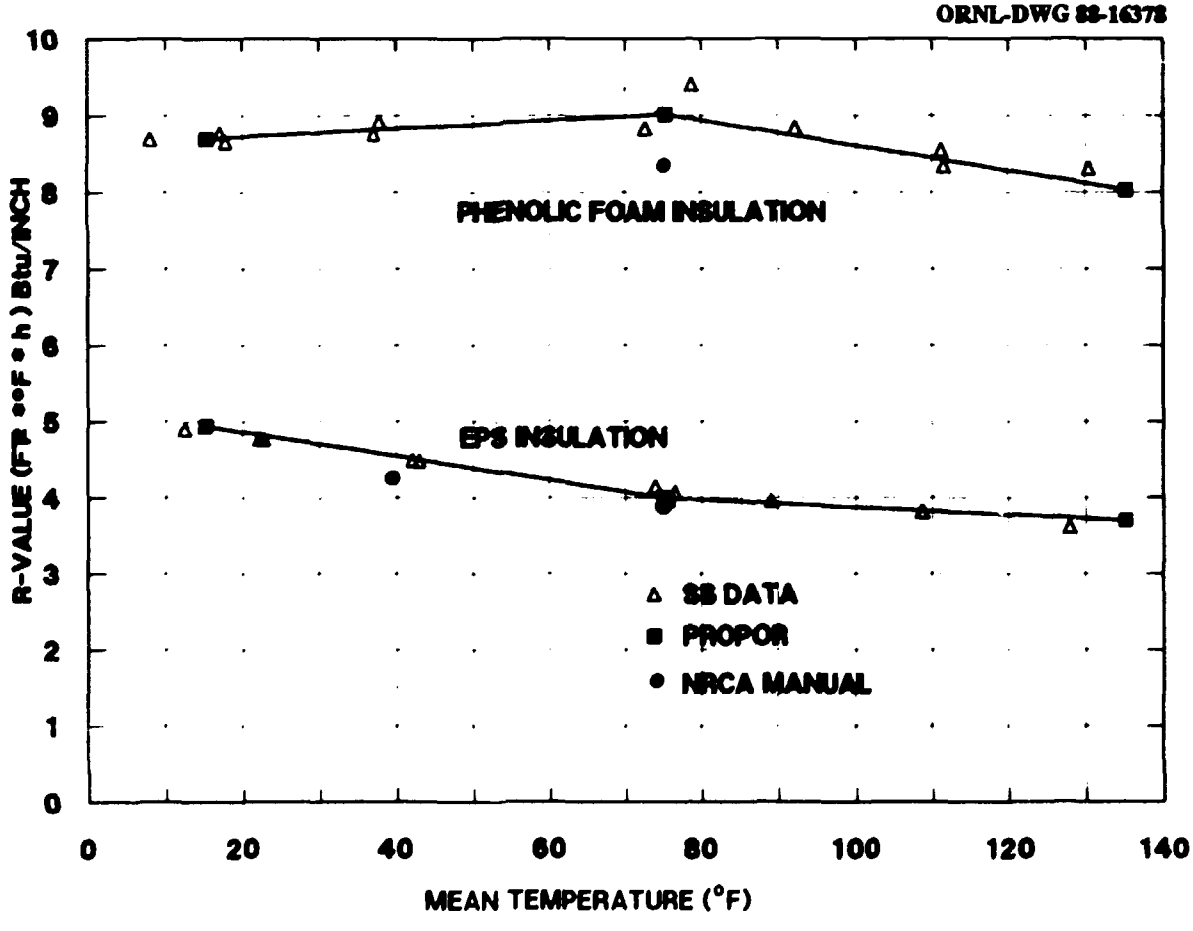


Fig. 5.4. Thermal resistance of roof insulations.

expected for conventional materials. The negative slope of the curve for the phenolic foam below 70°F (21°C) is associated with condensation of some of the CFC-11 gas.

A major consumer oriented fact sheet with recommendations on the appropriate insulation thickness for residential walls, attics, floors, and foundations was prepared and distributed to individuals and to consumer groups.[17] The program is labeled "ZIP" because the method used by consumers to identify their insulation zone is through their zip code.

During 1988, ORNL was active in support of industry efforts to prepare for restrictions in the availability of CFCs for production of foam insulation products. An industry workshop in June 1988 led to preparation of a research menu. In addition, ORNL has been monitoring the loss of thermal resistance in existing foam insulations and has supported an MIT study of radiative heat transfer through foam insulations.[18]

A Building Foundation Design Handbook was published during the year that compiles the latest information in recommended practices for foundation design and installation.[19] ORNL staff also played a significant role in preparing and providing testimony for an accepted set of foundation insulation levels for the Council of American Building Officials Model Energy Code (MEC). The standards for insulation levels were based almost entirely on an ORNL-published American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) technical paper and the Building Foundation Design Handbook. The Council adopted the ORNL recommendations and those for assigning thermal mass credits as a function of the relative location of the exterior envelope mass to the insulation layer.

Adoption of these recommendations into the MEC is a significant step toward increasing the use of these energy-saving technologies because of the incorporation of MEC into local building codes. Efforts are under way to get the MEC adopted as the revised U.S. Department of Housing and Urban Development Minimum Property Standard.

5.1.4 Existing Buildings Research

Research focusing on technical and program implementation issues for improving the energy efficiency of existing buildings is included in three programs for DOE: Existing Buildings Research Program for the Office of Buildings and Community Systems and the Residential and Commercial Conservation Program (RCCP) and the Weatherization Assistance Program, both for the Office of State and Local Assistance Programs.

5.1.4.1 Residential and Commercial Conservation Program

Responsibilities of RCCP include rule making, obtaining state and utility compliance with rules, providing technical information and assistance, and encouraging voluntary actions by state and utility program implementers to promote energy efficiency in all buildings. Efforts this year included publication of a report on the successful "Weatherize Portland" project in Portland, Maine; completion of cooperative support for the development of the ASEAM 2.1 computer software and manual for modeling energy use in buildings; completion of a guidebook on energy strategies for increasing productivity in the veneer and plywood industry (mostly small businesses); development of a report describing utility programs offering energy-efficiency improvements for commercial buildings; and finalization of a technology transfer plan.

5.1.4.2 Single-family buildings

One of the single-family research projects that appears to have significant technical promise is the installation of radiant barriers in attics of single-family houses. Previous experiments that determined the energy performance of radiant barriers showed that the radiant barrier reduced electric consumption for cooling by 15% and heating consumption by 10% in a Knoxville climate.

ORNL-Photo 4356-89

Through the Residential and Commercial Conservation Program, cooperative support was completed for the development of the ASEAM 2.1 computer software and manual for modeling energy use in building.

The FY 1988 experiments examined issues that could adversely affect the installation of radiant barriers. The radiant barrier research has been under joint sponsorship by DOE, the Tennessee Valley Authority (TVA), the Electric Power Research Institute (EPRI), and the Reflective Insulation Manufacturers Association.

The current work has focused on the horizontal barrier, which appears to be more effective than the truss barrier. An experiment conducted in the winter of 1987-88 examined the affect of moisture condensation on the underside of a perforated horizontal radiant barrier. The results of the test showed that moisture went through a diurnal cycle at the research houses. The moisture cycle occurring on a perforated horizontal barrier during a typical Tennessee winter caused no structural, wet insulation, or stained ceiling problems to the research houses.

The summer of 1988 experiment examined the effects of attic radiant barriers incurred by changes in the attic ventilation area, attic ventilation type, and the buildup of dust. The results of the testing showed that increasing the attic ventilation area ratio from the minimum recommended of 1/300 to 1/150 had little if any effect on the house cooling load with either a truss or horizontal radiant barrier. The dust experiment on a horizontal barrier showed measurable performance degradation. However, the dusted barriers were still superior to no radiant barriers.

Preretrofit monitoring, in compliance with the single-family monitoring protocol, was completed for five retrofit field experiments. The city of Austin, Texas, and the consulting firm of W. S. Fleming are determining the conservation benefits of replacing existing central-air-conditioning systems with high-efficiency air-conditioning systems in 15 houses. Their audit estimates savings of 40% of cooling electricity use and 1.5 kW per house of peak demand.

The Oregon Department of Energy and the consulting firm of Lambert Engineering are determining the energy savings resulting from repairing the ducts of central heating systems in Oregon. About one-third of the duct leakage can be economically sealed for an estimated savings of 5% of heating electricity use.

National Fuel Gas of Buffalo, New York, and ORNL staff are field testing the cost effectiveness of a refined audit system for a low-income program. New measures selection procedures are expected to increase energy

savings per dollar spent by 61% compared with results of the Wisconsin field test.

The state of Oklahoma and ORNL staff are evaluating the effectiveness of installing conservation measures to reduce electric cooling costs in low-income homes. The cooling retrofits to be tested include replacing existing window-air-conditioning units with high-efficiency units and adding radiant barriers in the attics of occupied homes.

5.1.4.3 Commercial buildings

The primary focus of the commercial program remains on procedures to provide reasonably consistent analysis and to report results from studies of energy-efficiency improvements. A local field test was initiated last year to study data collection and analysis methods. A field monitoring protocol for data collection has been developed in draft form, and it describes the general procedures for measuring and reporting energy-efficiency improvements.

A study of methods for evaluating the benefits of conducting research and development (R&D) on advanced cooling technologies is being conducted for the Gas Research Institute. Initial results of using gas-cooling technologies in commercial buildings show significant promise, but the benefits are strongly dependent on the rate structure for the competing electricity.

5.1.5 Evaluation and Technology Transfer

The major thrust of the evaluation research of the Evaluation and Technology Transfer Group continues to be detailed quantitative assessments of energy conservation programs. During FY 1988, several evaluation projects were completed. An analysis of residential wood use in the Pacific Northwest concluded that wood use displaces 21% of electricity used for space heating.[20] An investigation of programs that market residential energy conservation to the elderly looked at effective marketing techniques and organizational structures.[21] Several articles on Bonneville's Model Conservation Standards Program, including an analysis of energy savings in multifamily buildings and the results of infiltration testing in homes built to the new code, were completed.[22,23] Findings from these analyses have led to additional ORNL research in the multifamily sector. An evaluation of the Hood River Conservation Project included reports and articles addressing the project's electricity savings, load impacts, wood heat displacement, indoor temperature choice, and the effectiveness of water heater retrofits.

Among the technology transfer projects completed during the year were an assessment of the technology transfer program of DOE's Office of Transportation Systems (OTS) and a compilation of OTS-supported technical accomplishments.[24,25] A technology transfer plan for DOE's Residential and Commercial Conservation Program was developed.[26] An assessment of recent commercial progress of participants in DOE's Energy-Related Inventions Program (ERIP) documented a total of $272 million in sales of ERIP technologies through 1986, which represents a 6:1 return in terms of sales vs program appropriations (Fig. 5.5).[27]

A new international technology transfer initiative was launched, the United States became a member in the International Energy Agency's Center for the Analysis and Dissemination of Demonstrated Energy Technologies, and ORNL began providing support for the U.S. role in the Center. Work also began on a project for DOE's Office of Conservation involving an analysis of the technology transfer strategies used by DOE's five conservation programs.

5.1.6 Integrated Resource Planning for Electric Utilities

A new program was started during the summer of 1987 to assist state regulatory commissions and electric utilities in assessing alternative resources to meet future electric energy service demands. The program is

ORNL-DWG 89-6859

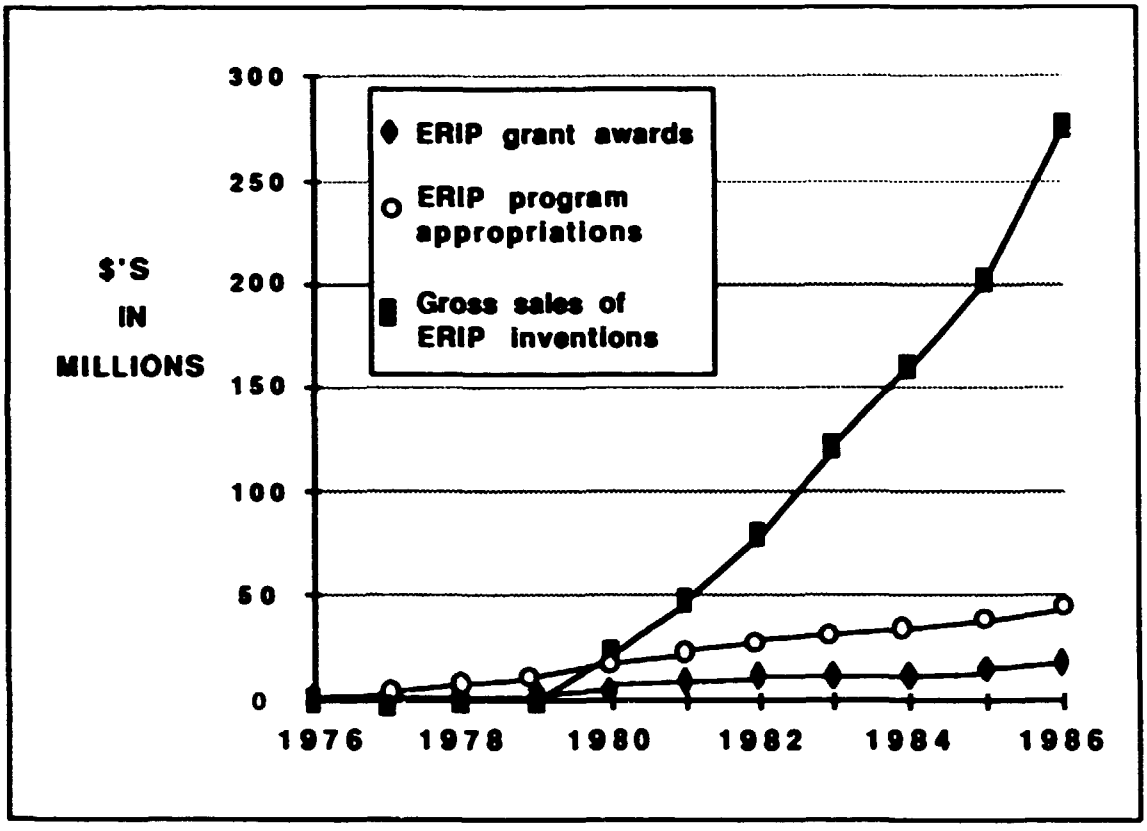


Fig. 5.5. Cumulative invention sales, inventor grants, and appropriations of DOE's Energy-Related Inventions Program.

funded by DOE's Least-Cost Utility Planning Program, Puget Sound Power & Light Company, Pacific Power & Light Company, and the Bonneville Power Administration.

Initially, the work emphasized documentation of the planning activities at Puget Power, where an ORNL staff member spent a year (July 1986 through July 1987), and generalization of that planning experience to other locations. Publications were prepared that described the Puget Power planning process,[28] the basic elements of integrated resource planning,[29] the responsibilities of state Public Utility Commissions for such planning,[30] and the use of marginal-cost-of-service analysis to assess the benefits and costs of different types of utility demand-side management programs.[31]

In early 1988, the work expanded to include three new projects. A review of DOE's Least-Cost Utility Planning Program focuses on the 14 grants made by DOE in the fall of 1987 and involves periodic reviews of their progress.[32] A formal report on the program and its accomplishments will be prepared in the spring of 1989. The second project deals with the treatment of uncertainty in utility planning by review of long-term resource plans from several utilities and related literature. Subsequent interviews with staff from utilities and commissions provided additional insight concerning the methods utilities use to treat

uncertainty in their planning and decision making.[33] Related efforts examined the role of energy-efficiency programs for new buildings in reducing load-growth uncertainties for utilities.[34,35]

5.1.7 Power Systems Technology Program

The objective of the Power Systems Technology Program (PSTP), supported by the DOE Office of Energy Storage and Distribution, is to conduct R&D aimed at meeting the long-term needs of the U.S. utility industry in the areas of transmission and distribution.

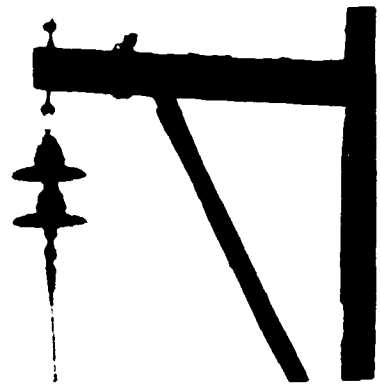
ORNL is the principal research laboratory for the DOE electromagnetic pulse (EMP) program. An important element is the investigation of steep-front short-duration (SFSD) surge impacts on power system insulation. Experiments to determine EMP-induced surge effects on energized equipment and insulators were performed this year. In tests on insulators with 1000-A, 60-Hz fault current, one of the insulators was punctured but did not fracture. When insulators were subjected to a 2500-A fault current, they fractured (Fig. 5.6). In several instances, the suspended lines did not drop even though all of the skirts were blown off and insulation integrity was lost.

In a series of transformer tests performed with tank-mounted arresters, no failures occurred. In tests conducted with the arrester mounted on a crossarm (remote from the transformer), the arrester failed to protect the transformer.

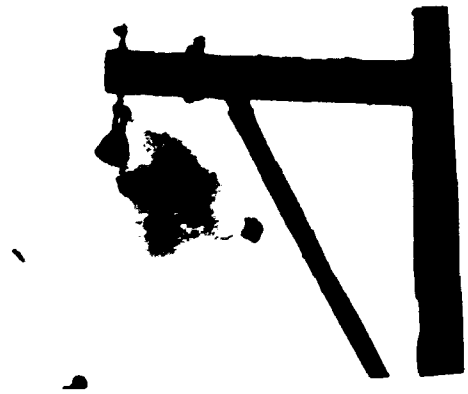
Preliminary conclusions from the SFSD testing include: the faster the rise rate of the impulse, the greater the likelihood of puncture; if available fault current is 2500 A or greater, structural damage is likely; for fault currents of 1000 A or less, structural damage may be delayed; transformer failure can occur with the arrester mounted on the crossarm; and the best protection for transformers is tank-mounted arresters.

Further experiments with the supervisory control and data acquisition system at the

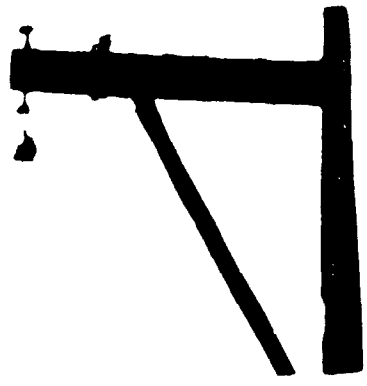
ORNL-Photo 06575-88



(a) PRETEST CONFIGURATION



(b) INSULATOR EXPLOSION DURING TEST



(c) POSTTEST CONFIGURATION

Fig. 5.6. SFSD impulse test of an energized insulator.

Athens Utilities Board showed that the primary potential improvements in capacity utilization through automated feeder reconfiguration are loss reduction and peak load reduction on equipment.

Power Technologies, Inc., has completed measurements and analysis of electric and magnetic fields under an experimental 6-phase line.[36] Figure 5.7 compares the magnetic fields for various line designs and shows that high-phase-order transmission line designs are a realistic option for the electric utility industry to meet future transmission needs within the same or stricter electric and magnetic field criteria.

A number of projects in materials research for power systems were completed during the year. A project at The University of Tennessee has been studying the basic mechanisms of prebreakdown events in liquid insulators. Prebreakdown current pulses have been observed that have been attributed to discharges within the low-density region.[37]

The University of Connecticut–Electrical Insulation Research Center has found that the extent of water-tree formation in extruded polymer power cable insulation increases with the amount of contamination in the semi-con shields and that certain water-soluble contaminants diffuse into the polymer insulation.[38] The testing procedures used in this project produce trees similar to those found in field-aged cables. It was shown that the adverse effect of impurities can be mitigated through adequate cleaning procedures. Technology transfer to

ORNL-DWG 89-6860

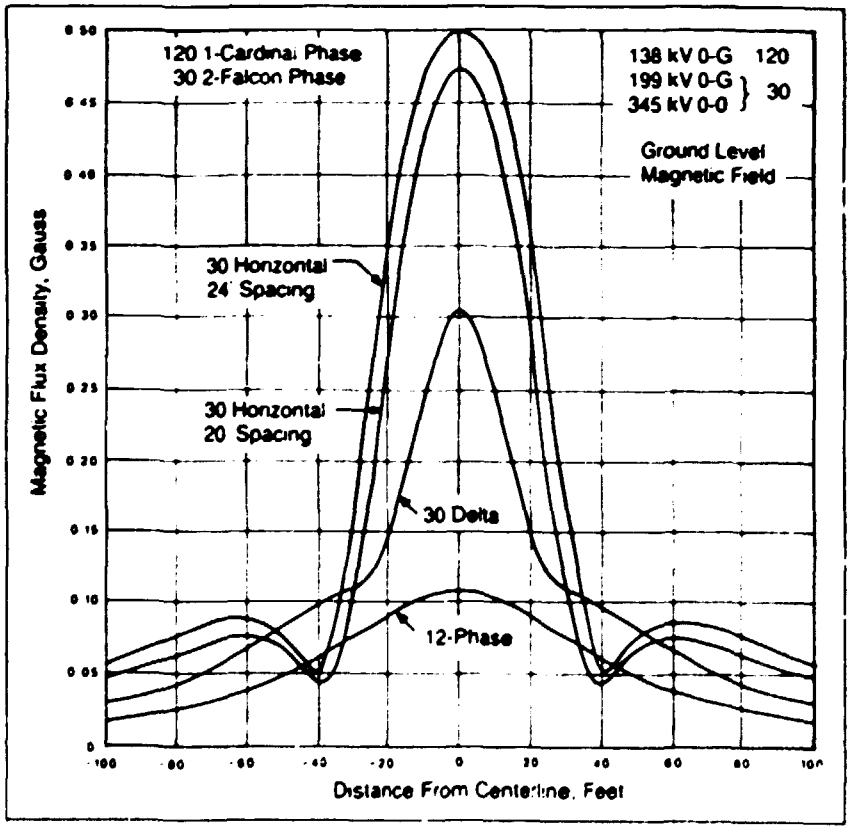


Fig. 5.7. Profile of ground-level magnetic fields for various line designs.

manufacturers such as Union Carbide, Dow Chemical, Cablec, and USI (Quantum) has been highly beneficial.

The decomposition of SF_6 in electrical discharges and the toxicity of the by-products formed are being studied in the Health and Safety Research Division at ORNL to provide basic information relating to environmental concerns, worker safety, and deterioration aging of the insulation system. Strong evidence for the formation of the highly toxic compound S_2F_{10} (ceiling limit 10 ppb) has been obtained in spark and corona discharges in SF_6.[39,40] A program has been planned to address the future research needs in this area and includes development of ultrasensitive detection techniques, formation mechanisms, and ameliorative treatments.

Work has continued in the Metals and Ceramic Division at ORNL to characterize the mechanical, electrical, and thermal properties of polymers for dielectric applications. Tensile strength and fracture strain tests conducted on several polymers over a temperature range from -196 to 200°C showed large variations for a given material and significant differences from one materi.l to another at the same temperature. Aging tests of polymers in SF_6 and N_2 environments under electrical stress and mechanical creep tests in transformer oil have been conducted.[41]

Four national laboratories were involved in an assessment of the energy applications of high-temperature superconductivity. The assessment covered nine energy technology areas of interest to high-temperature superconductivity applications: materials fabrication, material production, separations technology, power electronics, motors, transportation, electromagnetic pumping, magnetic heat pumps, and lighting.

During the Energy Division assessment of motor applications, a unique axial gap superconducting motor design was developed. An earlier permanent magnet design, which was developed by the K-25 Enrichment Technology Applications Center (now the Applied Technology Division of ORNL). was the basis for this design (Fig. 5.8). It uses power electronics for commutation and speed

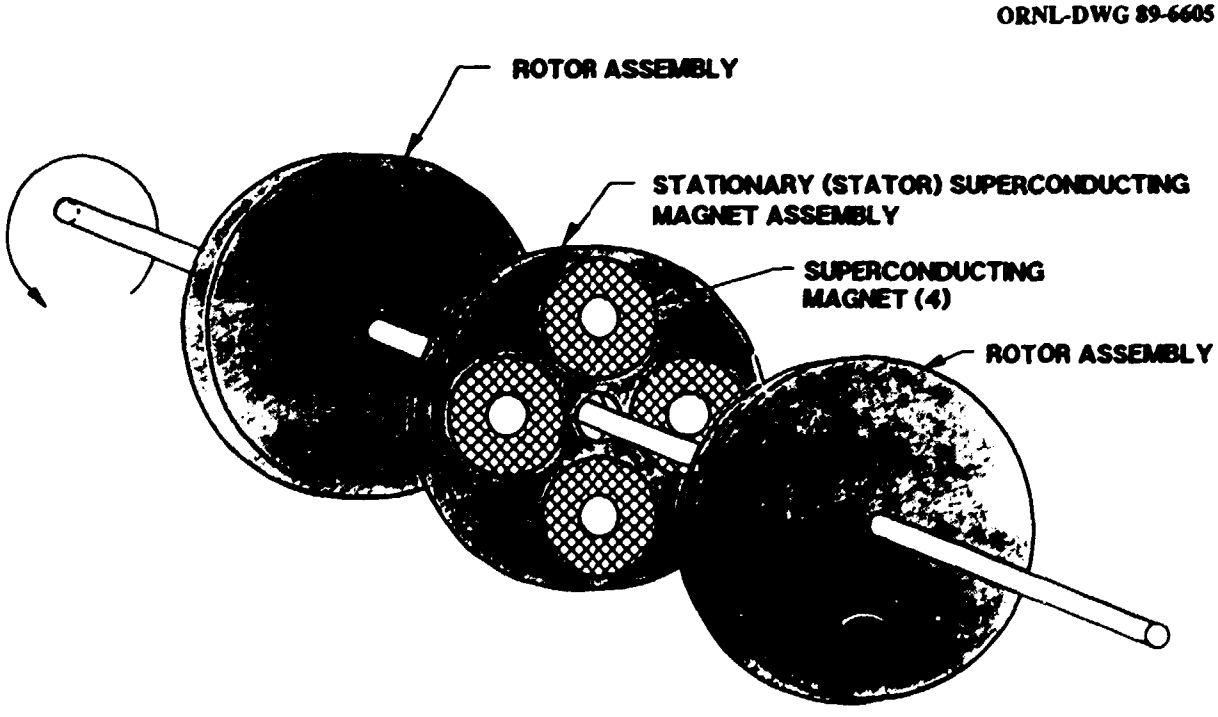


Fig. 5.8. Axial gap superconducting motor.

control and will remove a general dynamics problem that exists in superconducting motors. The concept is the basis for an ORNL Director's Fund project to fabricate the motor using low-temperature superconductors and to establish a general superconducting motor test bed.

5.1.8 Work for Others

As discussed in Sect. 5.1.4, ORNL has tested radiant barriers for DOE, TVA, and EPRI in three unoccupied ranch-style houses near Knoxville, Tennessee. The radiant barriers were found to be effective in reducing both the house cooling and heating loads. These positive results have prompted the U.S. Army Corps of Engineers, Construction Engineering Research Laboratory (CERL), to investigate the amount of energy savings that could be obtained in occupied Army family housing. ORNL prepared an experimental plan and has been responsible for installing data acquisition systems, collecting data, and reporting results from the Fort Benning, Georgia, testing.

Assistance also has been provided to CERL on central heat distribution systems. Pipe heat loss data are being collected from two test sections at Fort Jackson, South Carolina, where the pipes are part of an operational hot water district heating system. ORNL has installed instrumentation and a data acquisition system on two test sections to determine the heat loss from the insulated pipe. One test section is a new-design shallow trench system; the other is a direct-buried piping system. The heat loss data will assist the Army in selecting the type of system to use in the future.

Programs under way for the U.S. Army Corps of Engineers' Engineering and Housing Support Center (formerly Facilities Engineering Support Agency) include validation of energy and cost savings for selected facility retrofit projects under the DOD Energy Conservation Investment Program (ECIP) and evaluation of energy conservation devices and equipment in conjunction with the Army Conservation Equipment Evaluation and Testing Program.

During the reporting period, all ECIP project validation studies were completed (a total of 13 projects) and have been documented in individual project reports; a summary report for the overall ECIP project validation study effort was completed.

As a continuing effort, ORNL further developed the Army Facility Energy Technology Service database management system. At the end of FY 1988, ORNL research staff members had completed selection, screening, and input of bibliographic data to the data base for approximately 950 key documents within the scope of facility energy conservation equipment. ORNL also initiated a program of documenting important Army energy conservation "lessons learned" and disseminating this information to Army installations worldwide.

ORNL staff have developed a *Decision Guide for Roof Slope Selection* for the Air Force Engineering & Services Center.[a] The objective of the guide is to provide Air Force design personnel with a method, based on life-cycle costing, to address typical design questions concerning roof slope. The background study only weakly supported the conventional wisdom that a dead flat roof is more costly to maintain. Other conclusions provided by the work are that (1) positive slope (such that water does not collect) is achieved with a nominal slope of about one-quarter inch per foot of roof length; (2) once a positive roof slope is achieved, adding more slope is seldom cost effective; (3) adding slope to a roof during reroofing is seldom cost effective; and (4) conversion of small buildings from low-slope to pitched roofs usually is cost effective.

A project to develop design guidelines for direct expansion ground coil (DXGC) heat exchangers was undertaken with EPRI sponsorship. A laboratory breadboard DXGC system was constructed, and tests were begun to assess the viability of the concept and to serve as the basis for the design guidelines.

5.2 RESEARCH UTILIZATION

An industry advisory group for the refrigerator-freezer research area was organized in cooperation with the Association of Home Appliance Manufacturers (AHAM) and met to discuss R&D plans for CFC alternatives. The most significant outcome of this initial meeting was the degree of enthusiasm expressed by the industry participants to set up a mechanism for some official cooperative research with DOE/ORNL (through AHAM) through which participants could contribute either money, test data, or analyses. AHAM will investigate possible ways of organizing this effort next year.

Close interaction with the HVAC industry through both the Air-Conditioning and Refrigeration Institute and individual companies continued. A new cooperative agreement with Heil-Quaker, Inc., was initiated to integrate the variable-speed heat pump model into their internal analytical design system and to investigate adding a more detailed heat exchanger subroutine to the model. Representatives of 16 manufacturers attended a workshop early in the year. They voiced strong support for ORNL's analytical modeling work and for our planned system design option analyses (to be completed next year). In addition to the workshop, 12 companies were visited during the year to brief their upper management on ORNL's model development and on the latest Japanese technology developments in this area.

In addition to publication of several ORNL reports and journal articles, our work on integrated resource planning for electric utilities was presented in invited talks at conferences sponsored by EPRI, DOE, the National Association of Regulatory Utility Commissioners, and several electric utilities. ORNL's contribution to Puget Power's planning was presented before the Washington Utilities and Transportation Commission. Staff involved with these efforts are on advisory committees for EPRI and the Boston Edison Company. Finally, the Georgia Public Service Commission asked ORNL to help plan and moderate a conference (held in December 1988) on least-cost planning for Georgia.

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5.4 ABSTRACTS OF PUBLICATIONS

[5.4.1]

COMPUTER SIMULATION OF ABSORPTION HEAT PUMP USING AQUEOUS LITHIUM BROMIDE AND TERNARY NITRATE MIXTURES

M. R. Ally

(Abstract of ORNL/TM-10392, Oak Ridge National Laboratory, June 1988)

A new aqueous ternary mixture consisting of 53 wt % $LiNO_3$, 28 wt % KNO_3, and 19 wt % $NaNO_3$ is available for high-temperature heat pump applications. The pressure-composition-temperature and the specific enthalpy-concentration-temperature data in the form of correlated polynomial expressions are used in a computer program to simulate results of a temperature amplifier heat pump with LiBr/H_2O and ternary nitrate/H_2O mixtures as working fluids. Although the limits of applicability of the two fluids are different, a region of commonality exists where the comparison can be made. The difficulty is a lack of adequate thermophysical data on both mixtures in the temperature ranges of interest. In the absence of adequate thermophysical data for the fluids, the study serves as a best-guess first approximation. The results show that the ternary nitrate mixture potentially has approximately a 10% advantage in coefficient of performance and a 15% advantage in temperature lifts over aqueous LiBr at high temperatures. Ternary nitrates are hampered by crystallization at low waste heat temperatures and cannot operate competitively in the low lift and waste heat temperature regions. The potential performance advantage at high temperatures for the ternary nitrate mixture is sufficiently attractive to justify additional work to obtain adequate thermodynamic transport and corrosion data.

Research sponsored by the U.S. Department of Energy Office of Industrial Programs.

[5.4.2]

DESIGN CONSIDERATIONS FOR FIXED-BED METAL HYDRIDE HEAT PUMPS FOR HIGH-TEMPERATURE BOOSTS

M. R. Ally

[Abstract of *ASHRAE Trans.* 94(1), 267-79 (1988)]

Hydride alloy requirements for industrial size heat pumps (8.8×10^6 W) to achieve temperature amplification of up to 260°C or better are investigated on the basis of the mass transfer zone concept of absorption bed design, cost of energy at 0.474¢/10^6 J, and a return on capital investment of 2 years. The Van't Hoff curves for various metals in the temperature and pressure ranges of interest were found in the literature. Design equations pertaining to overall material and heat balances are presented. The computed results show that even under the idealized conditions of no resistance to mass transfer (stoichiometric

wave front), absence of hysteresis, resilience to poisoning, alloy stability, constant absorption capacity, and alloy durability for 2 years, the estimated alloy required per bed would be between 15,872 and 22,675 kg, depending on the particular alloys chosen. Based on alloy costs of $33/kg and cost of energy at 0.474¢/10^6 J, the allowable metal in each bed for a 2-year payback is 4535 kg. The actual alloy requirements are, therefore, four to five times greater than what process industries are willing to accept.

Research sponsored by the U.S. Department of Energy Office of Industrial Programs.

[5.4.3]

SIMULATED PERFORMANCE OF ABSORPTION HEAT PUMPS USING A MIXED AQUEOUS NITRATE WORKING FLUID

M. R. Ally

(Abstract of *ASME Winter Annual Meeting*, Paper 87-WA/AES-2, Boston, December 1987)

A new aqueous ternary mixture consisting of 53 wt % $LiNO_3$, 28 wt % KNO_3, and 19 wt % $NaNO_3$ is available for high-temperature heat pump applications. The pressure-composition-temperature and the specific enthalpy-concentration-temperature data in the form of correlated polynomial expressions are used in a computer program to simulate results of a temperature amplifier heat pump with LiBr/H_2O and ternary nitrate/H_2O mixtures as working fluids. Although the limits of applicability of the two fluids are different, there is a region of commonality where the comparison can be made. The difficulties are the lack of adequate thermophysical data on both mixtures in the temperature ranges of interest. In the absence of adequate thermophysical data, the study serves as a "best case" first approximation. The results show that the ternary nitrate mixtures potentially have approximately a 10% advantage in coefficient of performance and a 15% advantage in temperature lifts over aqueous lithium bromide mixtures at high temperatures. Ternary nitrates are hampered by crystallization at low waste heat temperatures and cannot operate competitively in the low-lift and temperature-boost regions. This potential performance advantage at high temperatures for the ternary nitrate mixtures is justification for additional work to obtain adequate thermodynamic transport and corrosion data.

Research sponsored by the U.S. Department of Energy Office of Industrial Programs.

[5.4.4]

VAPOR LIQUID EQUILIBRIUM (VLE) AND ENTHALPY-CONCENTRATION-TEMPERATURE (H-X-T) CORRELATIONS FOR TERNARY NITRATE MIXTURES

M. R. Ally

[Abstract of *ASHRAE Trans.* 94(2), 631-40 (June 1988)]

Ternary nitrate mixtures represent a new class of high-temperature working fluids for chemical heat pumps. Water is the refrigerant, and the solute is composed of 53 wt % $LiNO_3$, 28 wt % KNO_3, and 19 wt % $NaNO_3$. The fluid mixture is a competitor to existing chemical heat pump fluids and operates up to 260°C (500°F) without causing corrosion problems. This paper develops polynomial expressions using least square fit techniques that correlate experimental vapor-liquid-equilibrium and specific enthalpy-concentration data for the aqueous nitrate mixture. These equations are necessary for computer simulation of heat pump cycles.

Research sponsored by the U.S. Department of Energy Office of Industrial Programs.

[5.4.5]

DEVELOPMENT OF A HIGH-TEMPERATURE ABSORPTION FLUID FOR TYPES I AND II INDUSTRIAL HEAT PUMPS

S. L. Richlen* M. R. Ally

(Abstract of a paper presented at the International Energy Agency Annex IV, Japan, April 1988)

This paper describes a particular project in the development of a high-temperature absorption fluid known as alkitrate by Energy Concepts Company (EC) of Annapolis, Maryland. First, the thermodynamic properties of the alkitrate are described in terms of the pressure-composition-temperature and enthalpy-composition-temperature characteristics. Second, the performances of this fluid are compared with that of lithium-bromide (LiBr) mixtures in computer simulations. Third, actual data and operating conditions from a laboratory-scale prototype unit are described. Finally, near-term research on the alkitrate is discussed

Research sponsored by the U.S. Department of Energy Office of Industrial Programs.
*U.S. Department of Energy.

[5.4.6]

STEEP-FRONT SHORT DURATION VOLTAGE SURGE TESTS OF POWER LINE FILTERS AND TRANSIENT VOLTAGE SUPPRESSORS

P. R. Barnes T. L. Hudson*

[Abstract of *IEEE Trans.*, Paper No. 88 SM 541-5, (July 1988)]

Steep-front short-duration voltage surge tests were conducted on commercially available power-line filters and two types of transient voltage suppressors to determine their effectiveness for protection against nuclear electromagnetic-pulse (EMP)-induced power-line transients. The tested power-line filters were single-phase industrial-type units in the 120/208-V and 277/480-V class rated at 100 or 200 A. The vulnerability of power-line filters to the simulated EMP-induced surges was also inferred from the test results. It is found that the tested power-line filters provide from 38 to 54 dB of attenuation for steep-front voltage surges (20- to 40-ns rise time and 150- to 400-ns fall time to half-value waves for 2- to 20-kV peak voltage) and that transient voltage suppressors add an additional 2 to 8 dB of attenuation. Also, while the tested power-line filters provide good protection against EMP-induced surges, degradation of the filter characteristics may occur, and delayed failures of filter components are possible. Transient voltage suppressors reduce the EMP-induced surge by 40% and thus provide some protection for the filter.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
*Engineering Division.

[5.4.7]

EARLY-TIME RESPONSE OF AN INFINITELY LONG WIRE ABOVE A FINITELY CONDUCTING PLANE EARTH TO A TRANSIENT PLANE WAVE

P. R. Barnes R. A. Stevens

[Abstract of *Electromagnetics* 8(2-4), 159-70 (1988)]

This paper discusses the early-time responses of overhead lines to an exponentially decaying electromagnetic transient and investigates the early-time current, voltage, and radial electric field induced in a wire. A transient electromagnetic plane wave produces the driving electromagnetic force for the wire. The wire, which is assumed to be infinitely long and perfectly conducting, is situated above a finitely conducting plane earth. The plane wave is assumed to have its magnetic field perpendicular to the axis of the wire. The time history of the plane wave is described by a 50-kV/m decaying exponential pulse. It is found that peak currents of over 5 kA and associated voltage crests of several megavolts occur for small incident wave angles. These values are comparable to small lightning strikes to power transmission line structures. The rates of rise of the induced currents are greater than

100 kA/μs, which exceeds the maximum rate of rise of nearly all lightning negative first strokes.

Research sponsored by the U.S. Department of Energy Storage and Distribution.

[5.4.8]

EXPERIMENTAL DETERMINATION OF THE EFFECTS OF STEEP-FRONT SHORT-DURATION SURGES ON 25 KVA MOUNTED DISTRIBUTION TRANSFORMERS

C. H. Eichler* J. L. Legro*
P. R. Barnes

[Abstract of *IEEE Trans.*, Paper No. 88 SM 545-6 (July 1988)]

Steep-front short-duration (SFSD) surges have been implicated in the failure of distribution transformers. Researchers, through calculations and measurements, have determined that surges with rise times of less than 100 ns may occur as a result of lightning, SF_6 switching, and nuclear electromagnetic pulse. This paper documents a series of directly injected, SFSD surge tests performed on standard, commercial distribution transformers. The tests were conducted at Maxwell Laboratories, San Diego, in October 1986. The objectives of the tests were to (1) verify the insulation integrity of a small sample of pole-mounted distribution transformers of types commonly used by electric utilities, (2) subject these transformers to directly injected SFSD electrical surges, (3) determine the dielectric withstandingness of the transformers to such surges, and (4) complete the evaluation of transformer failure modes through disassembly of failed units at a transformer manufacturing facility.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
*Westinghouse Electric Corporation

[5.4.9]

A MULTICONDUCTOR MODEL FOR DETERMINING THE RESPONSE OF POWER TRANSMISSION AND DISTRIBUTION LINES TO A HIGH ALTITUDE ELECTROMAGNETIC PULSE (HEMP)

F. M. Tesche* P. R. Barnes

[Abstract of *IEEE Trans.*, Paper No. 88 SM 601-7, (July 1988)]

A method for determining the response of a multiwire transmission or distribution line to a high-altitude electromagnetic pulse excitation is discussed. An aboveground multiconductor model is developed to take into account wire-to-wire coupling, the earth

reflection and line propagation effects, and the effects of periodic grounding of shield or neutral conductors along the line. Sample numerical results are also presented.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
*LuTech, Inc., Lafayette, Calif.

[5.4.10]

DEVELOPMENT OF A NEW HIGH ALTITUDE ELECTROMAGNETIC PULSE (HEMP) ENVIRONMENT AND RESULTING OVERHEAD LINE RESPONSES

F. M. Tesche* P. R. Barnes

[Abstract of *Electromagnetics* 8, 213-39 (1988)]

This paper discusses the development of two alternate unclassified electromagnetic pulse (EMP) environment descriptions: one arising from a simple radiating dipole moment model, and the other resulting from a curve-fitting of the calculated fields from a computer code named CHAP. For both of these EMP models, the electric fields at two observation points are compared. These fields are then coupled to an aboveground line, and the resulting open-circuit voltage responses are compared. Using the CHAP EMP environment, a limited parametric study of the peak positive and negative open-circuit line voltage is then performed and surface plots of these peak voltages are presented.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
*LuTech, Inc., Lafayette, Calif.

[5.4.11]

EXTRAPOLATION OF MEASURED POWER SYSTEM RESPONSE DATA TO HIGH-ALTITUDE EMP EXCITATION

F. M. Tesche* P. R. Barnes

[Abstract of *IEEE Trans. Electromagn. Compat.* 30(3), 386-92 (August 1988)]

This paper discusses pulse injection measurements performed on an electrical generation plant in Sweden and illustrates how these data may be used to calculate the high-altitude electromagnetic pulse (HEMP) response of the system when it is connected to the power grid. It is found that the HEMP-induced current surges in overhead transmission lines are significantly attenuated as they propagate from the switchyard to the generator output terminals.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
*LuTech, Inc., Lafayette, Calif.

[5.4.12]

THE HEMP RESPONSE OF AN OVERHEAD POWER DISTRIBUTION LINE

F. M. Tesche* P. R. Barnes

[Abstract of *IEEE Trans.*, Paper No. 88 SM 602-5, (July 1988)]

This paper provides estimates of the transient voltage surges induced by a high-altitude nuclear detonation across a transformer in a single-phase distribution line. A multiconductor line coupling model is used, along with a newly-developed high-altitude electromagnetic pulse (HEMP) environment. For this study, both the open-circuit voltage across the transformer and the loaded voltage are considered. To obtain reasonable data for the frequency domain analysis used here, measured data of the pulse response of the transformer are used to obtain its input impedance in the required frequency range. The paper concludes with summary curves of the probability of exceeding specified voltage levels at the transformer.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
*LuTech, Inc., Lafayette, Calif.

[5.4.13]

OVERVIEW OF GROUND COUPLED HEAT PUMP RESEARCH AND TECHNOLOGY TRANSFER ACTIVITIES

V. D. Baxter V. C. Mei

[Abstract of pp. 75-82 in *Proc. 2d DOE/ORNL Heat Pump Conf.*, CONF-8804100 (August 1988)]

This paper presents highlights of DOE-sponsored ground-coupled heat pump (GCHP) research at Oak Ridge National Laboratory (ORNL). ORNL, in cooperation with Niagara Mohawk Power Company, Climate Master, Inc., and Brookhaven National Laboratory, developed and demonstrated an advanced GCHP design concept with shorter ground coils that can reduce installed costs for northern climates. In these areas, the design also can enhance the competitiveness of GCHP systems vs air-source heat pumps by lowering their payback from 6-7 years to 3-5 years. Ground coil heat exchanger models (based primarily on first principles) have been developed and used by others to generate less conservative ground coil sizing methods. An aggressive technology transfer initiative has been undertaken to publicize results of this research and make it available to the industry. This effort has included an international workshop, trade press releases and articles, and participation in a live teleconference on GCHP technology.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.14]

GAS HEATING SYSTEM RETROFITS FOR LOW-INCOME HOUSEHOLDS: EVALUATION RESULTS AND FUTURE DIRECTIONS

L. G. Berry P. Witte*

[Abstract of *Energy Sys. Policy* 12(2), 119-34 (1988)]

Evaluations were conducted of pilot programs, implemented in Kentucky, Minnesota, Michigan, and Pennsylvania, which were designed to encourage the inclusion of gas heating system retrofits in the Weatherization Assistance Program (WAP). The evaluations found that energy savings from the retrofits were less than anticipated and that the retrofits were not cost effective. The retrofits examined included heat extractors, power gas burners, electronic ignition and electric vent dampers, thermally actuated vent dampers, and tune-ups. The paper concludes that gas heating system retrofits do not save much energy unless great care is taken in their application. Without extensive furnace selection procedures and careful training and quality control, technically possible reductions in consumption will not be achieved. For the inclusion of heating system retrofits in WAP to be cost effective, better technical understanding and more highly individualized approaches to retrofit selection are required and the problem of developing organizational arrangements that can deliver highly individualized and technically demanding services must be solved. The incorporation of furnace retrofits into WAP is not recommended because furnace replacement is easier to implement and may be more cost effective.

Research sponsored by the U.S. Department of Energy Bonneville Power Administration.
*Michigan Public Service Commission, Lansing, Mich.

[5.4.15]

MARKETING AND DESIGN OF RESIDENTIAL ENERGY CONSERVATION PROGRAMS FOR THE ELDERLY

L. G. Berry M. Schweitzer
E. Freeman*

(Abstract of ORNL/CON-246, Oak Ridge National Laboratory, February 1988)

Because of barriers to energy conservation, the elderly have a greater need for programs that assist with the installation of energy-efficiency improvements. This report contains descriptions of 39 energy conservation programs for the elderly. Telephone interviews were conducted with the managers of these programs to identify marketing techniques and organizational structures. Interagency networking, presentations, and referrals are the most common methods of recruiting clients. Other marketing techniques in order of the frequency of use are direct mail, bill inserts, television, radio, printed materials, and telemarketing. Many managers consider word-of-mouth advertising from satisfied clients the most effective form of marketing. Interagency networking and support (financial, structural, and in-kind) can offer real advantages in the operation of conservation programs for the

elderly. The use of specific marketing techniques is probably less important to success in recruiting clients than the degree of trust potential clients have in the sponsoring organization(s).

Research sponsored by the U.S. Department of Energy Office of State and Local Assistance Programs.
*The University of Tennessee, Knoxville.

[5.4.16]

A POST-INSTALLATION REVIEW OF THE ENERGY MONITORING AND CONTROL SYSTEM AT RED RIVER ARMY DEPOT

F. D. Boercker J. A. McEvers*

(Abstract of ORNL/TM-10137, Oak Ridge National Laboratory, February 1988)

This document reports findings of a postretrofit validation study of the energy savings effected from an energy-monitoring and control system (EMCS) installed at the Red River Army Depot (RRAD) in November 1983. Because of system performance level and the lack of adequate energy metering, an accurate savings-to-investment ratio (SIR) could not be obtained. However, it was apparent that the system was not being used at full potential as a result of technical and administrative problems. Although the hardware for the EMCS is of good quality and has been installed in an organized manner, the system has never operated at full capability. Currently, the system saves little energy, and its SIR is less than 1.0. If the system were brought up to full operating capacity, its energy savings would increase but so would the total investment. This is the major dilemma facing those who must determine the future of the EMCS at RRAD.

Research sponsored by the U.S. Army Facilities Engineering Support Agency.
*Instrumentation and Controls Division.

[5.4.17]

FINAL REPORT: VALIDATION OF ECIP PROJECT NO. 87 ENERGY AND COST SAVING ANALYSIS OF MILITARY WAREHOUSE RETROFIT HIGH-PRESSURE SODIUM LIGHTING SYSTEM, OAKLAND ARMY BASE, CALIFORNIA

M. A. Broders M. S. Hileman*

(Abstract of ORNL/CON-230, Oak Ridge National Laboratory, November 1987)

Oak Ridge National Laboratory was selected by the U.S. Army to validate new energy-efficient lighting systems that were installed in five Oakland Army Base warehouses as a U.S. Department of Defense Energy Conservation Investment Program (ECIP) project. This ECIP project was justified on the basis of electrical energy and cost savings that would result from the replacement of 40-year-old incandescent lighting systems with new high-pressure-sodium (HPS) lighting systems. Based on warehouse usage, it is projected that

approximately 545 MWh (1861 MBtu) of electrical energy will be saved annually as a result of the installation of the more energy-efficient HPS lighting systems. These energy savings equate to first-year cost savings of approximately $103,000, a discounted savings-to-investment ratio of approximately 1, and a simple payback period of about 8 1/2 years. During periods when warehouse operations are increased significantly, these projected energy and cost savings increase significantly. Based on the results of this ECIP project validation study, it can be concluded that replacement of obsolete incandescent lighting systems with energy-efficient HPS lighting systems in Oakland Army Base military warehouses results in only marginal electrical energy and cost savings. Lighting system utilization is, however, a critical factor. In general, if warehouse lighting systems are operated more than 40% of the time, desired energy conservation and cost saving goals may be achieved, and installation of more energy-efficient lighting systems may become an economically viable alternative.

Research sponsored by the U.S. Department of the Army Facilities Engineering Support Agency.
*Instrumentation and Controls Division.

[5.4.18]

FINANCING ENERGY CONSERVATION: INNOVATIVE APPROACHES WITH GEOGRAPHIC PROBLEMS

M. A. Brown

[Abstract of *Can. Geogr.* 32(2), 169-72 (August 1988)]

Creative financing approaches to energy conservation are playing an increasingly important role as a means of financing energy conservation investments. Problems associated with implementing these approaches include (1) controlling for the impacts of weather, (2) implementing conservation at the community level, and (3) the behavioral takeback effect. This paper highlights the role that geographers could play in solving these problems.

Research sponsored by the U.S. Department of Energy Office of State and Local Assistance Programs.

[5.4.19]

HOW INFLUENTIAL IS THE AUDITOR? DETERMINANTS OF SALES EFFECTIVENESS IN ENERGY CONSERVATION PROGRAMS

M. A. Brown L. G. Berry
D. L. White D. Trumble

[Abstract of *Energy Syst. Pol.* 12(2), 135-49 (April 1988)]

This paper examines the determinants of auditor effectiveness in selling energy conservation to homeowners and reports the results of an analysis of the effectiveness of

energy auditors employed by the Florida Power and Light Company. These auditors market five conservation incentive programs to residential customers. Identification of the determinants of their closure rates (i.e., number of incentive program participants per 100 audits) is the subject of the analysis. The analysis shows that closure rates vary widely across auditors and are highly dependent upon the nature of the households and homes being audited. After household effects are removed, the additional variation explained by auditor characteristics averages about 20%. Among all the auditor characteristics examined, extroversion is the best predictor of customer response. Those auditors rated as extroverted by their supervisors have customer participation rates 17% higher than the rates for introverted auditors.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.20]

TECHNICAL ACCOMPLISHMENTS OF DOE's OFFICE OF TRANSPORTATION SYSTEMS

S. A. Snell* M. A. Brown
S. C. Davis**

(Abstract of ORNL/CON-267, Oak Ridge National Laboratory, September 1988)

The *Transportation Energy Data Book: Edition 9* is a statistical compendium prepared and published by Oak Ridge National Laboratory under contract with the Office of Transportation Systems in the U.S. Department of Energy. Designed for use as a desktop reference, the data book represents an assembly and display of statistics and information that characterize transportation activity and presents data on other factors that influence transportation energy use. This document presents relevant statistical data in the form of tables and graphs. Each major transportation mode–highway, air, water, rail, pipeline–is treated in a separate chapter or section.

Research sponsored by the U.S. Department of Energy Office of Transportation Systems.
*Hagler, Bailly & Company, Washington, D.C.
**The University of Tennessee, Knoxville.

[5.4.21]

TECHNOLOGY TRANSFER FOR DOE'S OFFICE OF TRANSPORTATION SYSTEMS: ASSESSMENT AND STRATEGIES

S. A. Snell* M. A. Brown
A. M. Zerega**

(Abstract of ORNL/CON-241, Oak Ridge National Laboratory, April 1988)

The technology transfer effort of the U.S. Department of Energy's Office of Transportation Systems (OTS) in offering recommendations for future technology transfer activities is reviewed and assessed in this report. The OTS technology transfer strategy calls for maximum industry involvement in both the identification and solution of research and development problems. This strategy is supported not only by using industry as the research contractor but also through a variety of other technology transfer activities. An inventory of recent OTS technology transfer activities is compiled, and detailed case studies of nine of these are completed that represent five distinct approaches to technology transfer and a wide array of mechanisms, including contracting to industry, licensing, demonstration projects, user facilities, and financial incentives. Interviews with program managers and researchers and a review of the literature revealed more than 80 OTS accomplishments.

Research sponsored by the U.S. Department of Energy Office of Conservation and Renewable Energy.
*Hagler, Bailly & Company, Washington, D.C.
**U.S. Department of Energy.

[5.4.22]

THE COMMERCIALIZATION PROCESS AND FUTURE ENERGY OPTIONS

M. A. Brown S. A. Snell*

[Abstract of *Proc. Int. Symp. Energy Options Year 2000* 2, 225-34 (September 1988)]

The commercialization of new energy technologies is a complex, difficult process. Few energy-related inventions are successfully translated into products; once on the market, many do not survive. Reasonable predictions about energy options in the year 2000 require a full understanding of the commercialization process as it pertains to new energy technologies. Drawing upon the experiences of the U.S. Department of Energy's Energy-Related Inventions Program (ERIP), this paper outlines some of the patterns, processes, and problems related to the commercialization of new energy technologies. Energy price fluctuations, inadequate investment capital, insufficient market demand, and inappropriate commercialization strategies are common problems besetting ERIP inventors.

Research sponsored by the U.S. Department of Energy Office of Conservation and Renewable Energy.
*Hagler, Bailly & Company, Washington, D.C.

[5.4.23]

STIMULATING ENERGY CONSERVATION BY SHARING THE SAVINGS: A COMMUNITY-BASED APPROACH

M. A. Brown D. L. White

[Abstract of *Environ. Plann.* 20(4), 517-34 (April 1988)]

This paper evaluates a novel shared-savings approach to residential energy conservation. The shared-savings program (RECAP) has reduced annual electricity consumption by 1556 kWh per household, or 6.6% of preretrofit consumption. Energy savings differ markedly across the four communities served by RECAP and are only weakly associated with installation costs. Savings are greater where audits are used to select participants with significant potential for conservation; households with large preretrofit electricity consumption generate particularly large savings. Regression analysis of survey data suggests that the net impact of behavioral and household changes upon electricity savings is minimal.

Research sponsored by the U.S. Department of Energy Office of Conservation and Renewable Energy.

[5.4.24]

IMPACT OF THE HOOD RIVER CONSERVATION PROJECT ON ELECTRICITY USE FOR RESIDENTIAL WATER HEATING

M. A. Brown D. L. White
S. L. Purucker

(Abstract of ORNL/CON-238, Oak Ridge National Laboratory, October 1987)

This report discusses the water-heater conservation results from the Hood River Conservation Project (HRCP), a 2-year experiment in which residential customers were monitored for 1 year before and after the installation of conservation measures. Monitoring involved recording electricity use at 15-min intervals for total consumption, space heat, and water heat. The principal findings are as follows:

- Average annual electricity savings for water heating are 542 kWh during the first year after retrofit, or 8.4% of preretrofit water-heater use.
- Average winter electricity savings are 12.2% per household.
- One-fourth (26%) of the total electricity savings of HRCP are the result of water-heater conservation measures, while these measures cost only 0.5% ($20) of the average total cost per household.
- Each first-year kWh of savings costs less than $0.04, representing a payback period of less than one year.
- Water-heater demand decreased by 0.09 kW during winter weekdays, at a cost of only $228 per kW.

- Most of the annual kWh savings are attributable to the water-heater wrap; it is estimated that each wrap saved an average of 714 kWh.
- The best predictor of water-heater savings is the preretrofit level of water-heater electricity use.

Research sponsored by the U.S. Department of Energy Bonneville Power Administration.

[5.4.25]

A NEW TECHNOLOGY TRANSFER PROCESS FOR DOE'S RESIDENTIAL AND COMMERCIAL CONSERVATION PROGRAM

M. A. Brown D. L. White
R. Vories* S. Kirchen**

(Abstract of ORNL/M-529 Oak Ridge National Laboratory, September 1988)

This report provides a technology transfer plan for DOE's Residential and Commercial Conservation Program (RCCP). It catalogs and classifies the types of research results and lessons developed and disseminated and examines the audiences for these results. The report then describes the process of assessing needs, analyzing potential technology transfer mechanisms, and evaluating progress that should be part of the technology transfer process for RCCP and its individual projects. A technology transfer strategy is proposed, and future technology transfer activities are recommended. A set of seven worksheets is also developed to help RCCP program managers design outreach efforts for their current and future projects.

Research sponsored by The Department of Energy Office of State and Local Assistance Program.
*Infinite Energy.
**U.S. Department of Energy.

[5.4.26]

AN OVERVIEW OF THE STIRLING ENGINE HEAT PUMP PROGRAM

F. C. Chen

(Abstract of pp. 177-88 in *Proc. 2d DOE/ORNL Heat Pump Conf., Washington, D.C., April 17-20, 1988*, CONF-8804100, August 1988)

This paper summarizes the recent developments in the Stirling engine-driven heat pump program activities sponsored by the U.S. Department of Energy through Oak Ridge National Laboratory. This technology has displayed its ability to meet thermal performance objectives. Enhanced technology options guided by value-engineering principles are being pursued toward the development of an economically viable household engine-driven heat pump.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.27]

IMPACT OF CFC RESTRICTIONS ON U.S. BUILDING FOUNDATION THERMAL PERFORMANCE

J. E. Christian

(Abstract of ORNL/CON-245, Oak Ridge National Laboratory, December 1987)

This report assesses the potential impact on energy conservation goals and develops a research plan to mitigate the impacts of restricting the use of chlorofluorocarbons (CFCs) in foundation insulation applications. Four foundation insulating scenarios from a worst case to a best case are examined. Clearly, some substitution of other foundation insulations will occur and an alternative blowing agent eventually will be developed. The analysis concludes that the impact of CFC restrictions on foundation energy savings will range from near 0 to 0.8 quad/year in the year 2010, with the most likely impact being about 0.13 quad/year.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.28]

THE FUTURE OF FOUNDATION INSULATION IN A NON-CFC PRODUCING ECONOMY

J. E. Christian

(Abstract of a paper presented at the *Substitutes and Alternatives CFCS and Halons, Jan. 13-15, 1988, Washington, D.C.*, April 1988)

This report addresses the energy-saving impacts based on state-level data of chlorofluorocarbon (CFC) restriction on foundation insulation and concludes that the total impact could be from near 0 to 0.8 quad in the year 2010, with the most likely impact being about 0.13 quad/year (quad = 10^{15} Btu). The risk of high impacts can be reduced by an accelerated research effort focused on developing and demonstrating alternative insulated foundation systems that have an overall performance equivalent or superior to that of exterior extended polystyrene insulated basement walls, crawl space walls, and slab-on-grade systems. Alternative products are batts placed on interior below-grade walls. Disadvantages of this approach are built on theory, without substantial field data validation. Insulation-drainage board products are viable alternatives when foundation drains are correctly installed. For relatively shallow foundation walls that are accompanied by good drainage characteristics, higher-quality molded expanded polystyrene boards may be suitable.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.29]

TECHNIQUES FOR IN SITU DETERMINATION OF THERMAL RESISTANCE OF LIGHT WEIGHT BOARD INSULATIONS

G. E. Courville J. V. Beck*

[Abstract of *Heat Transfer Build. Struct.* 78, 7-15 (March 1988)]

This paper describes and compares four techniques for determining the in situ thermal resistance of rigid board insulation installed in conventional low-sloped roofs. All techniques use measured temperature distributions and heat fluxes in the roof systems. Three of the methods, the averaging technique, the steady state least squares technique, and the absolute value technique are all based upon the assumption that transient effects will average out over long measurement periods. Thus, the measurement time increases as the heat capacity of a test specimen increases. Also, the averaging technique does not coverage to a unique value if the heat flow through the test system has a near-zero average, which limits its usefulness during the spring and fall. The fourth technique, PROPOR, is a numerical method bhased on least-squares analysis of test data and solutions to the transient heat transfer equation. All the methods are reliable when used under appropriate conditions. The range of usefulness of PROPOR is greater than that of the other methods.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Michigan State University, East Lansing, Mich.

[5.4.30]

MARKETING PLAN AND STRATEGIES–ROOF RESEARCH CENTER (RRC)

G. E. Courville J. Brewer*

(Abstract of ORNL/M-339, Oak Ridge National Laboratory, June 1988)

This report identifies the organizations in the roofing industry that would be most likely to participate in projects at the Roof Research Center (RRC) and devises a marketing plan and strategy to target these organizations. It was found that industry participants have a lack of awareness of RRC's unique capabilities. To increase awareness, a three-fold plan was suggested that includes placement of articles in trade publications, participation in National Roofing Contractors Association and Midwest Roofing Contractor's Association conventions, and publication and availability of a general information brochure. Forty initial target firms were identified as a result of this project. To move these target firms to commitment, a more concerted effort was suggested. This includes a direct mail campaign with telephone follow-up, a users manual with detailed information on steps to be taken to participate in the RRC and the rights and responsibilities of participants, and an open house/conference at the RRC to provide prospective participants with first-hand knowledge of the RRC's capabilities.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*The University of Tennessee, Knoxville.

[5.4.31]

A COMPARISON OF TWO TECHNIQUES FOR MONITORING THE FIELD THERMAL PERFORMANCE OF ROOF SYSTEMS

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A. R. Moazed* G. D. Derderian*
G. D. Stewart* L. S. Shu*

(Abstract of a paper presented at the *ASTM Meet., Bal Harbour, Fla.*, Dec. 6-9, 1987)

This paper compares two independent techniques, one intrusive and one nonintrusive, for monitoring the thermal performance of in situ roof systems. The intrusive technique requires thermocouples on inside and outside surfaces of the roof system and a heat flux transducer (HFT) embedded in the system. The nonintrusive procedure has the same thermocouple placement and a series of HFTs on the inside surface of the deck. The crucial difference in the methods is in the HFT placement and the technique for HFT calibration. Thermal resistance measurements for the two methods are within about 8% over the temperature range 10°C to 43°C, and both are within 7% of the steady state laboratory results for the same material over the same temperature range. The roof assembly is a built-up roof with molded expanded polystyrene insulation above a metal deck.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*W. R. Grace and Company.

[5.4.32]

A COMPARISON OF TWO INDEPENDENT TECHNIQUES FOR THE DETERMINATION OF IN SITU THERMAL PERFORMANCE

G. E. Courville A. O. Desjarlais*
R. P. Tye* C. R. McIntyre**

(Abstract of a paper presented at the *ASTM Meet., Bal Harbour, Fla.*, Dec. 6-9, 1987)

A parallel experiment has been performed on an insulated roof system installed in the Roof Thermal Research Apparatus at Oak Ridge National Laboratory. Separate sections of a 4 ft x 8 ft test panel were evaluated for more than 12 months using two different heat flux transducer (HFT) instrumentation packages; the data were treated independently. This paper discusses the instrumentation packages, sensor calibration procedures, and data collection and analysis methods and highlights the differences between the independent techniques. Generally, the two methods provided consistent results. However, absolute heat fluxes measured by the two techniques differed by about 8%, suggesting a calibration discrepancy. The same was true for thermal resistance measurements. In addition, one of

the analysis techniques used the averaging technique, which is known to be unreliable for low average heat flux.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Dynatech Scientific, Inc., Cambridge, Mass.
**Koppers Company, Inc., Monroeville, Pa.

[5.4.33]

ELECTRIC FIELD PROBES FOR QUANTITATIVE MOISTURE MEASUREMENTS IN BUILDING MATERIALS

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W. P. Murray* A. Blalock*
C. J. Remenyik*

(Abstract of a paper presented at the *ASTM Meeting, Bal Harbour, Fla.*, Dec. 6-9, 1987)

Three novel capacitance techniques for taking moisture measurements in insulated roof systems are being studied at Oak Ridge National Laboratory. These are designated as the pin probe, the thermocouple probe, and the planar probe. The pin probe, developed at the Massachusetts Institute of Technology, consists of two parallel lines of straight pins that function as the two probe electrodes. This is an intrusive probe that must be mounted within the system being tested. The thermocouple probe is also intrusive, and its use assumes that thermocouple junctions exist at known locations in the specimen for temperature measurements. The electronics of the probe allow high-frequency capacitance measurements between thermocouples without interfering with their temperature measurement function. The third probe, the planar probe, is nonintrusive and consists of a series of plate electrodes equally spaced in a box that sits on the surface of the roof. These electrodes provide several independent electrical signals from overlapping depths within the roof system. An analysis procedure was developed to identify the electrical properties of successively deeper layers of material. Prototypes of each of these probes have been constructed, and promising preliminary data are available. Probe calibration, circuit stability, and range of applicability are major issues that must be addressed.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Instrumentation and Controls Division.

[5.4.34]

CFC RESTRICTIONS: ENERGY IMPACTS AND TECHNOLOGICAL ALTERNATIVES

F. A. Creswick S. K. Fischer

(Abstract of pp. 93-99 in *Proc. 2d DOE/ORNL Heat Pump Conf., Washington, D.C., April 17-20, 1988*, CONF-8804100, August 1988)

Recent international negotiations have resulted in an agreement to restrict the production and use of fully halogenated chlorofluorocarbons (CFCs). ORNL has conducted a study of technological alternatives to the use of restricted CFCs in building applications and associated potential energy-use impacts. R-123 and R-134a have been identified as promising substitutes for R-11 and R-12. If these substitutes prove to be fully acceptable, energy-use impacts will be nominal. An urgent near-term need exists for information on the engineering properties of these fluids. If the use of substitutes does not prove to be acceptable, the energy-use impact would be an increase of about 1.0 quad/year if R-22 is available as a substitute and about 2.7 quads/year if not. The latter scenario is regarded as a serious consequence. The major impacts result from reduction in the R value of insulation for domestic refrigerator-freezers and in residential and commercial building insulation. In the long term, alternative technologies are available that could nullify any of the adverse energy-use impacts of CFC restrictions.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.35]

POTENTIAL IMPACTS OF CFC RESTRICTIONS ON REFRIGERATION AND SPACE-CONDITIONING EQUIPMENT

F. A. Creswick S. K. Fischer
J. R. Sand

[Abstract of *Int. J. Refrig.*, 11(4), 217-21 (July 1988)]

Several organizations have recently surveyed alternatives to the use of chlorofluorocarbon (CFC) compounds in refrigeration and space-conditioning applications. ORNL has conducted a preliminary analysis of potential energy-use impacts and an industry survey of research and development needs in response to CFC restrictions. Of the restricted compounds, R-11 and R-12 will have the major impact because of their wide use in automotive air conditioning, domestic and commercial refrigeration, and centrifugal chillers. Alternative refrigerants available in the short term include R-22, R-500, R-502, and certain blends, but these are not suitable substitutes for all applications. R-134a and R-123 are environmentally acceptable substitutes that appear promising for new equipment; however, information about them is preliminary and they will not be commercially available for several years. Blends of previously unused compounds present additional possibilities. If the new refrigerants prove to be fully acceptable substitutes, long-term adverse energy-use impacts

on new equipment will be minor. Impacts will be severe if identified substitutes prove to be unacceptable or if R-22 is restricted in the future. However, significant penalties may be incurred by the use of substitute insulation materials in appliances and buildings. Substitute refrigerants for existing equipment may be a major problem. Generation of comprehensive and accurate information on the engineering properties and health effects of R-134a and R-123 explored as replacement substitutes and for efficiency and modulation benefits that can be derived by the use of nonazeotropic mixtures. Alternative cycles need to be reexamined as backup substitutes.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.36]

DOE/EPRI ASSESSMENT OF ENERGY PRODUCTIVITY APPLICATIONS OF HIGH TEMPERATURE SUPERCONDUCTORS

S. J. Dale

(Abstract of p. 81 in *Spring Natl. Design Eng. Show Conf.*, Chicago, March 1988)

The U.S. Department of Energy (DOE) and the Electric Power Research Institute (EPRI) are jointly sponsoring an assessment of the application of the new high-temperature superconductor (HTSC) materials for energy productivity. The purpose of the study is to assess the potential benefits of applying HTSC conductors to energy technologies and to provide DOE and EPRI with a number of options for research on superconductors and superconducting technologies. The objective is to determine system and device parameters with potential application of HTSC and to determine the characteristics required of the superconductors to meet application requirements. This assessment has shown that several applications should benefit from the higher-temperature superconductors.

Research sponsored by the U.S. Department of Energy Office of Energy Conservation and Office of Fossil Energy.

[5.4.37]

MOBILIZING THE FEDERAL LABORATORIES FOR INDUSTRIAL TECHNOLOGY

S. J. Dale

(Abstract of a paper presented at the *Eng. Found. Conf. U.S. Technol. Polic.*, Mercersburg, Pa., July 31-Aug. 5, 1988)

Over the last few years, there has been a growing awareness that the U.S. economic performance must be strengthened. Technological capability is one of the most important factors supporting the nation's economic performance and growth, and this capability has been responsible for nearly half the growth since World War II. The federal government has a vast resource of technological capability in the federal laboratory system and

particularly in the large, multipurpose laboratories. Several studies have recommended better access to laboratory facilities by industry and more emphasis on technology transfer of federally funded technology from the laboratories. The usage remains low despite efforts to implement these various recommendations. The biggest obstacle to effective integration of the federal laboratories into the industrial economy is the traditional separation between the government's responsibilities and industry's responsibilities in the United States.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.

[5.4.38]

ROLE OF SEMICONDUCTING COMPOUNDS IN THE PREMATURE AGING OF XLPE CABLE INSULATION

M. S. Mashikian* J. H. Groeger*
S. J. Dale E. Ildstad**

(Abstract of pp. 314-20 in *Conf. Rec. 1988 IEEE Int. Symp. Electr. Insul.*, Boston, June 5-8, 1988)

A clean, cross-linked polyethylene insulating material was sandwiched between two parallel layers of semiconducting shield compound in test cells which simulated extruded medium-voltage cables. Four commercial and four experimental semiconducting compounds were used. Cells were aged at 60 Hz, with a stress of 2.6 kV/mm (65 V/mil) or 3.4 kV/mm (85 V/mil), with one shielding layer exposed to air and the other exposed to distilled, deionized water. This paper discusses the effects of water-soluble impurities in the semiconducting compounds on the number, size, and location of water trees developed in the insulation at the semiconducting shield interfaces. The movement of soluble impurities is also addressed.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
*University of Connecticut, Storrs, Conn.
**Norwegian Institute of Technology, Trondheim, Norway.

[5.4.39]

DOE ABSORPTION PROGRAM OVERVIEW

R. C. DeVault

(Abstract of pp. 105-09 in *Proc. 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988, CONF-8804100, August 1988)

Advanced technologies for gas-fired absorption heat pumps for building space conditioning (heating and/or air conditioning) are being developed with U.S. Department of Energy support. Single-effect cycle absorption heat pumps for residential application were demonstrated in the 1970s but proved to be uneconomic and were not manufactured. Advanced technology absorption heat pumps with substantially higher efficiencies are now

being developed that have the potential to be economically competitive with existing HVAC equipment while saving energy.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.40]

THE OAK RIDGE HEAT PUMP DESIGN MODEL: MARK III VERSION PROGRAM DOCUMENTATION

S. K. Fischer C. K. Rice
W. L. Jackson*

(Abstract of ORNL/TM-10192, Oak Ridge National Laboratory, March 1988)

Oak Ridge National Laboratory (ORNL) is a leader in the development of analytical tools for the design of electrically driven, air-to-air heat pumps. Foremost among these tools is the ORNL Heat Pump Design Model, which can be used to predict the steady-state heating and cooling performance of an electrically driven, air-source heat pump. The ORNL Heat Pump Design Model continues to evolve. Modifications to the heat pump model have resulted in the Mark III Version, which is three to five times faster, easier to use, and more versatile than earlier versions. The major changes made to earlier versions of the heat pump model relate to the organization of the input data, elimination of redundant calculations in the compressor and refrigerant property computations, improvement of thermostatic expansion valve and capillary tube correlations, revision of output format, and modifications to enable the model to run on a personal computer.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Computing and Telecommunications Division.

[5.4.41]

ENERGY MONITORING AND CONTROL SYSTEMS (EMCS) AT ARMY INSTALLATIONS–INITIAL EFFECTIVENESS EVALUATION

M. B. Gettings J. M. MacDonald

(Abstract of ORNL/CON-259, Oak Ridge National Laboratory, August 1988)

This report documents an initial evaluation of the effectiveness of the Army Energy Monitoring and Control Systems (EMCS). The study was restricted to eight systems constructed under more recent Army specifications. Areas of interest include operation of the systems; possible measures of effectiveness; and potential improvements in installation, operation, and maintenance. Histories of annual energy consumption are presented that reflect possible EMCS energy benefits. In Army installations where EMCS is used in a majority of the larger buildings, a reduction in energy use has resulted. The reduced energy use is calculated from total consumption data and from the increased ability of the

installations to remain within their consumption goal. Maintenance is found to be a significant factor in the overall effectiveness of and benefits derived from the systems. Recommendations suggested for the Army's consideration include the evaluation of current methods for estimating EMCS benefits, cost and benefit analyses for various levels of control systems, the evaluation of "multivendor" front ends to EMCS, the study of EMCS maintenance options with associated costs and benefits, and the evaluation of potential benefits of increased EMCS monitoring capabilities.

Research sponsored by the U.S. Army Construction Engineering Research Laboratory.

[5.4.42]

FIELD TEST EVALUATION OF CONSERVATION RETROFITS OF LOW-INCOME, SINGLE-FAMILY BUILDINGS IN WISCONSIN: BLOWER-DOOR-DIRECTED INFILTRATION REDUCTION PROCEDURE, FIELD TEST IMPLEMENTATION AND RESULTS

M. B. Gettings L. N. McCold
J. A. Schlegel*

(Abstract of ORNL/CON-228/P5, Oak Ridge National Laboratory, June 1988)

A blower-door-directed infiltration retrofit procedure was field tested on 18 homes in south-central Wisconsin. The procedure, developed by the Wisconsin Energy Conservation Corporation, includes recommended retrofit techniques as well as criteria for estimating the amount of cost-effective work to be performed on a house. A recommended expenditure level and target air leakage reduction, in air changes per hour at 50 P (ACH50), are determined from the initial leakage rate measured. The procedure produced an average 16% reduction in air-leakage rate. The average cost of retrofits per house was reduced by a factor of four compared with previous programs. The average payback period for recommended retrofits was 4.4 years, based on predicted energy savings computed from achieved air-leakage reductions. No statistically significant average annual energy savings were detected as a result of the infiltration retrofits. Measured savings for individual houses varied widely in both positive and negative directions, indicating that factors not considered affected the results. Large individual confidence intervals indicate a need to increase the accuracy of such measurements and understand the factors that may cause such disparity.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems and Office of State and Local Assistance Programs.
*Wisconsin Energy Conservation Corporation, Madison, Wis.

[5.4.43]

CREATING VIABLE UTILITY CONSERVATION/LOAD MANAGEMENT PROGRAMS

E. Hirst

(Abstract of pp. 4-1-4-22 in *Least Cost Energy Plann. Midwest: A Symposium*, EM-5846, Electric Power Research Institute, Palo Alto, Calif., June 1988)

This paper explains how an electric utility can determine the value of demand-side programs in its service territory. Developing alternatives for conservation and load management programs involves the following:

- Identify potential markets and end-use technologies to serve these markets.
- Estimate technical potential.
- Estimate cost-effective potential.
- Develop program options that deliver end-use improvements to customers.
- Estimate program participation, energy-use effects, and costs over time.
- Project electricity use with and without the program.
- Analyze program economics (benefits and costs).
- Test concept.
- Implement pilot program.
- Implement full-scale (systemwide) program.
- Evaluate programs.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.44]

DEVELOPING AN INTEGRATED PLANNING PROCESS: AN ELECTRIC UTILITY CASE STUDY

E. A. Hirst C. Knutsen*

(Abstract of ORNL/CON-247, Oak Ridge National Laboratory, January 1988)

This report describes activities of the Demand and Resource Evaluation (DARE) program from establishment in February 1986 through submission of the first plan to the Washington Utilities and Transportation Commission in November 1987. The DARE program is intended to improve the internal planning process and prepare a long-term integrated resource plan for the Company. Three specific examples of typical planning situations are presented, and key lessons learned from DARE are discussed.

Research sponsored by the U.S. Department of Energy.
*Puget Sound Power & Light Company, Bellevue, Wash.

[5.4.45]

EFFECTS OF ENERGY-EFFICIENCY PROGRAMS ON LOAD-GROWTH UNCERTAINTY FOR ELECTRIC UTILITIES

E. A. Hirst

(Abstract of ORNL/CON-260, Oak Ridge National Laboratory, August 1988)

As part of the DOE/ORNL analysis for the Least-Cost Utility Planning Program, ORNL examined the relationships between programs aimed at improving energy-efficiency of new facilities and load-growth uncertainties. Electric utilities face a variety of uncertainties that complicate their long-term plans to acquire future resources. These uncertainties concern future load growth; the performance and lifetimes of existing generating plants; and the costs, lead times, and performance of new demand and supply resources. Conservation programs can both provide cost-effective resources and reduce uncertainties. Ideas for programs that improve the energy efficiency of new buildings are explored and quantified with a simple computer model developed at Oak Ridge National Laboratory. A hypothetical example developed with the model shows a forecast of electricity use over a 30-year period and the effects on that forecast of changes in economic activity, electricity prices, and natural gas prices. The model is then used to explore the effects of standards and rebates that would reduce projected electricity use in new buildings by one-fifth. Depending on the economic growth rate, these conservation programs cut electricity use by 8-12% after 30 years.

Research sponsored by the U.S. Department of Energy Office of Policy Integration and the Office of Buildings and Community Systems.

[5.4.46]

INCORPORATING UNCERTAINTY INTO ELECTRIC UTILITY LONG-TERM PLANNING AND DECISION MAKING

E. A. Hirst

(Abstract of pp. 8.102-8.115 in *Proc. 1988 ACEEE Summer Study Energy Effic. Build.*, Pacific Grove, Calif., Aug. 28-Sept. 3, 1988, August 1988)

This paper discusses uncertainty as it affects the planning and acquisition of demand and supply resources by electric utilities. The basic elements of uncertainty and definitions of key terms are given to illustrate diverse types of uncertainties associated with different resources and with the utility's external environment. Various analytical methods employed by utilities to treat uncertainty are discussed. A suggestion is offered on ways to enhance analysis of uncertainty by focusing more on the decision making process (and therefore less on the simulation of utility operations and finances). An example shows how a particular

resource (programs aimed at improving energy efficiency of new buildings in this case) can affect other uncertainties that affect utility decisions.

Research sponsored by the U.S. Department of Energy Office of Policy Integration and the Office of Buildings and Community Systems.

[5.4.47]

THE KEY ELEMENTS OF INTEGRATED RESOURCE PLANNING FOR ELECTRIC UTILITIES

E. A. Hirst

[Abstract of *Forum Appl. Res. Pub. Pol.* 3(3), 26-34 (September 1988)]

Integrated resource planning is an important way to meet the future energy-service needs of a utility's customers. Such planning includes six key components: integration of a wide range of resources that the utility can deploy to meet customer needs, integration of the utility's planning departments and staff, explicit treatment of uncertainty, public involvement, implementation, and continuity of the planning process.

Research sponsored by the U.S. Department of Energy Office of Conservation and Renewable Energy and the Bonneville Power Administration.

[5.4.48]

INTEGRATED RESOURCE PLANNING: THE ROLE OF REGULATORY COMMISSIONS

E. A. Hirst

[Abstract of *Pub. Util. Forth.* 122(6), 34-42 (September 1988)]

Although much has been written about the obligations of utilities in integrated resource planning, little has been published on the responsibilities of commissions. This article discusses issues in that area that merit further consideration and seeks to stimulate discussion about structuring regulation to encourage (rather than require) utilities to develop integrated planning processes and plans. Better planning is likely to reduce energy-service costs for customers, increase flexibility for utilities and commissions, and decrease controversies over future resource acquisition.

Research sponsored by the U.S. Department of Energy Office of Conservation and Renewable Energy and the Bonneville Power Administration.

[5.4.49]

KEY ISSUES FOR STATE REGULATORS ON ELECTRIC-UTILITY INTEGRATED RESOURCE PLANNING

E. A. Hirst

(Abstract of a paper precated at the *NARUC Conf. Least Cost Util. Plann.*, Aspen, Colo., April 1988)

This paper briefly defines integrated resource planning and suggests new roles and responsibilities for commissions. Appropriate treatment of risk and uncertainty in utility planning and decision making are emphasized. Uncertainty is a critical element that strongly affects resource planning and implies substantial changes in the obligations of state regulatory commissions. The paper concludes that improved planning procedures can provide substantial benefits to customers, utilities, and regulators.

Research sponsored by the U.S. Department of Energy Office of Conservation and Renewable Energy and the Bonneville Power Administration.

[5.4.50]

MARGINAL COST-OF-SERVICE ANALYSIS: A POWERFUL MARKETING TOOL FOR ELECTRIC UTILITIES

E. A. Hirst

(Abstract of ORNL/CON-251, Oak Ridge National Laboratory, February 1988)

This report presents results from a marginal-cost study for a hypothetical utility in the Pacific Northwest. The results from this study can be used to assess different types of customer programs aimed at improving energy efficiency, retaining market shares, or increasing sales. The specific examples concern space conditioning an office building, retention of existing residential water-heating loads (which would otherwise be lost through conversion to natural gas), promotion of high-efficiency electric space heating in new single-family homes, and promotion of area lighting for large commercial buildings. Each example yields different insights about costs and revenues; their changes over time; and their sensitivities to load shapes, rate structures, and assumed lifetimes.

Research sponsored by the U.S. Department of Energy Bonneville Power Administration and the Office of Conservation and Renewable Energy.

[5.4.51]

REGULATORY RESPONSIBILITY FOR UTILITY INTEGRATED RESOURCE PLANNING

E. A. Hirst

(Abstract of ORNL/CON-249, Oak Ridge National Laboratory, January 1988)

As part of the DOE/ORNL program on least-cost utility planning, several issues related to state regulatory commission review of utility plans were examined. This report serves as an extended outline of issues that merit further consideration among commissions, the utilities they regulate, and other interested parties. It is likely that the current regulatory environment provides insufficient incentives for electric utilities to formally and publicly prepare integrated resource plans. Discussions about structuring regulation to encourage (rather than require) utilities to develop such plans will redue energy-service costs for utility customers, increase flexibility for utilities and commissions, and decrease controversies over future resource acquisition.

Research sponsored by the U.S. Department of Energy Office of Conservation and Renewable Energy and the Bonneville Power Administration.

[5.4.52]

THE HOOD RIVER CONSERVATION PROJECT: AN EVALUATOR'S DREAM

E. A. Hirst

[Abstract of *Eval. Rev.* 12(3), 310-25 (June 1988)]

This paper summarizes the remarkable (and largely successful) efforts of the Hood River Conservation Project (HRCP) to design a comprehensive evaluation to address energy policy issues important to the Pacific Northwest. HRCP was a major residential conservation project, intended to test the upper limits of a utility retrofit program. It was proposed by the Natural Resources Defense Council, funded by the Bonneville Power Administration and operated by Pacific Power & Light Company in Hood River, Oregon. Evaluation results presented concern project performance in three critical areas: (1) the number of eligible households that participated, (2) the number of recommended conservation actions adopted by participants and financed by HRCP, and (3) the actual electricity use and savings achieved by HRCP.

Research sponsored by the U.S. Department of Energy Office of Conservation and Renewable Energy and the Bonneville Power Administration.

[5.4.53]

THE ROLE OF STATE REGULATORY COMMISSIONS IN UTILITY INTEGRATED RESOURCE PLANNING

E. A. Hirst

(Abstract of a paper presented at the 99th *Ann. Conv. Symp. Natl. Assn. Reg. Util. Comm.*, Washington, D.C., November 1987)

This paper discusses several issues related to the roles and responsibilities of public utility commissions. Integrated resource planning is important for electric utilities and their state regulatory commissions. The paper seeks to stimulate discussion about structuring regulation to encourage (rather than require) utilities to develop integrated planning processes and plans. Better planning is likely to reduce energy-service costs for customers, increase flexibility for utilities and commissions, and decrease controversies over future resource acquisition.

Research sponsored by the U.S. Department of Energy Office of Conservation and Renewable Energy and the Bonneville Power Administration.

[5.4.54]

RESIDENTIAL RETROFIT MEASURES IN THE HOOD RIVER CONSERVATION PROJECT: RECOMMENDATIONS, INSTALLATIONS, AND BARRIERS

E. A. Hirst R. T. Goeltz

[Summary of *Energy Syst. Polic.* 11 (December 1987)]

The Hood River Conservation Project (HRCP) was probably the most ambitious residential retrofit research and demonstration project ever conducted in the United States. Because it focused on information needed to guide energy policy in the Pacific Northwest, a wealth of high-quality data was collected in Hood River, Oregon. Averaged over all the measures and homes in this analysis, 46% of the 15 measures theoretically available in teh HRCP package were installed by HRCP, 45% were neither recommended nor installed, and only 9% were recommended but not installed. Of the measures recommended in the energy audits, 83% were installed by HRCP, yielding an estimated energy savings of 93% of the potential. Almost half (45%) of the barriers that prevented installation of retrofit measures arose because a measure was already partially or fully in place, thus eliminating the cost effectiveness of further installation. Physical barriers accounted for 31% of the noninstallations, noncompatible conditions for 19%, customer concerns for 4%, and other barriers for the remaining 2%.

Research sponsored by the U.S. Department of Energy Bonneville Power Administration.

[5.4.55]

INTEGRATED RESOURCE PLANNING: A VIEW FROM THE TRENCHES

E. A. Hirst C. Knutsen*

(Abstract of a paper presented at the EPRI Conference, New Orleans, La., Dec. 1-3, 1987; pp. 95-116 in *Moving Toward Integrated Value-Based Planning: The Issues*, EPRI EM-5842, Electric Power Research Institute, Palo Alto, Calif., July 1988)

In early 1986, Puget Sound Power and Light Company established a Demand and Resource Evaluation (DARE) program to improve its internal planning process and prepare a long-term integrated resource plan. This paper describes DARE activities during its initial 18-month cycle. Key lessons learned from DARE include: the need for internal cooperation, the amount of time needed to establish a viable planning activity, the required commitment to planning from top management, the balance between analysis and experience, the value of public participation, and the necessity of developing realistic goals for the initial plan.

Research sponsored by the Puget Sound Power and Light Company and the U.S. Department of Energy Bonneville Power Administration and the Office of Conservation and Renewable Energy.
*Puget Sound Power & Light Company, Bellevue, Wash.

[5.4.56]

INTEGRATED RESOURCE PLANNING AT PUGET POWER: PROCESS AND RESULTS

E. A. Hirst C. Knutsen*

(Abstract of pp. 614-27 in *Energy Technol. XV, Repowering America*, Proceedings of the Energy Technology Conference, Government Institute, Rockville, Md., February 1988)

To meet the increased energy requirements forecast for Puget Power consumers, new coal plants were completed and began operating in the early 1980s. Puget Power's cost of providing electricity to its customers increased dramatically as a result of high inflation, rising fuel costs, and the introduction of new, higher cost power plants. The combination of higher electricity prices and a serious recession in the region greatly reduced load growth. Expected power deficits became a large regional surplus starting in the early 1980s. This paper reports the steps taken to improve resource planning to avoid future energy supply imbalances.

Research sponsored by the Puget Sound Power and Light Company and the U.S. Department of Energy Bonneville Power Administration and the Office of Conservation and Renewable Energy.
*Puget Sound Power & Light Company, Bellevue, Wash.

[5.4.57]

INFILTRATION TESTING OF HOMES CONSTRUCTED TO THE BPA MODEL CONSERVATION STANDARDS PROGRAM

J. O. Kolb

(Abstract of pp. 1.68-1.80 in *ACEEE 1988 Summer Stud.*, Pacific Grove, Calif., Aug. 28-Sept. 3, 1988, Paper 60, April 1988)

The Bonneville Model Conservation Standards (MCS) for homes require air sealing techniques to reduce incidental infiltration to below the levels resulting from conventional construction techniques. Measurements of infiltration in 35 MCS code-constructed homes were taken by two techniques: blower door depressurization and short-term tracer gas decay to measure incidental and total infiltration with an air-to-air heat exchanger. The Idaho homes had significantly greater success meeting the "tight" infiltration control standard than did the homes in western Washington. The results are discussed relative to the construction and air sealing practices and inspection techniques. Ventilation rates with air-to-air heat exchangers varied above and below the MCS code-specified rates in a significant number of homes.

Research sponsored by the U.S. Department of Energy Bonneville Power Administration.

[5.4.58]

RESOURCES FOR O/M TRAINING AND SERVICES IN THE COMMERCIAL BUILDING SECTOR

J. O. Kolb

(Abstract of ORNL/CON-204, Oak Ridge National Laboratory, April 1988)

Within many commercial buildings, the most economical energy conservation opportunities (ECOs) result from improved operation and maintenance (O&M) of heating, ventilating, and air conditioning systems and building envelopes that yield average energy and cost savings of 20%, with paybacks of 1 year or less. Yet, in many such buildings, the improved O&M ECO is not being implemented by building owners or occupants. This report presents the results of a study of (1) the scope and nature of resources for training and services in commercial building O&M, (2) the types of barriers that reduce the application of appropriate O&M procedures, and (3) the potential for increased penetration of O&M services. The study reveals that there is an excess of O&M training and service organizations and discusses barriers to the application of improved O&M procedures. General recommendations for stimulating improved O&M procedures in commercial buildings include (1) documentation of energy and cost savings and economic paybacks from actual O&M procedures, 92) strategic market development for O&M services through

existing public and private organizations, and (3) methods to improve O&M training for building operators and service personnel.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.59]

A REVIEW OF UTILITY CONSERVATION PROGRAMS FOR THE COMMERCIAL BUILDING SECTOR

J. O. Kolb M. S. Hubbard

(Abstract of ORNL/CON-235, Oak Ridge National Laboratory, January 1988)

This report presents the results of a survey of conservation program activities conducted by 26 public utilities. The purpose of the survey was to provide an information database on utility-sponsored conservation programs planned or in progress for the commercial building sector. This database is to be used by the Department of Energy (DOE) to define conservation programs that assist and complement utility conservation programs. Information on four types of conservation programs was solicited: (1) financial incentive programs, (2) energy service programs, (3) rate research and incentive programs, and (4) case studies and demonstration studies. Six utility programs are recommended as candidates for commercial program case studies for DOE on the basis of the data obtained in this survey.

Research sponsored by the U.S. Department of Energy Office of Site and Local Assistance Programs.

[5.4.60]

POWER GENERATION FROM WASTE INCINERATION

J. O. Kolb K. E. Wilkes

(Abstract of ORNL/TM-10484, Oak Ridge National Laboratory, June 1988)

This report presents a characterization of municipal solid waste incineration technologies, an energy market evaluation in the Denver Arapahoe Disposal Site area, an evaluation of energy recovery from waste tires, a conceptual design of an integrated incineration power plant, and an economic analysis of hazardous waste processing costs and potential savings with an integrated facility. Analyses of the amount and types of hazardous wastes, appropriate incineration technologies, a process design to size flue gas heat recovery equipment, and cost estimates for hazardous waste incinerator systems and heat recovery equipment were performed by Science Applications International Corporation in a companion study and used in this report. The primary conclusion of this study is that processing cost savings with an integrated waste incinerator power plant range from 6 to 20% of costs compared with separate hazardous waste incineration. However, this result depends on the amount and moisture content of the waste material and the electricity value

sold to the local utility. Other results and conclusions include the types of hazardous waste incineration technologies recommended, the market for energy products, and institutional restraints and requirements.

Research sponsored by the U.S. Department of the Air Force.

[5.4.61]

ENERGY MEASUREMENTS OF ATTIC RADIANT BARRIERS INSTALLED IN SINGLE-FAMILY HOUSES

W. P. Levins M. A. Karnitz

(Abstract of pp. 1.81-1.91 in *Proc. ACEEE 1988 Summer Study Energy Effic. Build.*, Pacific Grove, Calif., Aug. 28-Sept. 3, 1988, August 1988)

Testing was conducted by Oak Ridge National Laboratory to determine the energy savings attributable to radiant barriers installed in attics of unoccupied single-family houses. Three levels of fiberglass attic insulation (R-11, R-19, and R-30) were tested with two types of barrier installation (horizontal and truss). The results showed that horizontally installed radiant barriers are more effective than truss barriers in reducing heating and cooling loads. Measured cooling load reductions ranged from 0 to 22% (compared with same attic insulation R-value with no radiant barrier) and heating load changes from +4% to -10% were measured (compared with same attic insulation R-value with no radiant barrier). Radiant barriers appeared to decrease the heating and cooling loads more when lesser amounts of insulation (R-11 and R-19) were present in an attic. Minimal changes were measured when R-30 was present in an attic. Long-term effects of dust on the performance of radiant barriers as well as the effects of moisture condensing on the surface of a radiant barrier exposed to cold winter temperatures remain unanswered.

Research sponsored by the U.S. Department of Energy and the Tennessee Valley Authority.

[5.4.62]

HEATING ENERGY MEASUREMENTS OF SINGLE-FAMILY HOUSES WITH ATTICS CONTAINING RADIANT BARRIERS IN COMBINATION WITH R-11 AND R-30 CEILING INSULATION

W. P. Levins M. A. Karnitz

(Abstract of ORNL/CON-239, Oak Ridge National Laboratory, August 1988)

Test were conducted by Oak Ridge National Laboratory to determine the heating energy performance of two levels of fiberglass-batt attic insulation (R-11 and R-30) in combination with truss and horizontally installed radiant barriers. The tests, a continuation of work started in the summer of 1985, were conducted in three unoccupied ranch-style houses in Karns, Tennessee, during the winter of 1986-87. The measured results of the

heating tests showed that a horizontal radiant barrier used with R-11 attic insulation reduced the house heating load by 9.3% compared with R-11 with no radiant barrier, while a truss barrier showed essentially no change in the heating load. Horizontal and truss barriers each reduced the heating load by 3.5% when added to R-30 attic insulation. Moisture condensed on the bottom of the horizontal barrier during cold early morning weather but usually dissipated in the warmer afternoon hours and left no accumulation in the insulation. Depending on the level of attic insulation, an annual heating and cooling savings ranging from $5 to $65 is estimated to be attainable when a radiant barrier is installed in the attic at Karns.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems and the Tennessee Valley Authority.

[5.4.63]

POWER SIGNATURES AS CHARACTERISTICS OF COMMERCIAL AND RELATED BUILDINGS

J. M. MacDonald

(Abstract of pp. 80-87 in *Proc. Fifth Ann. Symp. Improv. Build. Energy Effic. Hot Humid Clim.*, Houston, Sept. 13-14, 1988, September 1988)

This paper proposes the use of "power signatures" as an important concept for building energy analysis. Power signatures are considered to contain "energy or power characteristics" of a building. Developing relationships between energy characteristics and building physical characteristics is seen as an important area for improvement of analytical tools for commercial and related buildings. Knowledge of the causes of variations in energy use, and the expected relative impacts of different schedules, functional uses, and energy systems, should be improved. A categorization of analysis methods is presented to define the parameters of interest for several currently used methods. Power signatures indicate building energy behavior with respect to time, so the parameters of interest are average power level and time of occurrence. Because a rate quantity (power) is used, comparisons between different time steps are practical. If practitioners would begin using power signature concepts to present energy use data on buildings, improved communication of results appears possible. Potential future study could be continued in several areas to improve the use of power signatures and energy analysis overall.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.64]

EVALUATION, MODIFICATION, AND DEPLOYMENT OF THE ECOP-II COMPUTER PROGRAM

J. M. MacDonald M. B. Gettings
D. Goldenberg* D. M. Wasserman

(Abstract of ORNL/CON-248, Oak Ridge National Laboratory, March 1988)

This project, conducted at Oak Ridge National Laboratory, covered the evaluation and modification of the ECOP-II computer program. The project also included the development of recommendations on the deployment of ECOP-II. The ECOP-II computer program (Energy Conservation Opportunity Program for small commercial and light industrial buildings) was previously developed under direction of the U.S. Air Force. This report presents the results of data-gathering efforts at 11 military installations, reviews of algorithms and calculations, validation analysis recommendations on the general use of ECOP-II, personnel requirements, and related recommendations for energy management efforts at military bases.

Research sponsored by the U.S. Department of the Army Engineering and Housing Support Center.
*EnerServ, Inc., Oak Ridge, Tenn.

[5.4.65]

MILITARY EMCS: IMPLICATIONS FOR UTILITIES, CITIES, AND ENERGY SERVICES

J. M. MacDonald M. B. Gettings

(Abstract of pp. 3.157-3.168 in *Proc. ACEEE 1988 Summer Study Energy Effic. Build.*, Pacific Grove, Calif., Aug. 28-Sept. 3, 1988, September 1988)

This paper discusses possible extensions of energy monitoring and control systems (EMCS) to a high-level control for many buildings over a large area (large-scale EMCS). Topics presented include an overview of certain factors that appear to have an impact for the large-scale EMCS concept, limited trend data available on energy and cost savings for the military systems that were evaluated, operational and maintenance considerations that impact use of the large-scale EMCS, a discussion of some implications for potential future use of large-scale EMCS, and recommendations for possible future work on study and implementation of such systems. The concept of large-scale EMCS offers important challenges and opportunities for utilities, cities, and energy services to advance the art and science of building energy and comfort control. The large-scale EMCS concept can lead to useful, real applications that provide benefits for many people and organizations. Significant benefits appear possible for extensions of current EMCS technologies, and significant work is needed to understand and promote these potential benefits.

Research sponsored by the U.S. Department of the Army Engineering and Housing Support Center.

[5.4.66]

AN OVERVIEW OF 3-D GRAPHICAL ANALYSIS USING DOE-2 HOURLY SIMULATION DATA

J. Haberl* J. M. MacDonald
A. Eaen**

[Abstract of *ASHRAE Trans.* 94(1), 212-17 (January 1988)]

This three-dimensional graphical approach for improving the potential of building energy analyses produces annual profiles from hourly data generated by DOE-2 computer program simulations using a statistical plotting package for specific quantities. The profiles provide a useful check of voluminous data in a condensed form, allowing several different types of data to be plotted over a year. The user can check simulation results, check for potential problems with user input, provide graphs for simple presentations, visualize interactions in simulations, and understand where inappropriate modeling conditions may exist. Future analysis may allow methods to check consistency between simulations, check for potential hidden errors in modeling buildings, and better understand how simulations compare with data from real buildings.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Princeton University.
**The U.S. Department of Energy Rocky Flats Plant.

[5.4.67]

RESEARCH UPDATE, EXISTING BUILDING EFFICIENCY RESEARCH, 1987-1988

J. M. MacDonald M. A. Karnitz
R. C. Diamond* R. L. Ritschard*
W. R. Mixon M. H. Sherman*

(Abstract of ORNL/CON-268, Oak Ridge National Laboratory, August 1988)

This update covers research on energy efficiency improvements for U.S. residential and commercial buildings. Improving the energy efficiency of existing buildings through retrofit measures offers the greatest potential for energy savings. The widespread use of retrofits for residential buildings could save 2.6 quadrillion Btu (quads) per year and reduce annual energy costs by $17 billion. Full penetration into the commercial building stock could save 2.5 to 3.5 quads per year and $15 billion to $20 billion per year. Plans are to assess what the long-term picture for advancing energy technologies will be and what approaches will have to be taken to best meet the needs associated with continuing to improve the energy efficiency of existing buildings.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Lawrence Berkeley National Laboratory, University of California.

[5.4.68]

APPLICATION OF SUPERCONDUCTORS TO ELECTRIC MOTORS

B. W. McConnell

(Abstract of pp. 457-65 in *Proceedings of the Conference on Superconductivity and Its Applications*, ed. H. S. Kwok and D. T. Shaw, Elsevier, New York, 1988.

This paper reviews experience in applying superconductors to electric motors and examines the difficulties encountered. While motors and generators have a common basis, several significant differences exist. The application of high-temperature superconductors to the major electric motor types is discussed, and expected difficulties are presented. The limitations imposed by various motor designs are reflected in a statement of the desired material properties for high-temperature superconductor electric motor applications.

Research sponsored by Argonne National Laboratory, Argonne, Ill.

[5.4.69]

THE POTENTIAL FOR THE APPLICATION OF HIGH-TEMPERATURE SUPERCONDUCTING TECHNOLOGY TO MAGNETIC SEPARATIONS

B. W. McConnell

(Abstract of pp. 149-52 in *Advances in Applied Superconductivity: A Preliminary Evaluation of Goals and Impacts*, ANL/CNSV-64, Argonne National Laboratory, Argonne, Ill., January 1988)

A preliminary estimate of the operating cost savings (excluding capital costs) shows a savings of 97% for a 77-K superconducting, high-gradient magnetic separation (HGMS) system when compared with a conventional HGMS system. An additional advantage is the ability to separate small-diameter and weakly magnetic properties that cannot be separated by conventional magnets. Inasmuch as high-temperature superconductor (HTSC) materials inherently offer a savings in operating costs, it is clear that a direct adaptation of existing methods would be economic. The cost analysis assumes that the LN_2 coolant in an HGMS/HTSC plant would be discarded after use (as is the currently used LHe because of handling problems). But LN_2 can be piped, stored, and recycled, which should provide additional savings and convenience as well as economies of scale. In addition, it might be possible to apply unusual magnet designs to the new systems.

Research sponsored by Argonne National Laboratory, Argonne, Ill.

[5.4.70]

THE POTENTIAL FOR THE APPLICATION OF HIGH-TEMPERATURE SUPERCONDUCTING TECHNOLOGY TO MOTORS

B. W. McConnell

(Abstract of pp. 115-23 in *Advances in Applied Superconductivity: A Preliminary Evaluation of Goals and Impacts*, ANL/CNSV-64, Argonne National Laboratory, Argonne, Ill., January 1988)

The attractiveness of superconductors for motors is similar to their attractiveness for generators. Superconductors offer an increase in motor efficiency, which must be balanced against the capital cost premium for the superconducting motor (including a refrigeration system). However, motors experience large forces in the windings during startup, and these forces may preclude the use of "brittle" superconductors.

Research sponsored by Argonne National Laboratory, Argonne, Ill.

[5.4.71]

THE POTENTIAL FOR THE APPLICATION OF HIGH-TEMPERATURE SUPERCONDUCTING TECHNOLOGY TO POWER TRANSFORMERS

B. W. McConnell

(Abstract of pp. 61-68 in *Advances in Applied Superconductivity: A Preliminary Evaluation of Goals and Impacts*, ANL/CNSV-64, Argonne National Laboratory, Argonne, Ill., January 1988)

Losses in power transformers are equal in magnitude to the output of five large-scale, based-load power plants. This report considers a design for a 1000-MVA generation step-up transformer with superconducting windings incorporating Nb_3Sn developed by Westinghouse Electric Corp. under contract to the U.S. Department of Energy in 1981. This design, together with the cost assumptions, formed the basis of this evaluation of the potential impact of the new high-temperature superconductors (HTSCs) on power transformers. Because almost nothing is known concerning the ac properties of the new HTSCs, Nb_3Sn properties were assumed (except for the high critical temperature). The results of this analysis indicate that the use of the new HTSCs will result in total life cycle costs 35% lower than for Nb_3Sn and 60% lower than for conventional power transformers of this size.

Research sponsored by Argonne National Laboratory, Argonne, Ill.

[5.4.72]

STEEP FRONT SHORT DURATION LOW VOLTAGE IMPULSE PERFORMANCE OF DISTRIBUTION TRANSFORMERS

L. M. Burrage* E. F. Veverka*
B. W. McConnell

[Abstract of *IEEE Trans. Power Delivery*, PWRD-2(4), 1152-56 (1987)]

An extensive literature search of steep front short duration (SFSD) impulse sources, their characteristics, and effect on power system equipment has led to the specification of a test program to evaluate key apparatus and insulations. Distribution transformers, although not overly susceptible to impulse damage, have been selected as one of the candidate apparatus for low- and high-voltage SFSD impulse tests. This paper covers the low-voltage SFSD impulse response of conventional oil-insulated shell-form and core-form distribution transformers.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
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[5.4.73]

AN ANALYTICAL INVESTIGATION OF ENERGY END-USE IN COMMERCIAL OFFICE BUILDINGS

H. A. McLain J. M. MacDonald
D. J. Downing*

(Abstract of ORNL/CON-250, Oak Ridge National Laboratory, March 1988;
GRI-87/0318, Gas Research Institute, Chicago, March 1988)

A library of data files listing the hourly values of the end-use energy components for commercial office buildings was created using the DOE-2.1B simulation program to gain an understanding of annual and hourly energy consumption in buildings. The results suggest that the optimum heating, ventilating, and air conditioning system is dependent on the climate. Internal load, such as lighting and office equipment, reduction results in lower energy consumption. Most of the savings is due to the reduction in the load itself. There is some attendant decrease in the cooling load and increase in the heating load.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems and the Gas Research Institute.
*Computing and Telecommunications Division.

[5.4.74]

HEAT PUMP GROUND COIL ANALYSIS WITH THERMAL INTERFERENCE

V. C. Mei

[Abstract of *ASME J. Sol. Energy Eng.* 110, pt. 2, 67-73 (May 1988)]

When two horizontal ground coils are buried in the same trench, one on top of the other, the total energy exchange between coils and ground increases drastically over that of a single coil for the same trench length. However, the thermal interference between the two coils makes the overall performance of the two-coil trench difficult to determine. Traditionally, this problem is handled by the line-source mirror-image approach, but estimating the strength of the source results in extremely conservative ground coil design. This paper provides a detailed mathematical model to describe the operation of the two-coil system, which can calculate more realistically the performance of the ground coils and could make the ground coil heat pump system more economically competitive. The effect of fluid inlet positions is also studied. The comparison of measured and calculated daily energy absorbed from the ground indicated a maximum error at less than 16%, with the calculated values on the conservative side.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.75]

TWO-PHASE REFRIGERANT FLOW MEASUREMENT WITH LIQUID AND VAPOR SEPARATION TECHNIQUE

V. C. Mei

[Abstract of *ASHRAE Trans.* 94(2), 238-43 (June 1988)]

Refrigerant flow rate measurement is always important in calculating the performance of refrigeration equipment. The task becomes difficult when the refrigerant is not fully condensed in the condenser. Conventional two-phase flow measuring techniques are either too expensive, have low accuracy, or both. This paper presents an accurate measurement in which the liquid and vapor are separated and the flow rate of each phase is measured with conventional flowmeters. A low-cost and low-pressure drop separator was built and tested on a split heat pump system. The results indicate that the separator worked as expected by separating the two-phase refrigerant for vapor quality from 6.1 to 14.7%, with refrigerant pressure drop ranging from 2 to 5 psi (13.8 to 34.5 kPa) in most tests.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.76]

COMPARISON OF A THERMOELECTRIC COOLING SYSTEM AND A GROUNDWATER HEAT PUMP

V. C. Mei F. C. Chen
B. Mathiprakasam*

[Abstract of *ASME Winter Ann. Meet.*, Paper 87-WA/AES-3 (December 1987)]

The performance of a groundwater thermoelectric (TE) heat pump system, based on today's state-of-the-art TE materials, was calculated and compared with that of a conventional groundwater heat pump under the same water inlet temperature and flow rate. It was found that the TE system was quite competitive for cooling, particularly for groundwater temperatures below 18°C (64°F). The TE system performance for heating mode operation was poor. A cooling coefficient of performance (COP) of 6.4 could be realized by a properly designed TE system at a groundwater temperature of 13°C (55°F), compared with a COP of 4.35 for a conventional heat pump. For heating mode operation at the same water temperature, the TE system achieved a COP of 1.82, while the conventional heat pump performed at a COP of 3.72. TE systems for many buildings, where part of the areas require year-round cooling, can be a satisfactory alternative if groundwater of sufficiently low temperature is available.

Sponsored by the U.S. Department of Energy Office of Buildings and Community Systems and Midwest Research Institutes.
*Midwest Research Institute, Kansas City, Mo.

[5.4.77]

LABORATORY CAPACITY MODULATION EXPERIMENTS, ANALYSES AND VALIDATION

W. A. Miller

(Abstract of pp. 7-21 in *Proc. 2d DOE/ORNL Heat Pump Conf., Washington, D.C., Apr. 17-20*, CONF-8808100, August 1988)

A combined experimental and analytical project was conducted on a breadboarded continuously variable-speed air-to-air heat pump (CVSHP). The split-system residential unit of nominal 2 3/4-ton (9.7-kW) cooling capacity was instrumented and tested in environmental chambers. The steady state, frosting/demand defrosting, and cycling efficiency characteristics of the CVSHP with first-generation components (e.g., heat exchangers, compressor, and indoor blower, both having variable-speed induction motors) were measured in the laboratory for compressor drive frequencies ranging from 15 through 90 Hz. Steady state efficiency data were used to validate an initial version of the Oak Ridge National Laboratory steady state modulating heat pump design program. The model matched the measured trends of coefficient of performance (COP) and capacity, slightly underpredicting heating COP and capacity by roughly 2 to 5% and overpredicting cooling COP and capacity by roughly 5 to 10%. Validation results indicated that the model is well suited for use in evaluation of design and operating options, provided that the heat exchangers were

efficiently circuited and operated with low to moderate [<20°F (11°C)] condenser subcooling and low evaporator superheat. Dynamic loss algorithms were developed from laboratory data and seasonal analysis simulations were made to estimate the potential energy savings due to compressor and indoor blower modulation. Seasonal analysis results for simulated oepration in Syracuse showed that a CVSHP improved annual perfo.mance factor (APF) 16% compared to an optimally controlled single-speed heat pump (SSHP). The test CVSHP operating in Knoxville or Fort Worth would improve APF roughly 27%. The major improvement in seasonal efficiency in the moderate climates resulted from the ability to unload the heat exchangers during low load operation. In the predominately heating load climate of Syracuse the major improvement resulted from the reduction of supplemental heat usage.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.78]

LABORATORY EXAMINATION AND SEASONAL ANALYSIS OF THE DYNAMIC LOSSES FOR A CONTINUOUSLY VARIABLE SPEED HEAT PUMP

W. A. Miller

[Abstract of *ASHRAE Trans.* 94(2), 1246-68 (July 1988)]

An air-to-air split-system, continuously variable-speed heat pump of nominal 2 1/2-ton (8.8-kW) cooling capacity was instrumented and tested in the laboratory. The system operating conditions, coefficient of performance, and system capacity were measured during frosting/defrosting tests and during both heating and cooling mode cycling tests. Frosting/defrosting tests were conducted for a range of compressor speeds, outdoor air temperatures, and relative humidities. Cycling tests were conducted for a range of compressor speeds and outdoor temperatures. Dynamic loss algorithms were developed from the data, and seasonal analysis simulations were made to estimate the potential energy savings due to compressor and indoor blower modulation. For Ft. Worth, Texas; Knoxville, Tennessee; and Syracuse, New York, analysis of energy cost savings due to modulation indicated a cost premium of $400 for three-year payback.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.79]

MODULATING HEAT PUMP COMPONENT AND ADJUSTABLE SPEED DRIVE EFFICIENCIES MEASURED IN THE LABORATORY

W. A. Miller

[Abstract of *ASHRAE Trans.* 94(1), 874-91 (January 1988)]

The operating efficiencies of an indoor centrifugal blower and a hermetic reciprocating compressor, both having induction motors, were measured in a breadboard heat pump test facility. The indoor blower was tested using a six-step voltage source inverter (VSI) produced in the early 1980s and also using a motor-generator (M-G) (ideal induction motor drive) for blower motor drive frequencies ranging from 20 to 60 Hz. The reciprocating compressor was driven in separate tests by a VSI, a pulse-width modulated inverter (PWMI), and an M-G to observe the effect of each adjustable-speed drive on the efficiency of the compressor for drive frequencies ranging from 15 to 90 Hz. Laboratory data indicated that the coefficient of performance (COP) of the heat pump and component efficiencies became increasingly sensitive to the magnitude of three-phase voltage input to the induction motors as drive frequency decreased from 60 to 15 Hz. A linear relation of volts per hertz yielded best compressor efficiency and thus best COP; however, for the indoor blower, the volts per hertz relationship was varied with speed for the best combination blower-and-blower-motor efficiency. A VSI efficiency of only 85%, measured at 60-Hz drive frequency, caused the overall blower and drive system (blower motor and inverter) efficiency to drop 16.5% of efficiency measured with the blower driven by the M-G set. The isentropic efficiency of the compressor was observed at 15-Hz speed to be roughly 30% less than that measured with the ideal induction motor drive because of the indirect effect of current harmonics on the compressor and compressor motor.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.80]

AN OVERVIEW OF THE BUILDING ENERGY RETROFIT RESEARCH PROGRAM

W. R. Mixon

(Abstract of pp. 119-21 in *Proc. Fifth Ann. Symp. Improv. Build. Energy Effic. Hot Humid Clim.*, Houston, Sept. 13-14, 1988, September 1988)

This research update presents the status of a U.S. Department of Energy program that addresses the technical, financial, and behavioral barriers to improving the energy efficiency of existing buildings. The program is implemented with expertise from four national laboratories, Princeton University, and the Alliance to Save Energy in cooperation with a large number of state, utility, and local agencies. The remaining potential for energy savings from cost-effective retrofit measures in existing buildings is impressive, but a variety of barriers have been identified that reduce conservation investment. One significant barrier

that the program can address is the large uncertainty about savings. Average savings for a large sample of retrofit homes is generally lower than expected, and savings in individual buildings varies unpredictably from negative to very high positive values. Our approach has been to provide reliable information on the performance and cost-effectiveness of energy-conserving technologies and practices. Field performance monitoring is in progress in each building sector, and development of diagnostic techniques and monitoring protocols is in progress.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.81]

AN ANALYTICAL STUDY OF HYBRID EJECTOR/INTERNAL COMBUSTION ENGINE-DRIVEN HEAT PUMPS

R. W. Murphy

(Abstract of pp. 163-68 in *Proc. 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988, CONF-8804100, Oak Ridge National Laboratory, August 1988)

Because ejectors can combine high reliability with low maintenance cost in a package requiring little capital investment, they may provide attractive heat pumping capability in situations where the importance of their inefficiencies is minimized. One such concept, a hybrid system in which an ejector driven by engine reject heat is used to increase the performance of an internal combustion engine-driven heat pump, was analyzed by modifying an existing ejector heat pump model and combining it with generic compressor and internal combustion engine models. Under the model assumptions for nominal cooling mode conditions, the results showed that hybrid systems could provide substantial performance augmentation–up to 17% increase in system coefficient of performance for a parallel arrangement of an enhanced ejector with the engine-driven compressor.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.82]

ESTIMATED FUEL SAVINGS FOR HEAT PUMP SYSTEMS THAT COMBINE EJECTORS AND ENGINE-DRIVEN COMPRESSORS

R. W. Murphy

(Abstract of a paper presented at the *ASME Winter Ann. Meet.*, Boston, December 1987)

An existing ejector heat pump model was modified and combined with generic internal combustion engine and compressor models to assess the potential for ejectors driven by engine reject heat to reduce the fuel consumption of heat pumps driven by internal combustion engines. Under the model assumptions for nominal cooling mode conditions, a parallel arrangement of the ejector with the engine-driven compressor decreased heat pump

system fuel consumption by 11% from the baseline engine-only case. For an ejector downstream in a series arrangement with the engine-driven compressor, the calculated fuel savings was 8% from the baseline. If assumed enhanced ejectors were employed in these situations, calculated fuel usage reductions were 19 and 17% respectively.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.83]

A MODEL OF AN AMMONIA-WATER FALLING FILM ABSORBER

H. Perez-Blanco

[Abstract of *ASHRAE Trans.* 94(1), 467-82 (January 1988)]

This paper describes a model of the absorption process in a falling film ammonia-water absorber. The model consists of two ordinary, first-order differential equations with suitable inlet and interface conditions. The model was validated by comparing its predictions to experimental data. The objective of the work was to define strategies to enhance the absorption process to downsize absorbers. It was found that in most situations of practical interest, the mass transfer process in the falling film controls the absorption rate. The possibility of water evaporation and migration in the absorber is discussed, outlining how it can degrade performance.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.84]

ABSORPTION ENHANCEMENT RESEARCH AND RELATED DIAGNOSTICS

H. Perez-Blanco M. R. Patterson*
D. A. Bostick** L. N. Klatt**

(Abstract of pp. 133-43 in *Proc. 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988, CONF-8804100, Oak Ridge National Laboratory, August 1988)

An understanding of the absorption process and of the techniques that can be employed for its enhancement is an important step in the development of the technology. This paper reports on ongoing experimental efforts toward developing that understanding, as well as on related research already completed in the area. The experimental apparatus under construction is described, with the techniques to be employed. Absorber performance data analysis requires accurate property values in the form of computer routines. The routines developed to date are described. A brief status report of the development of a

fiber-optics instrument, which will monitor concentration at different absorber locations, is also included.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Computing and Telecommunications Division.
**Analytical Chemistry Division.

[5.4.85]

FIBER-OPTICS REFRACTOMETER FOR ABSORPTION MACHINES

D. A. Bostick* L. N. Klatt*
H. Perez-Blanco

(Abstract of pp. 279-98 in *Heat Transfer Symp.*, University of Illinois at Urbana-Champaign, Oct. 1-2, 1987, October 1987)

Monitoring solution concentration in lithium bromide absorption units is of great importance to improve the thermal efficiency and the controllability of the units. The conventional way to measure concentration in lithium bromide water absorption machines is by means of refractometers. This technique requires the extraction of a sample from the machine. In situ, real-time measurements are then difficult, and implementing control strategies is impossible. The fiber-optic refractometer described in this work is capable of monitoring concentration in situ, giving instantaneous readings. The device consists of light sources, light detectors, and fiber-optics with a surface treatment that enables them to measure the index of refraction of the solution. Concentrations of brine solution were measured for a three month period in an absorber for ranges from 50 to 55% salt by weight. No appreciable calibration drifts were detected over the period. The fast fiber response allowed the measurement of fluctuations in the concentrations with about 15 time constants. This type of determination of transients was impossible before this instrument was developed.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Analytical Chemistry Division.

[5.4.86]

NUMERICAL FITS OF THE PROPERTIES OF LITHIUM-BROMIDE WATER SOLUTIONS

M. R. Patterson* H. Perez-Blanco

[Abstract of *ASHRAE Trans.* 94(2), 2059-77 (June 1988)]

The modeling and design of advanced absorption cycles call for numerical fits of the working fluids' properties. The numerical fits can be readily implemented in computers. Recently, a worldwide search of available properties of absorption fluids was completed. The current work presents numerical fits of the thermodynamic and transport properties of the

lithium bromide water solutions uncovered by the search. The range of existing correlations is extended, and the accuracy of the existing fits improved slightly. A simple test for the thermodynamic consistency of the vapor pressure fit is presented and carried out at one isotherm with good results.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Computing and Telecommunications Division.

[5.4.87]

ENGINE-DRIVEN HEAT PUMP PROGRAM OVERVIEW

G. T. Privon A. T. Braun*

(Abstract of pp. 155-59 in *Proc. 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988, CONF-8804100, Oak Ridge National Laboratory, August 1988)

This overview is a brief summary of the efforts that have taken place in the small commercial-sized internal combustion engine-driven heat pump project being carried out by Oak Ridge National Laboratory for the U.S. Department of Energy. Aspects of the project discussed are: objectives and effort scope, the engine-compressor-seal concept, early results, recent developments, current status, and future plans.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Tectonics Engineering Corporation, Minneapolis, Minn.

[5.4.88]

PERFORMANCE MEASUREMENTS FOR A DIAPHRAGM-COUPLED, FREE-PISTON STIRLING ENGINE HEAT PUMP MODULE

R. A. Ackermann* G. T. Privon

(Abstract of pp. 27-32 in *Proc. IECEC 1988 Meet.*, Denver, Colo., Jul. 31-Aug. 3, 1988, August 1988)

A free-piston Stirling engine heat pump has been under development at Mechanical Technology, Inc. (MTI) for the past several years. Recent advances have enabled a second-generation unit, the Mark I developed under the Gas Research Institute and the U.S. Department of Energy sponsorship, to achieve its performance goals and sufficient reliability to be tested at a heating, ventilating, and air conditioning manufacturer's facility. The objectives of this testing were to provide an independent evaluation of the unit's performance under conditions similar to those used on electric heat pump compressors and to establish the unit's reliability outside the research laboratory environment. Tests using an R-22 refrigerant calorimeter test loop were conducted at evaporator and condenser conditions simulating a wide range of ambient temperatures. The testing verified the

performance measured at MTI and enabled a comprehensive set of operating/performance maps to be generated.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Mechanical Technology, Inc., Latham, N.Y.

[5.4.89]

CAPACITY MODULATION COMPONENT CHARACTERIZATION AND DESIGN TOOL DEVELOPMENT

C. K. Rice

(Abstract of pp. 23-33 in *Proc. 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988, CONF-8804100, Oak Ridge National Laboratory, August 1988)

This effort focused on obtaining and evaluating modulating component and drive performance data for electric-driven, air-to-air residential heat pumps. The modulation means considered here are continuously variable-speed drives. The modulating performance data were obtained for purposes of establishing a technology base for modulating components, providing a foundation for modulating model development, and screening compressor and drive types to be used in modulating system design assessments. For the screening analyses, the relative performance of various compressors and drives was evaluated under appropriate modulating conditions. With the modulating components sufficiently characterized and the modulating models developed, the potential of advanced modulating heat pump systems for residential application can be assessed accurately.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.90]

EFFICIENCY CHARACTERISTICS OF SPEED-MODULATED DRIVES AT PREDICTED TORQUE CONDITIONS FOR AIR-TO-AIR HEAT PUMPS

C. K. Rice

[Abstract of *ASHRAE Trans.* 94(1), 892-921 (January 1988)]

Examples of system (motor plus inverter drive) efficiencies of two broad types of adjustable speed control are compared for predicted compressor and indoor blower load profiles. The two classifications are inverter-driven induction motors (IDIMs) and permanent-magnet electronically commutated motors (PM-ECMs). Reference sine-wave-driven induction motor efficiencies also are given. Currently, PM-ECM-driven blowers appear to be competitive with IDIM blowers on the combined basis of efficiency, cost, and reliability. For the compressor PM-ECM drives, if progress continues on cost and reliability

issues with minimal loss in efficiency, these drives will likely be a leading candidate for future-generation (5- to 10-year range) modulating heat pumps.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.91]

SAFETY

D. T. Rizy

[Abstract of *Electr. Eng.* 2(2), 67 (August 1988)]

Recommendations are made on the installation, maintenance, and repair of cogeneration and renewable-energy facilities and electric utility systems to which they are connected to ensure the safety of these facilities, the owner and operator, utility personnel, and the general public. The electrical interconnection of dispersed storage and generation (DSG) facilities at the transmission or distribution level of an electric utility system poses a number of concerns for the safety of utility personnel responsible for maintenance of the electric power system. These electric power producing devices may be capable of energizing feeder sections that have been otherwise disconnected from the utility source by utility personnel or by the operation of protection hardware. Line-independent DSGs, such as synchronous generators and self-commutated inverters, pose a particular hazard because they do not require excitation from the utility system to operate.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.

[5.4.92]

DISTRIBUTION AUTOMATION APPLICATIONS SOFTWARE FOR THE ATHENS UTILITIES BOARD

D. T. Rizy J. S. Lawler*
J. B. Patton** N. H. Fortson†

[Abstract of *IEEE/PES*, Paper 88 WM 097-2 (February 1988)]

The development of a distribution automation applications software package for assessing system reconfiguration opportunities and volt/var control on automated radial distribution feeders is discussed. The package, called SYSRAP (System Reconfiguration Analysis Program) was developed by Oak Ridge National Laboratory as part of the Athens Automation and Control Experiment (AACE). AACE is a large-scale distribution automation research project being conducted on the Athens Utilities Board (AUB) in Athens, Tennessee. SYSRAP is unique because it combines power flow and short circuit analyses with database management and is especially well suited for answering system operator questions with respect to switch orders, capacitor bank dispatch, and regulator tap adjustments. The program runs on a personal computer, executes power flow and short-

circuit analyses for detailed feeder models in tens of seconds, uses highly detailed feeder models including voltage-sensitive loads, and is adept at reorganizing the database to reflect switching operations and changes in the status of volt/var control equipment. Experimental observations on the AUB system have shown that voltage-insensitive load models (constant power sinks) are inadequate to accurately simulate system response to system reconfiguration and volt/var control which affect feeder voltage profile.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
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[5.4.93]

MEASURING AND ANALYZING THE IMPACT OF VOLTAGE AND CAPACITOR CONTROL WITH HIGH SPEED DATA ACQUISITION

D. T. Rizy J. S. Lawler*
J. B. Patton** W. R. Nelson

[Abstract of *IEEE/PES*, Paper 88 WM 098-6 (February 1988)]

Experimental results of the effects of capacitor switching on feeder operating variables as measured in the substation by a high-speed data acquisition system are presented. The switching in of a capacitor bank to improve power factor results in decreased reactive-power injection and increased phase voltages. Contrary to constant power load modeling, a reduction in real-power injection reflecting reduced line losses is not observable at the substation. In fact, the measured real-power injection increases. The switching out of a capacitor bank results in increased reactive power, decreased phase voltages, and decreased real power. Analysis of the experimental results, using voltage-sensitive load models, shows that while feeder losses are reduced following feeder power factor correction, the attendant improvement in voltage profile results in an increase in load that exceeds the amount of loss reduction. Distribution system operators employing supervisory control and data acquisition systems will not be able to observe the loss reduction associated with capacitor switching to improve the power factor. System planners will need to know the exact nature of load sensitivity to voltage to precisely quantify the economic benefits of installing capacitor banks. High-speed data acquisition provides a convenient means of obtaining the data necessary to determine load sensitivity to voltage.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
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[5.4.94]

IMPACT OF AUTOMATION ON THE RELIABILITY OF THE ATHENS UTILITIES BOARD'S DISTRIBUTION SYSTEM

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J. B. Patton† D. T. Rizy

[Abstract of *IEEE/PES*, Paper 88 WM 087-9 (February 1988)]

We discuss the reliability effects of distribution automation on the Athens Utilities Board (AUB) in Athens, Tennessee. Distribution feeder equipment on twelve feeders connected to three substations is remotely controlled from a central dispatch center. A supervisory control and data acquisition system provides substation and feeder monitoring and remote control of feeder circuit breakers, power reclosers, and load break switches. An analytical study is presented to show the improvement in conventional distribution system reliability indices that are achieved at AUB as a function of the penetration of automation equipment. The value of automation predicted by the study is highly sensitive to the historical outage data used in the analysis and to the economic worth of reliability assigned by the utility. These sensitivities are well known and account, at least in part, for the reluctance of some upper utility managers to invest in automation systems. Operating experience with the AUB automation system has shown that there are significant intangible reliability benefits and tangible cost savings associated with automation that are outside the scope of conventional distribution reliability indices. Eight case studies are described from actual AUB operations where the automation system resulted in significant cost savings and reliability benefits that are not captured by conventional reliability indices.

Research sponsored by the U.S. Department of Energy Office of Energy Storage and Distribution.
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[5.4.95]

PRE-RETROFIT HVAC ENERGY CONSUMPTION DATA AND UPDATED ECONOMICS OF A PLANNED HVAC SYSTEM RETROFIT: FINAL REPORT-ECIP PROJECT VALIDATION

M. P. Ternes

(Abstract of ORNL/TM-10254, Oak Ridge National Laboratory, October 1987)

This Energy Conservation Investment Program (ECIP) Project was to consist of upgrading and improving the heating, ventilating, and air-conditioning (HVAC) system in Greely Hall, Fort Huachuca, Arizona, to reduce electrical and natural gas consumption. However, the project was cancelled before the HVAC system was retrofitted, but after the pre-retofit data had been collected. The new project objectives included (1) determining the operating characteristics and annual energy consumptions of the existing HVAC system and its components and (2) reviewing and updating the previous economic analysis using current

information. The energy use of the chilled water pumps did not vary with the outdoor temperature because they were allowed to run almost constantly. The energy use of the remaining components varied with the outdoor temperature, with the exception of the cooling tower pumps, which varied inconsistently because of random operation. The annual energy consumption of the HVAC system for an average meteorological year was calculated to be 3,466,000 kWh of electricity and 19,551,000 ft^3 of natural gas. Previous estimates were within 7 and 30%, respectively, of these values. The electricity consumption of the water chillers (1,437,000 kWh) was the largest contributor to the total electrical consumption. The current savings-to-investment ratio (SIR) for the project is equal to 0.7, compared with 3.5 estimated previously. The difference is due to higher construction costs than originally estimated.

Research sponsored by the U.S. Army Facilities Engineering Support Agency.

[5.4.96]

FIELD TEST EVALUATION OF CONSERVATION RETROFITS OF LOW-INCOME SINGLE-FAMILY BUILDINGS IN WISCONSIN: SUMMARY REPORT

M. P. Ternes F. D. Boercker
L. N. McCold M. B. Gettings

(Abstract of ORNL/CON-228/P1, Oak Ridge National Laboratory, July 1988)

During the winter of 1985-86, a retrofit field test was performed in 66 occupied, low-income, single-family homes in Madison, Wisconsin. The primary objectives of the field test were to (1) determine the measured energy savings and the relative benefits of a combination of envelope and mechanical equipment retrofits that were selected following a new audit-directed retrofit procedure, (2) determine the energy savings and benefits due to performing infiltration reduction work following a recently developed infiltration reduction procedure, and (3) study general occupant behavior and house thermal characteristics and their possible change following retrofit installation. This report provides an overview of the project and summarizes the findings. The retrofit produced average annual savings of 207 therms per house. The blower-door-guided infiltration reduction procedure reduced expenditures for infiltration reduction to about one-fourth of previous program costs (from $570/house to $106/house). The procedure also reduced the average air leakage rate in the treated houses by 16%. Of the deviation between predicted and measured savings, 20 to 60% can be attributed to incorrect assumptions regarding the indoor temperature before and after retrofit. The occupants did not generally increase their indoor temperature after retrofit installation.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems and Office of State and Local Assistance Programs.

[5.4.97]

THE NATIONAL FUEL GAS END-USE EFFICIENCY FIELD TEST: EXPERIMENTAL PLAN

M. P. Ternes P. S. Hu

(Abstract of ORNL/TM-10760, Oak Ridge National Laboratory, September 1988)

The *National Fuel Gas End-Use Efficiency Field Test* will be performed to determine the performance and cost-effectiveness of a new audit-directed retrofit procedure and to develop and validate analysis techniques for evaluating conservation programs that can use the daily house gas use data that can be economically collected by gas telemetering equipment. The audit procedure is designed to improve conservation programs by (1) including mechanical system retrofits as retrofit options in addition to building envelope retrofits, (2) determining the most cost-effective retrofits for each house through individual analysis, and (3) following a rational decision process to determine the investment level of each house. This report is an experimental plan presenting (1) a detailed description of the audit procedure, (2) specific research goals and questions to be addressed by the field test, (3) the responsibilities of the six field test participants, (4) 16 tasks required to complete the field test, (5) a detailed description of the experimental design, (6) house selection and assignment procedures, (7) a detailed description of the data to be collected and the instrumentation to collect it, (8) a data management procedure to store the data and check it for errors, and (9) analysis procedures to be employed to study the collected data.

Research sponsored by the U.S. Department of Energy Building Energy Retrofit Research Program.

[5.4.98]

ENERGY AND COST SAVINGS DUE TO THE INSTALLATION OF CONDENSATE RETURN LINES: FINAL REPORT-ECIP PROJECT VALIDATION

M. P. Ternes J. M. MacDonald

(Abstract of ORNL/CON-243, Oak Ridge National Laboratory, April 1988)

This report presents the results of an Energy Conservation Investment Program (ECIP) validation study. Condensate return lines were installed in the 5000 building area of the Redstone Arsenal to return condensate from the buildings to the 4725 steam plant. The validation study was designed to (1) determine the energy savings actually achieved from the installation of the condensate return lines, (2) obtain a savings-to-investment ratio (SIR) for the project following life cycle cost analysis procedures prescribed in ECIP guidance documents and from actual project cost data, and (3) compare actual energy and cost savings with those predicted during the design phase. Energy savings were estimated from engineering calculations, weekly metered data, and historical plant data. Approximately 65 to 90% of the steam delivered to the 5000 building area was returned to the steam plant by the condensate system, depending on the ambient temperature. The total energy savings

was estimated to be 18,564 MBtu/year, with the majority of the savings realized from decreased fuel consumption at the steam plant. The overall SIR for the project was estimated to be 2.2 for an assumed 25-year life. The SIR estimated in this study was slightly higher than the original SIR estimate (2.01) used to justify the project, despite the fact that the actual annual energy savings was 30% less than that predicted. The decrease in expected energy savings was largely offset by a lower-than-anticipated investment cost.

Research sponsored by the U.S. Army Facilities Engineering Support Agency, Fort Belvoir, Va.

[5.4.99]

ENERGY AND COST SAVINGS FROM A WATER-SIDE FREE-COOLING SYSTEM USING A HEAT EXCHANGER: FINAL REPORT– ECIP PROJECT VALIDATION

M. P. Termes J. M. Morrison*

(Abstract of ORNL/CON-237, Oak Ridge National Laboratory, April 1988)

This report presents the results of an Energy Conservation Investment Program (ECIP) validation study. The central chilled-water system at the Walter Reed Army Medical Center was modified by including a water-side free-cooling system employing a heat exchanger. The purpose of the validation study was to (1) determine the actual energy savings achieved from the installation of the heat exchanger free-cooling system, (2) perform a life cycle cost analysis to obtain the savings-to-investment ratio (SIR) for the project, and (3) compare actual energy savings and cost savings to those predicted during the design phase. The annual electricity savings were estimated to be 1,507,905 kWh if the heat exchanger is used whenever thermally possible and 1,003,759 kWh if use of the heat exchanger is restricted to times when only one chilled-water pump is run. The overall SIR for the project was estimated to be between 6.3 and 3.2, depending on the operating strategy and economic life assumed (either 25 or 15 years). This SIR compares favorably with the original SIR estimate (7.8) used to justify the project, based on optimum use of the system and a 25-year life. The 1983 ECIP guidance requires that the SIR be greater than 1.0. The economics are such that the project would have paid for itself by the time the validation study was performed if average weather conditions prevailed over the past six years.

Research sponsored by the U.S. Army Facilities Engineering Support Agency, Ft. Belvoir, Va.
*Engineering Division.

[5.4.100]

THE EFFECT OF HOUSE INDOOR TEMPERATURE ON MEASURED AND PREDICTED ENERGY SAVINGS

M. P. Ternes T. K. Stovall*

(Abstract of pp. 9.169-9.181 in *Proc. ACEEE 1988 Summer Study Energy Effic. Build., Pacific Grove, Calif.*, Aug. 28-Sept. 3, 1988, August 1988)

In many major residential weatherization studies, the average measured energy savings have been less than the predicted savings and large scatter in the measured energy savings has been observed. Changes in the indoor temperatures of the houses before and after weatherization have often been cited as a possible explanation for these results. Our analysis indicated that only in isolated cases did occupants significantly change their indoor temperature following the installation of conservation measures. The average change was 0, and increases in temperature were as likely to be observed as decreases. Thus, these results do not support the supposition that changes in house indoor temperature significantly contribute to lower-than-expected savings observed in retrofit programs. They do, however, indicate that the isolated changes contribute to the variation observed in measured savings. The average measured indoor temperature was found to be about 70°F, a value that is typically assumed when predicting energy savings. However, the indoor temperature in one-third of the houses differed from this value significantly, further contributing to the variation in measured savings. We found from our studies that the difference between predicted and measured savings can be reduced in individual houses by 20 to 60% if the measured savings are adjusted on the basis of the same indoor temperature conditions assumed in making the predictions. For such an adjustment, indoor temperature must be measured and a house model that includes indoor temperature must be developed.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Engineering Technology Division.

[5.4.101]

LABORATORY TESTING OF A HEAT PUMP SYSTEM WITH WATER-TO-WATER COUNTERFLOW HEAT EXCHANGERS USING VARIOUS COMPOSITIONS OF AN R13B1/R152A NONAZEOTROPIC REFRIGERANT MIXTURE

E. A. Vineyard

[Abstract of *ASHRAE Trans.* 94(1), 292-303 (January 1988)]

Testing was performed with a nonazeotropic refrigerant mixture of R13B1/R152a to determine its ability to achieve (1) capacity control by adjusting the composition and (2) increased capacity, relative to R22, at low ambient temperatures. The selection of such a mixture could improve the efficiency of a heat pump by decreasing the cycling losses, which account for approximately 7 to 12% of the annual energy use, along with decreasing

the amount of resistance heat required at low ambient temperatures. Results for the mixture show a potential capacity modulation from 12,431 Btu/h (3,643 W) at 17°F (-8.3°C) to 855 Btu/h (2,506 W) at 47°F (8.3°C) in heating and from 7,451 Btu/h (2,184 W) at 82°F (27.8°C) to 9,188 Btu/h (2,693 W) at 95°F (35°C) in cooling. An analysis of the coefficients of performance for the mixture and its comparison is based on maintaining equivalent inlet and exit water temperatures in the evaporator and condenser for both R22 and the mixtures.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.102]

EVALUATION OF NONAZEOTROPIC REFRIGERANT MIXTURES FOR CAPACITY MODULATION

E. A. Vineyard J. R. Sand

(Abstract of pp. 47-54 in *Proc. 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988, CONF-8804100, Oak Ridge National Laboratory, August 1988)

A test program is under way to evaluate the potential performance improvements from using nonazeotropic refrigerant mixtures in residential heat pumps. The goals are to achieve (1) capacity control by adjusting the composition; (2) increased capacity, relative to R22, at low ambient temperatures; and (3) matching of the refrigerant temperature differentials to the source and sink fluid temperature differentials. Performance improvements are expected to result from decreasing the cycling losses and the amount of resistance heat required at low ambient temperatures along with reducing the irreversibilities in the heat exchangers. Initial results for a mixture of R13B1/R152a show a potential capacity modulation from 12,431 Btu/h (3,643 W) at 17°F (-8.3°C) to 8,550 Btu/h (2,506 W) at 47°F (8.3°C) in heating and from 7,451 Btu/h (2,184 W) at 82°F (27.8°C) to 9,188 Btu/h (2,693 W) at 95°F (35°C) in cooling. Other refrigerant pairs that are safer from an ozone depletion standpoint are under consideration for later testing.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.103]

MODELING OF RESIDENTIAL ATTICS WITH RADIANT BARRIERS

K. E. Wilkes

(Abstract of pp. 161-68 in *Proc. Fifth Ann. Symp. Improv. Build. Energy Effic. Hot Humid Clim.*, Houston, Tex., Sept. 13-14, 1988, September 1988)

This paper summarizes the efforts at Oak Ridge National Laboratory in modeling residential attics with radiant barriers. Analytical models based on a system of macroscopic

heat balances have been developed, as have separate models for horizontal radiant barriers laid on top of the insulation and for radiant barriers attached to the bottom of the top chords of the attic trusses. The models include features such as a radiation interchange analysis within the attic space, convective coupling with the ventilation air, and sorption/desorption of moisture at surfaces facing the attic enclosure. The report gives details of the models and the engineering assumptions that were made in their development and on the status of efforts that are under way to verify the models by comparing their predictions with the results of laboratory and field tests on residential attics and test cells, both with and without radiant barriers. Comparisons are given for a number of selected sets of experimental data. Suggestions are given for needed model refinements and additional experimental data. Plans for usage of the models for extrapolation to seasonal and annual performance in a variety of climatic conditions are also described.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.104]

STATUS OF RESEARCH ON RADIANT BARRIERS AND REFLECTIVE INSULATION

K. E. Wilkes

(Abstract of a paper presented at the *Build. Therm. Envelope Coord. Counc.-Mater. RCC*, Vol. II, Washington, D.C., Oct. 6, 1987, October 1987)

Insulation systems based on highly reflective surfaces have been in existence for several years. Renewed interest in the application of these systems to buildings has been generated by recent experiments, especially those on the class of systems that are known as radiant barriers. Experiments by a number of groups have clearly demonstrated that radiant barriers are effective in reducing heat flows through ceilings of buildings, especially under conditions where the building is cooled. While the results are in qualitative agreement in indicating heat flow reductions, there is a controversy regarding the quantitative thermal performance of radiant barriers. The possibility of a long-term degradation of performance and potential moisture problems are two other issues relating to these systems. This report reviews past experiments and the current status of R&D. Recommendations are made for future study.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.

[5.4.105]

EFFECT OF SURFACE MASS ON ROOF THERMAL PERFORMANCE

K. E. Wilkes P. H. Shipp
J. P. Sanders*

(Abstract of pp. 326-34 in *Fifth Ann. Symp. Improv. Build. Energy Effic. Hot Humid Clim.*, Houston, Sept. 13-14, 1988, September 1988)

The roof of a building is exposed to the most severe environment experienced by any component of a building envelope. Diurnal peak surface temperatures of 140 to 185°F are not uncommon. The addition of thermal mass to the exterior surface of the roof should lessen the severity of the environment experienced by the roof membrane and the roof insulation. The exterior mass should result in attenuation of both temperature extremes and heat flux variations. It also may result in lowered net heat flow through the roof. This report presents some results of a combined experimental and analytical study to quantify the effects of surface mass. Measurements were made on roof test panels exposed to the weather of eastern Tennessee. The test panels consisted of glass fiber insulation with a modified bitumen membrane. Experiments were conducted on a bare panel and on panels that were loaded with either concrete pavers or aggregates. A heat transfer model for the bare panel and the panel with concrete pavers was developed to calculate the internal temperatures and heat fluxes using measured indoor and ambient conditions. The model was validated by comparing its predictions with measured values. Following validation, the model was used to perform a parametric study of the effects of various levels of surface mass.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Engineering Technology Division.

[5.4.106]

RADIANT BARRIER RESEARCH PLAN

K. E. Wilkes D. W. Yarbrough*

(Abstract of ORNL/CON-256, Oak Ridge National Laboratory, June 1988)

Tennessee Valley Authority (TVA) and Oak Ridge National Laboratory (ORNL) organized a National Radiant Barrier Workshop held at TVA headquarters in Chattanooga, Tennessee, in May 1986. Following this meeting, the Department of Energy (DOE) and ORNL organized a Radiant Barrier Systems Technical Panel, which met on March 10-11, 1987, in Washington, D.C., and two subsequent meetings have been held. The participants included manufacturers, trade organizations, utilities, government laboratories, private sector laboratories, and DOE staff. The objective of the panel was to assess the status of technology, identify the key issues that limit the understanding or application of radiant barrier systems, and develop a research plan to resolve the issues identified. The recommendations made by the panel were used as a basis for developing this Radiant Barrier Research Plan. Key areas where research was felt to be needed were the determination of the effects on radiant barrier performance because of radiant barrier

location, attic ventilation, level of mass insulation, emittance changes such as those caused by dust accumulation, and climatic conditions; the determination of seasonal and annual performance; the potential for moisture problems; standardized procedures for reporting field test results; standardized methods for testing and labeling RBS; and development of analytical models.

Research sponsored by the U.S. Department of Energy Office of Buildings and Community Systems.
*Metals and Ceramics Division.

[5.4.107]

FETS AUTOMATED DATABASE SYSTEM—USER'S GUIDE

K. H. Zimmerman J. L. Bledsoe*
M. A. Broders

(Abstract of ORNL/TM-10621/V1, and ORNL/TM-10621/V2, Oak Ridge National Laboratory, February 1988)

The FETS Automated Database System is a document-retrieval system developed by Oak Ridge National Laboratory (ORNL) for use by FETS. FETS is a technical information response service that aids Army personnel in the area of facility energy management. The main objective of the FETS Automated Database is to provide an information-retrieval system that will increase FETS staff responsiveness to its customers. The system contains bibliographic data from documents that have been screened and acquired by ORNL engineering staff. Document selection was directed toward providing a base of documents pertinent to the FETS mission of energy technology evaluation. The scope of the database is facility energy conservation with an emphasis on equipment performance. Volume I provides procedural documentation for the FETS Automated Database System, provides the system user procedures and examples for manipulating the system in response to field requests, and contains samples of the standard reports. Volume II contains information on system access and the computer coding for the following areas of the system: FETS Custom Menu System, standard reports, PERFORM screen access, Data Entry Form, and Data Verification Reports.

Research sponsored by the U.S. Department of the Army Engineering and Housing Support Center, Ft. Belvoir, Va.
*Computing and Telecommunications Organization.

Planning and Coordination 6

T. J. Wilbanks, Senior Planner

PLANNING AND COORDINATION

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DEVELOPING COUNTRY PROJECTS

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TECHNICAL POLICY CENTER

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Planning and Coordination 6

6.1 OVERVIEW

In FY 1988, the continuing realignment of the Energy Division organization, together with the continuing ORNL commitment to examine long-term energy technology issues, reshaped the Planning and Coordination function of the Division. Division Director W. Fulkerson spent a major part of the year leading an assessment for ORNL of the state of energy technology research and development (R&D). Upon Fulkerson's return to the Division, R. B. Shelton—who served as interim division director in Fulkerson's absence—was named associate director of the Energy Division, assuming responsibility for several crosscutting programs that had previously operated under Planning and Coordination, including emergency preparedness. The major programmatic areas remaining in Planning and Coordination as such were international applications and technology policy research (the latter jointly responsible to Shelton). In addition, Planning and Coordination continued to support Division long-range planning and program development and to serve as a mechanism for conducting high-priority research and assessment activities related to emphases in the Division's Long-Range Plan.

6.1.1 Directions for Energy Technology R&D

One critical requirement for ORNL's institutional planning is up-to-date knowledge of the state of energy technology R&D: technology status, recent or anticipated breakthroughs, and technology needs in the United States and the rest of the world. To take stock of developments during the 1980s, Murray Rosenthal, ORNL's associate director for Advanced Energy Systems, commissioned a wide-ranging assessment during FY 1988, asking W. Fulkerson to lead this effort. Fulkerson was assisted by Alan Crane (U.S. Office of Technology Assessment), Don Kash (the University of Oklahoma), A. M. Perry (Energy Division), David Reister (Engineering Technology Division), Kay Zimmerman (Energy Division), and a host of other Laboratory experts on particular technology areas.

The study[1] concluded that two major uncertainties preclude gaining a clear picture of future energy technology needs: (1) uncertainty about future energy demand and (2) uncertainties about the urgency of the greenhouse effect and other major environmental, health, and safety problems. To allow for these uncertainties, it is essential to have an R&D strategy that is balanced with respect to its focus on improved energy sources and on improved end-use efficiency.

Whatever the future holds, however, energy efficiency improvement is attractive in both the short term and the longer term. The potentials in this regard from both applying existing technologies and developing further improvements are substantial. In spite of this, the rate of future progress remains uncertain because so many institutional obstacles must be overcome. For this reason, and to help correct existing and anticipated future problems in our energy system, it is imperative to improve energy supply technologies, especially in nonfossil sources.

Based on its survey of energy technology R&D, the study describes a rich variety of

ORNL-Photo 4358-89

A wide-ranging assessment was commissioned of the state of energy technology R&D.

energy technology R&D options, offering a prospect of the needed balance in an energy R&D strategy. Given the importance of energy to the U.S. and world economies, though, the current level of R&D investment from both public and private sources (amounting to less than 1.5% of total expenditures for energy services) appears to be too low, and the current set of R&D activities is inadequate to prepare us to respond to concerns about a greenhouse effect. A much more intensive effort is needed to develop and improve nonfossil energy sources to enable a reduction in CO_2 emissions without unacceptable economic costs, and at least as great an effort is needed to develop and disseminate technologies to improve the productive use of energy (especially from fossil fuels.)

6.1.2 International Applications

During FY 1988, the Division's program of analysis and technical assistance related to the energy needs of developing countries continued to focus on two major responsibilities for the Office of Energy, U.S. Agency for International Development (AID): (1) energy planning and policy development and (2) renewable energy applications and energy for rural areas. In both cases, interagency agreements between AID and DOE make it possible for field missions and other AID offices, as well as the Office of Energy, to have access to ORNL resources. In addition, the Energy Division expanded its role in supporting the work of DOE's Office of Photovoltaics Technology related to developing countries, along with supporting several other DOE offices.

The main thrust of the Division's work during the year was improving the general understanding of how to implement good energy ideas (especially innovative energy technologies) in developing countries. It is widely agreed that, even though better options are always welcome, there are far more energy technologies and policies already on hand that make sense in developing countries than have in fact been adopted. Improving the process by which good energy ideas are implemented is

ORNL-Photo 5182-88

A focus of Planning and Coordination activities is improving the understanding of how to implement good energy ideas in developing countries.

perhaps the most fundamental way to contribute to economic and social development through changes in the energy sector.

Clearly, one key to improving the implementation process is to make financing more readily available for good ideas. One problem in this regard is that lenders may not be operating from the same base of information as are energy analysts. During FY 1988, the Energy Division continued to provide the "secretariat" for the Multi-Agency Working Group on Power Sector Innovation (MAGPI), created in 1987 at AID's initiative to improve the dialogue with major lending agencies on strategies for the electric power sector in developing countries. A second problem, especially for efficiency improvement and renewable energy applications, is providing financing for small investments: for example, purchases by households or small businesses of equipment with attractive life-cycle costs but relatively high front-end costs. To encourage the use of photovoltaic cells in villages in the Dominican Republic not served by the central power grid, Dan Waddle and Bob Perlack, working with Richard Hansen of Enersol, Inc. (supported by DOE), developed an innovative approach to financing (Fig. 6.1) that may serve as a model for other technologies and countries as well.

Another key is to experiment with and learn from innovative approaches to placing new technologies into use. One major initiative by AID, to which the Energy Division is contributing information and advice, is a Project to Accelerate the Commercialization of Energy Research (PACER) in India, which is building stronger linkages between Indian energy R&D centers and users of energy technologies, especially in the power sector. In another effort during FY 1988, H. G. (Mike) Jones of Oak Ridge Associated Universities (ORAU) and Glenn Stevenson of the Energy Division joined with several Kenyan colleagues to assess the experience in that country with commercializing improved cookstoves.[2] The study concluded that the notable success in Kenya occurred mainly because the Kenya Ceramic Jiko stove was disseminated through existing Kenyan institutions, production systems, and markets. The stove was manufactured locally, after careful attention to local needs and conditions; when initial commercial success turned it into an

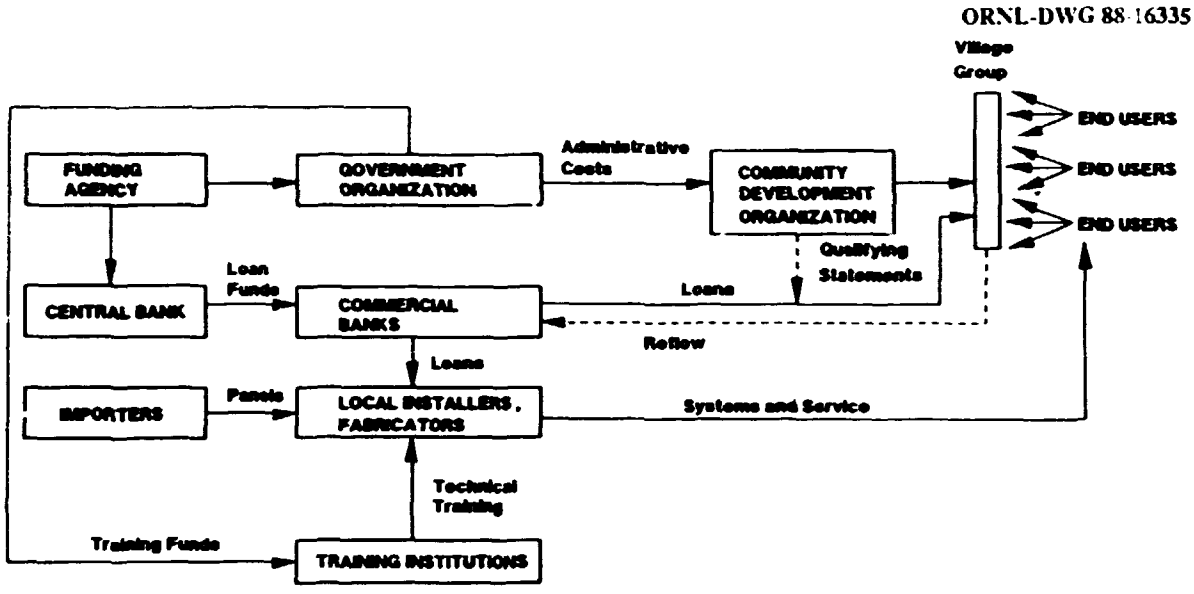

Fig. 6.1. Financial and institutional structure proposed to encourage the use of photovoltaic cells in villages in the Dominican Republic not served by the central power grid. This proposal could serve as a model for other technologies and countries.

entrepreneurial opportunity for the local private sector, the resulting sales efforts easily expanded the use of the improved stove.

In a broader assessment of issues for power generation in Central America, John Reed joined with Jose Herrera and Tom Reddoch of Electrotek Concepts to outline potentials to reduce power losses in transmission and distribution systems in developing countries.[3] Preventing or reducing power losses is one of

ORNL-Photo 4419-89

Local private entrepreneurs in Kenya have found that manufacturing and selling more energy-efficient cookstoves can be a good business opportunity.

the central elements of any comprehensive strategy to increase efficiency in the power sector (Fig. 6.2).

A further key is to improve the performance of energy institutions in developing countries—government agencies involved with the energy sector, electric utilities, and others. A summary of the lessons learned from a decade and a half of experience with national energy planning was published during the year,[4] and on AID's behalf the Division began participating in a major two-year multiagency project to examine organizational efficiency improvement strategies for electric utilities in developing countries.

One more key is to improve policy conditions for energy decision making. The priorities are (1) to improve energy pricing in the many instances where subsidized or controlled prices—especially for electricity—send misleading signals to decision makers and represent a heavy burden on a developing economy and (2) to improve the consideration of environmental impacts as energy decisions are made. Larry Hill continued his research on energy price reform in developing countries,[5] emphasizing a case study of energy pricing in Korea (which in some connections can be seen as a "success experience" with price reform). A new program was also initiated in environmental management in the energy sector, related to the Division's interests in global environmental change. The first activity was an analysis of possible environmental impacts of oil shale development in Jordan.

In other activities during this fiscal year, the Energy Division continued its role in connecting the Laboratory's expertise in fossil energy with energy needs of developing countries. Besides completing several years of institution-building assistance to India's Bharat Heavy Electrical related to fluidized-bed coal combustion R&D (led by Radha Krishnan of the Engineering Technology Division), ORNL played a major role in assessing a proposal to generate electric power in Jordan from that country's oil shale resource.[6] Working with Bechtel and others on a prefeasibility study for AID, Larry Hill analyzed the economic and financial viability of the project; Carl Petrich, assisted by Dick Roop and experts from several other ORNL divisions, examined the environmental implications; and Bob Holcomb of the Engineering Technology Division assessed the suitability of the proposed

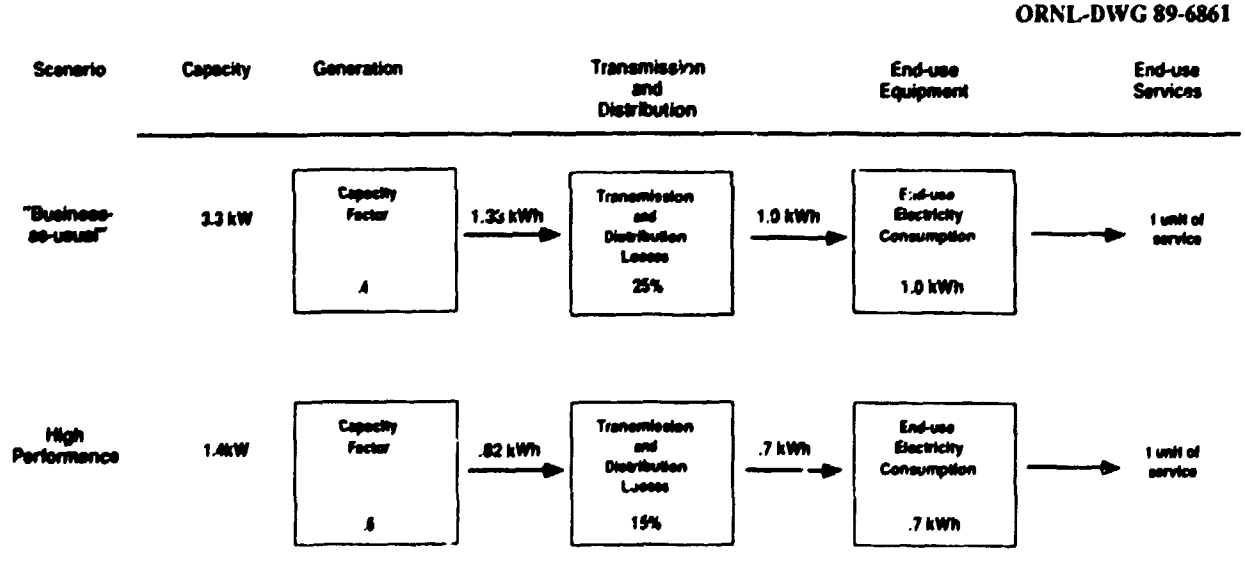

Fig. 6.2. Impacts of technical improvements on overall productivity of capital in the power sector of less developed countries.

circulating fluidized-bed technology. Hill's analysis showed that a 50-MW plant would be economically attractive under only very favorable conditions (Table 6.1); because of scale economies, a larger plant would be more attractive economically but would be subject to a wider range of uncertainties. Environmentally, Petrich identified no "show-stoppers" for the proposed project, although waste disposal and water quantity and quality impacts would require careful attention.

The Division also continued its assistance to AID's Regional Office for Central American Programs (ROCAP) in monitoring a major National Rural Electric Cooperative Association (NRECA) rural electrification strategy project and its assistance to AID's Africa Bureau in energy program and project development (assisted by ORAU). The Division also began project design and evaluation assistance to AID/Cairo. Finally, the Division assisted AID's Office of Energy in developing a technical assistance agenda related to energy needs in rural areas in developing countries.

6.1.3 Technology Policy

In FY 1988, ORNL and the Energy Division continued an effort to assess the feasibility of establishing a center at the Laboratory to carry out research on technology utilization. Under the leadership of John Sorensen, four small research activities were conducted as building blocks for the process: a review of the technology transfer literature in economics to determine remaining needs, a review of the experience with commercializing DOE energy technologies, a review of approaches to

Table 6.1. Selected sensitivity results under an assumed tariff increase[a] by capacity factor and capital expenditures. (Scenarios: 50-MW option)

Capacity factor (%)	50 MW[b] (%)				
	0.75	1.00	1.25	1.50	2.00
75	9.16	6.15	4.08	2.54	0.31
60	5.92	3.32	1.51	0.14	c
50	3.40	1.09	c	c	c

[a]The current tariff structure yields on average $0.06/kWh for electricity sales. This scenario assumes that average revenues were increased by 25% to $0.075/kWh. Also, the results include an 80/20 debt/equity assumption for the capital structure of the mining/processing and spent ash disposal operations.

[b]Number headings refer to the five capital expenditure scenarios.

[c]Internal rate of return is less than zero.

Source: L. V. Hill and C. H. Petrich, Potential Use of Oil Shale for Direct Production of Power in Jordan," *Nat. Resour. Forum*, to be published, November 1989.

resolving conflicts in energy facility siting, and the development of a bibliographic database on technology acceptance.

Late in the year, because of Sorensen's growing commitment to emergency preparedness work, Martin Katzman was appointed leader of the research effort, which was retitled "technology policy" to represent more clearly its collateral interest in technology development and technology use. One consequence was an expanded attempt to connect the assessment with concerns of the Laboratory beyond those of the Energy Division.

In one new initiative, the Technology Policy Program began an examination of the ongoing experience of the new High Temperature Superconductivity Pilot Center. This center has been given the authority to negotiate intellectual property rights related to the commercial use of new high-temperature superconducting materials. Supported by the Office of Technology Applications, Martin Marietta Energy Systems, and the pilot center itself, the assessment begun in FY 1988 will provide a basis for evaluating this innovation.

Meanwhile, the program is exploring the possibility of holding a major workshop or conference on the implementation of energy efficiency improvement options as a further step toward a decision about whether to establish a formal center for research on technology applications and policy.

6.1.4 Special Studies

Continuing its established role in carrying out broad technology-related assessments related to ORNL missions and the Energy Division Long-Range Plan, the Planning and Coordination activity also produced (1) an overview of the potential for new energy technologies to help developing countries, as part of a series of seminars jointly sponsored by the National Academy of Sciences and AID,[7] and (2) the energy portion of the National Geographic Society's Centennial Symposium on *Earth '88: Changing Geographic Perspectives*.[8] In addition, an updated version of the Long-Range Plan itself was developed.

6.2 RESEARCH UTILIZATION

Most of the research, assessment, and technical assistance activity reported in this chapter serves three purposes: to answer questions posed by the sponsors of the work, to serve as a building block for the Division's thinking about critical issues and its program development related to those issues, and to contribute a broader understanding in the research and policy communities of issues and options. Besides usage by sponsors, both the energy technology R&D study and the international assistance program produced information and views that were used widely at ORNL for institutional planning; and the work of the Energy Division was also used by the community at the Laboratory. In addition, the growing level of support from DOE related to developing countries is an example of the application of experience and capabilities developed in the AID program.

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4. T. J. Wilbanks, "Lessons from the National Energy Planning Experience in Developing Countries," *Energy J.*, 8 (1987): special issues on less developed countries, 169-82.

5. L. J. Hill, "Implementing Energy Price Reform in Developing Countries," *Nat. Resourc. Forum*, 12(1), 56-67 (February 1988).

6. L. J. Hill et al., *An Assessment of Using Oil Shale for Power Production in the Hashemite Kingdom of Jordan*, ORNL-6559, to be published.

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8. T. J. Wilbanks, "Impacts of Energy Development and Use, 1888-2088," pp. 96-114 in *Earth '88: Changing Geographic Perspectives*, National Geographic Society, Washington, D.C., 1988.

6.4 ABSTRACTS OF PUBLICATIONS

[6.4.1]

LESSONS FROM THE NATIONAL ENERGY PLANNING EXPERIENCE IN DEVELOPING COUNTRIES

T. J. Wilbanks

[Abstract of *Energy J.* 9, 167-80 (1988)]

Most of the effort to solve the energy problems of developing countries since 1973 has been devoted to demonstrating particular energy technology options. Ineffective energy planning has often led to unwise selection of energy options; wastes of scarce fiscal and human resources; energy shortages, higher than necessary energy costs, and unreliabilities in energy supply that become obstacles to the development process; and reduced confidence

in energy and other institutions. One response has been to emphasize the importance of integrated, comprehensive national energy planning and to provide technical assistance to developing countries in building institutions. This paper offers a summary of what has been learned so far, together with some thoughts about where to go from here.

Research sponsored by the U.S. Agency for International Development.

[6.4.2]

THE IMPACTS OF ENERGY DEVELOPMENT AND USE, 1888-2088

T. J. Wilbanks

(Abstract of pp. 96-114 in *Earth '88: Changing Geographic Perspectives*, National Geographic Society, Washington, D.C., 1988)

Energy development and use has transformed American life through the technologies it has powered. One theme has been the emergence of petroleum, especially in connection with transportation fuels. A second has been the sweeping adoption of electricity. Energy development and use has shaped global trade and advantage, especially in the rise of the Middle East in international significance since World War II. We now find ourselves in a time of transition. We must wean ourselves from dependence on petroleum and natural gas, but other problems seem more immediate. By 2088, we can expect that the shift away from petroleum and natural gas will be well advanced while the need for energy services will have grown substantially, especially in developing countries. Handling this shift will have been difficult because environmental and health issues shape many choices. It is hoped that by then we will have developed better energy options and that we will have rediscovered the same sense of excitement and mission in the field of energy that our early nuclear and solar energy pioneers knew.

Publications and Professional Activities

7

Publications and Professional Activities 7

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7.2 PUBLICATIONS BY ENERGY DIVISION STAFF

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7.4 PROFESSIONAL ACTIVITIES AND AWARDS

Adler, M. V., Referee, *Nuclear Safety.*

Baxter, V. D., ASHRAE TC 7.6 on Unitary Air Conditioners and Heat Pumps and ASHRAE TC 9.4 Applied Heat Pump/Heat Recovery Systems; American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Bownds, J. M., Reviewer, *Mathematical Reviews.*

Bownds, J. M., Referee, *Journal of Integral Equations and Applications.*

Brown, M. A., Chair, Energy Specialty Group, Association of American Geographers, 1986–88.

Brown, M. A., Editorial Board, *Annals of the Association of American Geographers.*

Brown, M. A., National Councillor, Association of American Geographers, 1988–1991.

Brown, M. A., Editorial Board, *The Professional Geographer.*

Brown, M. A., Program Planning Committee, Fourth International Energy Conservation Program Evaluation Conference.

Cantor, R. A., Manuscript Referee, Duke University Press.

Cantor, R. A., Recipient, Martin Marietta Energy Systems Significant Event Award, January 1988.

Cantor, R. A., President, Board of Directors, Matrix Organization, The Business Center for Women and Minorities, Knoxville, Tennessee.

Cantor, R. A., Manuscript Referee, *Risk Analysis: An International Journal.*

Cantor, R. A., Session Chair, Standards Session, Society for Risk Analysis, November 1987.

Chen, F. C., ASHRAE TC 9.5 on Cogeneration Systems and ASHRAE TG/EDHP on Engine Driven Heat Pumps, American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Chen, F. C., Chairman, ASME Heat Pump Technical Committee, American Society of Mechanical Engineers.

Christian, J. E., Insulation Advisory Committee, Exxon Foundation.

Christian, J. E., ASHRAE 90.2P Energy Efficient Design of New Low-Rise Residential Building Standards Committee, American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Christian, J. E., Energy and the Indoor Environment Review Board, University of Minnesota.

Christian, J. E., Editorial Board, *Light Construction Research Journal.*

Courville, G. E., Member, ASTM C16 on Thermal Insulation, D-8 on Roofs, American Society of Testing and Materials.

Courville, G. E., Technical Committee, Single Ply Roofing Institute.

Courville, G. E., Board of Directors, Building Thermal Coordinating Council.

Courville, G. E., ASHRAE TC 1.2 on Instruments & Measurements, ASHRAE TC 4.4 on Thermal Insulation & Moisture Retarders, and ASHRAE TC 4.9 on Building Envelope Systems; American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Creswick, F. A., ASHRAE TC 6.3 on Central Forced Air Heating and Cooling Systems, ASHRAE TC 7.6 on Unitary Air-Conditioning and Heat Pumps, and ASHRAE TG-EDHP on Engine-Driven Heat Pumps; American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Dale, S. J., Technical Advisory Board, Power Silicon and Monolithic Technologies Corporation.

Dale, S. J., Committee on Technology Management, American Association of Engineers Society.

Fairchild, P. D., Invited Advisor, Research and Technology Committee, Air-Conditioning and Refrigeration Institute.

Fairchild, P. D., Chairman, ASHRAE TC 9.4 on Applied Heat Pump/Heat Recovery Systems and member ASHRAE TG-HE on Halocarbon Emissions; American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Feldman, D. L., Referee, *Choice, The Association of College and Research Libraries.*

Feldman, D. L., Referee, *The Environmental Professional.*

Fulkerson, W., Applied Science Division Review Committee, Lawrence Berkeley Laboratory.

Fulkerson, W., Committee of the Energy Engineering Board, Commission on Engineering and Technical Systems, National Research Council, National Academy of Sciences to review the Gas Research Institute's RD&D Program.

Gant, K. S., Referee, *Nuclear Safety.*

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Greene, D. L., Chairman, Energy Conservation and Transportation Demand, Transportation Research Board.

Greene, D. L., Member, Board of Directors, Transportation Specialty Group, Association of American Geographers.

Greene, D. L., Editorial Advisory Board, *Journal Transportation Research.*

Hillsman, E. L., Referee, *Energy Systems and Policy.*

Hillsman, E. L., Referee, *Geographical Analysis.*

Hillsman, E. L., Board of Directors, AAG Energy and Environment Specialty Group, 1988-1991.

Hirst, E. A., Energy Committee, Sierra Club.

Hirst, E. A., Editorial Boards, *The Energy Journal, International Journal of Energy Systems, Journal of Environmental Systems, Evaluation and Program Planning, Energy Systems and Policy,* and *Energy Policy.*

Hirst, E. A., Member, Demand-Side Management Advisory Committee, Boston Edison Company, 1987-89.

Hirst, E. A., Member, Demand-Side Planning & Information Group, Electric Power Research Institute.

Hirst, E. A., Achievement Award for *The Hood River Conservation Project: Cooperation and Community Conservation*, International Technical Publications Competition, Society for Technical Communication, 1988.

Hirst, E. A., Leader, Organizing Committee, Panel on Planning and Forecasting, Summer Study of Energy Efficiency in Buildings, American Council for an Energy-Efficient Economy.

Hirst, E. A., Advisory Committee, Energy Conservation Coalition.

Hirst, E. A., Associate Editor, *Energy*.

Hunsaker, Jr., D. B., Technical Reviewer and Review Coordinator, *Journal of the Air Pollution Control Association*.

Katzman, M. T., Book Reviewer, *Choice*, May 1980–present.

Katzman, M. T., Research Grants Review Board, S. S. Huebner Foundation for Insurance Education, Wharton School, University of Pennsylvania, September 1986–present.

Katzman, M. T., Reviewer, *Journal of Risk and Insurance*.

MacDonald, J. M., ASHRAE TC 9.6 Subcommittee on Building Monitoring and ASHRAE Standards Project Committee 100.5 on Energy Conservation in Existing Buildings–Institutional; American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Mei, V. C., ASHRAE TC 1.3 on Heat Transfer and Fluid Flow, American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Mei, V. C., ASME Heat Pump Technical Committee, American Society of Mechanical Engineers.

Miller, W. A., ASHRAE TC 1.2 on Instruments and Measurements, American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Miller, R. L., Referee, *Journal of the Air Pollution Control Association*.

Mixon, W. R., Advisors Group, Cogeneration Program, Gas Research Institute.

Mixon, W. R., ASHRAE TC 9.6 on Systems Energy Utilization, American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Mixon, W. R., Advisory Committee, Annual Symposium on Improving Building Energy Efficiency in Hot and Humid Climates.

Peelle, E. B., Recipient, East Tennessee Chapter, American Women in Science Award–Distinguished Leader and Advocate, May 1988.

Perez-Blanco, H., ASHRAE 8.3 on Absorption and Heat Operated Machines, American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Privon, G. T., Heat Pump Advisory Group, Gas Research Institute.

Purucker, S. L., Distribution Automation Working Group, IEEE Power Engineering Society.

Purucker, S. L., System Planning Subcommittee, IEEE Power Engineering Society.

Reed, J. H., Demand Side Management Tutorial Subcommittee, Power Engineering Society, Institute of Electrical and Electronics Engineers.

Reed, J. H., Editorial Advisory Panel, Electric Power Systems Research Journal.

Rogers, G. O., Referee, *Nuclear Safety*.

Rogers, G. O., Referee, *International Journal of Mass Emergencies*.

Roop, R. D., Ecology Committee, Water Pollution Control Federation.

Russell, M., Advisory Committee, Wharton Risk and Decision Processes Center, 1986–present.

Russell, M., Member, Committee on Risk Perception and Communication, National Research Council, 1987-1989.

Russell, M., Member, Board of Editors, *Journal of Cultural Economics*, 1978-present.

Russell, M., Member, Science Advisory Board, U.S. EPA Committees on Global Climate.

Russell, M., Member, National Research Council, Board on Environmental Studies and Toxicology, 1988-present.

Russell, M., Advisory Group on Integrated Pollution Control in Europe and North America, The Conservation Foundation.

Russell, M., Member, Panel on Technological Risks and Opportunities for Future U.S. Energy Supply and Demand, U.S. Congress Office of Technology Assessment, 1987-present.

Solanki, R. S., Referee, *Networks*.

Sorensen, J. H., Referee, *International Journal of Mass Emergencies and Disasters.*

Sorensen, J. H., Referee, *The Environmental Professional.*

Sorensen, J. H., Member, Atomic Industrial Forum, National Environmental Studies Project Task Force on Emergency Evacuation.

Sorensen, J. H., Member, National Research Council, Commission on Physical Sciences, Mathematics, and Resources, Earth Sciences Board, Subcommittee on Earthquake Research.

Sorensen, J. H., Referee, Directorate for Social and Economic Sciences, National Science Foundation.

Sorensen, J. H., Referee, Critical Engineering Systems, Earthquake Hazards Mitigation Program, National Science Foundation.

Southworth, F., Member, Subcommittee on Activity and Travel Pattern Analysis, Transportation Research Board, National Research Council.

Vineyard, E. A., Vice-Chairman, ASHRAE TC 9.1 on Large Building Air-Conditioning Systems and member ASHRAE TC 7.1 on Residential Refrigerators and Food Freezers, American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Wilbanks, T. J., Treasurer and Board of Directors, 27th International Geographical Congress (1992), 1986–present.

Wilbanks, T. J., Editorial Board, *Annals of the Association of American Geographers*, 1987–present.

Wilbanks, T. J., Councilor, American Geographical Society, 1985–present.

Wilbanks, T. J., Vice Chairman, U.S. National Committee for the International Geographical Union, National Academy of Sciences/National Research Council.

Wilbanks, T. J., Board of Visitors, Graduate School of Planning, University of Tennessee, 1983–present.

Wilbanks, T. J., Mapping Science Advisory Committee, National Academy of Sciences/National Research Council, 1987–90.

Wilbanks, T. J., Task Force on Engineering for Developing Countries, American Society of Mechanical Engineers, 1987–present.

Wilbanks, T. J., Working Group on Energy, 1980-88; Executive Secretary, 1986-88; International Geographical Union.

Wilkes, K. E., Vice-Chairman, ASHRAE TC 4.4 on Thermal Insulation and Moisture Retarders, and ASHRAE TC 4.9 on Building Envelope Systems; American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Wolfe, A. K., Membership Committee, Society for Applied Anthropology.

7.5 WORKSHOPS AND SYMPOSIA ORGANIZED BY ENERGY DIVISION STAFF

Capacity Modulation Workshop, Washington, D.C., Nov. 3-4, 1987, organized by V. D. Baxter.

DOE/EPRI Superconductivity Review Meeting, Washington, D.C., July 13-14, 1988, organized by S. J. Dale.

DOE/ORNL Roofing Industry Research Advisory Panel Meeting, Lakewood, Colo., May 4, 1988, organized by G. E. Courville.

ERIP Meeting, Washington, D.C., Mar. 3-4, 1988, organized by M. A. Brown.

IEA Annex XI Workshop, Washington, D.C., July 11-13, 1988, organized by F. C. Chen.

Integrated Resource Planning Meeting, Oak Ridge, Tenn., Nov. 10, 1987, organized by E. A. Hirst.

International Meeting of Absorption Experts, Dallas, Tex., Feb. 4-6, 1988, organized by R. C. Devault.

Meeting on Data Quality, Oak Ridge, Tenn., Apr. 21-22, 1988, organized by G. E. Liepins.

Modernizing Information Systems: Strategic and Tactical Considerations, Oak Ridge, Tenn., June 13-14, 1988, organized by J. A. Morrell.

NEPA/EIS Issues, National Association of Environmental Professionals Annual Meeting, Orlando, Fla., Apr. 19-22, 1988, organized by D. B. Hunsaker, Jr.

1988 DOE/ORNL Heat Pump Conference, Washington, D.C., Apr. 17-20, 1988, organized by P. J. Lewis.

Oak Ridge Navy Data Conference, Oak Ridge, Tenn., Oct. 20-22, 1987, organized by R. G. Tudor.

ORNL/CFC Research Advisory Group Meeting, Washington, D.C., Sept. 14, 1988, organized by V. D. Baxter.

Superconductivity Assessment, Chicago, Ill., Apr. 13-14, 1988, organized by S. J. Dale.

Superconductivity Assessment, Washington, D.C., June 30-July 1, 1988, organized by S. J. Dale.

Workshop on Analytical Economic Geography and Regional Economic Change, held at Annual meeting of the Association of American Geographers, Phoenix, Ariz., Apr. 7, 1988, organized and led by D. W. Jones.

Workshop of the Multi-Agency Working Group for Power Sector Innovation, Washington, D.C., April 1988, organized by E. L. Hillsman.

7.6 ENERGY DIVISION CONSULTANTS AND SUBCONTRACTORS

7.6.1 Consultants

P. R. Achenbach
J. W. Anderson
M. K. Anderson
J. S. Armstrong
M. H. Barnes
C. Barrett
M. L. Baughman
W. Bechtel
J. V. Beck
W. J. Biermann
F. D. Boercker
B. W. Brown
S. A. Burchfield
N. G. Buss
E. R. Cadotte
J. M. Calm
J. Carmody
B. Cheng
J. S. Chipman
R. L. Church
G. W. Clark
W. F. Clevenger
P. C. Devergie
J. C. Dunkerley
H. A. Fine
P. L. Fisher
C. A. Franchuck
A. A. Frank
J. B. Fussell
S. Gass
P. A. Gnadt
D. Goldberg
E. I. Griggs
R. E. Grimshaw
G. Grossman
W. D. Gunther
J. Halldane
J. R. Hammond
D. T. Harrje
C. M. Ho
R. M. Jefferson
R. H. Jones
D. E. Kash
M. A. Katz
W. C. King
L. W. Koch
G. Lady
P. E. Lau
E. E. Leamer
M. Lessen
C. Longmire
G. S. Maddala
C. J. Mankin
R. S. Mariano
L. A. McNeely
J. L. Medford
R. E. Minturn
D. F. Montague
E. M. Neufville
L. L. O'Mary
J. Patterson
J. B. Patton
R. W. Peplies
J. A. Pietsch
F. J. Powell
J. W. Pratt

W. R. Pumfrey
J. P. Quirk
J. Raby
W. A. Radasky
R.C. Robertson
D. J. Salisbury
L. A. Salomone
A. J. Schaffhauser
W. R. Schriver
D. B. Shonka
G. J. Smith II
V. L. Smith
H. O. Spauschus
W. F. Stoecker
R. W. Stoffle
S. C. Suboleski
R. L. Sullivan
J. Sypniewski
K. L. Terasawa
R. N. Tolbert
M. A. Toman
R. H. Turner
L. J. Valverde, Jr.
J. M. Veigel
R. C. Waag
C. Wagner
P. Wagner
H. Wainer
D. Wasserman
R. L. Webb
R. Wehrmann
J. M. Weingart
D. L. White
L. White
R. D. White
R. Wilson
A. S. Wineman
S. Wright
T. S. Wood
D. R. Younger
V. Zarnowitz
H. E. Zittel

7.6.2 Subcontractors by Company

3CI Company
Advanced Systems Technology Corporation
Aftab Associates Ltd.
Alliance to Save Energy
American Consulting Engineers Council
American Management Systems, Inc.
Analysas Corporation
Applied Management Sciences, Inc.
Argonne National Laboratory
Arthur D. Little, Inc.
Association of Collegiate Schools of Architecture
ATDL
Athens Utility Board
Automated Sciences Group, Inc.
Automation Associates, Inc.
A. T. Kearney, Inc.
Battelle Columbus Laboratories
BBN Laboratories, Inc.
Biomass Energy Research Association
Boston College, Office of Research
Brookhaven National Laboratory
Building Thermal Envelope Coordinating Council
Burns & Roe Company
Camden Corporation
Carnegie-Mellon University
Carrier Corporation
Case Western Reserve University
Centro Meso Americano De Estudios Sobre Tecnologia Apropiada
Charles River Associates, Inc.
Collieries Management Corporation
Colorado State University
Computer Aided Planning and Scheduling
Computer Data Systems, Inc.
Crown Technology, Inc.
Dames & Moore
De Lucia & Associates, Inc.
Decision Systems Technologies, Inc.
Development Planning & Research
Development Sciences, Inc.

Distribution Systems Technologies
East Tennessee State University
Economic System Analysis, Inc.
Ecotope, Inc.
Editor's Ink of Washington
Edwards & Associates
Electric Research & Management, Inc.
Electrotek Concepts, Inc.
Eli Corporation
Energy & Environmental Analysis, Inc.
Energy Concepts
Energy International, Inc.
Enersol Associates, Inc.
ENSYS, Inc.
Environmental Protection Agency
E-Systems, Inc.
Evaluation Research Corporation
F & F Associates
Fachinformation Karlsruhe
Flow Research Company
Genasys Corporation
Georgia Tech Research Corporation
Golder & Associates
H & R Technical Associates, Inc.
Hagler, Bailly & Company
Harvard University
Heat Pump Technology, Center of Japan
Home Energy
Honeywell, Inc.
Idea, Inc.
Infinite Energy
Institute of Gas Technology
Integrated Computer Systems
Integrated Systems, Inc.
International Energy Associates Ltd.
International Planning & Analysis CE
IRT Corporation
IT Power, Inc.
JSR Synergetics
Kenneth Labs
Knoxville College
Lambert Engineering, Inc.
Lutech, Inc.
MacGregor-Bates, Inc.
Massachusetts Institute of Technology
McGraw-Edison Corporation
McGraw-Edison Power Systems Group
MCI/Consulting Engineers, Inc.
Mechanical Technology, Inc.
Meridian Corporation
Metallurgical Associates Corporation
Michigan State University
Minnegasco
Mississippi State University
Mitre Corporation
Mohawk Research Corporation
MSBDFA & Buhler & Abraham, Inc.
NASA Lewis Research Center
National Association of Home Builders
National Institute of Standards and Technology
New Jersey Institute of Technology
Niagara Mohawk Power Corporation
North Carolina State University
Nuclear Assurance Corporation
Nuclear Resources International, Inc.
Oak Ridge Associated Universities
Oracle Corporation
Pacific-Sierra Research Corporation
PAI Corporation
PEI Associates, Inc.
Phillips Engineering Corporation
Portland Cement Association
Power Technologies, Inc.
Purdue Research Foundation
Rann, Inc.
Rensselaer Polytechnic Institute
Resource Consultants, Inc.
Resource Dynamics Corporation
Resource Management Associates
Resources for the Future
RE/SPEC, Inc.
Robinson Technical Services
ROH, Inc.
Rocky Research Corporation
Ronson Management Corporation
R. W. Graf Construction Company
Sandia National Laboratories
Science Applications International
Society of Building Science
Software Solutions, Inc.
Solar Energy Research Institute
Stanley Martin & Associates
Sterling Hobe Corporation
Steven Winter Associates, Inc.

Stone & Webster Engineering Corporation
Structured Systems Specialists, Inc.
Sumner-Rider & Associates
Sunpower, Inc.
Syscon Corporation
Systems Research Applications, Inc.
Systems/Software, Inc.
Tectonics Research, Inc.
Tennessee State University
Tennessee Technological University
Tennessee Valley Authority
The University of Tennessee
Thomas Vonier Associates, Inc.
Thomas W. Mason Associates, PC
T. J. Murphy & Associates
Trane Company
Twin City Buick, Inc.
Unisys Corporation
United Nations
United Way of America
University of California
University of Connecticut
University of Florida
University of Minnesota
University of Nevada-Reno
University of New Orleans
University of North Carolina
University of Pittsburgh
University of Southern California
University of Texas
University of Virginia
University of Wisconsin
URS Company
U.S. Department of Agriculture
U.S. Department of the Interior
U.S. Export Council for Renewable Energy
Utility Customer-Interface, Inc.
Utility Data Institute, Inc.
Vanderbilt University
Virginia Polytechnic Institute and State University
Vitro Corporation
VSE Corporation
VVKR, Inc.
Westat, Inc.
Westinghouse Electric Corporation
World Computer Systems Services
Z, Inc.

7.7 PUBLICATIONS BY SUBCONTRACTORS

ACEC Energy Committee et al., *Management Approaches to Energy Cost Savings in Existing Commercial Buildings*, ORNL/Sub-86/56579/1, Oak Ridge National Laboratory, October 1987.

Ackermann, R. A., "Development of a Residential Free-Piston Stirling Engine Heat Pump," *Proc. 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988, CONF-8804100, August 1988.

Ackermann, R. A., *Free-Piston Stirling Engine Diaphragm-Coupled Heat-Actuated Heat Pump Component Technology Program, Volume 1, Phase IIA and IIB Final Report: Technical Discussion*, ORNL/Sub/86-47985/2, Vol. 1 and Vol. 2, Oak Ridge National Laboratory, January 1988.

Applied Management Sciences, Inc., *Primos Basics for Scientific and Engineering Computer System (SECS) Users*, ORNL/Sub/62K-AA663C/1, Oak Ridge National Laboratory, January 1988.

Applied Management Sciences, Inc., *Scientific and Engineering Computer System (SECS) Management Plan,* ORNL/Sub/62K-AA663C/4, Oak Ridge National Laboratory, June 1988.

Applied Management Sciences, Inc., *Scientific and Engineering Computing System (SECS) Operations Manual,* ORNL/Sub/62K-AA663C/2, Oak Ridge National Laboratory, February 1988.

Applied Management Sciences, Inc., *SECS Contingency Plan Test Report, Phase 1 Test Report, Disk Dual Port Switching Test,* ORNL/Sub/62K-AA663C/3, Oak Ridge National Laboratory, January 1988.

Beale, W. T., and G. Chen, "Preliminary Assessment of a Magnetically Coupled Free-Piston Stirling Engine," *Proc. 2d DOE/ORNL Heat Pump Conf.,* Washington, D.C., Apr. 17-20, 1988, CONF-8804100, August 1988.

Brinkman, C. R., and H. E. McCoy, "Multistress Aging of Polymer Films," *Proc. IEEE Symp. Electr. Insul.,* Boston, June 1988.

Bronfman, B. H., M. H. Haeri, and D. I. Lerman, *Evaluation of the Bonneville Power Administration Low Income Residential Weatherization Program,* ERC/PO-28, ERC International, Portland, Oreg., July 1988.

Childs, K. W., *Analysis of Seven Thermal Bridges Identified in a Commercial Building,* K/CSD/TM-78, June 1988.

Childs, K. W., *Calculation of Heat Flow and Temperature Fields for Building Envelopes Containing Thermal Bridges,* ORNL/M-566, Oak Ridge National Laboratory, June 1988.

Chu, F. Y., I. Sauers, and G. D. Griffin, "A Review of S2F10 in Practical SF6-Insulated Equipment," pp. 131-34 in *Conf. Rec. 1988 IEEE Int. Symp. Electr. Insul.,* June 1988.

Degrush, D., and W. F. Stoecker, *Measurements of Heat-Transfer Coefficients of Nonazeotropic Refrigerant Mixtures Condensing Inside Horizontal Tubes,* ORNL/Sub/81-7762/6 and 01, Oak Ridge National Laboratory, November 1987.

Dugan, R. C., McGraw-Edison, and D. T. Rizy, *Harmonic Considerations for Electrical Distribution Feeders,* ORNL/Sub/81-95011/4, Oak Ridge National Laboratory, March 1988.

Dugan, R. C., et al., *Electric Power System Harmonics Design Guide,* ORNL/Sub/81-95011/3, Oak Ridge National Laboratory, March 1988.

Griffin, G. D., et al., "Biological Effects of Sparked-Decomposed SF6," *J. Electrochem. Soc. Rev. News* 35(8) (August 1988).

Haeri, M. H., *Electricity Savings Three Years After Participation in the Bonneville Power Administration Regionwide Weatherization Program*, ERC/PO-34, ERC International, Portland, Oreg., September 1988.

Haeri, M. H., *Energy Use in Homes Built to Model Conservation Standards: A Follow-up of the Tacoma MCS Evaluation*, ERC/PO-31, ERC International, Portland, Oreg., August 1988.

Hughes, P. J., and R. J. Hackner, *Field Performance Validation of an Advanced Design Earth-Coupled Heat Pump System*, ORNL/Sub/85-22035/1, Oak Ridge National Laboratory, January 1988.

Jou, W. H., G. S. Knoke, and C. M. Ho, "Mixing Enhancement of a Supersonic Jet for an Advanced Ejector," *Proc. 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988, CONF-8804100, August 1988.

Kornhauser, A. A., and J. L. Smith, Jr., "A Comparison of Cylinder Heat Transfer Expressions Based on Prediction of Gas Spring Hysteresis Loss," *ASME Winter Ann. Meet.*, December 1987.

Kornhauser, A. A., and J. L. Smith, Jr., "Integration of Analysis and Experiment for Stirling Cycle Processes," Part I: Gas Spring Hysteresis Loss, *Proc. 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988, CONF-8804100, August 1988.

Labs, K., et al., *Building Foundation Design Handbook*, ORNL/Sub/86-72143/1, Oak Ridge National Laboratory, May 1988.

Little, A. D., "Workshop Summary Report–Stirling Engine Technology, Status and Development Issues," IEA-A11-3, International Energy Agency, October 1987.

MaCriss, R. A., J. M. Gutraj, and T. S. Zawacki, *Absorption Fluids Data Survey: Final Report on Worldwide Data*, ORNL/Sub/84-47989/3, Oak Ridge National Laboratory, February 1988.

Melton, B. S., et al., *Building Envelope Thermal Anomaly Analysis*, ORNL/Sub-85/00294/1, Oak Ridge National Laboratory, December 1987.

Merriam, R. L., "Evaluation of Vapor Compression Cycles Using Nonazeotropic Refrigerant Mixtures," *Proc. 2d DOE/ORNL Heat Pump Conference*, Washington, D.C., Apr. 17-20, 1988.

Modahl, R. J., and F. C. Hayes, "Evaluation of a Commercial Advanced Absorption Heat Pump Breadboard," *Proceedings of the 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988, CONF-8804100, August 1988.

Modine, F. A., *Evaluation of New Metal-Insulator-Semiconductor Varistor*, ORNL/TM-10886, Oak Ridge National Laboratory, August 1988.

Monteen, L. D., et al., "Impact of Automation on the Reliability of the Athens Utilities Board's Distribution System," *IEEE Trans.*, Paper 88 Wm 087-9, February 1988.

Mulroy, W., et al., "An Evaluation of Two Refrigerant Mixtures in a Breadboard Air Conditioner," Preprints: Purdue–IIR Conference, Purdue University, National Bureau of Standards, July 1988.

Mulroy, W., et al., "An Evaluation of Two Refrigerant Mixtures in a Breadboard Air Conditioner," *Proc. 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988, CONF-8804100, August 1988.

Pace, M. O., et al., "Effects of Pressure Near One Atmosphere on Prebreakdown Current Pulses at a Needle Cathode in Hexane," pp. 23-26 in *Conf. Rec. 1988 IEEE Int. Symp. Electr. Insul.*, Boston, June 1988.

Petersen, S. R., "Technical and Economic Analysis of CFC-Blown Insulations and Substitutes for Residential and Commercial Construction," NBSIR 88-3829, July 1988.

Phillips, B. A., "Development of an Absorption Advanced Cycle Heat Pump for Residential Applications," *Proc. 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988, CONF-8804100, August 1988.

Reed, J. H., et al., "Monitoring Load Control at the Feeder Level Using High Speed Monitoring Equipment," *IEEE Trans. Power Delivery*, Paper 88 WM 095-2, February 1988.

Reimann, R. C., and G. Melikian, "Development and Proof-Testing of Advanced Absorption Refrigeration Cycle Concepts, Phase II," *Proc. 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988; CONF-8804100, August 1988.

Stewart, J. R., *Characteristics of Twelve-Phase Power Transmission*, ORNL/Sub/85-00212/1, Oak Ridge National Laboratory, April 1988.

Suelze, L. R., *The Development of a Unique Power Converter*, ORNL/Sub/81-09079/1, Oak Ridge National Laboratory, May 1988.

Thomson, E. M., P. J. Medelius, and M. A. Uman, "A Remote Sensor for Three Components of Transient Electric Fields," *IEEE Trans. Indus. Electron.* 35(3) (August 1988).

Thomson, E. M., et al., "Horizontal Electric Fields from Lightning Return Strokes," *J. Geophys. Res.* 93(D3), 2429-41 (March 1988).

Turner, R. H., et al., "Modeling a Thermally Activated Heat Pump With Desiccant Cooling," *ASME Winter Annual Meeting*, Paper 87-WA/AES-1, December 1987.

Ushimaru, K., "Assessment of Japanese Variable Speed Heat Pump Technology," *Proc. 2d DOE/ORNL Heat Pump Conf.*, Washington, D.C., Apr. 17-20, 1988, CONF-8804100, August 1988.

Vance, E. F., and M. A. Uman, "Differences Between Lightning and Nuclear Electromagnetic Pulse Interactions," *IEEE Trans. Electromagn. Compat.* 30(1) (February 1988).

Vincent, R. J., "Dynamic Behavior of a Free-Piston Stirling Engine Driven Heat Pump With Magnetic Coupling," *Proc. Int. Compressor Conf.*, Purdue University, July 1988.

Westat, Inc., *Quality Assurance Reviews of Manual and Automated Data Handling Procedures, Annual Electric Utility Report, EIA-861*, ORNL/Sub/87-63609/7, Oak Ridge National Laboratory, January 1988.

Westat, Inc., *Quality Assurance Reviews of Manual and Automated Data Handling Procedures, Annual Refinery Report, EIA-820*, ORNL/Sub/87-83609/16, Oak Ridge National Laboratory, September 1988.

Westat, Inc., *Quality Assurance Reviews of Manual and Automated Data Handling Procedures, Annual Report of Major Electric Utilities, Licensees and Others, FERC-1*, ORNL/Sub/87-83609/10, Oak Ridge National Laboratory, April 1988.

Westat, Inc., *Quality Assurance Reviews of Manual and Automated Data Handling Procedures, Application for Determination of Maximum Lawful Price Under the Natural Gas Policy Act, FERC-121, and Survey of Surplus Natural Gas Supplies, IE-400*, ORNL/Sub/87-83609/5, Oak Ridge National Laboratory, November 1987.

Westat, Inc., *Quality Assurance Reviews of Manual and Automated Data Handling Procedures, Coal Production Report, EIA-7A*, ORNL/Sub/87-83609/9, Oak Ridge National Laboratory, April 1988.

Westat, Inc., *Quality Assurance Reviews of Manual and Automated Data Handling Procedures, Domestic Uranium Mining Production Report, EIA-851*, ORNL/Sub/87-83609/12, Oak Ridge National Laboratory, May 1988.

Westat, Inc., *Quality Assurance Reviews of Manual and Automated Data Handling Procedures, First Purchase System, EIA-182*, ORNL/Sub/87-83609/13, Oak Ridge National Laboratory, July 1988.

Westat, Inc., *Quality Assurance Reviews of Manual and Automated Data Handling Procedures, Nuclear Fuel Data Survey, RW-859*, ORNL/Sub/87-83609, Oak Ridge National Laboratory, December 1987.

Westat, Inc., *Quality Assurance Reviews of Manual and Automated Data Handling Procedures, Semiannual Report on Status of Reactor Construction, EIA-254*, ORNL/Sub/87-83609/11, Oak Ridge National Laboratory, May 1988.

Westat, Inc., *Quality Assurance Reviews of Manual and Automated Data Handling Procedures, Standard Contract for Disposal of Spent Nuclear Fuel and/or High Level Radioactive Waste–Quarterly Report–Standard Remittance Advice–Appendix G–Annex A, NWPA-8306*, ORNL/Sub/87-83609/15, Oak Ridge National Laboratory, July 1988.

Westat, Inc., *Quality Assurance Reviews of Manual and Automated Data Handling Procedures, Typical Net Monthly Bills, EIA-213*, ORNL/Sub/87-3609/8, Oak Ridge National Laboratory, March 1988.

Westat, Inc., *Quality Assurance Reviews of Manual and Automated Data Handling Procedures, Uranium Industry Annual Survey, EIA-858*, ORNL/Sub/87-83609/14, Oak Ridge National Laboratory, July 1988.

7.8 INVITED SPEAKERS

Date	Subject	Speaker
	1987	
October 9	Energy Planning and Pakistan	William Barron, Institute of Energy Analysis
October 12	What Is the Emergency Preparedness Special Interest Group?	Marcus Wezeman and Sue Painter, Oak Ridge Associated Universities
November 5	The Consensus Problem for Discrete Structures	F. R. McMorris, Office of Naval Research
November 10	Integrating GIS Structures into Location Allocation Models–Some Initial Results	Richard L. Church, Professor and Chairman, Department of Geography, University of California, Santa Barbara
November 19	Recent Developments in Stirling Cycle Cooler Technology	Stephen F. Malaker, President, Cryodynamics, Inc., Mountainside, New Jersey
November 23	A Flexible Routing Tool for Express Airline Scheduling	Cheng Liu, Operations Research Division, Federal Express Corporation, Memphis, Tennessee

INVITED SPEAKERS (continued)

Date	Subject	Speaker
December 4	Technological Development in the Third World: Selected Questions and Suggestions	Dilmus D. James, Professor of Economics, University of Texas at El Paso
December 7	Joint Response '82–An Emergency Response Exercise at the Feed Materials Production Center	Steven J. Wentzel, Westinghouse Materials Company of Ohio
December 9	Ethical Issues in Professional Practices	Glenn Graber, Department of Philosophy, The University of Tennessee
December 10	Power Systems and Power Research in India	M. Ramamoorty, Director General, Central Power Research Institute, Bangalore, India
December 11	Energy Activities at the U.S. Congress	Alan T. Crane, Office of Technology Assessment, Congress of the United States
	1988	
January 25	Not If, But When–(An Orientation to DOE's Transportation Safeguards Division)	William T. Taylor, U.S. Department of Energy
January 29	The Brazilian Radiation Accident–An Update	Clarence C. Lushbaugh, Oak Ridge Associated Universities
January 29	Evaluating Environmental Risks: Evolving Approaches to Toxicology and Policy at EPA	John A. Moore, Environmental Protection Agency

INVITED SPEAKERS (continued)

Date	Subject	Speaker
February 5	The Recommended Integrated Energy Program for Liberia: Three Years Later	E. Miedi-Himie Neufville, Assistant Minister of Energy, Government of Liberia
February 18	Overview of the Canadian Nuclear Fuel Waste Management Program	Judy Tamm, Whiteshell Nuclear Research Establishment, Atomic Energy of Canada, Manitoba, Canada
February 23	Demand-Side Planning in Austria	Peter J. Jansen, Institute of Energy Economics, Technology University of Vienna, Austria
March 21	Risk Communication and Decision Making in Europe: A Legislative History of the Seveso Directive	Harry Otway, European Communities Joint Research Centre, Ispra, Italy
March 31	Learning to Predict by the Methods of Temporal Differences	Richard Sutton, GTE Laboratories, Inc., Waltham, Massachusetts
April 5	Applying Quadtree Theory to Spatial Analysis	Giulio Maffini, TYDAC Technologies, Ottawa, Canada
April 11	Expert System for Regulating Hazardous Waste	G. Anandalingam, Professor, University of Pennsylvania
April 14	Computers and Environmental Protection	Judith A. Perrolle, Northeastern University
April 18	The Tennessee Emergency Management Agency and Emergency Response Planning for DOE facilities	Elgan H. Usrey, Tennessee Emergency Management Agency

INVITED SPEAKERS (continued)

Date	Subject	Speaker
April 20	Informal Discussion on Social Scientists' Roles in the Basalt Waste Isolation Project	Edward B. Liebow, Battelle Human Affairs Research Center, Seattle, Washington
April 22	EPA's Integrated Environmental Management Program: An Experiment in Meshing Risk Analysis and Public Participation	Daniel P. Beardsley, Director, Regulatory Integration Division, Environmental Protection Agency
April 27	Unfinished Business: EPA's Comparative Risk Study	Richard D. Morganstern, Environmental Protection Agency
May 2	Hygro Diode Membrane–New Vapor Retarder for Flat Roofs	Vagn Korsgaard, Thermal Insulation Laboratory, Technical University of Denmark
May 16	Allocating Gas Pipeline Capacity: Experimental Results of Auctions and Brokerage	Douglas R. Bohi, Office of Economic Policy, Federal Energy Regulatory Commission
May 19	Energy for a Sustainable World	Robert H. Williams Center for Energy and Environmental Studies, Princeton University
May 20	ICAITI's Role in Research, Development, and Technology Transfer in Central America	W. Ludwig Ingram, Jr., Acting Director, Central American Research Institute for Industry (ICAITI), Guatemala, Central America

INVITED SPEAKERS (continued)

Date	Subject	Speaker
July 6	Flood Hazard Research in the United Kingdom	Lise Clausen, Binnie and Partners, United Kingdom, Philip Bossman-Aggrey, Flood Hazard Research Centre, Middlesex Polytechnic
July 11	Transportation Emergency Response Assets and Procedures	John A. Lamb, Sr., Science Applications International Corp.
August 2	Can Public Information Programs Affect Risk Perceptions?	V. Kerry Smith, Department of Economics and Business, North Carolina State University
August 8	Emergency Response and the Maginot Line Syndrome	John G. Davis, Automated Sciences Group, Inc.
August 16	A Policy Background to the NO_x Protocols	Richard A. Bradley, Department of Energy, Office of Environmental Analysis
September 16	Metered Data Analysis to Improve Building Operation and Maintenance	Jeff Haberl, Center for Energy and Environmental Studies, Princeton University
September 26	The Energy Situation in Holland and Research at the Institute of Energy and Environmental Problems	Mark Geerts, University of Groningen, The Netherlands
September 30	Eliciting and Validating Preferences for Alternative Settlement System Characteristics in Australia	Gerard Rushton, Department of Geography, University of Iowa

INVITED SPEAKERS (continued)

Date	Subject	Speaker
September 30	Some Issues in Manpower Forecasting	J. Scott Armstrong, Wharton School, University of Pennsylvania

7.9 ENERGY DIVISION PATENT INFORMATION

Patents Granted in FY 1988

Title	Inventor	U.S. Patent No.	Date
Triple Effect Chiller Utilizing Two Refrigeration Circuits	R. C. DeVault	4,732,008	3-22-88

7.10 FINANCIAL STATEMENT

ENERGY DIVISION SPONSORS, EXPENDITURES, AND COMMITMENTS OF SCIENTIFIC STAFF FOR FY 1988

Sponsor	Expenditures[a] (10^3 $)	Scientific staff (person-years)		Direct person-year costs[c] (10^3 $)	Subcontract costs with overhead[d] (10^3 $)
		Energy Division	Other divisions[b]		
Department of Energy Work					
Conservation and Renewable Energy					
Buildings and Community Systems	8,885	26.3	0.2	3,281	4,070
Electric Energy Systems	2,855	4.3	1.6	706	1,609
Industrial Energy Conservation	324	1.0	0.5	193	11
Multisector	200	0.5	0.0	79	63
Solar Energy	308	1.2	0.1	171	105
State/Local Programs	279	0.2	0.0	60	196
Transportation	334	0.8	0.0	129	143
	13,185	34.3	2.4	4,619	6,197

FINANCIAL STATEMENT (continued)

Sponsor	Expenditures[a] (10^3 $)	Scientific staff (person-years)		Direct person-year costs[c] (10^3 $)	Subcontract costs with overhead[d] (10^3 $)
		Energy Division	Other divisions[b]		
Civilian Radioactive Waste Management	79	0.2	0.0	42	21
Defense Waste and Environmental Restoration	1,892	3.5	1.5	592	852
National Energy Information System	1,489	2.2	0.2	297	1,029
Energy Research					
Magnetic Fusion	16	0.0	0.0	5	1
Multiprogram Facilities	73	0.0	0.1	13	52
	89	0.0	0.1	18	53
Environmental Safety and Health	860	3.8	0.0	453	178
Federal Energy Regulatory Commission	639	1.6	0.4	220	315
Fossil Energy					
Coal	32	0.1	0.1	30	0
Innovative Clean Coal Technology	175	1.2	0.1	156	0
International Affairs	29	0.0	0.0	0	28
Strategic Petroleum Reserve	174	0.9	0.0	120	13
	410	2.2	0.2	306	41
Energy Emergencies Utility Programs	12	0.0	0.0	4	5
Policy, Planning and Analysis	229	0.4	0.0	66	145
Argonne National Laboratory	23	0.1	0.0	21	0
Bonneville Power Administration	895	3.5	0.0	478	277
Oak Ridge Operations Office	670	3.5	0.4	454	98
Y-12 East Chestnut Ridge	303	0.7	0.0	87	78
	1,891	7.8	0.4	1,040	453
Total U.S. Department of Energy (DOE) work	20,775	56.0	5.2	7,657	9,289

FINANCIAL STATEMENT (continued)

Sponsor	Expenditures[a] (10^3 $)	Scientific staff (person-years) Energy Division	Scientific staff (person-years) Other divisions[b]	Direct person-year costs[c] (10^3 $)	Subcontract costs with overhead[d] (10^3 $)
Other Federal Agencies Work					
Department of Defense					
Department of the Air Force					
Air Training Command	33	0.0	0.0	0	28
Engineering & Services Center	1,653	6.8	0.4	859	384
Logistics Command	130	0.8	0.2	125	(7)
Military Airlift Command	3,224	7.7	0.9	1,116	1,755
Strategic Air Command	90	0.4	0.0	53	19
Systems Command					
Engineering and Services Directorate	227	1.0	0.2	152	30
Tactical Air Command	40	0.1	0.0	15	0
U.S. Transportation Command	257	1.1	0.0	149	49
	5,714	17.9	1.7	2,469	2,258
Department of the Army					
Armament R&D and Engineer Center	1	0.0	0.0	0	0
Civilian Personnel Center	581	2.8	0.0	346	168
Combat Systems Test Activity	4	0.0	0.0	2	0
Construction Engineering					
Research Laboratory	214	0.9	0.0	112	11
Corps of Engineers	146	0.3	0.0	55	58
Facilities Engineering					
Support Agency	232	0.8	0.2	160	7
Forces Command	178	0.6	0.0	86	49
Laboratory Command	64	0.3	0.0	37	15
Material Command	270	1.0	0.6	213	5
Toxic & Hazardous					
Materials Agency	1,638	7.6	1.9	1,101	142
	3,328	14.3	2.7	2,112	455
Department of the Navy					
David Taylor Naval Ship R&D Center	25	0.0	0.0	9	7
Energy and National Resources					
R&D Division	294	1.2	0.0	173	54
Marine Corps	427	0.4	0.0	56	350
Naval Military Personnel Command	1,814	1.9	0.0	221	1,350
Naval Regional Data Automation	348	0.3	0.0	36	0
Naval Sea System Command	3,460	1.9	0.2	275	2,988
Naval Supply Systems Command	54	0.0	0.0	0	49
Navy Personnel R&D Center	78	0.5	0.0	58	5
	6,500	6.2	0.2	828	4,803

FINANCIAL STATEMENT (continued)

Sponsor	Expenditures[a] (10^3 $)	Scientific staff (person-years)		Direct person-year costs[c] (10^3 $)	Subcontract costs with overhead[d] (10^3 $)
		Energy Division	Other divisions[b]		
Joint Agencies					
Defense Nuclear Agency	54	0.0	0.0	0	52
Military Traffic Management Command	2,071	6.5	0.0	744	1,117
National Guard Bureau	326	0.6	0.0	83	131
Office of Joint Chiefs of Staff	1	0.0	0.0	0	0
	2,452	7.1	0.0	827	1,300
Subtotal U.S. Department of Defense work	17,994	45.5	4.6	6,236	8,816
Bureau of Land Management	21	0.0	0.0	3	16
Department of State–Agency for International Development	2,226	7.9	0.1	983	826
Department of Transportation	338	0.7	0.0	103	146
Environmental Protection Agency	545	0.7	0.0	79	187
Federal Emergency Management Agency	913	3.3	0.0	409	206
General Services Administration	3	0.0	0.0	3	0
National Center for Toxicological Research	304	0.1	0.0	19	201
National Library of Medicine	86	0.2	0.1	52	20
Nuclear Regulatory Commission	140	0.1	0.3	76	35
Tennessee Valley Authority	118	0.9	0.0	105	0
Total other federal agencies work	22,688	59.4	5.1	8,068	10,453

FINANCIAL STATEMENT (continued)

Sponsor	Expenditures[a] (10^3 $)	Scientific staff (person-years)		Direct person-year costs[c] (10^3 $)	Subcontract costs with overhead[d] (10^3 $)
		Energy Division	Other divisions[b]		
Private Organizations Work					
Battelle Northwest	1	0.0	0.0	1	0
CCSCE	21	0.1	0.0	17	3
Earth Systems	10	0.0	0.0	0	10
Electric Power Research Institute	396	1.4	0.2	210	76
Gas Research Institute	146	0.6	0.0	82	56
International Energy Agency	7	0.0	0.0	7	0
KLD Associates	20	0	0	0	20
National Home Builders Association	163	1.0	0.0	135	0
Pacific Power & Light Company	9	0.0	0.0	7	0
Puget Sound Power & Light Company	22	0.1	0.0	17	0
Swedish National Energy Agency	12	0	0	0	12
Total private organizations work	807	3.2	0.2	476	174
Total non-DOE work	23,495	62.6	5.3	8,544	10,627
Total DOE work	20,775	56.0	5.2	7,657	9,289
Total Energy Division work	44,270	118.6	10.5	16,201	19,916

[a]The difference between total expenditures (Column 2) and the sum of Columns 5 and 6 is money spent on computer, programmer, and analyst support from Computer Services; travel; material purchases; technical information services; etc.

[b]Includes the following research divisions: Analytical Chemistry, Biology, Chemical Technology, Engineering Physics and Mathematics, Engineering Technology, Environmental Sciences, Fusion Energy, Helth and Safety Research, and Metals and Ceramics.

[c]Includes technical staff labor costs for Energy Division and other research and support divisions and Laboratory overhead.

[d]Includes Laboratory overhead for on-site services and the subcontract surcharge for off-site services. The subcontract surcharge is to pay for the costs of accounts payable, auditing, and accounting.

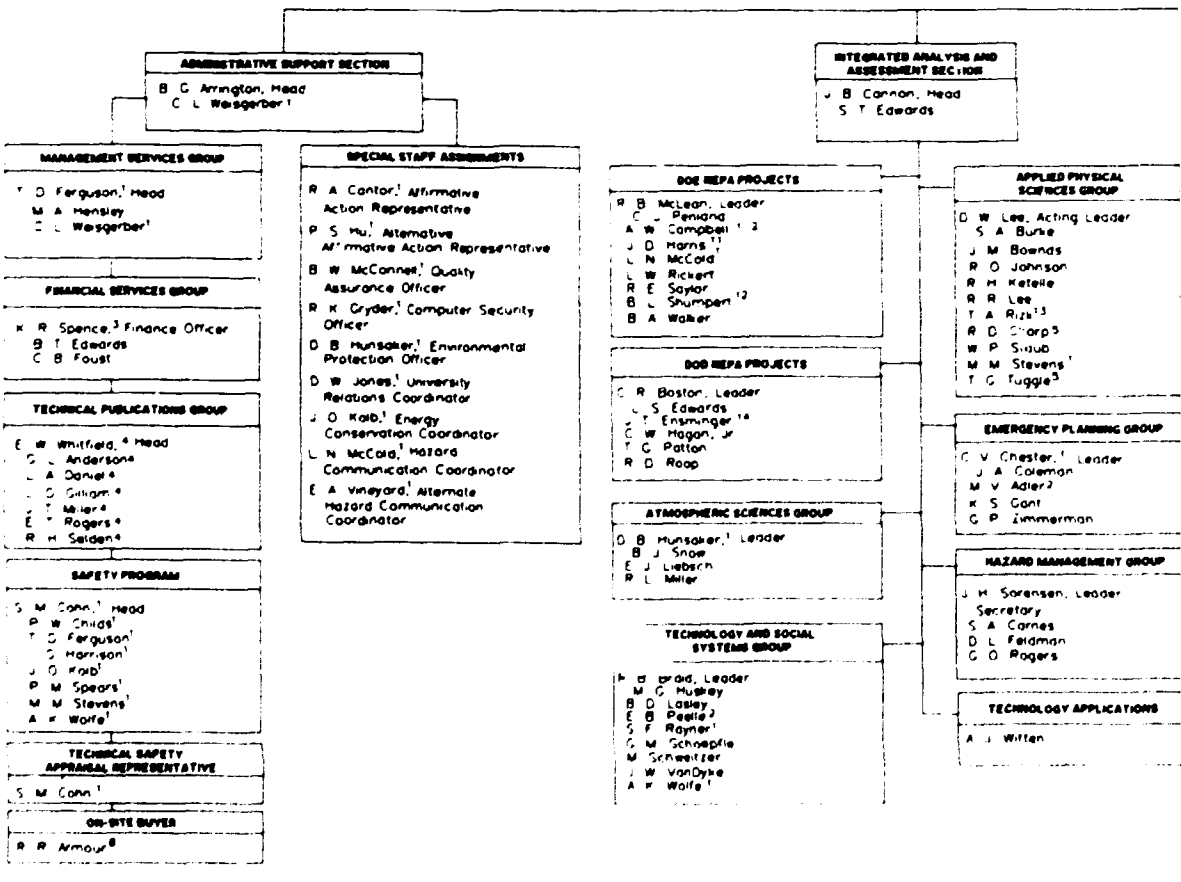
7.11 ENERGY DIVISION PERSONNEL BY DISCIPLINE
[Full-time equivalents (FTEs)]
September 1988

Discipline[a]	IAAS	EEAS	TSRS	ERRS	P&C	Division administration	Total (FTEs)
			Technical professional				
Social sciences							
Anthropologists	3.0						3.0
Economists	1.0	16.5				1.0	18.5
Geographers	1.0	2.0	7.0	1.0	1.0		12.0
Planners	1.0		2.0				3.0
Political scientists	4.0						4.0
Sociologists	1.5	1.5					3.0
Total social sciences	**11.5**	**18.5**	**10.5**	**1.0**	**1.0**	**1.0**	**43.5**
Physical and life sciences							
Biologists	2.5		1.0				3.5
Chemists	3.0		1.0	1.0			5.0
Ecologists	1.0						1.0
Geologists	3.0						3.0
Meteorologists	3.0						3.0
Physicists	1.0			5.0	1.0		7.0
Total physical and life sciences	**13.5**		**2.0**	**6.0**	**1.0**		**22.5**
Engineering sciences							
Chemical engineers	1.0		1.0	4.0		1.0	7.0
Civil engineers			3.0				3.0
Electrical engineers	1.0		3.0	4.0			8.0
Engineering physicists				1.0			1.0
Engineering scientists	1.0			2.0			3.0
Environmental engineers	1.0						1.0
Mechanical engineers	6.0		1.0	16.0		1.0	24.0
Nuclear engineers				1.0			1.0
Agricultural engineers				1.0			1.0
Other				1.0			1.0
Total engineering sciences	**10.0**		**8.0**	**30.0**		**2.0**	**50.0**

ENERGY DIVISION PERSONNEL BY DISCIPLINE (continued)

Discipline[a]	IAAS	EEAS	TSRS	ERRS	P&C	Division adminis-tration	Total (FTEs)
Data systems							
Computer sciences		1.0	3.0				4.0
Mathematicians/ statisticians	2.0		10.0	1.0			13.0
Operations research			1.0				1.0
Systems analysts			1.0				1.0
Other			3.5				3.5
Total data systems	**2.0**	**1.0**	**18.5**	**1.0**			**22.5**
Total technical professionals	**37.0**	**19.5**	**39.0**	**38.0**	**2.0**	**3.0**	**138.5**
Administrative and technical support							
Accountants						1.0	1.0
Accounting clerks			1.0				1.0
Administrative assistants						1.0	1.0
Administrative support	8.0	5.5	6.0	11.0	1.0	6.0	37.5
Technical support	3.0	1.0	4.5	7.0	1.0		16.5
Total administrative and technical support	**11.0**	**6.5**	**11.5**	**18.0**	**2.0**	**8.0**	**57.0**
Total	**48.0**	**26.0**	**50.5**	**56.0**	**4.0**	**11.0**	**195.5**

[a]IAAS = Integrated Analysis and Assessment Section; EEAS = Energy and Economic Analysis Section; TSRS = Transportation and Systems Research Section; ERRS = Efficiency and Renewables Research Section; and P&C = Planning and Coordination.


ADMINISTRATIVE SUPPORT SECTION
B G Arrington, Head
C L Weisgerber[1]
MANAGEMENT SERVICES GROUP
T O Ferguson,[1] Head
M A Hensley
C L Weisgerber[1]
FINANCIAL SERVICES GROUP
K R Spence,[3] Finance Officer
B T Edwards
C B Foust
TECHNICAL PUBLICATIONS GROUP
E W Whitfield,[4] Head
S L Anderson[4]
L A Daniel[4]
J O Gilliam[4]
J T Miller[4]
E T Rogers[4]
R H Selden[4]
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P W Childs[1]
T O Ferguson[1]
S Harrison[1]
J O Kolb[1]
P M Spears[1]
M M Stevens[1]
A F Wolfe[1]
TECHNICAL SAFETY APPRAISAL REPRESENTATIVE
S M Conn[1]
ON-SITE BUYER
R R Armour[6]
SPECIAL STAFF ASSIGNMENTS
R A Cantor,[1] Affirmative Action Representative
P S Hu,[1] Alternative Affirmative Action Representative
B W McConnell,[1] Quality Assurance Officer
R K Cryder,[1] Computer Security Officer
D B Hunsaker,[1] Environmental Protection Officer
D W Jones,[1] University Relations Coordinator
J O Kolb,[1] Energy Conservation Coordinator
L N McCold,[1] Hazard Communication Coordinator
E A Vineyard,[1] Alternate Hazard Communication Coordinator
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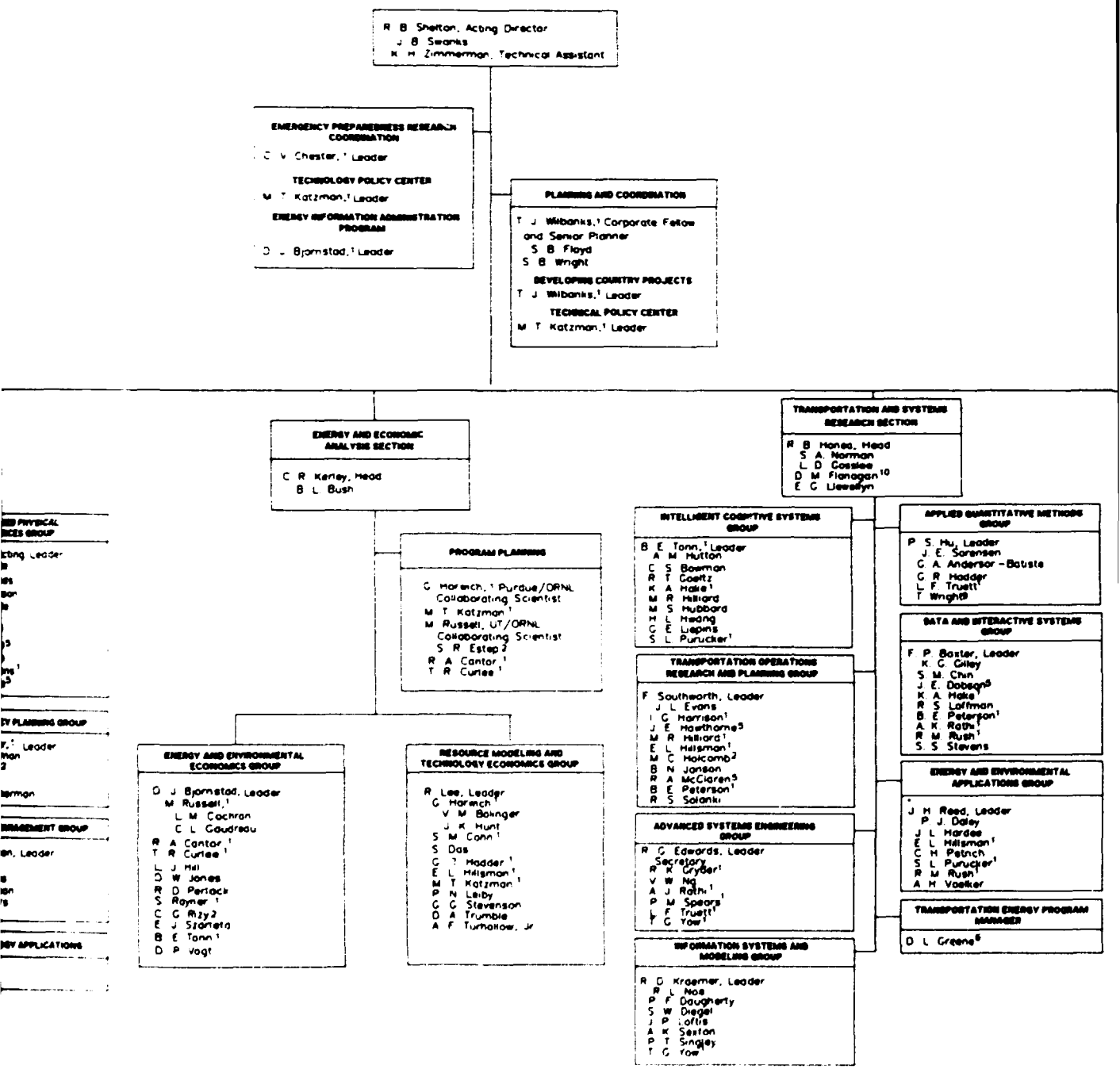
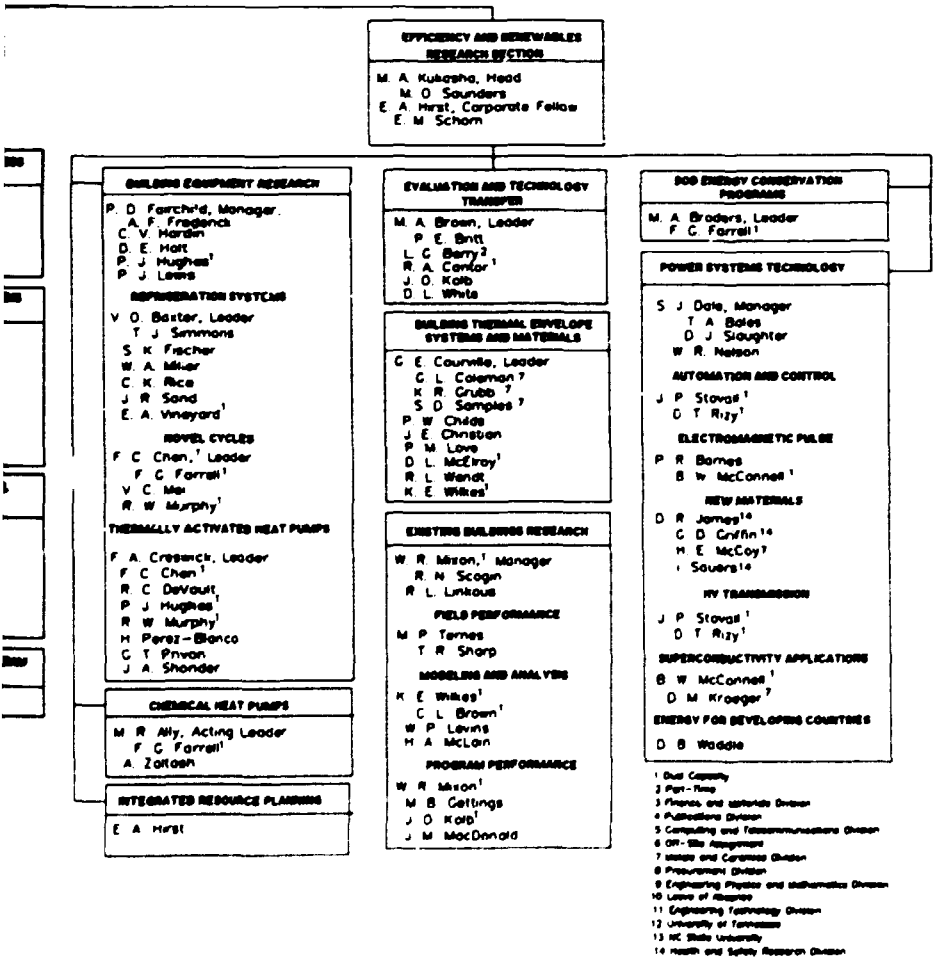
S T Edwards
DOE RAPA PROJECTS
R B McLean, Leader
C J Penland
A W Campbell[1,2]
J D Harris[1,2]
L N McCold[1]
L W Rickert
R E Saylor
B L Shumpert[1,2]
B A Walker
DOD RAPA PROJECTS
C R Boston, Leader
L S Edwards
J T Ensminger[1,6]
C W Hagan, Jr
T C Patton
R D Roop
ATMOSPHERIC SCIENCES GROUP
D B Hunsaker,[1] Leader
B J Snow
E J Liebsch
R L Miller
TECHNOLOGY AND SOCIAL SYSTEMS GROUP
A B Brad, Leader
M G Huskey
B D Lasley
E B Peelle[2]
S F Rayner[1]
G M Schnapfle
M Schweitzer
J W VanDyke
A F Wolfe[1]
APPLIED PHYSICAL SCIENCES GROUP
D W Lee, Acting Leader
S A Burke
J M Bownds
R O Johnson
R H Ketelle
R R Lee
T A Rizk[1,5]
R D Sharp[5]
W P Staub
M M Stevens[1]
T G Tuggle[5]
EMERGENCY PLANNING GROUP
C V Chester,[1] Leader
J A Coleman
M V Adler[2]
K S Gant
G P Zimmerman
HAZARD MANAGEMENT GROUP
J H Sorensen, Leader
Secretary
S A Carnes
D L Feldman
G O Rogers
TECHNOLOGY APPLICATIONS
A J Witten

ENERGY DIVISION

June 1988

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J. Sauers[14]
HV TRANSMISSION
J. P. Stovall[1]
D. T. Rizy[1]
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D. M. Kroeger[7]
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152. J. H. Sorensen
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158. A. W. Trivelpiece
159. L. F. Truett
160. E. A. Vineyard
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