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ENERGY DIVISION
ANNUAL PROGRESS REPORT
For Period Ending September 30, 1981

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UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

Contents

Abstract

This report covers work done during FY 1981 by the staff of the Energy Division, its subcontrators, and by colleagues from other ORNL divisions working on Energy Division projects. The work can be divided into four areas: (1) analysis and assessment, (2) models and data, (3) efficiency improvement and renewable energy technology development, and (4) research utilization. Support came principally from the U.S. Department of Energy (DOE) and the Nuclear Regulatory Commission and also from the Department of Interior, the Federal Emergency Management Agency, the Department of Agriculture, the Department of Housing and Urban Development, and the Electric Power Research Institute.

The analysis and assessment areas of concentration were environmental issues (including those deriving from the preparation of environmental impact statements), energy use analysis and forecasting, and emergency preparedness. Environmental efforts included completion for DOE of the final environmental statements on proposed coal liquifaction and gasification demonstration plants, evaluation of the use of incentives to communities in siting nuclear waste repositories, estimation of the energy supply and demand implications of CO_2, and study of the energy resource potential of proposed Wilderness Study Areas. Energy use analysis attempted to identify the major causes for the profound shifts in energy demand trends which have occurred in each sector of the economy over the past decade. Causative factors such as price, gross national product, and government programs were analyzed. Emergency preparedness research involved a variety of studies such as the effects of substitution of electricity for oil and gas during an oil shortage, factors influencing public cooperation, and use of vegetable oils for fueling farm equipment.

The models and data work involved the development of appropriate models; the collection and maintenance of a wide variety of energy- and environment-related data bases; and the evaluation of the quality, relevance, and limitations of data bases and models. This latter included completion of ten energy data system evaluations for the Energy Information Administration (EIA) of DOE, and work on validating the Long-Range Energy Analysis Program (LEAP) model of EIA. Model development included a cooling tower plume model, single-point and multipoint source stochastic air pollution models, a life-cycle cost model for analyzing efficiency improvements for commercial buildings, and an integrated set of models for electric energy demand and load forecasting at the state, utility, and rural electric cooperative levels.

Technology development included research on improving the efficiency of energy use, particularly for the buildings and electrical energy sectors, and some work on the development of renewable energy sources. A major thrust was heat pump technology, including absorption heating and cooling, heat-engine-driven machines, and the computer simulation of air-to-air, electric-driven devices for design optimization. Field and laboratory tests of subcontractor-developed advanced appliances substantiated major cost-effective efficiency improvements. Additionally, research involved

underground structures, development of diagnostics for buildings, the measurement and computer simulation of on-road automobile fuel use characteristics, and advanced heat exchangers for geothermal and ocean thermal energy conversion (OTEC) applications. Electric power technology included research on problems related to load control, high-voltage ac and dc components, and dispersion within the grid of generation and storage facilities such as wind machines and photovoltaic sources. Although some of the research and development was done in-house, a substantial fraction was subcontracted to industries and universities.

An important aspect of all the work was research utilization. Because the Energy Division is doing applied research, results, by definition, are intended to solve problems or answer questions of DOE and other sponsors. But there are other users, and research utilization activities include technology transfer, commercialization efforts, outreach to state and regional organizations, and, of course, information dissemination.

1. Introduction and Executive Summary

W. Fulkerson

1.1 INTRODUCTION

The Energy Division is one of fifteen research divisions at Oak Ridge National Laboratory (ORNL). It was established in 1974 to bring together (1) work on environmental, technological, and regional assessments related to energy development and (2) research on energy demand analysis and on improving the efficiency of energy use and conversion (energy conservation). Because of this broad scope, the staff of the Division has always been multidisciplinary. During FY 1981, scientific and technical professionals numbered about 132, including 56 engineers, 32 physical and life scientists, and 44 social scientists. The Division is the home for all of the practicing social scientists at ORNL. Although primarily economists and geographers, there are also political scientists, sociologists, psychologists, demographers, and others.

Over the past several years the Division has accepted the responsibility for helping the U.S. Department of Energy (DOE) manage a variety of research programs concerned with increasing the efficiency of building equipment and systems, improving electric power technology, and evaluating energy data and models. These responsibilities have required extensive subcontracting and more than half of the $38,000,000 in expenditures during FY 1981 was subcontracted to universities and private firms. The list of subcontractors (Sect. 8.6) shows the range of institutions involved. In addition to subcontractor activity, research managed and conducted by the Division depends on collaboration with people from other ORNL divisions, including Engineering Physics, Engineering Technology, Environmental Sciences, Fusion Energy, Health and Safety Research, Information, Instrumentation and Controls, Metals and Ceramics, Engineering, Computer Sciences, Chemistry, Physics, and Chemical Technology.

This eighth annual report of the Division covers work done during FY 1981 (October 1, 1980, through September 30, 1981). As with these documents in the past,[1-7] the format follows approximately the organizational structure of the Energy Division. Chapters 2–6 summarize the activities of the sections of the Division: Environmental Impact Section, headed by H. E. Zittel; Regional and Urban Studies Section, R. M. Davis; Economic Analysis Section, R. B. Shelton; Data and Analysis Section, A. S. Loebl; and Efficiency and Renewables Research Section, J. W. Michel. In addition, work on a variety of projects which cut across section lines is reported in Chap. 7, Integrated Programs. These activities are under the supervision of T. J. Wilbanks, Associate Director for the Division.

The organization chart at the end of the report represents the Division as of September 1981. Several major organizational changes took place during the year. In April 1981, T. H. Row left the Division to become head of the Nuclear Waste Programs at ORNL, and H. E. Zittel replaced Row as the head of the Environmental Impact Section. In June 1981, parts of the Conservation and Use Analysis Section were combined with the Conservation and Conversion Technology Section to form the Efficiency and Renewables Research Section under J. W. Michel. This change consolidated technology development work into a single section. A second new section, Data and Analysis, was formed under the direction of A. S. Loebl. This change was made to manage more effectively the growing activities in energy data and models being done for the Energy Information Administration (EIA) of DOE. C. V. Chester was named coordinator for all emergency preparedness studies in the Division including research related to civil defense and contingency planning for energy emergencies such as an oil import embargo or a nuclear reactor accident. Finally, the former Solar and Special Studies Section was merged into the Regional and Urban Studies Section.

During FY 1981, the research efforts were supported by a variety of federal agencies, but primarily by DOE (91% of expenditures), the Nuclear Regulatory Commission (NRC), and the Department of the Interior. Important support also came from the Department of Housing and Urban Development (HUD), the Federal Emergency Management Agency (FEMA), the Department of the Navy, the Environmental Protection Agency, the Tennessee Valley Authority, and the Rural Electric Administration of the U.S. Department of Agriculture. Within DOE, support came from five assistant secretaries (Conservation and Renewable Energy; Fossil Energy; Environmental Protection, Safety and Emergency Preparedness; Energy Research; and Nuclear Energy); from two administrators (EIA and the Economic Regulatory Administration); from the Office of Policy Planning and Analysis; from the Federal Energy Regulatory Commission; and from other DOE national laboratories. Work was also supported by the Electric Power Research Institute, and cooperative efforts continued with the Gas Research Institute on high-efficiency gas appliances and heat pumps.

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1. S. E. Beall et al., *Energy Division Annual Progress Report for Period Ending December 31, 1974*, ORNL-5030 (April 1975).
2. W. Fulkerson et al., *Energy Division Annual Progress Report for Period Ending December 31, 1975*, ORNL-5124 (April 1976).
3. W. Fulkerson et al., *Energy Division Annual Progress Report for Period Ending September 30, 1976*, ORNL-5250 (April 1977).
4. W. Fulkerson et al., *Energy Division Annual Progress Report for Period Ending September 30, 1977*, ORNL-5364 (April 1978).
5. W. Fulkerson et al., *Energy Division Annual Progress Report for Period Ending September 30, 1978*, ORNL-5513 (March 1979).
6. W. Fulkerson et al., *Energy Division Annual Progress Report for Period Ending September 30, 1979*, ORNL-5638 (June 1980).
7. W. Fulkerson et al., *Energy Division Annual Progress Report for Period Ending September 30, 1980*, ORNL-5740 (November 1981).

During FY 1981, the DOE sponsorship in many areas became uncertain because of the change in the administration and the reorganization of DOE. Despite these changes, much was accomplished during FY 1981.

1.2 ACCOMPLISHMENTS

The work of the Division is very diversified, but it can be divided into three major categories: analysis and assessment, models and data, and technology development. Analysis and assessment contribute information and informed perspectives on important energy issues and on policy and technological alternatives, identify research and development (R&D) needs, and help to set R&D priorities. The primary focus during FY 1981 was on (1) environmental issues (including those deriving from the preparation of environmental impact statements), (2) energy use analysis and forecasting, and (3) emergency preparedness. Related to the analysis and assessment area is work on models and data. This work includes the development of appropriate models and the collection and maintenance of a wide variety of energy- and environment-related data bases. It also includes evaluation of the quality, relevance, and limitations of data bases and models. Technology development includes research on improving the efficiency of energy use, particularly for the buildings and electrical energy sectors, and a smaller effort on the development of renewable energy sources. Significant accomplishments in each of these areas are listed in Table 1.1, and each item includes a reference to the relevant section in the body of the report.

1.3 RESEARCH UTILIZATION

The principal users of the results of Energy Division research are, of course, sponsors. But the results often have broader usefulness, and it is incumbent upon the staff to encourage utilization by others. Specifically, this utilization effort may involve technolgy transfer or technical assistance to encourage commercialization, outreach to state and local governments, and other various avenues of technical communication and information dissemination.

Models developed by the staff are being used for and by various organizations around the country. For example, the ORNL energy demand models are being applied by state energy offices, utilities, private consultants, and regional power planning commissions. At present the staff is providing limited consulting services (on a full cost-recovery basis) to private commercial organizations who have contracts to install or use our energy demand models for their customers. For NRC, a phase of transferring electricity demand forecasting models to state governments has been entered. The heat pump simulation model has been sent to 55 requesters, including 27 industrial firms, and our stochastic air quality model has been used for the state and city of New York.

Technical assistance to state and local governments involves not only models; for example, the extensive experience of the Division with energy facility siting problems is being applied to aid states in siting low-level radioactive waste repositories. Work for the Office of Surface Mining on compiling an inventory of abandoned mine problems is of direct benefit to participating states. The several years of effort with Minneapolis–St. Paul on district heating have resulted in the initiation of a system for St. Paul using heat from an existing coal-fired power plant. In a collaborative effort with Argonne National Laboratory, technical assistance on district heating is being provided to 12 other cities. A color movie on district heating was produced, providing a good introduction for cities

Table 1.1. FY 1981 significant accomplishments of the Energy Division together with other collaborating ORNL divisions and subcontractors

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I. ANALYSIS AND ASSESSMENT

A. Environmental Issues

- Fifteen environmental statements and twelve environmental assessments were completed, including the final statements for Solvent Refined Coal–I (SRC-I) and SRC-II and the Memphis Light, Gas and Water coal conversion projects. These latter statements were pathfinding documents on proposed demonstration plants for coal liquifaction and gasifacation (Chap. 2 and Sect. 3.2.2).
- Incentives to communities for hosting high-level nuclear waste repositories were identified and evaluated (Sect. 3.2.1); these incentives include payments in lieu of taxes derived from facility user fees (Sect. 4.4.3).
- A stochastic air pollution model was developed and used to evaluate the effects of (1) the variability of the sulfur content of coals and (2) plant operation on the meeting and setting of emission standards (Sect. 2.6.2).
- The implications for atmospheric CO_2 levels of various energy supply and-demand scenarios were estimated (Sect. 7.1.2).
- The energy resource potential of proposed Wilderness Study Areas was estimated (Sect. 3.2.4).
- The role of geographic scale seems to be important in making and sustaining major energy decisions (Sect. 7.1).

B. Energy Demand, Renewables, and Fuel Switching

- Trends in U.S. energy use, by sector, over the past decade indicate that the major factors in reduced demand have been efficiency improvements, behavior changes due to increases in fuel prices, lower economic growth, and, possibly, government energy conservation programs (Sect. 5.3.3).
- An analysis of the barriers that reduce the effectiveness of market forces in stimulating energy efficiency improvements indicate that government programs are having a significant catalytic effect (Sect. 7.1.3).
- Causes for the declining demand for gasoline during the 1978–1980 period were identified, and the effects of each cause quantified. Well over half the decline is attributable to a short-run response to the more than 50% increase in fuel prices during this period. New-car fuel economy improvements were the second largest factor, accounting for one-eighth and one-fourth of the 1979 and 1980 declines, respectively. The much-publicized fuel shortage of the summer of 1979 reduced total consumption by only an estimated 1% (Sect. 3.4.2).
- In a utility experiment in Vermont, time-of-day pricing was found to have a significant impact on consumer behavior and potential peak load (Sect. 4.3.3).
- From an analysis of 48 hospital audits, it was estimated that the average hospital could achieve a potential energy savings of 20% with an average payback period of one year (Sect. 5.3.2).
- A survey of 50 industrial representatives produced information on factors influencing boiler investments and the use of coal (Sect. 5.4.2).
- Analysis of the economics of direct and passive solar systems for residences indicates that a payback period of less than 20 years is possible only in areas of high insolation or high electricity costs (Sect. 5.4.3).

Table 1.1 (continued)

C. Emergency Preparedness

- During an oil shortage, the substitution of electricity by individuals or businesses (e.g., increased lighting or use of ovens or portable heaters) could result in increased use of oil and gas by utilities. These increases could far exceed the savings by consumers of premium fuels (Sect. 7.1.1).
- Factors that may influence public response to emergencies were identified, which led to the suggestion of principles for emergency planning (Sect. 7.1.1).
- The impacts of oil disruptions on U.S. refining activity are being analyzed to account for changes in oil types and quantities (Sect. 4.4.2).
- Use of indigenous vegetable oils for fueling farm equipment may improve agricultural self-sufficiency in times of fuel shortages; the price of vegetable oils may be competitive with petroleum-derived fuels by the end of the decade (Sect. 3.3.3).
- Three new handbooks are being developed on radiological defense for the U.S. population in the event of nuclear war. The first of these handbooks presents a detailed description of the potential for radiation exposure for people who remain in shelters after a nuclear attack and a description of the equipment and methods for determining radiation exposure following an attack (Sect. 3.3.1).

II. MODELS AND DATA

A. Models

- ORFAD, the ORNL cooling tower plume model, is being completely reformulated on the basis of first principles. Tests indicate that the new model can quantitatively simulate observed plumes (Sect. 2.6.3).
- Single- and multipoint source stochastic air pollution models have been developed to account for the effect of variability of emissions on the probability of exceeding ambient air quality standards (Sect. 2.6.2).
- A pattern recognition test is being used in conjunction with field tracer experiments to evaluate the performance of various atmospheric dispersion models for use at reactor sites during emergency situations (Sect. 2.6.1).
- REED, the rural electric energy demand forecasting model, was updated, using data from 1969 to 1979; a supply-side component was added that forecasts the growth in the total operating costs of cooperatives (Sect. 4.2.3).
- Documentation was completed describing the integrated system of ORNL models for forecasting electric energy demand and load at the state and utility-service-area levels, and a submodel was developed to forecast durable appliance saturations (Sect. 4.2.2).
- A life-cycle cost model was developed for analyzing efficiency improvement measures in the design of commercial buildings (Sect. 6.8).
- The tax credit eligibility model was modified to account more accurately for oil and gas savings (due to energy-saving appliances) by electric utilities; an equipment-choice model was developed to estimate new appliance sales for each of ten federal regions, to evaluate the impact of a tax credit (Sect. 4.2.1).
- The ORNL residential energy demand model has been improved in response to a variety of evaluation studies, and the improved model was used to show that the new ASHRAE 90A-1980 standard is close to optimal cost-effectiveness for current fuel prices (Sect. 5.4.3).
- ORNL neared its goal of developing a comprehensive set of state of the art, energy-demand forecasting models of each transportation mode with the completion of air-passenger use and heavy-truck diesel fuel demand models. The heavy-truck model indicated that diesel fuel demand was most sensitive to economic growth and much less sensitive to the number of trucks or to fuel prices (Sect. 3.4.3).

Table 1.1 (continued)

- In collaboration with the Engineering Physics Division, validation studies were completed for three models for DOE/IEA including the long-term energy analysis program (LEAP) model (Sect. 4.3.2).

B. Data

- Ten EIA energy data system evaluation studies were completed, as were four data requirement reviews in the areas of natural gas data; petroleum imports; fuel substitution policy, implementation, and analysis; and coal production data (Sect. 5.2).
- One of the data system evaluation studies revealed that for the four-year period of 1977–1980 approximately 42 × 10^6 t/year of "old" oil was not reported under the entitlements program (Sect. 5.2).
- In the evaluation of energy data systems, precise statistical calculation of probable error is often irrelevant because of larger errors introduced by bias or by a misinterpretation or misapplication of definitions (Sect. 5.2).
- Automatic data-editing breakthroughs resulted in the development of an efficient, discrete error localization algorithm which can be applied to large data bases (Sect. 5.2).
- Preliminary energy audit data from ten states were edited to eliminate outlier errors and then analyzed to yield statistically meaningful evidence concerning the effects of factors such as fuel prices, floor area, climate, occupancy, and building type on institutional building energy use (Sect. 5.3.2).

III. TECHNOLOGY DEVELOPMENT

A. Efficiency Improvements

- Two natural-gas-driven absorption heat pumps have been developed by subcontractors; these demonstrate a heating coefficient of performance (COP) of about 1.2 at 8.3°C and, for one of them, a cooling COP of 0.45 (Sect. 6.2.1).
- An advanced lithium bromine (LiBr) absorption heat pump was conceived for using low-grade waste heat (approximately 60°C) to produce steam at temperatures in excess of 120°C, and a two-stage LiBr absorption chiller built and tested by a subcontractor met the design expectations by producing chilled water at 5°C from low-grade 60°C heat (Sect. 6.5.1).
- Field measurements of a commercially available, high-efficiency, electric air-to-air heat pump showed a heating COP that actually decreased slightly with increasing outdoor temperatures in sharp contrast to steady-state behavior. This effect is apparently due to increased cycling losses at higher temperatures (Sect. 6.3).
- The ORNL Heat Pump Computer Simulation Model was used to show that analytical optimization can significantly improve heat pump design (Sect. 6.2.3).
- Field and laboratory tests of subcontractor-developed appliances substantiated major cost-effective efficiency improvements, e.g., in electric water heaters, refrigerator-freezers, and compressors used in refrigerator-freezers (Sect. 6.4).
- Earth-sheltered houses of a size typical for single-family dwellings were found to be significantly more costly than conventional dwellings, and the added cost probably can not be justified by energy savings on a life-cycle basis. This conclusion may not be true for commercial-size buildings (Sect. 6.7.3).
- Field tests by utilities across the country indicated that many central residential thermal energy storage systems available on the market do not perform adequately for load management applications; therefore, additional research and development is needed (Sect. 6.6).

Table 1.1 (continued)

- Subcontractor studies indicated that aerial infrared sensing of houses using state of the art techniques can give meaningful comparative information about insulation levels and heat-loss differences (Sect. 6.7.2).
- Construction of a hot water district heating system for St. Paul, Minnesota, will begin in 1982 — partially as a result of technical assistance provided by DOE through ORNL and its subcontractors (Sect. 6.5).
- Measurements of on-road, automobile-fuel-use characteristics coupled with computer simulation and an optimizing procedure were used to calculate the driver behavior which would minimize fuel consumption over any given terrain and for any given trip conditions or constraints. For example, optimal driving of a Ford Fairmont over rolling hills of 6% grade requires 12% less fuel than driving at constant speed for the same trip (Sect. 3.4.4).

B. Renewables

- Tests at Raft River, Idaho, of an ORNL-designed (high-efficiency, horizontal, fluted tube) condenser for geothermal applications confirmed predicted enhanced performance and indicated that as much as a 40% reduction in condenser capital costs could be realized (Sect. 6.5.2).
- Measurements of the output of a photovoltaic system (the John F. Long photovoltaic house in Phoenix, Arizona) indicated that present inverter designs (dc to ac) are lacking in their ability to produce high-quality, 60-Hz electricity and that improvements will be required before large-scale intertie of photovoltaic sources to utility grids will be practical (Sect. 6.6).
- Analysis of the performance of concentrating photovoltaic collectors at the Mississippi County Community College demonstration at Blytheville, Arkansas, showed that photovoltaic output could be degraded by as much as 50% by a gravitationally induced twist of the collector about the sun-tracking axis (Sect. 6.10).
- Studies indicate that arrays of large wind turbines can cause operating problems for electric utility systems unless supplementary control is added to either or both the array and the electric utility system (Sect. 6.6).

considering this option. For HUD the staff is contributing technical support to three cities on their municipal refuse-to-energy projects. Revised handbooks on radiological safety are being developed for FEMA, and a draft of the first of these was distributed to state radiological defense officials.[8]

Efforts to accelerate the commercialization of energy-efficient equipment were pursued through extensive subcontracting with manufacturers for work on heat pumps, appliances, low-grade heat recovery, and power system technology. Work on the Annual Cycle Energy System during FY 1981 focused on informing utilities about the results of the research and the load-leveling potential of the system. Finally, under the *Building Thermal Envelope Systems and Insulating Materials* program, the staff is collaborating with many organizations in the building industry to develop information useful in establishing better methods to improve the efficiency of existing and new buildings.

Technical communications and information dissemination included interaction with peers, sponsors, and the interested public and a recording of results of the work (Chap. 8). During FY 1981, the staff published 58 articles in scientific or technical journals and 21 others were accepted for

8. C. M. Haaland, *A Proposed New Handbook for the Federal Emergency Management Agency: Radiation Safety in Shelters*, ORNL-5766 (September 1981).

publication. In addition, 55 ORNL reports, 3 books, and 6 book chapters were published; 33 papers were printed in the proceedings of technical meetings; and 27 environmental impact statements or assessments were issued. Additionally, the Division held five workshops and symposia and hosted many visitors from universities, government organizations, industry, and other research institutions. There were a number of foreign visitors, and some staff members presented papers abroad.

Our staff remains active in a wide range of technical professional organizations, as indicated in Sect. 8.1. During FY 1981, Axel Rose and David Greene served on the National Academy of Sciences Committee on Energy Conservation and Transportation, and Thomas Wilbanks served on the National Academy of Sciences Committee on Behavioral and Social Aspects of Energy Consumption and Production.

2. Environmental Impact Section

H. E. Zittel

2.1 INTRODUCTION

During the past year the Environmental Impact Section has undergone a number of changes in response to the changing times and needs of our sponsors. The section has been reorganized (see organization chart at end of Sect. 8.11) to meet more fully the diversity of problems and sponsors which we foresee dominating the future. While work for our long-time sponsors — Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC) — still constitutes a large fraction of our work load, we are increasingly aware that other sponsors such as the Department of Defense (DOD) and the Environmental Protection Agency (EPA) are interested in and need the expertise the section represents. Because ORNL is a national laboratory, we are attempting to extend our services to state and local governments as well.

The section has a growing research effort in support of National Environmental Policy Act (NEPA) activities. Work on transfer models by the Applied Physical Sciences Group is concerned with predicting the dispersion of pollutants in the biosphere. The NRC Nuclear Projects Group is becoming increasingly active in support of the agency in terms of providing technical reports not directly related to NEPA.

These new areas of work and involvement with agencies other than our traditional sponsors represent a positive, healthy outlook for the section and the Division.

2.2 NRC NUCLEAR PROGRAMS

M. J. Kelly[1]

J. S. Baldwin	R. L. Kroodsma[2]	A. M. Solomon[3]
R. Blumberg	D. W. Lee	W. P. Staub
K. S. Gant	P. J. Mulholland[2]	V. Tolbert[2]
G. S. Hill[3]	C. B. Powers[2]	L. D. Voorhees[2]
R. B. Honea	R. M. Rush	J. W. Webb[2]
R. H. Ketelle	F. E. Sharples[2]	S. Wright[3]

1. Project manager.
2. Environmental Sciences Division.
3. Health and Safety Research Division.

This group prepares Environmental Impact Assessments (EIAs) and Environmental Impact Statements (EISs) on nuclear facilities involved in licensing action by NRC and also prepares topical reports to assist the NRC licensing staff in developing technical bases for the formulation of positions applicable to specific categories of licensing actions.

2.2.1 Fuel Cycle Projects

Table 2.1 shows the status of fuel cycle licensing projects. Only the Bison Basin Project was completed in FY 1981. Three projects active in FY 1980 were delayed or cancelled in FY 1981 because of the decreased demand for uranium.[4]

Only two uranium production facilities EISs were initiated in FY 1981, namely the new Teton-Nedco solution mining project in Wyoming and a revival of the Kerr-McGee Powder River Mill project started in 1977. Three fuel fabrication EIAs were initiated, two for relicense of fuel fabrication facilities and one for a license amendment on a UF_6 production facility. No major impacts have been identified in the above projects.

In addition to the above, we were assigned responsibility for preparation of eight topical reports (Table 2.2). These state of the art reports are in support of NRC licensing staff reviews of tailings management programs submitted under the new requirements of 10 CFR Part 40, Appendix A.

4. W. Fulkerson et al., *Energy Division Annual Progress Report for Period Ending September 30, 1980*, ORNL-5740 (November 1981), p. 21.

Table 2.1. Nuclear fuel cycle facilities in licensing actions in FY 1981[a]

Facility	Work started	PEIA	EIA	PDES	DES	FES
In situ mining						
Bison Basin (Wyoming)						X
Teton Project (Wyoming)	X					
Uranium mills						
Conoco (Wyoming)				X		
Fed-Am Partners (Wyoming)[b]				X		
Powder River (Wyoming)	X					
Fuel fabrication						
Combustion Engineering (Connecticut)	X					
General Atomics (California)	X					
Westinghouse (Alabama)[c]					X	
UF_6 preparation						
Kerr-McGee (Oklahoma)	X	X				
Tailings disposal						
Edgemont (South Dakota)					X	
Low-level waste disposal						
Barnwell (South Carolina)[d]			X			

[a]Acronyms used: PEIA, Preliminary Environmental Impact Agreement; EIA, Environmental Impact Assessment; PDES, Preliminary Draft Environmental Statement; DES, Draft Environmental Statement; FES, Final Environmental Statement.

[b]Not yet issued, by applicant's request.

[c]Project cancelled by applicant.

[d]Agreement state project.

Table 2.2. Topical reports for the NRC uranium recovery licensing branch

Title[a]	In progress	Draft to NRC	Issued
1. Rock Cover vs Vegetation		X	
2. Upward Geochemical Migration		X	
3. Radon Attenuation	X		
4. Techniques of Groundwater Restoration		X	
5. In Situ Dewatering Techniques	X		
6. Tailings Consolidation Techniques and Requirements	X		
7. Cost-Benefit Aspects of Long-Term Performance	X		
8. Land Ownership Requirements			

[a]Summary of required material in above topical reports:

1. Rock Cover vs Vegetation—Based on current available data, this report is to detail the relative merits of rock cover vs revegetation as a means of providing erosion protection for tailings piles.

2. Upward Geochemical Migration—This report is to assemble and summarize the current available information regarding the potential for, impacts of, and means of minimizing upward geochemical migration of contaminant constituents of uranium tailings.

3. Radon Attenuation—A summary of currently available knowledge on how to predict average equilibrium radon emissions from tailing piles, this report also provides recommendations for postreclamation radon monitoring and/or evaluation models for annual cycle radon emissions.

4. Techniques of Groundwater Restoration—This report is to summarize the current knowledge regarding the effectiveness, practicability, reliability, applicability, and cost of techniques for groundwater restoration. The report addresses groundwater restoration of strata affected by uranium solution mining as well as water table and aquifer contamination induced by seepage from tailings and evaporation ponds.

5. In Situ Dewatering Techniques—This report is to address the feasibility, effectiveness, reliability, and cost of in-place dewatering of uranium mill tailings.

6. Tailings Consolidation Techniques and Requirements—This report is to evaluate tailings consolidation requirements necessary to ensure long-term stability of a tailings pile and to determine the degree to which using dewatering techniques alone would achieve these requirements.

7. Cost-Benefit Aspects of Long-Term Performance—Based on currently available information, data, and experience, this report is to quantify to the extent possible both the costs and benefits of those design, siting, reclamation, cover, and erosion protection alternatives bearing on the question of long-term performance in maintaining buried tailings isolated from the human environment.

8. Land Ownership Requirements—Land ownership requirements the NRC must or should impose, with respect to proposed final disposal sites for uranium tailings and/or other above-ground surface wastes produced by licensable uranium extraction activities, are to be covered in this report.

2.2.2 Low-Level-Waste Project

The group completed an EIA on the Chem-Nuclear Low-Level-Waste Disposal Facility at Barnwell, South Carolina. This assessment was requested by the Department of Health and Environmental Control of the state of South Carolina for their use in relicensing the facility. Because South Carolina is an agreement state[5] the document was not required under NEPA.

5. The provisions of the Atomic Energy Acts of 1954 allow states to enter into agreement with NRC to perform as the regulatory authority. Because no federal action on a license in such a state is taken thereafter, NEPA provisions are not applicable.

Because new applications are expected for low-level-waste sites, ORNL staff and NRC prepared the EIA at a treatment level expected for an EIS. This experience in an area previously unaddressed by NEPA has prepared the staff to produce credible EISs when needed.

The staff found that the Barnwell Facility is being operated at the state of the art and that, with the initiation of some proposed operational improvements, it will have little environmental impact. Such operational improvements include (1) improved trench design; (2) segregation and placement of waste packages according to concentration, size, and volume; and (3) expansion of the groundwater monitoring program.

2.3 DOE NUCLEAR PROGRAMS

J. B. Cannon

The major thrust of projects in the DOE nuclear area has been and continues to be concerned with magnetic fusion energy and radioactive waste disposal. Ongoing activities included development of the technical basis for assessing the potential environmental implications of the national Magnetic Fusion Energy Program (Sect. 2.3.1) and development of a draft EIS for construction and operation of a defense waste-processing facility at the Savannah River Plant (Sect. 2.3.2). We also provided assistance to DOE–Savannah River Operations in conducting NEPA reviews for away-from-reactor (AFR) spent fuel storage facilities. New endeavors include (1) an area-wide screening study to locate potentially suitable areas in Tennessee for a low-level-waste burial site and (2) a pathways analysis study to ascertain the acceptability of potential sites on the Portsmouth, Ohio, reservation for shallow land burial of low-level wastes from the proposed gas centrifuge enrichment plant (Sect. 2.3.3).

2.3.1 Fusion Environmental Assessment Program

J. B. Cannon

The purpose of this program is to provide technical assistance to DOE's Office of Fusion Energy in coordination and preparation of NEPA compliance documents. The current focus of the program is on development of a generic environmental impact statement (GEIS) pursuant to advancement of the national Magnetic Fusion Energy Program from basic and applied research to engineering development. In FY 1981 significant progress was achieved in developing a technical basis document for the GEIS. The sole purpose of this document is to demonstrate that the technology is sufficiently advanced to allow for preparation of a realistic GEIS. Based on favorable reviews of this draft report (>1000 pp.), DOE made a decision to proceed with development of the GEIS. Accordingly, efforts were initiated to upgrade the report for use as a major reference for the GEIS.

2.3.2 Defense Waste-Processing Facility Project

J. W. Boyle

Work on developing a draft EIS for a defense waste-processing facility at the Savannah River Plant was completed.[6] This facility will be used to immobilize high-level radioactive waste, which will eventually be disposed of in a mined geologic repository. Impacts from constructing and operating the facility will include disturbing 120 to 150 ha of land with resulting disruption of wildlife, siltation of streams, and elimination of one Carolina bay — a natural wetland. Some socioeconomic impacts on housing, schools, and community services over a six-county area will result primarily from the influx of construction workers. Overall, the potential impacts of the proposed facility were judged to be minimal.

2.3.3 Gas Centrifuge Low-Level-Waste Disposal Facility Pathways Analysis

R. Blumberg

The purpose of this project is to perform a pathways analysis for potential shallow land burial sites on the Portsmouth, Ohio. reservation. These burial sites would accommodate low-level radioactive wastes from the proposed gas centrifuge enrichment facility. Efforts were aimed at geological explorations to obtain data needed for modeling subsurface migration of leachate from the wastes. Preliminary analysis indicates that the pathways of most concern are (1) leachate migration into groundwater during flooding events after the landfill cover has deteriorated and (2) human intrusion on the site after institutional controls no longer exist.

2.4 FOSSIL ENERGY ENVIRONMENTAL PROGRAM

C. R. Boston

The Fossil Energy Environmental Program provides DOE with environmental assessments and technical support during the development of advanced fossil fuel facilities. Work during the past year focused on three principal areas: (1) guidance to DOE industrial partners, (2) interactive technical assistance activities, and (3) environmental assessment. In the synfuels work, emphasis has been on coal liquefaction and gasification demonstration facilities.

In addition to the work described below, ORNL carried out the following tasks: (1) reviewed the environmental report for the commercial-scale Breckinridge, Kentucky, H-Coal Project for direct liquefaction of coal; (2) conducted a workshop and published proceedings on industrial

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6. *Draft Environmental Impact Statement, Defense Waste Processing Facility, Savannah River Plant, Aiken, S.C.*, DOE/EIS-0082-D (September 1981).

hygiene/occupational medicine in coal conversion facilities;[7] and (3) initiated a triweekly, regulatory and legislative update that provides a concise overview of current changes in environmental regulations.

2.4.1 Synfuels Project

During FY 1981, ORNL completed EISs on five of DOE's synfuels demonstration projects — three gasification and two liquefaction plants. The gasification plants included two high-Btu gasification plants, Conoco and Illinois Coal Gasification Group (ICGG),[8,9] and a medium-Btu plant, Memphis Light, Gas and Water (MLGW).[10] The two direct liquefaction plants were Solvent Refined Coal–I (SRC-I)[11] and Solvent Refined Coal–II (SRC-II).[12]

Gasification Projects — A. J. Witten

The MLGW draft EIS was issued in October 1980. A public hearing was held in December of the same year in Memphis, Tennessee. Most of the public comments on the draft statement (either submitted in writing or given at the hearing) concerned two issues: floodplain/wetlands and occupational health. In preparation of the final EIS, the floodplain/wetlands issues were addressed by providing greater information on alternative sites. This was done to support DOE's findings that no practicable alternative existed. The occupational health concerns were addressed by ranking the materials of concern based on an analysis of pilot plant data. The study revealed that the materials of most concern are carbon monoxide and hydrogen sulfide. These are commonly encountered substances with established safety procedures.

Draft EISs were near completion on ICGG and Conoco when DOE requested that work be stopped. The work completed at that time was documented and delivered to DOE as preliminary draft EISs.

Liquefaction Projects — S. G. DeCicco

ORNL pioneered in environmental, health, and social assessment of the emerging synthetic fuel industry by preparing the first EISs on direct coal liquefaction plants (SRC-I and SRC-II).

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7. *Proceedings of Workshop on Industrial Hygiene and Occupational Medicine in Coal Conversion Projects, November 6–7, 1980*, CONF-801143, September 1981.

8. *CONOCO Pipeline Gas Demonstration Plant, Noble County, Ohio*, Review Draft Environmental Statement, March 1981.

9. *Illinois Coal Gasification Group, Pipeline Gas Demonstration Plant, Cutler, Illinois*, Review Draft Environmental Statement, March 1981.

10. *Draft Environmental Impact Statement, Memphis Light, Gas and Water Division, Memphis, Shelby County, Tennessee*, DOE/EIS-0071-D (October 1980).

11. *Final Environmental Impact Statement, Solvent Refined Coal-I Demonstration Project, Newman, Daviess County, Kentucky*, DOE/EIS-0073 (July 1981).

12. *Final Environmental Impact Statement, Solvent Refined Coal-II Demonstration Project, Fort Martin, Monongalia County, West Virginia*, DOE/EIS-0069 (January 1981).

Regardless of the fate of these specific projects (SRC-II has been cancelled), the EISs should have generic value in developing an environmentally acceptable synfuels industry and in setting a precedent for future synfuel EISs.

Topics assessed included occupational and public health risks; air quality impacts from point and fugitive emissions; water quality impacts from wastewater discharge, spills, and water consumption; groundwater impacts from solid waste disposal; aquatic and terrestrial ecological impacts; noise impacts; traffic impacts from commuting workers; competition for skilled labor with other projects; community impacts from in-migrating workers; cumulative impacts with other projects; preliminary hazards identification; and hazards of siting on floodplains.

Environmental monitoring and industrial hygiene programs and specific mitigation plans for lessening adverse impacts were also specified.

2.4.2 Fuel Use Act Project

R. C. Martin

E. L. Churnetski[13]	P. R. Intemann	A. W. Reed
E. D. Copenhaver[14]	F. C. Kornegay	D. N. Secora
J. E. Delene[13]	D. W. Lee	L. L. Sigal[15]
L. C. Fuller[13]	A. S. Loebl	W. P. Staub
R. E. Greene	P. J. Mulholland	P. J. Walsh[14]
W. L. Greenstreet[13]	M. L. Myers[13]	A. P. Watson[14]
N. E. Hinkle	K. M. Oakes[15]	D. J. Wilkes

The purpose of this project was to provide technical assistance to ERA-DOE in its implementation of the Powerplant and Industrial Fuel Use Act of 1978 (FUA). ORNL received task orders to prepare technical support documents and Environmental Impact Reports (EIRs) related to proposed prohibition orders issued to power plants in New York City (Arthur Kill[16] and Ravenswood[17]); Huntington, Long Island (Northport); and Salem, Massachusetts (Salem Harbor). These task orders required preparation of an engineering analysis technical report, a fuel supply and transportation analysis report, an environmental regulations technical report, and an EIR. ORNL also received task assignments for special studies in the following areas:

1. Preparation of air quality and public health impact analyses and supporting studies for the Northeast Regional EIS being prepared by DOE to evaluate the cumulative impact of the possible conversion to coal of 42 generating stations in the northeastern United States.
2. Utility dispatch analyses to assist DOE in determining load factors to be used in financial feasibility studies.

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13. Engineering Technology Division.

14. Health and Safety Research Division.

15. Environmental Sciences Division.

16. *Draft Environmental Impact Report, Conversion of Arthur Kill Generating Station Units 2 and 30*, U.S. Department of Energy, July 1981.

17. *Draft Environmental Impact Report, Conversion of Ravenswood Generating Station Units 30N and 30S*, U.S. Department of Energy, July 1981.

3. Development of a rate impact model for use by DOE in evaluating the changes in the cost of power resulting from use of alternative fuels.

The technical feasibility of four primary and six secondary alternative fuel options was evaluated in the engineering analysis of the conversion of the Arthur Kill and Ravenswood facilities. All options were determined to be technically feasible. Cost estimates and supporting information were provided to DOE for use in economic analyses. The fuel supply and transportation analyses for these facilities indicated that conversion under any of the primary (coal) options would not be constrained by the availability or transportation of fuel. The analysis of the environmental impacts indicated that conversion could be accomplished without violation of the applicable ambient air quality standards if appropriate control and mitigation measures are employed. Impacts to terrestrial and aquatic ecosystems are expected to be small and to be confined to the plant and solid waste disposal sites. Impacts to public health are not expected to be significant.

The preliminary air quality analysis for the Northeast Regional EIS predicted that conversion under the scenarios resulting in the maximum SO_2 emissions could contribute to exceeding slightly the annual average SO_2 standard near the Mason station and in New York City. Exceeding the 24-h SO_2 standard could also occur in the Boston and New York subregions. It was concluded that mitigative techniques could eliminate the potential for exceeding the standard. The health impacts resulting from the predicted 10% increases in ambient sulfate concentrations were not considered to be significant. Impacts resulting from a predicted 2% increase in levels of nitrogen oxides could not be predicted.

2.5 CONSERVATION AND RENEWABLE RESOURCES PROGRAM

L. J. Mezga[18]

H. M. Braunstein[19] K. M. Oakes[20] G. W. Suter[20]
C. S. Dudney[21] C. D. Powers[20] V. R. Tolbert[20]
G. K. Eddlemon[20] A. W. Reed J. W. Webb[20]
P. R. Intemann W. P. Staub D. J. Wilkes
J. F. McBrayer[20]

The Environmental Impact Section is responsible for preparing EISs and EIAs for virtually all DOE geothermal research, development, demonstration, and loan guaranty projects and for designated solar and conservation projects. The geothermal support activity began in March 1976 and has maintained a steady level of effort. EIAs have been prepared for projects in nine states and for programs in the western United States, the Gulf Coast, and the eastern Coastal Plains regions. Projects addressed have ranged from exploration to direct end use of heat and electrical generation.

18. Manager, on loan to DOE Low Level Waste Management Program.
19. Industrial Safety and Applied Health Physics Division.
20. Environmental Sciences Division.
21. Health and Safety Research Division.

The geothermal resource program expanded during FY 1981 to include assessment activities in support of the Navy's geothermal development and utilization program. The solar support activities have evolved from preparation of the Biomass Programmatic Assessment[22] to providing environmental support to the Alcohol Fuels Program.

2.5.1 DOE Geothermal Projects

L. J. Mezga

A. W. Reed[23]

During FY 1980, ORNL continued or began work on 13 EIAs or other environmental documents in support of the DOE Geothermal Energy Program. Table 2.3 describes the environmental documents worked on during FY 1981. No one activity dominated Geothermal Environmental Assessment Program activities during FY 1981, and activities were undertaken in support of the Hydrothermal, Geopressure, and Geothermal Loan Guaranty Program. Activities of the past year are characterized by a series of projects having their own unique and scientifically interesting issues but having "no significant impact" in the connotation of the Council on Environmental Quality. In addition to environmental assessments and evaluations for specific projects, ORNL assisted the Division of Geothermal and Hydropower Technology in developing and evaluating the effects of environmental policies, laws, and regulations on the development and utilization of geothermal energy. Specific tasks include analysis of the impacts of the Clean Air Act on geothermal energy[24] and identification of applicable state of Louisiana environmental requirements.

2.5.2 Department of the Navy Environmental Assistance Projects

L. J. Mezga

A. W. Reed

This new activity was initiated in FY 1981 and consists of preparation of a programmatic EIS for geothermal energy development and utilization at the Fallon Naval Air Station (NAS), Fallon, Nevada. The Navy is evaluating the potential for use of alternative energy sources at its facilities and as part of that activity is evaluating the potential geothermal resource at the Fallon NAS. No potentially significant impacts were identified in the EIS; however, project activities will be evaluated in more detail as the program progresses.

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22. W. Fulkerson et al., *Energy Division Annual Progress Report for Period Ending September 30, 1979*, ORNL-5638 (June 1980).

23. Acting manager.

24. *Implications of the Clean Air Act and Other Air Quality Regulations on Geothermal Development in the United States*, Draft, September 1981.

Table 2.3. Geothermal environmental documents worked on during FY 1981[a]

Project name and description	Location	Status
Geopressure energy subprogram		
Lafourche geopressure well (drilling and flow testing of one well)	Lafourche Bayou, Louisiana	Final EIA in preparation
Gladys McCall well (drilling and flow testing of one well)	Cameron Parish, Louisiana	Final EIA issued 1/81
Geopressure subprogrammatic for the Wilcox and Tuscaloosa formations (geopressure well drilling and flow testing)	Texas and Louisiana Gulf Coast Region	Draft EIA submitted 9/81
Blessing well (drilling and flow testing of one well)	Matagorda County, Texas	Evaluation completed 9/81
Analysis of state of Louisiana environmental requirements		In preparation
Hydrothermal energy subprogram		
Helical screw expander project	Cesano, Italy, and Broadlands, New Zealand	International EIA completed 8/81
Analysis of the impacts of the Clean Air Act on geothermal energy development and utilization		Draft EIA completed 9/81
Analysis of enviromental, safety, and health requirements for DGHT		In preparation
Geothermal Loan Guaranty Office		
Oregon Trail Mushrooms Geothermal Loan Guaranty (direct heat application of geothermal resource to produce mushrooms)	Vale, Oregon	EIA issued 2/81
South Geysers—Rorabaugh Leasehold Geothermal Loan Guaranty (well drilling and steam production)	Sonoma County, California	EIA issued 7/81
Boise Geothermal Partners (direct heat application)	Boise, Idaho	Enviromental evaluation completed 6/81

[a]Acronyms used: EIA, Environmental Impact Assessment; DGHT, Division of Geothermal and Hydropower Technology.

2.5.3 Commercial and Apartment Buildings Conservation Service Program

D. J. Wilkes

The Commercial and Apartment Buildings Conservation Service (CACS) Program is proposed to be implemented as mandated by Congress in Subtitle D of the Energy Security Act of 1980 (Public Law 96-294). The program is designed to promote the installation of energy conservation and renewable resource measures in residential and commercial buildings. ORNL supported DOE in this effort through preparation of an EIS which was issued as a supplement to the EIS prepared for the Residential Conservation Service (RCS).[25]

25. *Environmental Impact Statement, Draft Supplement, Residential Conservation Service Program Expansion to Multifamily and Commercial Buildings*, DOE/EIS-0050-DS (December 1980).

The EIS identified the eligible buildings inventory, the estimated participation rates, the energy to be saved, and the materials to be consumed because of the program. From these estimates, projections of the likely environmental impact were obtained. Other issues, including indoor air quality, health and safety impacts, and socioeconomic effects, were examined independently. Positive impacts of the program included reduction in consumption of electricity, oil, and natural gas. This reduction results in progress toward national energy independence and pollution reduction. Negative impacts included potential contributions to indoor concentrations of air pollutants.

2.6 APPLIED PHYSICAL SCIENCES GROUP

A. J. Witten

J. S. Baldwin[26]	F. C. Kornegay	R. D. Roop
C. C. Gilmore	D. W. Lee	D. N. Secora
D. B. Hunsaker	E. C. Long[27]	R. D. Sharpe[27]
P. R. Intemann	F. G. Pin[28]	W. P. Staub
R. H. Ketelle	A. W. Reed	

The Applied Physical Sciences Group is concerned with the dynamics of oceans, rivers, lakes, aquifers, and the atmosphere and with the dispersion of pollutants in these geophysical systems. The group performs independent research and provides technical support in preparation of EISs and EIAs.

Ongoing group projects include the study of atmospheric flow over complex terrain, turbulent diffusion, stochastic transport, dynamics of buoyant plumes, groundwater flow, and the dispersion of pollutants in the saturated and unsaturated zones.

2.6.1 Evaluation of Atmospheric Dispersion Models Program

F. C. Kornegay

The objective of the model evaluation program being carried out for NRC is to identify the most accurate available atmospheric dispersion models for use at reactor sites during emergency situations.

The program has developed criteria for judging atmospheric dispersion models through a "pattern recognition test." This procedure has been used in examining the performance of the Lawrence Livermore National Laboratory (LLNL) Atmospheric Release Advisory Capability (ARAC) system in actual field tests, in addition to determining the usability of other dispersion models when compared with measured data. The field test data, obtained in extensive tests carried out at Idaho Falls, is currently being documented.

26. Part-time.
27. Computer Sciences Division.
28. University of Rochester.

The predictive capabilities of existing atmospheric dispersion models will be examined under various circumstances. The most accurate techniques for given conditions will be determined by the pattern recognition criteria developed in the earlier phase of this study. The final role of this program is to provide recommendations to the NRC for implementing the best models at operating reactors.

2.6.2 Stochastic Air Quality Model

A. J. Witten   T. C. Kornegay   E. C. Long[29]

Emission rates from coal-fired power plants may vary from day to day as a result of the variability in the composition of the feed coal and in plant operations. One way to incorporate this variability is to treat the emission rate as a random variable. Given the statistics of the emission rate, it is possible to calculate the statistics of the resulting ground-level concentration.

This approach has been used to develop a single-source[30] and a multiple-source stochastic model. The models require typical stack parameters as input along with the mean emission rate and emission rate standard deviation. The model assumes that the emissions are log-normally distributed. Outputs from the models are the probabilities of no exceedances, one exceedance, and two or more exceedances of given standards, either on a receptor-by-receptor basis or over the entire modeled region.

The stochastic approach has important implications in air quality regulations. If air quality regulations were modified to account for the variability of the sulfur content in coal, the regulatory agency could specify a fixed violation probability that would not be exceeded by the utility. The regulatory agency would develop an operating curve such as that shown in Fig. 2.1 for the hypothetical power plant. This figure assumes that the allowable violation probability is 10% per year. This operating curve allows a range of means and standard deviations for the allowable SO_2 emissions. This range is defined by the compliance area shown in this figure. For a fixed conversion rate from percentage of sulfur in coal to SO_2 emissions, allowable coal specifications can be developed. These are also shown in this figure. The compliance space under the existing regulations is also shown in this figure. Comparing currently allowable operating parameters with those generated by the stochastic approach, it becomes clear that accounting for the variability of emissions allows utilities significantly greater flexibility in plant design, plant fuel selection, and plant operating procedures.

2.6.3 Modified ORFAD Study

F. G. Pin[31]   A. J. Witten

The ORFAD cooling tower plume model is being redeveloped by J. Molyneux and F. G. Pin. The original ORFAD code is based on an integral formulation utilizing many empirical relationships. While this approach can reliably calculate drift deposition, it is inadequate for predicting

29. Computer Sciences Division.

30. A. J. Witten et al., "An Alternative Technique for Analyzing Sulfur Dioxide Concentrations from a Single Source," *J. Air Pollut. Control Assoc.* 31(7): 773–78 (July 1981).

31. University of Rochester.

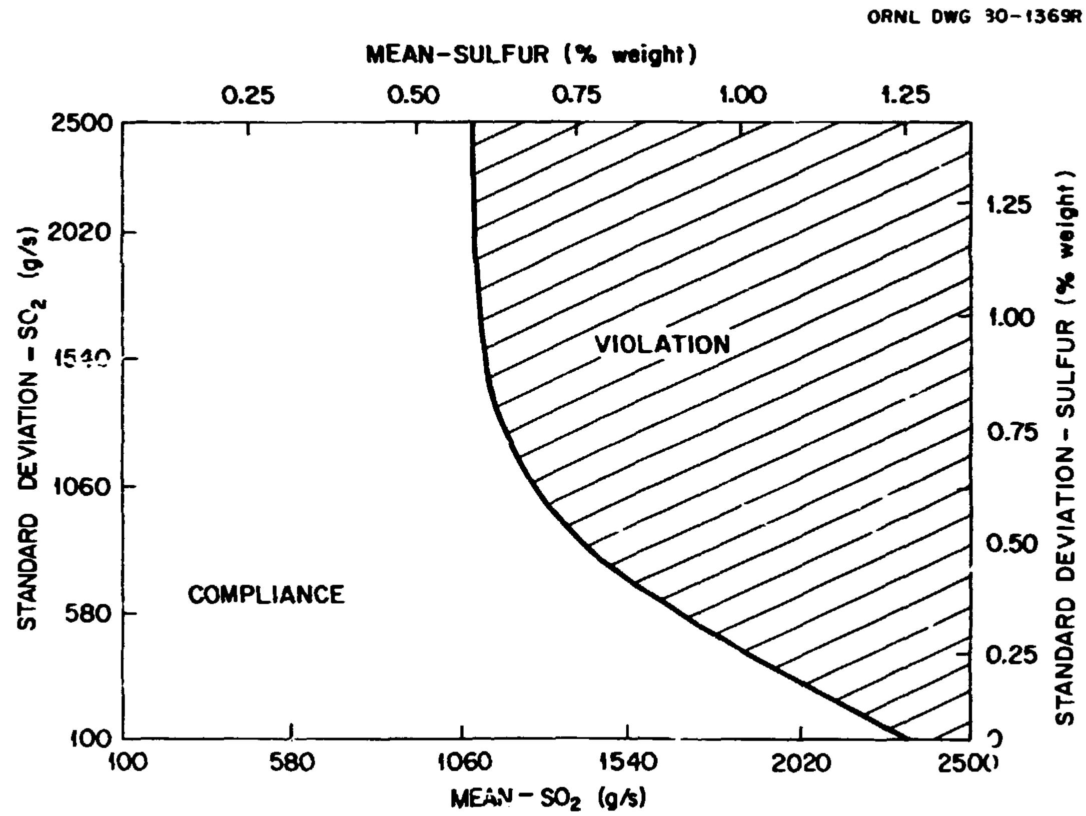

Fig. 2.1. Compliance/violation plot showing values of mean and standard deviation of SO_2 (in grams/second) and sulfur (percentage of weight) satisfying a 10% probability (once in ten years) of violating the 24-h Prevention of Significant Deterioration increment.

other aspects of cooling tower plume behavior. The new version of ORFAD is based on first principles, numerically solving a set of coupled partial differential equations. The modeling effort gives special attention to the microphysical cloud dynamics and to the treatment of turbulence.

A preliminary two-dimensional model is being tested against available data. These tests indicate that the model can quantitatively reproduce observed cooling tower plumes. Figure 2.2 shows contours of constant cloud water (the visible part of the plume) concentration under calm conditions and a strong atmospheric inversion. The plume is seen to travel vertically, penetrating the inversion, then to spread laterally along the inversion. The dashed line on this plot represents the boundary of the visible plume based on field observations. This result shows excellent agreement with observations.

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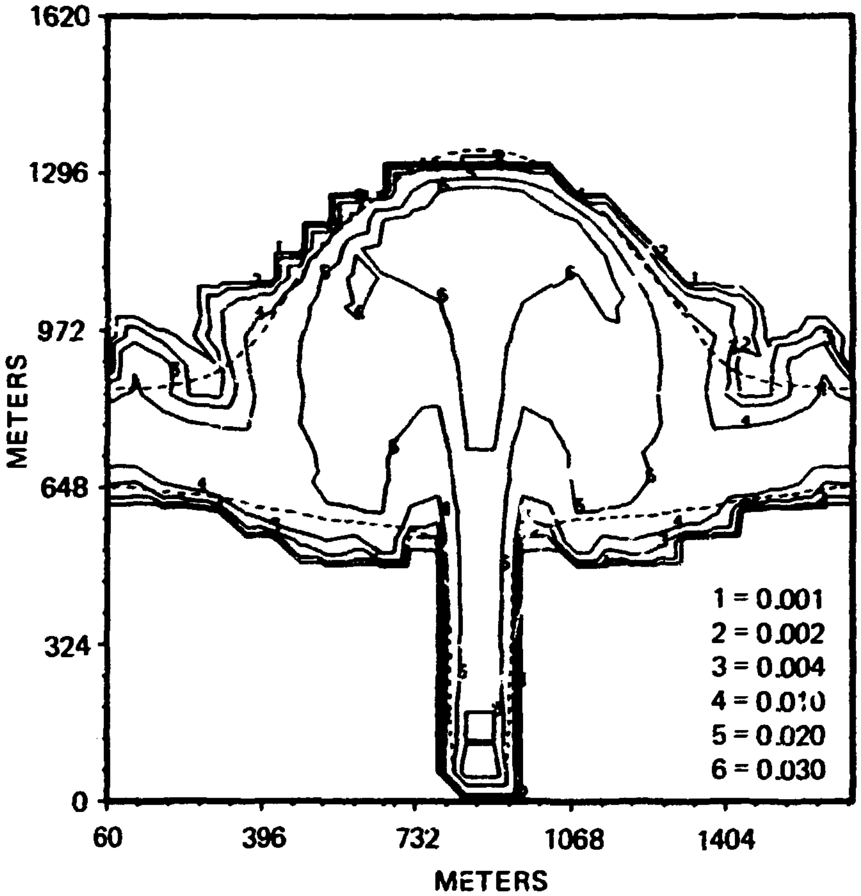

Fig. 2.2. Contours of constant percent cloud water predicted after 1200 s of cooling tower operation. For this case, there is no ambient wind, and a strong atmospheric inversion exists. The cooling tower exit velocity is taken to be 2.5 m/s, and the exit temperature is taken to be 15°C above the ambient temperature.

3. Regional and Urban Studies Section

R. M. Davis

3.1 INTRODUCTION

The principal objective of the Regional and Urban Studies Section (RUS Section) is to analyze the social, resource, transportation, and emergency planning effects of alternative energy policies and technological options. The programs are designed around three related themes: (1) social and resource assessments, (2) emergency planning, and (3) energy-use analysis — primarily for the transportation sector. Social and resource assessments are conducted to analyze the societal impacts of energy technologies and energy resource development. Emergency planning programs develop and assess the feasibility of various options for responding to energy shortages. Our energy use analysis combines analytical and experimental studies to assess the demand and conservation potential for fuels in all modes of transportation.

Toward the end of the fiscal year, several new programs were initiated that are scheduled to expand in the coming fiscal year. For example, (1) a major effort in human factors research was begun for the U.S. Nuclear Regulatory Commission (NRC) to improve the current examination and training of nuclear power plant operators; (2) several tasks were started to increase our energy and civil defense preparedness; (3) a program was initiated to evaluate the civil defense and energy efficiency of underground housing; and (4) an experimental program was established to test the energy efficiency of several classes of highway passenger cars. During FY 1981 the major sources of support for these and other RUS Section programs included the U.S. Department of Energy (DOE), the U.S. Department of the Interior (DOI), the NRC, the Federal Emergency Management Agency (FEMA), and the U.S. Department of Transportation (DOT). The work was carried out by staff members from the section's four groups: (1) Resource Analysis (RA). (2) Social Impacts Analysis (SIA), (3) Emergency Planning (EP), and (4) Transportation Energy (TE), in conjunction with others from the Energy Division, other Laboratory researchers, and subcontractors.

3.2 SOCIAL AND RESOURCE ASSESSMENTS

W. B. Barron	J. E. Dobson[2]	C. H. Petrich
L. G. Berry	A. M. Fullerton	J. H. Reed
R. B. Braid, Jr.[1]	E. L. Hillsman	M. Schweitzer
L. M. Bronfman	R. Lee	E. J. Soderstrom
S. A. Carnes	E. G. Llewellyn	J. H. Sorensen
N. E. Collins	E. Peelle	A. H. Voelker

The RUS Section continued work on several social and resource assessments in FY 1981. In addition, work was completed on an evaluation primer for DOE's Office of Conservation and Renewable Energy (CE).[3] The primer, described in detail in Sect. 5.2.3, is designed to aid program managers in understanding evaluations and provides details on how to conduct an evaluation. This year we also completed work on the Decentralized Solar Energy Technology Assessment (DSETAP), sponsored by DOE/CE. This program, discussed in detail in last year's Annual Report,[4] analyzed the energy planning effects of several local communities under different levels of government support and involvement. Several other assessments currently under way are discussed below.

3.2.1 Siting of Nuclear Waste Repositories

An investigation of the role of incentives in nuclear waste repository siting was conducted for the Office of Nuclear Waste Isolation in FY 1981.[5] While various people had previously mentioned the possible use of incentives, this systematic study classified incentives according to functional categories (mitigation, compensation, and reward), outlined conditions which would be prerequisites to the use of incentives (guarantee of public health and safety, some measure of local control, and official authorization of negotiations as a decision-making tool during siting), and developed criteria for evaluating diverse incentive systems. Figure 3.1 presents a simplified version of the criteria-based framework that was developed for evaluating the usefulness of incentive systems. Table 3.1 defines various types of incentives, identifies a range of options within each type, and provides examples of mechanisms that might be used for implementing the incentive.

It was found that incentive packages, as opposed to single incentives, may be useful in developing support and decreasing opposition to high-level-waste repositories in potential host communities. Secondly, it was found that nonmonetary incentives, such as independent monitoring and access to credible information, may be as important in eliciting support as monetary incentives, such as direct payments to the community. In addition, without careful attention to prerequisites, it is not likely that incentives will facilitate the siting process.

1. Leader, Social Impacts Analysis group.
2. Leader, Resource Analysis group.
3. E. J. Soderstrom, L. G. Berry, E. Hirst, and B. H. Bronfman, *Evaluation of Conservation Programs: A Primer*, ORNL/CON-76 (July 1981).
4. W. Fulkerson et al., *Energy Division Annual Progress Report for Period Ending September 30, 1980*, ORNL-5740 (November 1981).
5. S. A. Carnes et al., *Incentives and the Siting of Radioactive Waste Facilities*, Office of Nuclear Waste Isolation, Columbus, Ohio, 1981.

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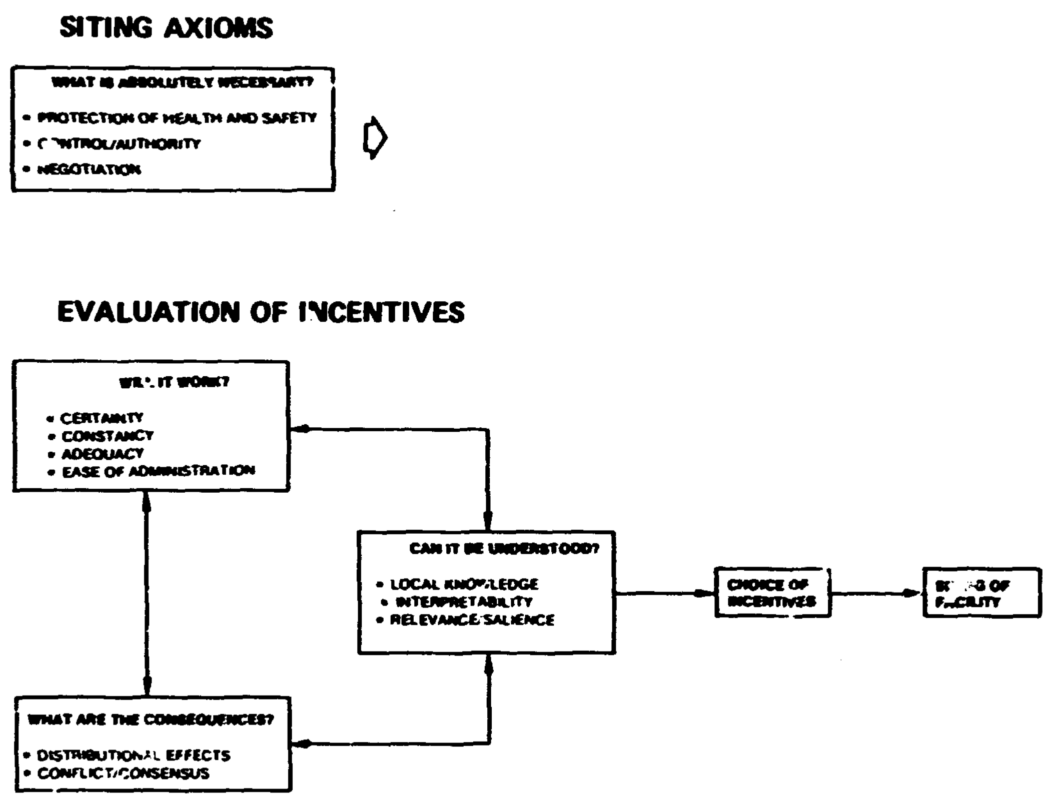

Fig. 3.1. A framework for evaluating incentives for high-level-waste repository siting.

Table 3.1. Incentives classification system

Incentive type	Brief definitions	Range of possible strategies	Example of corresponding implementation mechanisms
Mitigation	Actions geared toward preventing, reducing, or eliminating adverse impacts before they occur	Buffers/land use management	Purchase of easements
		Monitoring/detection	Dosimeter program
		Emergency preparedness	Contingency plans
		Safety design	Establishment of acceptable risk levels
		Public education	Distribution of information brochures
		Socioeconomic impact mitigation	Job-training programs
		Land value guarantees	Property dedication program
Compensation	Payments for actual damages in the event of an accident or an anomalous event	Trust funds	Excise taxes on wastes
		Insurance programs	Government-backed policies
		Assumption of liability	Contracts with local governments
Rewards	Actions designed to award benefits to communities assuming risks for facilities that provide public benefit	Direct monetary payments	Payments-in-lieu-of-taxes (PILOTS)
		Bonus community services	Programs such as the Comphrehensive Employment Training Act (CETA)
		Tax incentives	Elimination of sales taxes
		Subsidies (advance)	Reduced interest rates
		Infrastructure development	Public works projects
		Linking	Federal appropriations
		Avoidance of other hazardous facilities	Presidential order

3.2.2 Socioeconomic Impacts of Synthetic Fuel Plants

Late in FY 1981 the SIA group concluded its lengthy involvement for DOE's Office of Fossil Energy (DOE/FE) in writing the environmental impact statements (EISs) for five synthetic fuel-coal-conversion demonstration plants. This program, described in more detail in Sect. 2.4.2, identified the potential impacts at the Solvent Refined Coal-I (SRC-I) plant in Newman, Kentucky, and the SRC-II facility in Morgantown, West Virginia. The EIS prepared for the SRC-I facility identified important cumulative impacts. The potential cumulative impacts in the SRC-I area from a total of four synfuel plants and seven coal-fired power plants were deemed so substantial as to potentially create a boomtown situation in a nonisolated area, normally a highly unlikely event in the East. The impact of the SRC-I project is represented in Fig. 3.2 with the relative population impacts of the project being greatest in 1982 and 1989, the peak years of construction for the demonstration and commericalization phases, respectively. Potentially severe highway impacts around the SRC-I site warranted special treatment in the EIS and resulted in the development of a detailed, multistep mitigation plan. Socioeconomic impacts projected in the analysis received considerable attention from the news media and interested groups.

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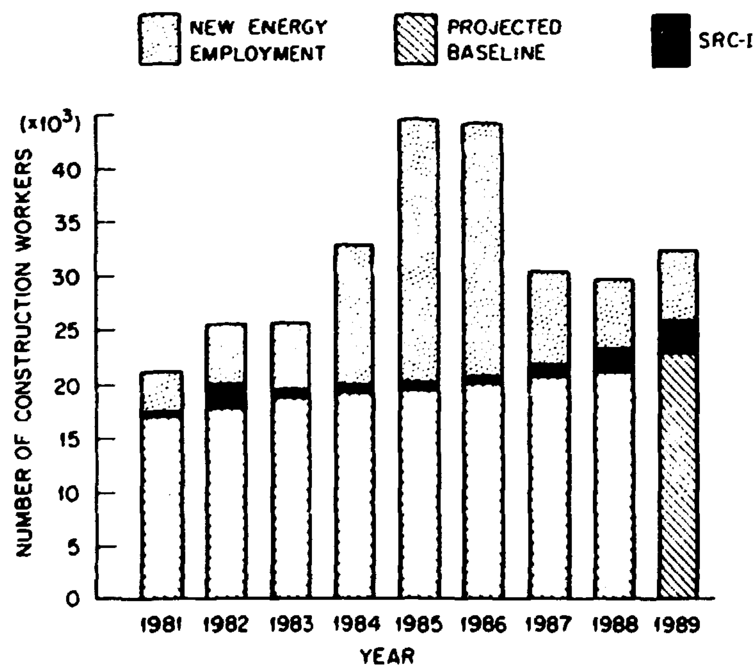

Fig. 3.2. Estimated cumulative labor demand for the SRC-I region. Labor demand is based on the forecasted construction schedule for four synfuel plants and seven coal-fired power plants added to the projected baseline construction in the region.

3.2.3 Regional Coal Production Goals and Data Bases

In cooperation with the Los Alamos National Laboratory (LANL), ORNL continued work on a study supported by DOE/FE to improve the methods and data used in developing regional coal production goals. DOE has used a linear programming model to simulate the functioning of regional coal markets. The ORNL/LANL study examined each major component of such a modeling system to determine needed improvements in the input data and model structure. The project staff reviewed the most recent data available on coal reserve estimates, transportation costs, and demands. Information was updated as needed (e.g., for transport costs), and variations in existing estimates were documented (e.g., coal reserve data and coal demand projections). These studies underscored the uncertainty associated with available data for a number of key data bases. Extensive sensitivity analysis is required to determine the implications of this uncertainty on the credibility of linear programming models to project regional coal production levels. Existing models do not permit the ready substitution of data sets needed for such extensive sensitivity analyses. To address this need, the project staff developed the Regional Coal Allocation model (RCA model). The RCA model is created from components of existing models but incorporates a much higher degree of user orientation to modify data inputs. The RCA model is being used to evaluate the implications of variability in input data assumptions (e.g., the level of coal reserves existing in a given region) on the model's projections of relative demand for coal from that region.

In a related ongoing study sponsored by the Energy Information Administration, ORNL is collaborating with the Synergic Resources Corporation to provide the first detailed documentation of the methods and data sources used to derive the Demonstrated Reserve Base (DRB) of coal in the United States. The DRB is an estimate of the potentially minable coal in each state. The study found that the methods and data sources varied considerably from state to state. Comparisons of the DRB with other related estimates revealed considerable differences (Table 3.2). Nevertheless, the estimates provide important information on the geographical distribution of coal energy resources (Fig. 3.3), and the range in estimates provides a measure of their precision.

3.2.4 Wilderness Area Energy Resource Evaluation

Work continued for DOE/FE to evaluate the potential energy resources on areas being considered for possible designation as Wilderness Study Areas by the Bureau of Land Management (BLM). With major assistance from Science Applications, Inc., we completed a report assessing the overall energy resource availability impact of withdrawing the proposed BLM Wilderness Study Areas in the lower 48 states from mineral leasing.[6] The report concludes that the potential collective contribution of these areas would be small — a slight percentage of the national resource base for most minerals. However, local impacts in areas having high coincidence of Wilderness Study Areas and a high resource potential could be important. We identified several areas as having a high conflict potential (Fig. 3.4) and selected BLM districts for evaluation on the basis of these areas.

The report also examined the availability of federal land for mineral exploration and extraction. The current level of formally and highly restricted land was found to be 40% or less of the total public federal land, with another 5% estimated to be affected by administrative restrictions of various types. These percentages are significantly lower than a recent industry estimate of 75% and

Table 3.2. Comparison of coal demonstrated reserve base estimates, by state (10^6 tons)[a] as listed by six different sources[b]

Anthracite excluded

State	Estimates, by source[b]					
	1979 DRB	1974 DRB	RAMC	Keystone	ICF, Inc.	NCRDS
Alabama	6,760	1,955	1,705		2,872	1,978
Alaska	6,156	11,645	2,386	7,000[c]	5,000	7,028
Arizona	424	350	350	387[d]	800	8,116
Arkansas	315	666	595	1,803	661	430
Colorado	16,190	14,869	5,585	16,300	14,863	16,122
Georgia	4	1	0		0	1
Idaho	4	0	0	0	0	5
Illinois	67,705	65,665	34,400	161,818[e]	143,188	60,643
Indiana	10,621	10,623	7,588	17,458	10,633	13,798
Iowa	2,199	2,885	1,796	3,501[f]	2,892	2,883
Kansas	995	1,388	529	997	1,386	1,075
Kentucky	34,240	25,541	15,337	72,074[g]	25,830	38,971
Louisiana	0	0	0	1,100	0	0
Maryland	826	1,048	915	1,230	1,043	312
Michigan	128	118	0	0	0	96
Missouri	6,077	9,487	3,677		3,808	7,743
Montana	120,469	108,396	102,384	291,639[h]	108,167	169,773
New Mexico	4,539	4,395	4,367	6,504[i]	4,388	3,884
North Carolina	11	32	0	0	0	20
North Dakota	9,971	16,003	12,676	16,003	16,099	59,638
Ohio	19,035	21,077	17,756	20,451	21,007	22,030
Oklahoma	1,644	1,294	835	7,216[j]	1,296	1,339
Oregon	18	2	0	0	0	25
Pennsylvania	23,332	16,759	21,273	34,000[k]	31,088	12,703
South Dakota	336	428	200	0	408	1,856
Tennessee	998	987	753		987	1,035
Texas	12,694	3,272	7,000	12,984	8,174	3,272
Utah	6,502	4,043	3,557	24,300[l]	4,047	5,045
Virginia	3,412	3,376	2,899		3,657	4,630
Washington	1,580	1,954	609	6,179	68[illegible]	1,670
West Virginia	39,985	39,590	27,128	38,000	40,944	11,574
Wyoming	70,014	53,336	48,988	55,952	89,514	45,899
Total[m]	467,211	421,182[n]	323,958	796,896	543,434	503,594

[a]Short tons are units of measurement used by the coal industry and all coal statistics sources. For conversion to metric tons, multiply by 0.90718.

[b]Sources:

1. 1979 DRB—Energy Information Administration, Department of Energy, Table 2 in *Demonstration Reserve Base of Coal in the United States on January 1, 1979*, DOE/EIA-0280(79), U.S. Government Printing Office, Washington, D.C., 1981.
2. 1974 DRB—Robert D. Thomson and Harold F. York, Table 1 in *The Reserve Base of U.S. Coals by Sulfur Content—Part 1, The Eastern States*, BM-IC-8680, U.S. Bureau of Mines, 1975; and Patrick A. Hamilton, D. H. White, Jr., and Thomas K. Matson, Table 1 in *The Reserve Base of U.S. Coals by Sulfur Content—Part 2, The Western States*, BM-IC-8693, U.S. Bureau of Mines, 1975.
3. RAMC—Complied from Resource Allocation and Mine Costing input data file provided July 1981 by Ramesh Dandekar, Coal Division, Energy Information Administration, Department of Energy.
4. Keystone—State geological survey reports, various pages in the *1980 Keystone Coal Industry Manual*, McGraw-Hill, New York; may include anthracite.

5. ICF, Inc.—ICF, Inc., Table 3.8 in *Coal and Electric Utilities Model Documentation*, draft, Washington, D.C., 1980.
6. NCRDS—Calculated from the ECOAL and WCOAL data files of the National Coal Resources Data System, U.S. Geological Survey, Branch of Coal Resources, 1981; reserve estimates are as of the dates of the individual source documents.

[c]Text suggests that this is an underestimate.
[d]Text suggests that this is an underestimate.
[e]Illinois uses a different resource classification system.
[f]Text suggests that this is an overestimate.
[g]Text suggests that this is an overestimate.
[h]Tonnage is for "identified" resources (of which the demonstrated reserve base is a subset).
[i]Estimate is for only surface resources in the San Juan Basin.
[j]Includes total resources.
[k]Tonnage is for "recoverable reserves" over 71 cm (28 in.) thick.
[l]Includes "inferred" reserves.
[m]Data may not add to totals shown due to rounding. No entry in the table indicates that no estimate is available.
[n]Includes 126×10^6 tons of western anthracite.

somewhat higher than the 30% quoted by environmental interests.[6] Our estimate is expected to be reduced by 15% as review processes, set in motion by past legislation, are completed in the next few years.

We also have assisted the BLM staff in more detailed evaluations for specific districts using the resource evaluation methodologies developed earlier in this program. In FY 1981 we completed our evaluation of the Coeur d'Alene District in Idaho,[7] and technical conclusions for the Cedar City District in Utah were transferred to the BLM staff of that district.[8]

3.3 EMERGENCY PLANNING

M. V. Adler	G. A. Cristy	G. E. Kamp
M. Baker	K. S. Gant	J. M. Schreyer
D. J. Bjornstad	C. M. Haaland	H. B. Shapira
F. D. Boercker	E. L. Hillsman	R. N. Thurmer
C. V. Chester[9]		

Emergency planning includes work directed at coping with a variety of energy-related emergencies. Included is DOE work on radiological emergencies for the Division of Radiological Controls, emergency alternative energy supplies for the Division of Biomass Technology, and technical assistance to the Office of Energy Emergencies. Work on measures to survive nuclear war is done for FEMA.

6. E. H. Oakes and A. H. Voelker, *Bureau of Land Management's Wilderness Review Program and the Future Availability of Energy Resources: An Overview* (in review; to be published as an ORNL/TM report).

7. E. H. Oakes et al., *The Department of Energy's Energy-Resource Evaluation of Wilderness Study Areas Administered by the Bureau of Land Management, the Coeur d'Alene District, Idaho*, draft report, Science Applications, Inc., May 29, 1981.

8. E. H. Oakes et al., *The Department of Energy's Energy-Resource Evaluation of Wilderness Study Areas Administered by the Bureau of Land Management, the Cedar City District, Utah*, draft report, Science Applications, Inc., Apr. 20, 1981.

9. Leader, Emergency Planning group.

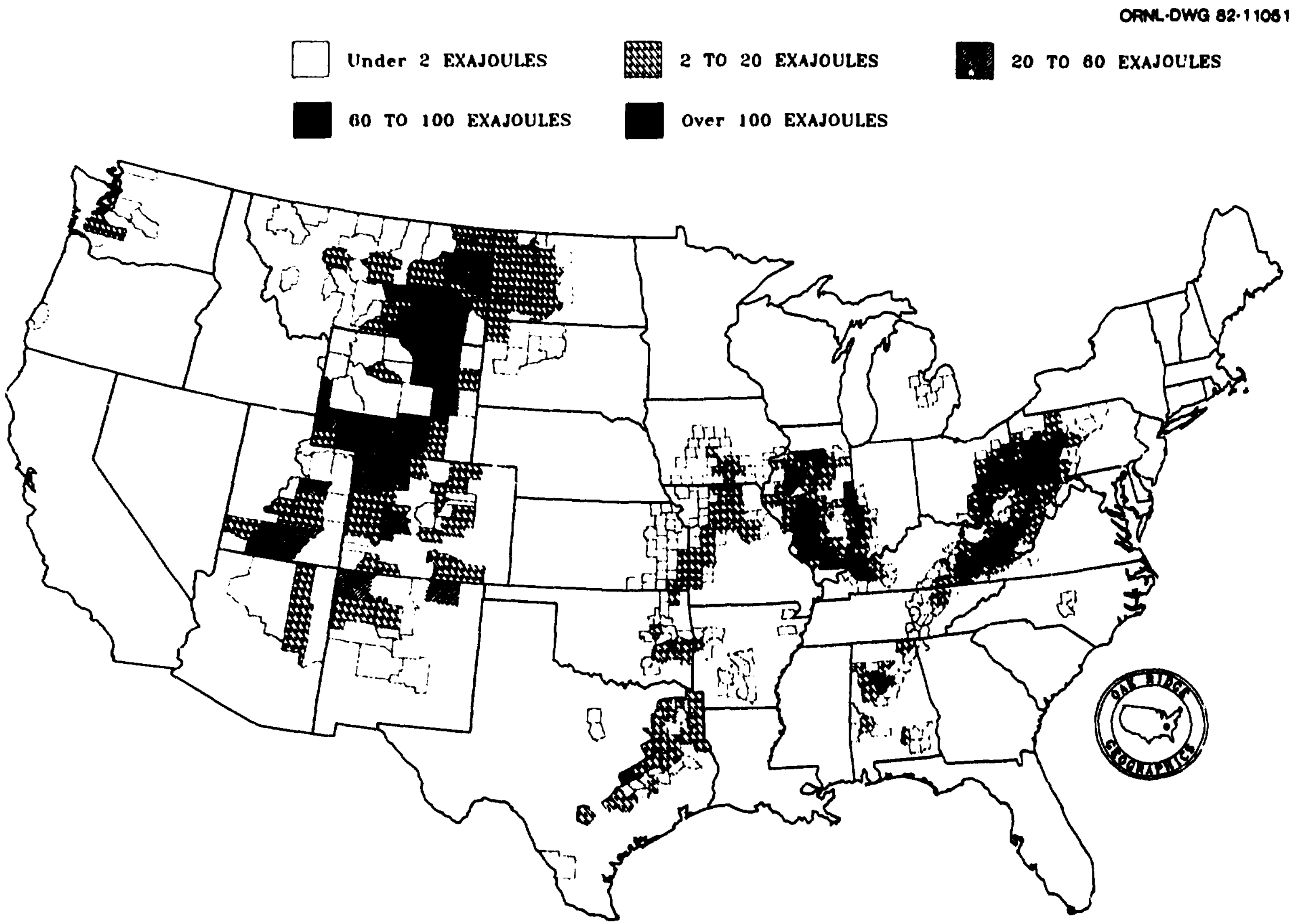

Fig. 3.3. Coal resources in the 1979 DRB.

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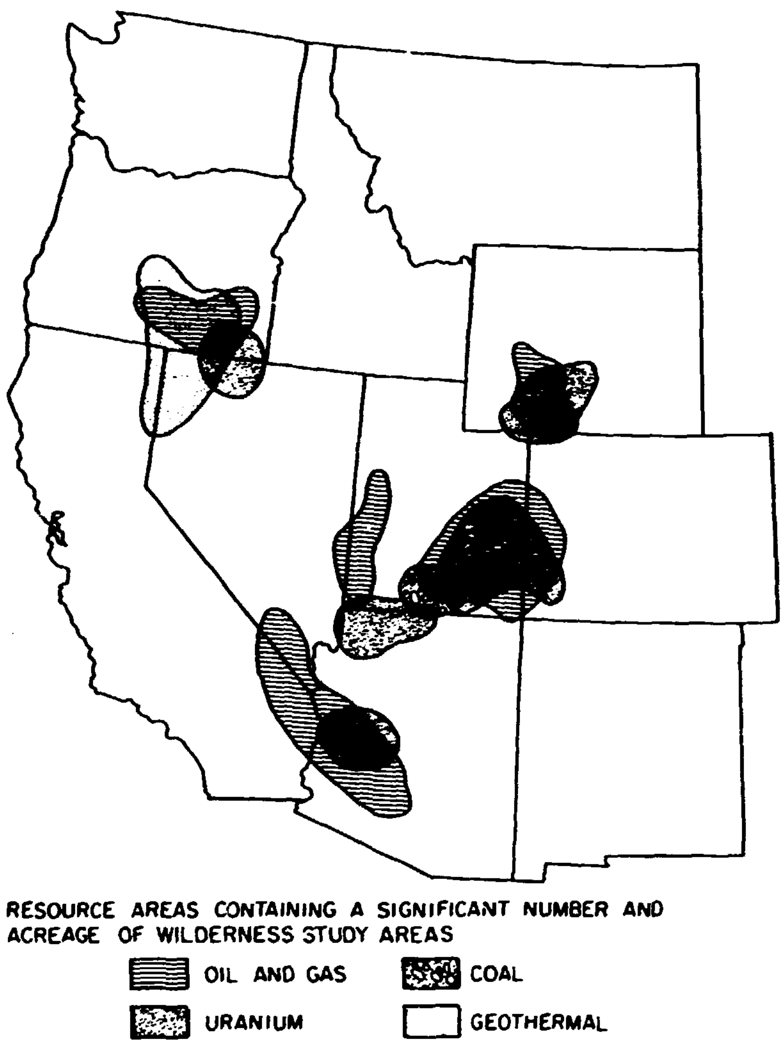


Fig. 3.4. Regions recommended to the BLM for accelerated Wilderness Study Areas suitability studies based on the coincidence of Wilderness Study Areas and areas of important energy-resource potential.

3.3.1 Radiological Assessment and Planning

FEMA's recent radiological emergency planning regulations assigned the role of coordinating offsite radiological monitoring and assessment activities to DOE. The Emergency Planning Group assisted DOE in developing a Federal Radiological Monitoring and Assessment Plan (FRMAP) to replace the old Interagency Radiological Assistance Plan, adopted in 1961. The plan under development consists of a generic radiological assistance plan with annexes containing additional information for specific types of incidents. The annex dealing with commercial nuclear power plant incidents is currently being reviewed by the participating agencies. In a related task sponsored by the NRC, we analyzed the proposed changes in the criteria for siting commercial nuclear power plants that would restrict the population density and distribution — and thus the population at risk -- within 48 km (30 miles) of the proposed plant site.[10]

In addition, three new handbooks are being developed for FEMA on radiological defense for the U.S. population in the event of nuclear war. The first handbook to be prepared deals with radiation safety for the millions of people who may have to remain in shelters for days, possibly weeks, after a nuclear attack — until the radioactivity from nuclear fallout decays to less hazardous levels.[11] This handbook has been published and distributed to health physicists. Two additional handbooks are concurrently being developed. One deals with radiation safety for those people who must leave shelter to perform emergency work while the radiation levels from fallout remain hazardous. The second describes a monitoring and reporting system for fallout. In preparation for writing the latter two handbooks, a method by radiological defense officers has been developed to solve the problem of forecasting radiation levels and accumulated exposure to radiation resulting from superimposed fallout from many nonsimultaneous, upwind groundbursts.[12]

3.3.2 On-Farm Applications of Solar Process Heat

DOE has continued to support a research program by the Science and Education Administration–Federal Research of the U.S. Department of Agriculture to develop on-farm process applications of solar heat.[13] The Emergency Planning Group's technical monitoring assistance to DOE in this area continued in FY 1981.

The solar systems designed and developed were directed toward providing farmers and food processors with information that could reduce U.S. consumption of conventional fuels. Techniques that were shown to be effective include solar collectors integrated into farm buildings, solar pasteurization of fluid foods (Fig. 3.5), hops drying by use of solar and biomass energy, solar-heated brooder houses, and a multilayer, thermal blanket for energy conservation in greenhouses. While the capital costs of the collector system for the solar pasteurization of foods will probably never be competitive with other methods of providing the heat, developing the control system to maintain product quality despite varying solar intensity was a major technical accomplishment.

3.3.3 On-Farm Applications of Biomass

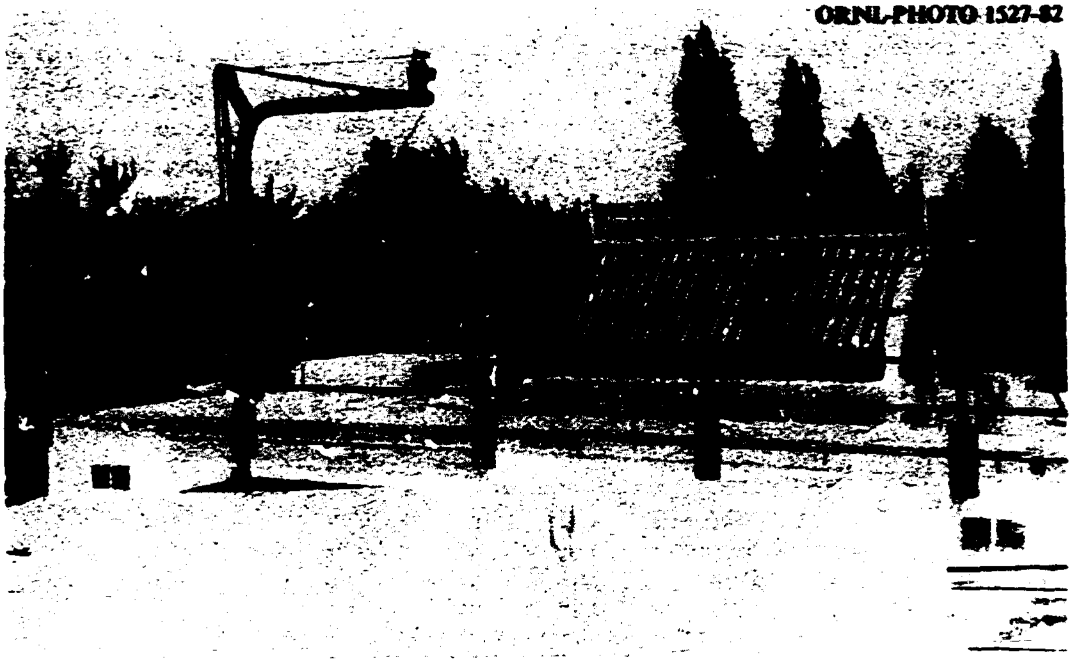
Biomass fuels are particularly attractive for on-farm use because of the proximity of feedstocks and because of the potential for agricultural self-sufficiency in times of fuel shortages or price increases. Research funded by DOE's Office of Emergency Contingency Planning during FY 1981 focused on studying the cost effectiveness of alternative biomass fuels relative to centrally delivered fuels in the agricultural sector and evaluating the availability of feedstocks to meet agricultural

10. K. S. Gant and M. Schweitzer, *Protective Actions as a Factor in Power Reactor Siting* (to be published as an ORNL report).

11. C. M. Haaland, *A Proposed New Handbook for the Federal Emergency Management Agency: Radiation Safety in Shelters*, ORNL-5766 (September 1981).

12. C. M. Haaland, "Forecasting Radiation Exposure from Fallout from Multiple Nonsimultaneous Upwind Groundbursts" (to be submitted to *Health Physics*).

13. L. B. Altman et al., "Agricultural Solar Research Programs   An Overview and Highlights" (submitted to *Transactions of the ASAE*, May 1981).



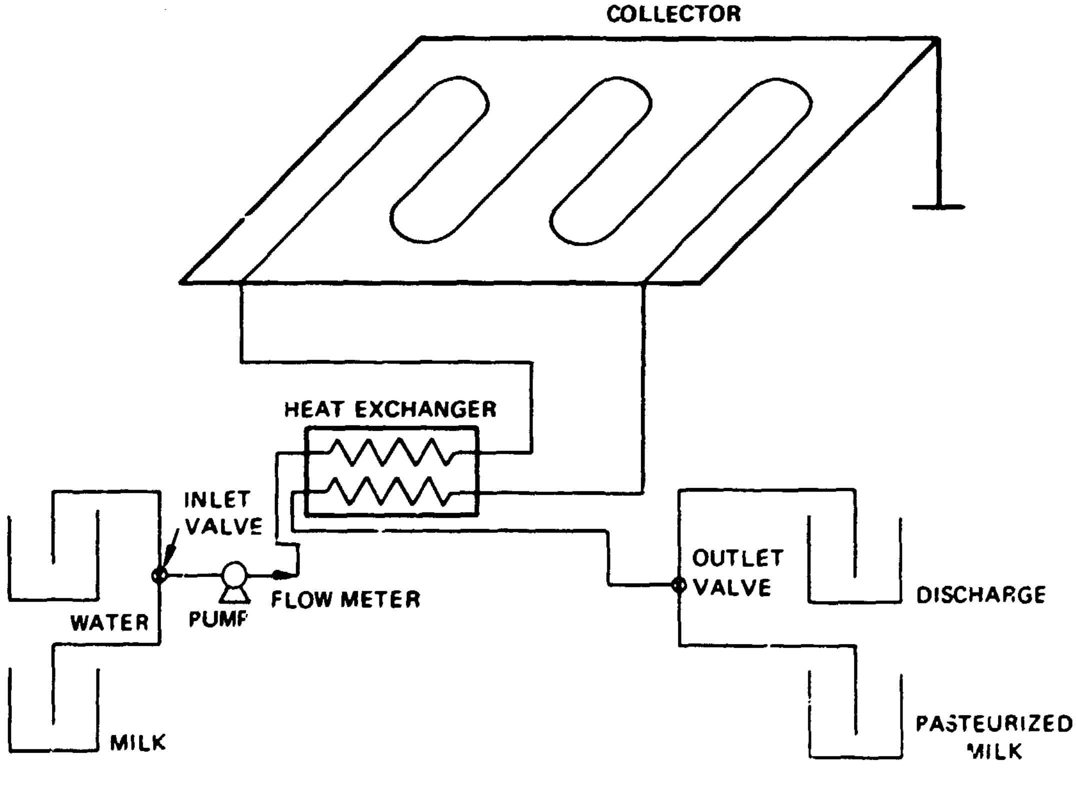


Fig. 3.5. Washington State University solar milk-pasteurizing unit.

energy needs.[14] The results indicate that at present only the direct combustion of such fuels as wood, crop residues, and animal residues is cost competitive with central fuels. But vegetable oils may soon become cost competitive with diesel oils. Table 3.3 illustrates this by presenting the ratio of biomass fuel cost to diesel oil price for solvent-extracted vegetable oils. Two elements will be crucial in determining cost competitiveness: (1) the price of centrally delivered diesel oil and (2) the market value of oil-seed meal by-products, some of which are not currently marketed. It appears that for the nation as a whole, adequate feedstocks are available. However, individual regions might need to adjust cropping practices if extensive transport of fuels is to be avoided.

Table 3.3. Ratio of biomass fuel costs to diesel oil price by feedstock and year

Feedstock	1980	1985	1990
Sunflowers	1.42	1.22	0.97
Soybeans	1.31	1.09	0.87
Peanuts	3.77	3.27	2.61
Corn	1.59	1.29	1.02

Source: D. J. Bjornstad et al., *The On-Farm Use of Biomass Fuels: Market Penetration Potential in a Fuel Emergency*, draft ORNL/TM report.

3.4 TRANSPORTATION ENERGY USE TRENDS

D. L. Greene[15] M. L. Johnson G. F. Roberts
M. C. Holcomb G. Kulp A. B. Rose
J. N. Hooker B. E. Peterson

3.4.1 Transportation Energy Use Analysis

In support of a project for the DOE Office of Policy, Planning, and Evaluation, the TE group made use of the ORNL Highway Gasoline Demand Model and time-series analysis to examine recent trends in transportation energy use. Declines in energy use in 1973-1974 and again in 1979-1980 (Fig. 3.6) were largely the result of short-run responses to higher fuel prices. Recessionary periods reinforced the short-run price effect. Together, these factors accounted for two-thirds to three-quarters of the decline in energy use in each episode.

Short-run responses primarily consist of reductions in transportation activity and of operational changes to increase system energy efficiency, such as higher load factors or greater use of more efficient equipment. Declines in energy use resulting from technical efficiency improvements were less significant. Although growing rapidly now, technological improvements in the fuel economy of new

14. D. J. Bjornstad et al., *The On-Farm Use of Biomass Fuels: Market Penetration Potential in a Fuel Emergency*, draft ORNL/TM report.

15. Leader, Transportation Energy group.

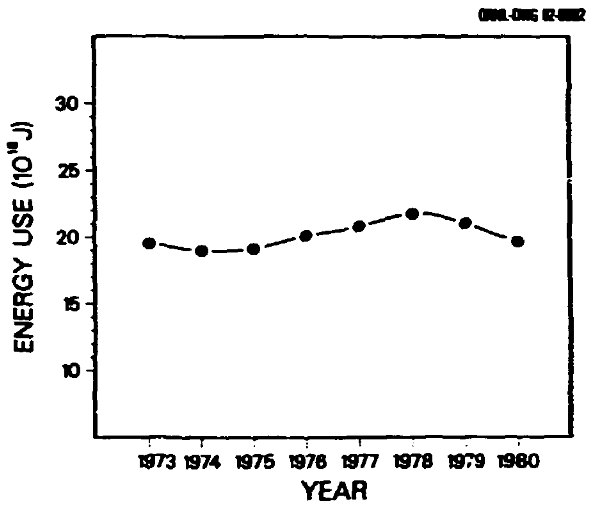


Fig. 3.6. Transportation energy use, 1973–1980. Source: D. L. Greene et al., *Transportation Energy Use 1973–1980: Trends, Changes, and Causes* (in preparation as ORNL/TM-7953).

cars and light trucks in 1980 probably accounted for only 25% of the decline in highway gasoline use between 1979 and 1980 (Table 3.4). Increased use of more efficient wide-body jets accounted for some of the decline in aircraft energy intensity between 1973 and 1980. Data for other modes indicated little or no technological improvement in stock fuel efficiency, partly because of lesser incentives and slower capital stock turnover rates. In addition, freight modes appear to be less price responsive in the short run, their demand being driven primarily by economic activity. Highway diesel fuel demand, for example, indicated a short-run price elasticity of −0.1, about one-half that of gasoline. In the case of rail freight, a simple time-series model was calibrated in which gross national product (GNP) was used to forecast revenue ton-miles. The model produced a constant elasticity estimate for GNP of 0.6, indicating that rail freight activity is highly responsive to changes in GNP.

Table 3.4. Estimates of sources of recent declines in gasoline consumption

	Percentage decrease		Percentage of forecasted decrease	
	1978–1979	1979–1980	1978–1979	
Price	−4.3	−4.3	61	55
Household income	−0.7	−1.4	10	18
Fuel economy	−0.8	−1.9	12	24
Diesel penetration	−0.2	−0.2	3	3
Shortage	−1.0	0.0	14	
Other (includes increase in households)	+2.2	+2.5		
Total estimated by model	−3.7	−5.2		
Total actual	−3.7	−4.8[a]	100	100

[a]The estimated decline is based on motor gasoline sales through September 1980.

3.4.2 ORNL Highway Gasoline Demand Modeling[16]

Over the past four years, ORNL has done considerable research in analyzing and modeling gasoline demand for DOE. We analyzed the determinants of differing regional patterns of demand,[17] constructed a state-level forecasting model for DOE's Energy Information Administration,[18] developed and exercised a system for setting emergency gasoline conservation targets under the Emergency Energy Conservation Act,[19] estimated individual, monthly gasoline use forecasting models for all 50 states,[20] and, most recently, analyzed the causes of recent declines in gasoline use in the United States.[16] In a recent study for DOE, ORNL used its mid-range gasoline demand model to dissect the 1979–1980 decline in U.S. gasoline use and determine the relative importance (to consumption reduction) of automobile fuel economy improvements, dieselization, and reduced travel. Actual historical data on prices, income demographics, new-car-and-truck fuel economies, and discrepancies between in-use and EPA-measured miles per gallon were input to the model.

In 1978, 425 × 10^9 L of gasoline were consumed on U.S. highways. This dropped to 409 × 10^9 L in 1979 and to 383 × 10^9 L in 1980, the first consecutive two-year decline in highway gasoline use since 1942–1943 and the first in peacetime since the Great Depression years 1932–1933. Our analysis indicates that well over half of this decline is attributable to a short-run response (primarily from reduced travel) to the more-than-50% increase in constant-dollar fuel prices in those two years (Table 3.4). New-car fuel economy improvements were the second largest factor, accounting for one-eighth and one-fourth of the 1979 and 1980 declines, respectively.[16] Reduced real household incomes were slightly less important and dieselization of automobiles and light trucks accounted for less than 5% of each year's decline. The much-publicized fuel shortages of the summer of 1979 reduced total consumption by only an estimated 1% — about 15% of the total demand reduction (Fig. 3.7).

The impact of fuel economy improvements roughly doubled from 1979 to 1980.[16] The incremental effects of new-car fuel efficiency improvements will continue to grow, at least through 1985, in accordance with the Corporate Average Fuel Economy standards mandated by law. Because of these improvements, it is likely that highway gasoline demand will continue to decline through the mid-1980s even in the presence of lower real fuel prices and economic and population growth.

3.4.3 Highway Diesel Fuel Demand Modeling

ORNL neared its goal of developing a comprehensive set of state of the art energy demand forecasting models for each transportation mode with the completion of air-passenger energy use

16. D. L. Greene and G. Kulp, "An Analysis of the 1978–80 Decline in Gasoline Consumption in the United States" (accepted for publication in *Energy*).

17. D. L. Greene, "State Differences in the Demand for Gasoline: An Econometric Analysis," *Energy Sys. Policy* 3(2): 191–212 (1978).

18. D. L. Greene, "A State-Level Stock System Model of Gasoline Demand," *Trans. Res. Rec.* **801**: 44–50 (1981).

19. D. L. Greene and G. H. Walton, "Data and Methodological Problems in Establishing State Gasoline Conservation Targets," *Trans. Res. Rec.* **815**: 24–30 (1981).

20. D. L. Greene and C. K. Chen, "A Time-Series Analysis of State Gasoline Demand, 1975–1980" (to be published).

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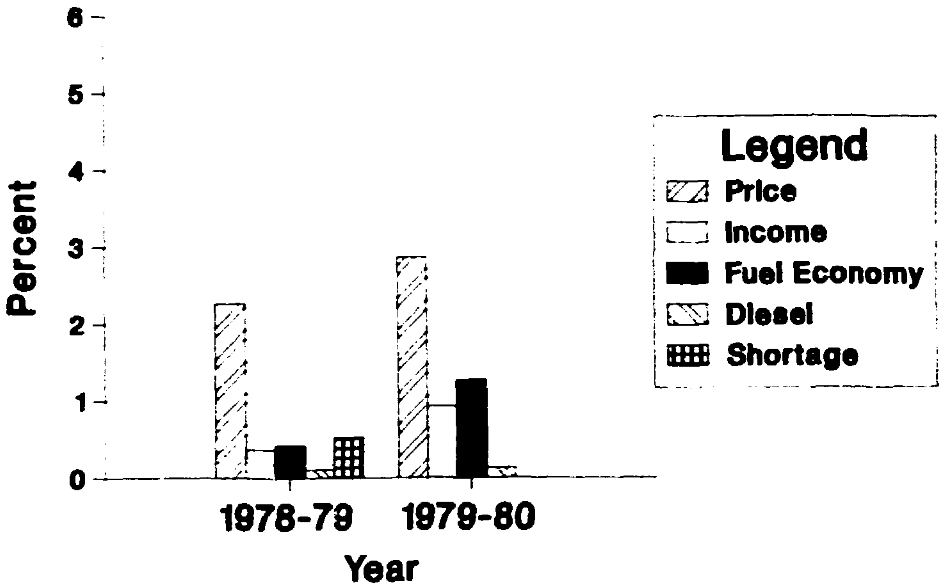

Fig. 3.7. Estimates of sources of recent declines in gasoline consumption.

and heavy-truck, diesel fuel demand models.[21] The highway diesel fuel model is based on the economic theory of production and views heavy trucks and the fuel used to propel them as inputs to the production process of the economy. A significant problem that has hindered the development of highway diesel fuel demand models in the past is the general dearth of data on heavy-truck stocks. This problem was successfully overcome by estimating a simple logistic scrappage model for a known subset of the heavy-truck fleet and estimating stock by applying the model to historical sales and truck-price data. In this way, both total and heavy-truck, diesel stock estimates were created which replicate, with remarkable accuracy, truck stock age distributions based on national survey data (Fig. 3.8). Estimation of a new heavy-truck demand equation indicated elastic demand with respect to GNP but inelastic response to truck prices. Heavy-truck demand was found to be highly sensitive to short-term GNP trends, as is evident in the recessionary periods of 1975 and 1980 (Fig. 3.9). Diesel fuel demand was found to be most responsive to economic growth and considerably less sensitive to the number of diesel trucks. Short-run price elasticity was found to be quite small, even less than that of gasoline. This is hardly surprising in view of the fact that diesel fuel use continued to increase in 1979 and 1980 despite unprecedented price increases.

3.4.4 Vehicle Testing

The TE group carried out a vehicle-testing program in support of DOE's Driver Energy Conservation Awareness Training program. The aim was to investigate the effect of driver behavior on fuel economy and particularly to determine optimal control for minimum fuel consumption.

21. D. L. Greene, "A Derived Demand Model of Regional Highway Diesel Fuel Use" (to be published).

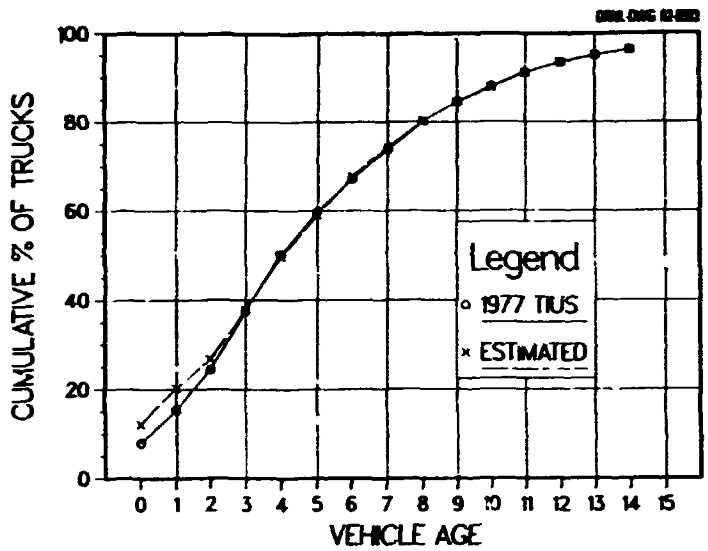

Fig. 3.8. Age distribution of diesel heavy trucks estimated using the ORNL scrappage model as compared with the 1977 truck inventory and use survey (TIUS).

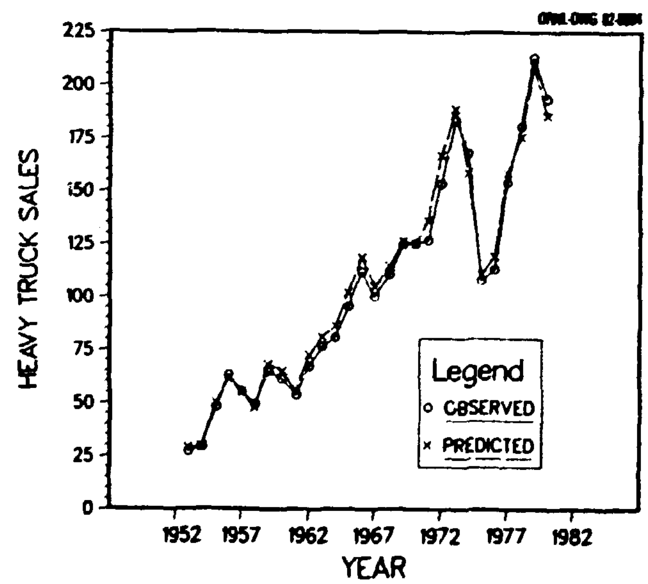

Fig. 3.9. Observed and predicted heavy-truck sales.

One phase of the investigation determined that, in two 1979 model automobiles, one cannot save fuel by closing the windows and turning on the air conditioner, contrary to previous claims (Table 3.5).[22] The second and most substantial phase involved developing maps of on-road fuel consumption versus speed and acceleration,[23,24] like that in Fig. 3.10. These maps were the basis for a very fast and accurate vehicle simulator. For the third phase of the project, the simulator provided the objective function in dynamic programming routines that calculated optimal control of a Ford Fairmont for fuel economy.[25] The most fuel-efficient way to drive was computed for accelerating to cruising speed (Fig. 3.11), driving a block with a stop sign at either end, and driving over various hills. Optimal driving over rolling hills of 6% grade, for instance, requires 12% less fuel than driving at constant speed without loss of time.

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22. G. F Roberts and A. B. Rose, "Detecting Small Differences in Fuel Economy: Air Conditioning vs. Open Windows," to be presented at 1982 SAE International Congress and Exposition, Detroit, Mich., Feb. 22–26, 1982, and to be published in *SAE Technical Paper Series*.

23. J. N. Hooker, A. B. Rose, and G. F. Roberts, "A Holistic Approach to Vehicle Simulation" (to be submitted for journal publication).

24. A. B. Rose et al., "A Data-Based Simulator for Predicting Vehicle Fuel Consumption," to be presented at 1982 SAE International Congress and Exposition, Detroit, Mich., Feb. 22–26, 1982.

25. J. N. Hooker, A. B. Rose, and G. F. Roberts, "Optimal Control of Vehicles for Fuel Economy" (submitted to *Transportation Science*).

Table 3.5. Contribution of open windows and air conditioning to fuel economy, based on an ordinary least-squares regression

	Test condition	Predicted fuel economy (km/L)	95% confidence interval (km/L)
Chevette	Control[a]	13.89	±0.071
	Driving opposite direction	−0.19	±0.063
	Windows open	−0.01	±0.089
	A/C, normal setting	−0.29	±0.089
	A/C, maximum setting	−0.44	±0.089
Fairmont	Control[a]	11.03	±0.048
	Driving opposite direction	−1.13	±0.043
	Windows open	+0.04	±0.060
	A/C, normal setting	−0.43	±0.060
	A/C, maximum setting	−0.66	±0.060

[a]Windows closed, air conditioner off, driving north at 90 km/h on a slight downgrade.

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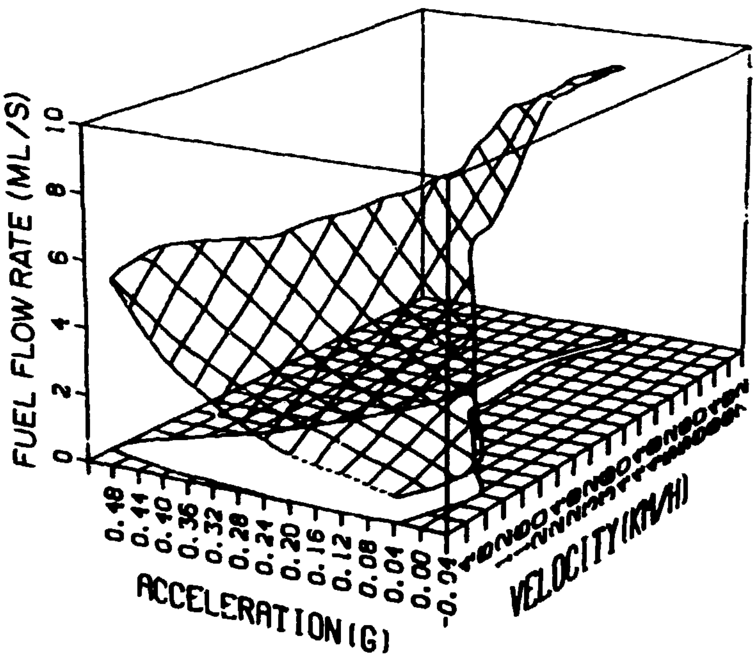

Fig. 3.10. Fuel flow rate (mL/s) vs speed and acceleration in first gear for a 1979 Ford Fairmont station wagon with automatic transmission. The boundaries of the surface define the operating region for first gear.

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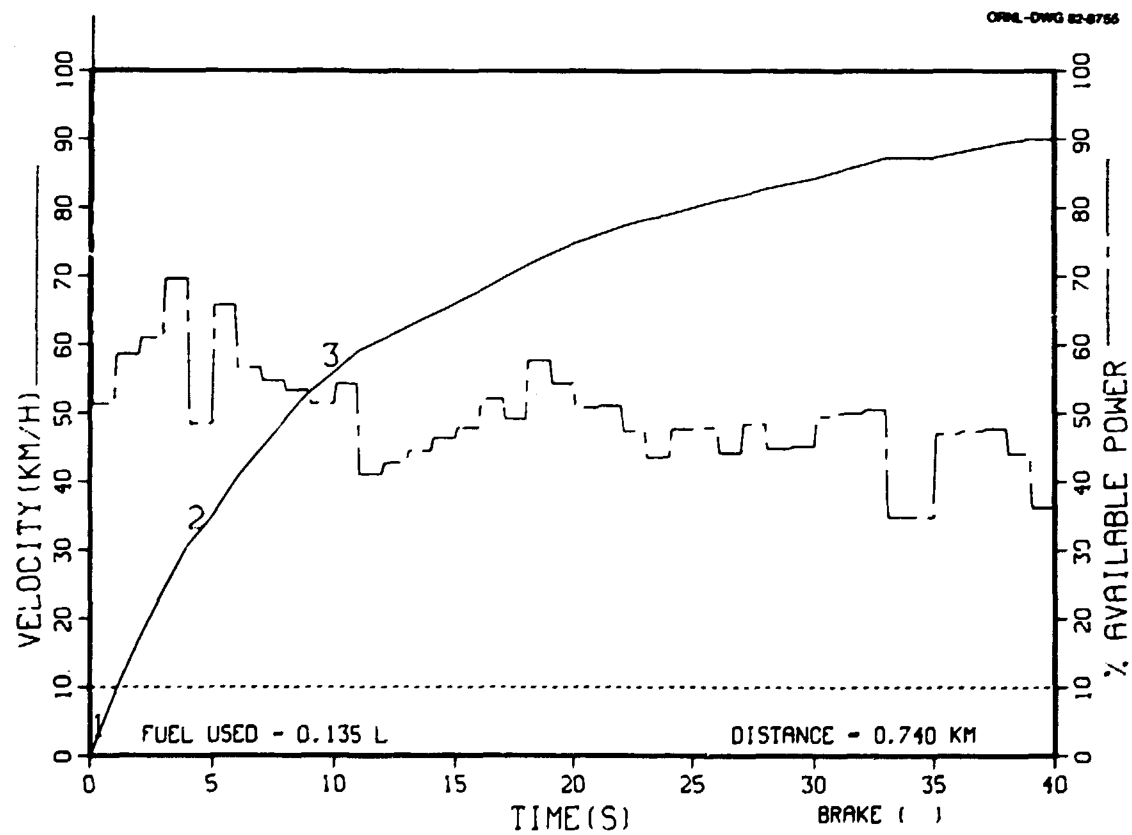

Fig. 3.11. Optimal acceleration from rest to a cruising speed of 90 km/h for the 1980 Ford Fairmont station wagon. The solid line shows the optimal speed trajectory. The finely dashed line at the bottom indicates the terrain, which in this case is a level road. The third line shows the percentage of available power used, where 0% refers to coasting and 100% to wide-open throttle. The numbers on the speed line indicate points at which the transmission shifts into the gear indicated.

4. Economic Analysis Section

R. B. Shelton[1]

4.1 INTRODUCTION

The Economic Analysis Section is involved in a wide range of research, and the major activities are reflected in the responsibilities of the section's three research groups: the Energy Demand Analysis Group, the Energy Modeling and Analysis Group, and the Resource and Regulatory Analysis Group. The Energy Demand Analysis Group focuses on the broad spectrum of energy-demand issues; the primary research activity during the past year has been the development of econometric models of electricity demand, along with helping other groups in the development of engineering/economic end-use models and work on tax credits. The group's work continued this year with the use, maintenance, and revision of the buildings sector end-use models of residential and commercial energy demand. The Energy Modeling and Analysis Group's modeling activities have been directed into areas of energy supply and regional modeling issues. The group is currently assisting in the modeling of the natural gas industry for the Energy Information Administration (EIA) and utilizing regional models in the analysis of regional energy issues. This group also has developed considerable expertise in the evaluation of models, an important emerging research area. The Resource and Regulatory Analysis Group has worked on a wide range of issues involving the use of energy resources and their impact on the environment and has looked at issues such as the impact of regulations on the wheeling of electricity in the United States. An important contribution to research activities in other sections has been impact analysis of energy facilities. Emergency planning has been an evolving research activity, both within the section and in other sections.

Much of the section's research activity involves working with groups in the Division's other sections and also with other Laboratory divisions. Because the section is "home" for all of the economists at the Laboratory, input must be provided to all projects that require economic analysis. As the needs of energy research in the various sections and divisions change, the section's research program will reflect these changes. The section attempts to remain flexible in terms of the types of economic skills provided for research projects in the Laboratory. This need for versatility is shown in the following detailed discussion of each group's activities during the past year.

1. Section head.

4.2 ENERGY DEMAND ANALYSIS GROUP

R. J. Maddigan[2]

W. S. Chern[3] D. M. Hamblin[4]
S. M. Cohn[4] R. D. Perlack
C. A. Gallagher

4.2.1 Introduction

Economists in the Energy Demand Analysis Group have been involved in the investigation of a range of energy issues this year. Emphasis has been in the further development of empirical, computer-based models to support the analysis of changing trends in energy demand, the impacts of energy policy, and the development of domestic energy resources.

The group has provided technical support to projects which are described in detail elsewhere in this report. Work continued with the Buildings and Industrial Energy Demand Group in the use, maintenance and revision of the buildings sector end-use models of residential and commercial energy demand.[5] The group's economists also helped complete a survey of life-cycle cost (LCC) models for buildings' load-simulation programs and assisted in the construction of an LCC code for analysis of innovative building designs.[6] The analysis of residential energy tax credits for new energy-saving appliances was continued this year with the Data and Analysis Section. The tax-credit eligibility model was modified to account more accurately for oil and gas savings by electric utilities. In addition, an equipment-choice model was developed to estimate new appliance sales for each of the ten federal regions, so that the impact of a tax credit can be evaluated.[7] In cooperation with the Regional and Urban Studies Section, the group has been involved in developing an interactive cost-accounting model for the economic evaluation of short-rotation woody biomass plantations.[8] The group has also been involved in improving the demand data and methods required to help establish priorities for future coal-leasing and coal-production goals. The refinement and use of a regional coal model for these priorities has been the major focus of the project.[9]

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2. Group leader and Wigner post-doctoral fellow.
3. On leave of absence.
4. Dual capacity.
5. S. Cohn et al., *A Commercial Energy Use Model for the Ten U.S. Federal Regions*, ORNL/CON-40 (March 1981); E. Hirst et al., *Energy Use from 1973 to 1980: The Role of Improved Energy Efficiency*, ORNL/CON-79 (to be published); D. M. Hamblin and T. A. Vineyard, *Modeling Buildings Sector Conservation Impacts of ASHRAE 90A-1980*, ORNL/CON-82 (to be published).
6. G. A. Cristy et al., unpublished internal document.
7. S. M. Cohn and N. S. Cardell, *Residential Energy Tax Credit Eligibility: A Case Study for the Heat Pump Water Heater*, ORNL/CON-71 (to be published).
8. W. F. Barron and R. D. Perlack, "Designing Cost Accounting Models for Woody Biomass Systems and Direct Application of Geothermal Energy," *Proceedings of the Fourth Miami International Conference on Alternative Energy Sources*, Miami, December 1981.
9. W. F. Barron et al., *Integrated Regional System for Setting Coal Production Goals Project*, ORNL draft report (to be published).

4.2.2 State-Level and Service-Area Specific Electricity Demand Analysis

The continuing development of the electricity demand models for the Nuclear Regulatory Commission (NRC) focused this year on completion of the description of the model interactions,[10] estimation of the Varying Elasticity Model,[11] and development of the appliance-saturation forecasting submodel.[12]

Documentation describing the integrated system for forecasting electric energy and load was completed this year.[13] The forecasting system consists of three components: the State-Level Electricity Demand (SLED) forecasting model, the Utility Service Area Disaggregation (USAD) forecasting model, and the Load Distribution (LD) model. SLED forecasts of state-level, sectoral electricity demand and prices are input to the USAD model, which in turn produces a similar set of forecasts for a utility. The aggregate demand projection obtained from USAD is input to the LD model, which forecasts minimum and maximum hourly load and the load-duration curve for the service area.

At the request of NRC, an analysis of the future demand growth of the Northern Indiana Public Service Company's (NIPSCO) service area was conducted using the integrated forecasting system.[14] NIPSCO has an unusual service area in that approximately 70% of its sales are in the industrial sector. Table 4.1 compares the state-level forecasts with the forecasts estimated for the service area.

Work continued on the development of the Varying Elasticity Model (SLED-VEM), which represents the demands for electricity in the residential and commercial sectors as functions of the percentage of buildings that own electricity-using durable goods such as air conditioners.[15] In addition to this innovation in the specification of demand in a state-level model, SLED-VEM also differs from the partial-adjustment specification of SLED in that state-specific, own-price elasticities are estimated rather than applying regional elasticities to every state within that region. Results

10. W. S. Chern et al., *An Integrated System for Forecasting Electric Energy and Load for States and Utility Service Areas*, ORNL/TM-7947 (to be published).

11. W. S. Chern, R. E. Just, and H. S. Chang, *A Varying Elasticity Model for Electricity Demand with Given Applicance Saturation*, ORNL/NUREG/TM-438 (to be published).

12. J. L. Trimble, *An Analysis of Residential Fuel Choice* (to be published as an ORNL/TM report).

13. Ref. 10.

14. C. A. Gallagher and L. J. Hill, *Electricity Demand Forecasts for the Northern Indiana Public Service Company*, ORNL draft report (July 1981).

15. Ref. 11.

Table 4.1. Comparison of annual growth rates (%) of electricity demand by sector for the state of Indiana and Northern Indiana Public Service Company from 1978 to 1990

Sector	State of Indiana				Northern Indiana Public Service Company			
	Historical	Forecast 1978–1990			Historical	Forecast 1978–1990		
	1965–1978	Base price	Low price	High price	1965–1978	Base price	Low price	High price
Residential	7.0	3.7	4.3	3.4	6.2	1.9	2.7	1.5
Commerical	6.7	4.1	4.8	4.1	1.0	2.2	2.9	2.1
Industrial	6.2	4.9	6.1	4.8	8.3	5.4	7.0	5.2
Total	6.5	4.4	5.3	4.2	7.5	4.8	6.2	4.5

from this estimation of SLED-VEM indicate that the variation in elasticities among states can be substantial. The short-run-average, own-price elasticity of residential demand varies from −0.04 in North Dakota to −0.85 in Mississippi. The model was estimated and the forecasting methodology derived this year. Forecasts using SLED-VEM will be completed early next fiscal year.

Another task dealing with state-level electricity demand modeling completed this year was the estimation of a submodel that can be used to forecast durable appliance saturations, using fundamental demand determinants. A maximum likelihood estimate of a multinominal logit model was calculated for the saturations of electric space heat, electric water heating, and air conditioning. The estimate was based on the Department of Energy (DOE) 1979 National Interim Energy Consumption Survey of some 4000 households in the United States.[16] The analysis indicates that families living in homes built before 1959 tend to rely on fuels other than natural gas or electricity, while homes located in warmer climates are more likely to be heated with natural gas.

4.2.3 Rural Electricity Demand Analysis

The research on modeling electricity demand for the rural electric cooperatives, sponsored by the U.S. Department of Agriculture's Rural Electrification Administration (REA), continued into its second year. The purpose of the project has been to develop the methodology for making state-level forecasts of electricity sales and average price for the cooperatives' residential, commercial, industrial, and irrigation sectors. REA, which administers a loan program for the cooperatives, plans to use this study in its analysis of future growth of the rural electric borrowers.

The first version of the Rural Electric Energy Demand (REED) forecasting model, completed last year, used state-level data on the cooperatives and their customers from 1969 to 1977.[17] The model is similar in structure to Version II of SLED — in that the submodels are specified using a partial-adjustment, log-linear demand equation and a quadratic price equation. The irrigation submodel includes a third equation, which reflects the long-run growth in irrigation customers using electricity. Forecasts using REED I were developed in this fiscal year. Although the cooperatives had experienced an average annual growth in total sales of 9.8% between 1969 and 1977, the six scenarios examined project annual growth from 1977 to 1990 of only 5.4 to 6.6%.

Comparable versions of REED and SLED were estimated to highlight the differences between rural and total residential electricity demand.[18] The results of the study indicate that rural residential customers are more sensitive to changes in electricity pricing than average, state-level customers. On the other hand, average, state-level customers are more responsive to changes in the prices of substitute fuels than their rural counterparts.

One of the major activities this year has been the development of a supply-side component of REED that forecasts the growth in the cooperatives' total operating costs.[19] Unlike the rest of the

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16. Ref. 12.

17. R. J. Maddigan et al., *The ORNL Rural Electric Energy Demand Forecasting Model*, ORNL/TM-7863 (September 1981).

18. C. A. Gallagher, R. J. Maddigan, and W. S. Chern, "A Comparison of State-Level and Rural Residential Electricity Demand," *American Statistical Association 1981 Proceedings of the Business and Economic Statistics Section* (to be published).

19. R. J. Maddigan and C. A. Gallagher, "The Impact of Changing Interest Rates on the Rural Electric Cooperatives' Total Costs," presented at the Western Economic Association Annual Meeting, San Francisco, Calif., July 1981.

industry, less than 30% of the cooperatives' power is self-generated, making them dependent upon wholesale purchases of electricity. The cooperatives are also set apart from the investor-owned utilities by low interest rates on loans guaranteed by the government, income-tax exemptions, and their not-for-profit status. The Total Rural Electricity Cost (TREC) forecasting submodel takes these factors into account. The four-equation system is estimated for the five REA regions, using annual, state-level observations on the cooperatives from 1969 to 1979. Total electricity sales, average price, average operating cost, and the wholesale cost of power are determined simultaneously by TREC. The estimation of the submodel was completed this year. REED has also been reestimated using data from 1969 to 1979, and this version will be combined with TREC to develop a new set of forecast scenarios next year.

4.3 ENERGY MODELING AND ANALYSIS GROUP

Larry Hill[20]

K. E. Johnson C. R. Thomas
J. L. Trimble D. P. Vogt

4.3.1 Introduction

During FY 1981, the efforts of members of the Energy Modeling and Analysis Group were focused on an array of research activities, with the use of models and their application in energy policy analysis as the common underlying theme. Much effort was directed toward activities related to the EIA-sponsored model validation program. Additional work involved analysis of a time-of-day pricing program in Vermont.

Individual members of the group also made substantial contributions to other ongoing projects within the Economic Analysis Section and to other Energy Division groups. The most significant contribution involved use of the regional modeling and regional analysis expertise within the group. Regional modeling and analytical support was provided to the Integrated Impact Analysis Group and to a program sponsored by the DOE Office of Emergency and Contingency Planning. Ancillary research support was also provided for projects involving the study of oil supply disruptions and to various energy conservation studies.

4.3.2 Model Validation Activities

During the past year, members of the Energy Modeling and Analysis Group made a significant contribution to the EIA-sponsored Model Validation Program (Sect. 5.2). In concert with the Engineering Physics Division, members of the group completed an evaluation of the Long-Term Energy Analysis Program (LEAP), a long-range energy forecasting tool used by EIA,[21] and initiated and completed evaluations of the EUREKA Uranium Mining and Milling Model[22] and the

20. Group leader.

21. J. A. Hansen, M. Becker, and J. L. Trimble, *The Economic Foundations of Leap Model 22C*, ORNL-5748 (April 1981).

22. C. R. Thomas et al., *An Assessment of the EUREKA Uranium Mining and Milling Model*, ORNL-5839 (to be published).

National Utility Financial Statement (NUFS) Model.[23] Additionally, a research project was undertaken to evaluate the allocation methodologies utilized in different energy modeling frameworks.[24]

With respect to the evaluation of LEAP, it was concluded that the principal economic deficiencies of the model lie in the simplifying assumptions used to characterize energy markets and the heavy reliance on information exogenous to the modeling framework. The latter characteristic of LEAP necessitates the use of exogenous data that in many cases have not been estimated empirically and therefore must be determined by the user on a judgmental basis.

EUREKA is a supply-side model of U.S. uranium mining and milling activity that is used by EIA to forecast the quantity of each of 75 categories of uranium that will be placed into production annually. Because the model is oriented to the potential supply of uranium, the quantity of uranium demanded must be provided by the user. One of the principal conclusions of the evaluation effort was that, because of the exogenous nature of demand in the model and the use of empirically nonestimable "psychological" factors, a potential user of EUREKA must be an expert on the intricacies of uranium markets. In an effort related to the evaluation of EUREKA, a comprehensive survey of nuclear fuel-cycle models was undertaken for identification of models that are potentially useful to EIA's Nuclear Energy Analysis Division.[25]

The NUFS model was constructed for the primary purpose of evaluating the financial feasibility of forecasted electric utility capacity expansion profiles emanating from an electric utility capacity expansion model. NUFS is specified as a series of financial accounting relationships that characterize the intricacies of the electric utility regulatory environment. The primary deficiency of the modeling framework is that capital supply curves are not modeled; therefore, the user determines the cost and availability of capital in the industry. Using the results of a comprehensive sensitivity analysis, it was concluded that the use of NUFS outside of a broader electricity demand-and-supply modeling framework will lead to results that are inconsistent with extant economic theory.

In the recent past, there has been a proliferation of technical models developed to describe the relationships between energy-related variables and to forecast their values. Although the models vary widely in their structural features and objectives, they share at least one common attribute: an energy allocation problem (i.e., methods for allocating energy demand or supply among the various end uses or sources).

By distinguishing problems of disaggregation as *pure allocations* and *pure assignments*, an evaluation was undertaken of four methodological approaches that are commonly utilized in representing the energy allocation problem in the production sector of energy models. These approaches were evaluated in the context of the neoclassical theory of production with special emphasis given to the problems posed by aggregation over both inputs and micro units and the formulation of short-run versus long-run dynamics.

One of the principal conclusions of the research is that only the process optimization and translog aggregator approaches are consistent with economic theory. The probabilistic and log-odds approaches are not consistent with theory and, therefore, must be regarded as ad hoc approximations to the underlying process that is being modeled. It should also be acknowledged, however, that

23. L. J. Hill et al., *An Evaluation of the National Utility Financial Statement (NUFS) Model*, ORNL-5831 (to be published).

24. V. K. Smith and L. J. Hill, *The Role of Allocation Rules in Energy Models*, ORNL draft report (September 1981).

25. C. R. Thomas et al., *A Survey of Nuclear Fuel-Cycle Codes*, ORNL/TM-7747 (April 1981).

all of these methods can be regarded as approximations and, as such, one would not necessarily require them to be derived from economic theory. Under this interpretation, the only basis for comparison would be in terms of their performance in predicting desired energy measures.

4.3.3 Time-of-Day Pricing Project

The time-of-day (TOD) electricity rate is a potentially effective conservation incentive. Members of the group surveyed TOD and non-TOD electricity customers in Vermont, where an optional TOD rate has been in effect for the past six years.[26] By comparing the two groups, the extent of appliance purchases and usage adaptation resulting from the rate structure was evaluated. The results show that TOD customers, who are mostly large users, reduce their average cost to 4.1¢/kWh from the 7.3¢/kWh that they would be required to pay under the conventional rate (even though peak rates are 13.6¢/kWh). The TOD customers accomplish this primarily by using timers to control space heaters (68% of the sample), water heaters (81%), freezers (26%), and other major appliances and by changing the timing of their consumption patterns. In all, the results show that the TOD rate can effectively provide an incentive for large users to reduce peak consumption.

4.4 RESOURCE AND REGULATORY ANALYSIS GROUP

R. C. Tepel[27]

D. J. Bjornstad	C. R. Kerley
N. S. Cardell	J. W. Van Dyke
T. R. Curlee	

4.4.1 Introduction

The Resource and Regulatory Analysis Group has been involved in a variety of research projects during the past year, some of which involved commitments of research staff members to research activities with other groups in the section and with other sections in the Division and Laboratory. An important contribution to research activities in other sections has been in the analysis of impacts of energy facilities. This work has involved cost/benefit analysis, estimation of employment impacts, and compensation plans to those adversely affected by the facilities. A second major activity involving research both within the section and in other sections has been emergency planning. Projects in this area involved estimation of the effects of petroleum disruptions and potential use of biomass energy on farms. In the regulatory area, the group was involved in assessments of the Residential Conservation Service (RCS) program and in studies of the wheeling of power between electric utilities. The detailed discussion of the group's research activities will concentrate on the impact of oil disruptions and payment-in-lieu-of-taxes programs.

26. J. L. Trimble et al., *A Survey of Electricity Consumers in Vermont: Evidence of Long-Range Adjustments to Time-of-Day Electricity Prices*, ORNL/TM-7992 (to be published).

27. Group leader.

4.4.2 Impacts of Oil Disruptions on the Domestic Refinery Mix

An oil disruption in a particular region of the world will alter the mix of crudes available on the world market. A disruption will result in a general increase in oil prices as well as a change in relative prices of oil types (defined according to sulfur contents and specific gravities). Thus, the severity of an oil disruption to our economy and national security will depend not only on the size of a disruption but also on the flexibility of domestic refineries to be able to produce certain refined products from crudes of different types. With perfect flexibility, the costs associated with a disruption may be large or small. However, if little flexibility exists, the impacts of even a small disruption in certain refined product markets may cause exaggerated impacts on the economy and national security.

The problem of flexibility may be significant because of the types of refineries that have been constructed during the past decade. Of those new refineries, 62% had initial operating capacities of no more than 10,000 bbl/d. These small refineries tend to have simple refining process capabilities, and many are not capable of processing sour crudes into light products such as gasoline.

ORNL is combining simple models of world-crude supply and domestic-refined-product demand with a linear programming refinery model to determine the impacts of several selected oil disruption scenarios on the domestic refinery mix. The model minimizes the cost of refiners — given estimated relationships between crude oil prices and crude quantities and between refined product prices and refined product quantities. The modeling system will be solved iteratively so that refiners' costs are minimized and world oil prices, import quantities, refined product quantities, and refined product prices conform to the estimated crude-supply and product-demand schedules.

In addition, ORNL will determine the impacts of using the anticipated strategic petroleum reserve (SPR) during a disruption. The sensitivity of SPR to changes in the types of oil it contains will be determined.

Initial results indicate that only a small short-run supply response would be possible during a disruption. The increased supply would be primarily from Mexico. Use of the refinery model suggests that we would be able to adjust to the different oil types available during a disruption, but this result may be overly optimistic due to the level of refinery aggregation in the model. To analyze this possibility, disaggregation to similar types of refineries is being attempted.

4.4.3 Payment-in-Lieu-of-Taxes Programs and the Storage of Nuclear Waste

Frequently firms that produce, use, or dispose of nuclear fuel are linked to the federal government and are not liable for local taxation. Tax payments are often a major local benefit from facility siting; in their absence, communities tend to be more resistant to siting efforts.[28] One way to overcome this lack of local siting incentives is for the facility to make payments to replace the taxes that would be made if the facility were taxable. These monies are termed payments in lieu of taxes.

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28. D. J. Bjornstad, "Economic Impacts Associated with Pure Taxable Capacity Changes," *Land Economics* (February 1982); D. J. Bjornstad, "How Nuclear Reactor Siting Affects Local Communities," *Survey Bus.* 11(5) (May/June 1976); and D. J. Bjornstad, *Fiscal Impacts Associated with Power Reactor Siting: A Paired Case Study*, ORNL/NUREG/TM-86 (February 1977).

As part of a larger study conducted on incentives (Sect. 3.2.1), these payments were studied to determine their applicability to high-level nuclear waste isolation facilities. This work consisted of a conceptual review of these payments and a case study for which hypothetical payments in lieu of taxes were added to user fees for a typical isolation facility.

The conceptual review indicated that several types of payment plans could create local incentives but that incentives would not be created unless the payment were keyed to cover all local costs, including loss of local taxes from alternative taxpaying facilities.[29] To do this would be counter to current federal practices which treat such payments as a form of aid. The review also indicated that many communities outside the jurisdiction of siting would also suffer costs and that payments in lieu of taxes might also be used to compensate for these costs.

The case study reviewed payments in lieu of taxes from a more practical perspective than the conceptual analysis and prepared estimates of the impact of such payments on facility user fees.[30] These payments were calculated on the basis of the amount that the facility would have paid in property taxes, had it been taxable and paying a national-average tax rate, under a variety of assumptions regarding the exact form of payment calculations. It was determined that the payment might add between 8.0 and 12.0% to the facility user fee but that this amount could yield a highly significant amount of revenue for communities of modest size. It was further demonstrated that failure to make payments of any kind could result in an out-of-pocket cost to local communities for providing additional local public services.

29. D. J. Bjornstad and K. E. Johnson, "Conceptual Aspects of Fiscal Interactions Between Local Communities and Federally Owned, High-Level, Radioactive Waste Isolation Facilities," Office of Waste Isolation, Battelle Memorial Insitute, Columbus, Ohio (to be published).

30. D. J. Bjornstad and E. Goss, "Issues in the Use of Payments in Lieu of Taxes to Provide Nuclear Waste Isolation Facility Siting Incentives," *Rad. Waste Manage.* (to be published).

5. Data and Analysis Section

A. S. Loebl

5.1 INTRODUCTION

The Data and Analysis Section (DAS) was formed in the summer of 1981 to coordinate and more strongly focus Energy Division efforts toward the development and improvement of energy data systems and mathematical models. Current work includes evaluations of existing energy data systems and models; formulation of specifications for data systems and models; development of ways to fulfill these specifications; construction and improvement of models; and research to develop concepts and procedures appropriate for such evaluations, specifications, and model constructions.

The latter kind of research may be considered more basic than applied. It includes research that may facilitate the satisfactory completion of ongoing applied tasks, but more generally, the results of such research help prepare for increased effectiveness in continuing efforts to develop and improve the collection, accessibility, and use of data. It also improves our core capability to conduct the evaluation, analysis, and assessment tasks that are the thrust of the DAS's technical responsibility to its sponsors. Because of the far-reaching importance of such research, the DAS seeks projects that provide opportunities for some basic research, as well as opportunities for developing generally useful skills in our staff.[1]

Improvements in data and models are needed so that energy policy can be based on better information. Energy policy includes actions by federal, state, and local governments, as well as by business and even private citizens. Thus, the users of energy data and models include a broad spectrum of individuals and organizations. Also, good data and models are needed so that energy regulations can be enforced justly.

Progress during FY 1981 was consistent with the general goals and interests outlined above. The progress described represents but is not exhaustive of the work of the three groups of the DAS—the Evaluation Group, the Data Methods Group, and the Buildings and Industrial Energy

1. Results of this type of work include presentations and publications such as E. A. Hirst, "Disaggregate Data: A New Foundation for Energy Models," presented at the University of California at Berkeley, May 1981; J. L. Blue, "The Importance of Scale in Evaluation of Energy Conservation Programs," presented to the Association of American Geographers, November 1981; M. R. Chernick, "The Influence Function Method Applied to Energy Time Series Data," presented at the Department of Energy Statistical Symposium, October 1981; C. R. Weisbin, R. W. Peelle, and A. S. Loebl, "An Approach to Evaluation of Energy Economic Models," *Energy* 6(10): 999–1027 (1981).

Demand Group. The work of the Evaluation Group included analysis of government energy conservation program impacts.[2]

Work of the Buildings and Industrial Demand Group during FY 1981 includes improvement of ORNL energy-economic models (for the residential and commercial sectors). Progress in the Data Methods Group included formulation and codification of methods, procedures, and concepts for evaluating energy data and determining requirements of energy data.[3]

5.2 DATA METHODS GROUP

G. A. Dailey

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S. Cantor	J. E. Horwedel[4]	C. R. Thomas
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J. D. Dischler[4]	G. E. Liepins	J. L. Trimble
D. J. Downing[5]	J. H. Marable[4]	H. J. Tsao
D. M. Flanagan[6]	B. F. Maskewitz[4]	C. R. Weisbin[4]
W. Ford[5]	S. A. McGuire[5]	T. Wright[5]
M. Goldstein[4]	E. M. Oblow[4]	

ORNL continues to support the Energy Information Administration (EIA) in evaluating the quality of energy information by determining and documenting the validity of data, models, and analyses used by the Department of Energy (DOE) and particularly EIA; improving the methodologies available for such assessments; and supporting the development of requirements and specifications for energy information. Work completed during FY 1981 and currently continuing work include mathematical methodology research to support data validation with a focus on applied research to improve automatic data editing, error localization, and data frame development.

Management of these efforts is located within the Data Methods Group of the DAS, although additional staff support for the EIA program is drawn from other groups within the DAS and from the Economic Analysis and the Regional and Urban Studies sections of the Energy Division. The program also frequently uses staff from other divisions within ORNL, namely, Engineering Physics (expertise on model assessments), Computer Sciences (computer assistance and mathematics and statistical research expertise), Physics (expertise in electric power production and assessment), and Chemistry (awareness of current petroleum production methods and handling techniques). ORNL staff members are also assisted by technical experts from universities, consulting firms, and other

2. An example of work resulting in improved understanding of energy use is Eric Hirst et al., *Energy Use from 1973 to 1980: The Role of Improved Energy Efficiency*, ORNL/CON-79 (December 1981).

3. *Guidelines and Procedures for the Conduct of a Review of Data Requirements*, DOE/EIA-0276 (March 1981); A. S. Loebl and S. Cantor, "Energy Data Validation: An Overview and Some Concepts," presented at the Annual Meeting of the American Statistical Association, Detroit, Mich., August 1981.

4. Engineering Physics Division.

5. Computer Sciences Division.

6. Technical Services, Oak Ridge Gaseous Diffusion Plant.

7. Physics Division.

subcontractors. Working with universities and companies in the private sector allows ORNL to maintain a greater staff flexibility in responding to EIA needs in a rapid and efficient manner.

The key to the reasonableness and credibility of energy information is a viable quality control effort that will (1) ensure that the data being collected are needed, (2) reduce and control errors in data reporting, and (3) assist in the interpretation of that data. At first glance, the data quality problem seems to be a statistical question — an issue of sample size, sampling error, and response bias. To be sure, valid data rest on obtaining information from a *representative* sample of the universe of interest, but they also rest on the clarity and understandability of the survey questionnaire used to collect the data. One of the most significant conclusions of our work to date is that a precise statistical calculation of probable error is irrelevant compared to questions of bias. It is not that we found rampant misrepresentation, nor that one needs to deal with the probability that respondents and nonrespondents are from different populations. Rather, we found that the energy sector is so heterogeneous that data provided in response to a question may be full of idiosyncratic responses. That is, there is much more room for error in interpretation or applicability or variation in definition than there is for uncertainty due to random variation. We have had to go beyond classical statistics (because the sources of error are outside the sample design) and beyond classical auditing (because *that* precision is not worth the cost).

Data validation studies completed at ORNL (Table 5.1) dealt with energy data systems in the petroleum, coal, and electric power sectors of the energy sector. These studies help define the bounds of industry data and its accuracy. One of the data systems evaluated at ORNL was the Domestic Crude Oil Entitlement (DCOE) System. This system was designed by DOE to ensure that the benefits of cheaper, price-controlled domestic oil were distributed equitably to all refiners when the price controls were enforced by the federal government (January 1977–December 1980). Data for DCOE were collected monthly on a form (ERA-49) sent to all U.S. refiners of crude oil. The ORNL-led evaluation of this system showed that during the period of January 1977 through December 1980, a total of approximately 53×10^6 m^3 (335×10^6 bbl) of old oil was not reported as part of the DCOE system and that 42×10^6 m^3 (269×10^6 bbl) of stripper well oil were not reported by first purchasers during the same period.[8] The report showed that during this period significant under-reporting of domestic crude oil production was common.[9] Table 5.2 shows that an average of "missing" old oil per day over the three-year period was 36.5×10^3 m^3/d (230×10^3 bbl/d). The results of the study showed that possible explanations for the disappearance of old oil included nonrefinery uses of crude oil, inventory practices, definitional differences of petroleum types by company, and miscertification (labeling new oil as "old"). It was not possible to quantify each error because of insufficient resources. The first three explanations are technical in nature and appear to explain why similar petroleum data systems do not agree in aggregate total. The last explanation may account for the disappearance of old oil. This investigation did not constitute a complete field investigation or audit of the data and was unable to prove or disprove that miscertification had taken place. However, the Economic Regulatory Administration (ERA) Office of

8. The actual study was conducted under subcontract by Transportation and Economic Research Associates (TERA), Inc.

9. For example, see C. G. Everett and R. D. Farmer, "A Comparison of Lower-48 Production Data from Three Crude Oil Data Systems," DOE Analysis Memorandum (September 1978); House Committee on Interstate and Foreign Commerce, *The Case of the Billion Dollar Stripper* (October 1980).

Table 5.1. Summary of findings from validation studies[a]

Study/report title/group/date	Purpose/requirements of data	Conclusions and recommendations
Joint Petroleum Reporting System (EIA-87, -88, -89, -90), *Validation of the Joint Petroleum Reporting System*, TERA (June 1980)	To collect and process complete, comprehensive, detailed, and accurate information on the supply and derived demand, stocks, and flows of crude oil and refined petroleum products within the United States and its territories and to make that information available to analysts, regulators, and policymakers in the federal government and in the public-at-large. This is a mandatory data collection system as determined by law.	The broad purposes of this data file work to limit accomplishing all that is expected. Except for EIA, limited access and lack of timeliness prevent satisfying all DOE data requirements, but changes in the data collection form with attention to respondent frame and universe, combined with modification allowing certain greater access, would increase both use and validity. Certain designated adjustment procedures need to be eliminated, but data editing and analyses of completeness are needed. Strong enforcement of procedures to reduce late reporting along with greater attention to user needs were also recommended.
Domestic Crude Oil Entitlements System (ERA-49), *Validation of the Crude Oil Entitlements Information System*, OEIV, EIA, DOE, Oak Ridge data validation team, and TERA (August 1981)	To collect the necessary information for the calculation of entitlements prices and obligations as specified in the regulations. The DCOE system gathers data on volumes and weighted average costs of crude oil receipts by category or tier, and on volumes of crude runs-to-stills from domestic refiners. The system also collects volumetric data on certain imports of residual fuels and naptha, on deliveries of crude oil to the Strategic Petroleum Reserve, and on production of petroleum substitutes used for fuel (e.g., shale oil and ethyl alcohol).	Since the DCOE system is being eliminated as part of the President's decontrol of oil, no recommendations are made concerning the operation of the system. However, secondary users of the DCOE data should be warned concerning their use. The following caveat should be published with these data: "Entitlements data are financial or accounting constructs. They may not measure refinery operations or physical flows of oil. Therefore, the data are not appropriate as a surrogate for otherwise unavailable data on refining operations."
Mandatory Crude Oil Allocation System (ERA-56, -57), *Validation of the Mandatory Crude Oil Allocation System* (Buy/Sell), TERA (April 1981)	To support the management information requirements of the regulatory program that determines crude oil allocations and sales obligations, decides on directed sales, and monitors and regulates program activity. As a management information system, it is not intended to provide statistical information or to support secondary users.	No recommendations were made. The program was expected to end with the expiration of the Emergency Petroleum Allocation Act on Sept. 30, 1981.

Table 5.1 (continued)

Study/report title/group/date	Purpose/requirements of data	Conclusions and recommendations
Supply and Disposition of Natural Gas System (BOM 6-1340-A, BOM 6-1341-A, EIA-176), *An Evaluation of the Supply and Disposition of Natural Gas System*, ORAU (September 1981)	To provide an annual measure of the consumption of natural gas by major end-use category and by state. This system was originated by the BOM in 1915 when it was given the right "to investigate the mineral fuels . . . ." The submission of data to the BOM was voluntary. Starting with the 1981 collection of 1980 data, the two BOM forms were replaced by a single form, EIA-176. Completion of EIA-176. Completion of EIA-176 is mandatory.	Prospective data users should be warned that the SDNGS published data are not the same as the data that are collected from respondents. The size of the nonresponse problem and of the respondent errors should be clearly stated, and the subjective nature of data alterations should be clearly explained. Users should be informed that although state data may be greatly in error, national data are better because they are constrained by external sources. Recommended changes in the data system include: • Expand and document the procedures to be followed in the operation of the SDNGS and also record actual operations, to ensure consistency and objectivity in the processing of raw data. • Give immediate attention to problems of frame maintenance, nonresponse, and the failure of editing procedures to eliminate large errors to improve accuracy of the SDNGS data. • Set up a respondent identification system applicable to all EIA natural gas data operations to facilitate system maintenance and data correction. • Shift the emphasis of EIA from correcting data errors to preventing them. • Integrate the SDNGS data with other EIA natural gas data collections to make the data more meaningful, consistent, and comprehensive.

Table 5.1 (continued)

Study/report title/group/date	Purpose/requirements of data	Conclusions and recommendations
Natural Gas Curtailments Systems (EIA-50), *Validation of the Natural Gas Curtailments System*, ORAU and ORNL Computer Sciences Division with the Mathematics and Statistics Research Department (August 1979)	To provide an early indicator of geographic areas most susceptible to changes in gas curtailment and alternate fuel needs, thus allowing for alternate contingency planning and/or action at all levels of government in areas where potentially serious conditions may exist. To enable DOE's ERA to collect the data necessary to meet its responsibility for allocating oil and petroleum products equitably among users throughout all regions of the United States and sectors of the petroleum industry. To enable DOE to inform state and federal agencies and the public about developments related to natural gas curtailment that may occur during the winter.	The data will never be quantitatively precise, and consistency and uniformity of data should be improved. The proper source of information (respondent universe) has been properly identified and the problems, flaws, questionable meaningfulness, and timeliness of the data base indicate revision rather than abolishment of the system is in order. By tailoring the annual report of this system to user needs (which have been and can be identified), changing respondent instructions and directions, and improving the form as indicated in the report, the system will be useful to state energy offices and public service commissions. By adding caveats to all published reports and data files, this system can be carefully employed for allocation and planning purposes.
Natural Gas Supply, Requirements and Usage (EIA-149) Field Validation Study, TERA in association with Alexander Grant and Company (March 1981)	Form EIA-149 was designed to collect the necessary information for regulation of Titles II and IV of the Natural Gas Policy Act.	Data users within DOE should be identified and their potential future use of the existing data base defined. If there are potential future uses for the data base, OEIV should consider the following steps for each application: • Analyze the potential application and approaches to be used. • Design a set of simple edit checks for the data, based upon the Field Validation Study results to eliminate outliers. • Determine which respondents within the base have the greatest impact on the approach to be used. • Drawing on the results of this study, perform detailed validation procedures on those respondents who impact the approach.

Table 5.1 (continued)

Study/report title/group/date	Purpose/requirements of data	Conclusions and recommendations
An Evaluation of Published EIA Gasoline Supply Estimates, OEIV, EIA, DOE (April 1980)	To compare the estimates of the monthly U.S. domestic supply of automotive gasoline produced by four systems: (1) the Joint Petroleum Reporting System, (2) the Market Shares Monitoring System's Refiner/Importer Monthly Report of Petroleum Product Distribution (Form P306), (3) the Federal Highway Administration (FHWA) compilation of reports from state tax agencies, and (4) the Prime Supplier's Monthly Report Form of gasoline deliveries (EIA-25).	All available information should be used to construct a new frame for P306, to select an expanded sample, and to initiate direct estimation of total product supplies using the existing form. This should produce reliable estimates of monthly gasoline supply and might be used to estimate historical errors in the P306 estimates. The petroleum product definitions in JPRS should be revised to eliminate all definitions which require knowledge of the intended use of a product (e.g., potential gasoline components should be classified according to their chemical characteristics). To implement these changes, form EIA-87 of the JPRS must be revised and its frame must be expanded.
Oil and Gas Information System (EIA-23), *Field Validation of the OGIS Estimate of Proved Reserves of Oil and Gas in the United States as of December 31, 1977*, OEIV, EIA, DOE (June 1981).	To collect annually detailed verifiable information on the crude oil, natural gas, and natural gas liquids proved reserves and production of the United States and its outer continental shelf. The validation deals with the present restriction of Form EIA-23 to data on crude oil and dry natural gas.	The OEIV has not, in the first year of its validation effort, made any specific recommendations.
Federal Energy Conservation Performance Report, *The Federal Energy Conservation Performance Report*, the Oak Ridge data validation team (August 1978)	To collect and distribute information concerning energy consumption by fuel type and purpose for each of 25 federal agencies. This system is part of the Federal Energy Management Program. This review was initiated to provide an adequate backdrop for work on the industrial energy conservation report; it is not a complete system validation.	The FECPR should not be considered as an independent candidate for a detailed validation at the present time. Such a validation would appear to be meaningless since there are so few users and uses of the information produced by the system. The prime users appear to be the FECPR office and the responding agencies, and the major uses of the information are for project maintenance, information verification purposes, and general public relations. If significant system improvements were made (more than those to be included in the new system programming) the system information would probably increase in usefulness. Such improvements could center on the initiation (actually reestablishment) of a well-designed activity measurement indicator so that increases and decreases in agency activities could be reflected in their baseline figures or the utilization of year by year comparisons.

Table 5.1 (continued)

Study/report title/group/date	Purpose/requirements of data	Conclusions and recommendations
Boiler Manufacturers Report of Order(s) Received (ERA-97). *Validation of the ERA-97 "Boiler Manufacturers Report of Order(s) Received" System*, Evaluation Research Corporation (September 1981)	To collect data on each order for a boiler with a heat input rate of 50×10^6 Btu/h or more for use in monitoring compliance with the fuel use restrictions in Public Law 95-620 entitled "Powerplant and Industrial Fuel Use Act of 1978."	The major alternatives that DOE should consider to improve the ERA-97 system are form modifications (including expansion of the instructions, form redesign, expansion and clarification of data collected, and new and expanded definitions), system and data dissemination modifications (including improved handling of forms and modification and documentation of the data processing system), inclusion of caveats for users of the forms or computerized data, and development and implementation of quality control and frame update procedures.
Industrial Energy Efficiency Improvement Program/Voluntary Business Energy Conservation Program, *Data Validation of the Industrial Energy Efficiency Improvement Program and the Voluntary Business Energy Conservation Program*, Evaluation Research Corporation (May 1979)	Some ambiguity exists as to the purposes of these systems. According to the Energy Policy and Conservation Act, the IEEIP mandatory data collection system is to measure progress toward voluntary energy efficiency improvement targets for the ten most energy-consumptive industries (the respondent universe was expanded as a result of the passage of National Energy Conservation and Policy Act). Similarly, the VBECP voluntary data collection system is to provide energy progress measurements sufficiently credible and accurate that the government and the public accept them as indicators of business conservation efforts. Also, in response to the Energy Policy and Conservation Act, sponsors of both programs hope that the system will aid in stimulating government/industry dialogue about energy use and measurement and increase energy efficiency awarene[illegible]. The program offices are concerned that a too rigorous pursuit of the measurement aspect of these systems may compromise the conservation promotion objective. This report focuses on the extent to which the data collection systems serve either of these purposes.	Numerous caveats should be applied to the data; for example, data values are relative (not absolute) and use to which the data may be put is limited, because reporting practices vary over time and produce inconsistencies. Also the intended purpose is not fully achieved since the data, due to the above and other examples, may not measure absolute levels of achieved progress. There are seasonal distortions due to reporting practices as well, and the plethora of reporting forms (over 50) needs to be reduced to a single form, thus allowing for comparison not o[illegible]ly within industry but between industries. Aggregation problems must be corrected, adjustments to data must be documented and standarized, and timeliness of data release and the requirements for credible energy conservation data should be determined. DOE is presently reorganizing this system and examining its collective faults and strengths, in a large measure based upon ORNL's efforts and with ORNL's continued assistance.

Table 5.1 (continued)

Study/report title/group/date	Purpose/requirements of data	Conclusions and recommendations
Prime Suppliers Monthly Report (EIA-25). *Data Validation Study of the Prime Suppliers Monthly Report (EIA-25)*. TERA (April 1980)	The purpose of the EIA-25 system is not precisely defined by a single piece of legislative text. The specification of the data elements and the responsibilities cited in the statutory authority imply that the system is to assist state and federal allocation officials to effect an equitable distribution of designated petroleum products according to priorities established under the Mandatory Petroleum Allocation Program by monitoring past and anticipated supply and demand by state and supplier.	Clarification of prime supplier as anyone who produces, refines, manufactures, or introduces into a state an allocated petroleum product for sale in that state would be a good starting point for upgrading this system. Additionally, five other recommendations are made: 1. direct all prime suppliers to report allocation fractions and total supply monthly; 2. collect total delivered, supply obligations, and amounts not subject to allocation from a separately defined frame consisting of those persons or firms who purchase an allocated petroleum product for direct use or resale within a given state; 3. periodically verify the data collected in No. 2; 4. identify nonrespondent prime suppliers through the use of state revenue, licensing, or energy office information; and 5. revise data verification and editing procedures to incorporate knowledge about the petroleum product distribution phenomena.
Monthly Power Plant Report (FPC Form 4). *Validation of the Monthly Power Plant Report System*, ORNL Computer Sciences Division and Mathematics and Statistics Research Department assisted by the Evaluation Research Corporation (October 1980)	To collect generating plant data from all electric utilities owning or operating power plants and from industrial plants with at least 10-MW nameplate capacity. (Since January 1980, only hydroelectric plants have been surveyed in the industrial sector.) Data are used by the FERC, DOE, Congress, and other governmental bodies to perform their regulatory and policymaking activities and to provide a historical record of domstic electric power generation operation.	The collection form should be improved and caveats on the data provided to all users. More detailed information is needed on fuel oil use, boiler start-up, flame stabilization procedures, generation, pumped storage plants, and cogeneration facilities. A standard identification code scheme should be implemented and data editing/updating reduced as far as practical where human intervention judgment is employed. All data entry/update procedures should be documented and a fixed schedule instituted to avoid confusion regarding different data base updated files being used.

Table 5.1 (continued)

Study/report title/group/date	Purpose/requirements of data	Conclusions and recommendations
Monthly Power Plant Report (FPC Form 4), *Analysis of Supplemental Form FPC-4 Issues*, Synergic Resources Corporation (September 1981)	To collect generating plant data from all electric utilities owning or operating power plants and from industrial plants with at least 10-MW nameplate capacity. (Since January 1980, only hydroelectric plants have been surveyed in the industrial sector.) Data are used by FERC, DOE, Congress, and other governmental bodies to perform their regulatory and policy-making activities and to provide a historical record of domestic electric power generation operation.	Utilities were generally capable of providing data on fuel use by combustor and gross generation by generator, but these values were often not the result of direct measurements. Fuel consumption is measured for approximately 66% of the units, while gross generation is measured at approximately 95% of the units. The study estimated that unit level reporting would increase respondent burden from a present burden of about 1.4 h per utility per month to a burden ranging from 3.6 to 4.5 h per month.
	This report addressed three general areas: (1) the history of the collection of FPC-4 data elements, (2) the accuracy of reported FPC-4 data elements, and (3) the availability of selected additional information.	The additional availability issues were addressed under the assumption that unit level reporting would occur. The additional information was either already available at the utility or could be provided if required. Although the additional information is available, substantial additional respondent burden (+6.6–9.7 h) would result from its collection.
Monthly Report of Cost and Quality of Fuels for Electric Plants (FPC-423), *Validation of the Monthly Report of Cost and Quality of Fuels for Electric Plants*, Synergic Resources Corporation (September 1981)	To provide monthly information to federal officials on the availability and cost of fossil fuels to electric utility companies. The information is used in current analysis of energy and fuel supply, in review of electric utility rates, and in evaluation of developments in fuel supply that may affect the reliability of electric service, emergency preparedness, or environmental improvement programs.	The instructions to Form FPC-423 should be clarified and expanded. Edit checks to identify nonreporting and error-reporting institutions should be established. The frame should be updated and maintained. In addition, caveats to the users are recommended as solutions to certain problems.

Table 5.1 (continued)

Study/report title/group/date	Purpose/requirements of data	Conclusions and recommendations
Capacity of Petroleum Refineries System (Form 6-1334-A), *Validation of the Capacity of Petroleum Refineries System*, Evaluation Research Corporation (February 1979)	To collect and publish statistical data measuring the current sustainable capacity of the significant facilities of all refineries located in the United States and Puerto Rico. Data are collected to support activities of assessing the domestic, regional, and local capacity to process crude oil; monitoring changes in the national and regional capability of refineries to meet the domestic demand for petroleum products; describing the composition, flexibility, and capability of major processing and storage facilities at each refinery; forecasting capacities available (assuming current trends in operating conditions); and anticipating capacity additions about to become available.	Consistent with other studies, proper caveats to avoid misuse of data and redesign of the form are necessary. This study warned users of serious problems with certain published data, including overestimation of published capacity estimates. The study indicated that the System Administrator of the Division of Oil and Gas and Gas Statistics should investigate respondent reporting practices to CPRS as well as another reporting system. Also the study developed and proposed a new form in response to findings indicating that the form failed to provide enough information on the configuration and capacity of modern refineries and that the form contributed to a misunderstanding of reporting requirements. These recommendations have heavily influenced the form redesign efforts, which are currently nearing completion and promise to incorporate many of the modifications recommended by the study. A revalidation of this system was recommended after introduction of major improvements.

[a]Acronyms used: TERA, Transportation and Economic Research Associates; EIA, Energy Information Administration; OEIV, Office of Energy Information Validation of EIA; DOE, Department of Energy; DCOE, Domestic Crude Oil Entitlements; SDNGS, Supply and Disposition of Natural Gas System; ORAU, Oak Ridge Associated Universities; BOM, Bureau of Mines; ERA, Economic Regulatory Administration; JPRS, Joint Petroleum Reporting System; OGIS, Oil and Gas Information System; FECPR, Federal Energy Conservation Performance Report; IEEIP, Industrial Energy Efficiency Improvement Program; VBECP, Voluntary Business Energy Conservation Program; ORNL, Oak Ridge National Laboratory; FERC, Federal Energy Regulatory Commission; CPRS, Capacity of Petroleum Refineries System.

Table 5.2. Comparison of first purchase and Domestic Crude Oil Entitlements (DCOE) data[a]

[m^3/d (bbl/d)]

	1977	1978	1979	1980
Old oil	−30,300 (−190,600)	−34,400 (−248,000)	−34,000 (−214,000)	−42,000 (−264,100)
New oil	7,000 (44,000)	5,300 (33,600)	−4,110 (−25,900)	−33,300 (−209,400)
Stripper well oil	−2,300 (−14,200)	−2,200 (−13,700)	32,000 (205,700)	84,400 (530,800)
Other domestic	−43,000 (−272,600)	−8,500 (−53,600)	−9,200 (−57,800)	−18,800 (−118,000)
Total domestic	−70,500 (−433,100)	−44,800 (−281,900)	−14,800 (−92,900)	−9,700 (−60,700)

[a]Entries are DCOE data minus first purchaser (ERA-182) data, which records the volumes of crude oil the first purchaser receives each month. Negative volumes indicate that crude disappeared; positive volumes indicate that crude appeared.

Enforcement has found miscertification by resellers.[10] As of April 1981, ERA had completed audits for the period prior to 1979 of 96 of 400 crude oil resellers it had identified. Their investigation showed that prior to the entitlements program enaction, the quantity of oil misrepresented per day averaged approximately 1100 m^3 (7500 bbl). After the entitlements program was begun, this average was found to be 4300 m^3/d (27,000 bbl/d).

The second basic type of study conducted at ORNL is that of a review of information requirements (Table 5.3). This type of study is for the determination of information needs by DOE and the ability of a respondent industry to meet those needs. Currently ORNL is conducting an information requirements review of industrial energy consumption for EIA. This study, while still in its early stages, has already shown that many information requirements of DOE cannot be met by industry because the information is not available or considered to be proprietary. Corporate data and especially plant-level data are considered sensitive because in a competitive market details of plant operation can make a critical difference in profitability and ultimate survival. The study has also shown that energy data systems within the federal government have not clearly categorized industry for placement into the standard industrial codes (SIC), which are normally used to identify industries by types.

The principal in-house activity of the Data Methods Group is statistics research applicable to EIA programs. This research includes reviewing and testing available statistical techniques and adapting them to the data assessment studies. ORNL also develops new techniques as needed and recommends appropriate statistical techniques for specific studies. Fiscal year 1981 saw the beginning of coalescing automatic data editing, statistical outlier detection, and preliminary data screening techniques into a collection of relatively general software components. These techniques and

10. The figures are based upon DOE Enforcement documents issued as of Apr. 30, 1981, against 61 resellers.

Table 5.3. Summary of findings from requirements reviews[a]

Report title/group/date	Purpose	Conclusions and recommendations
A Review of Requirements for Natural Gas Data, ORAU (December 1980)	To determine DOE requirements for information on natural gas and to compare these requirements with the existing data collection systems. Additionally, the task will use the knowledge of requirements to recommend a framework for conducting future validation studies on specific DOE natural gas data systems. The study is focused on three areas: (1) the physical flow of natural gas from production through distribution, (2) the legally mandated requirements for natural gas data, and (3) the users of natural gas information within DOE. Specifically excluded are the areas of natural gas exploration and end-use, the forms which primarily gather other fuel data, and the data needs of FERC. These topics are to be covered in other studies.	The existing natural gas data collection system is not unified or comprehensive. Definitions vary among forms so it is difficult to link data collected by separate efforts. For the same reason, a number of similar data elements are collected by separate forms although little exact duplication exists. Most of the required data types are collected. The major omissions are wellhead prices, monthly state consumption, and LNG storage. Data user services need improvement. Users are confronted with poor documentation, long publication lags, and limited access to nonprint media.
A Review of Requirements for Petroleum Imports Information, OEIV, EIA, DOE, ORNL, Evaluation Research Corporation (March 1981)	To determine information requirements on the importation of crude oil and petroleum products. The report is to also aid development in the NOIRS. Petroleum importation is viewed as an integrated process that begins when agreements are made for the acquisition of foreign petroleum and ends only when foreign identity is no longer distinguishable. Five major stages are important to DOE: contract, loading, in-transit, landing, and disposition.	Consistent definition of the terms, shipments, and geographic coverage involved in data collection is needed to reduce duplication in and increase utility of existing collection systems. Timeliness of the release of data is an important user concern that is not being well met. Presently, respondents are allowed "continuous updating." With no final accounting required, the data base is in constant flux. Users are reluctant to rely on ever-changing data.
A Review of Data Requirements for Fuel Substitution Policy Implementation and Analysis, Evaluation Research Corporation (June 1981)	To assess the data required to support four functional areas: (1) fuels conversion policy implementation, (2) emergency fuel-switching policy implementation, (3) fuels conversion policy analysis, and (4) emergency fuel-switching policy analysis. The study was limited in scope to fuel-burning electric utilities and fuel-burning manufacturing firms and the combustion-related equipment, material, land, and information resources of those two types of fuel burners. Only DOE user requirements were considered.	Two sets of data items to be collected are presented. Set A would collect annually a profile of each fuel burner and its planned use. Set B would collect an additional group of data items on fuel storage, fuel stocks, fuel costs, and substitution studies.

Table 5.3 (continued)

Report title/group/date	Purpose	Conclusions and recommendations
DOE Information Requirements for Crude Oil and Other Refinery Feedstocks, Evaluation Research Corporation (December 1979)	To identify the information needed regarding petroleum feedstock supply and consumption, to evaluate the ability of present petroleum information systems to meet those needs, and to recommend system enhancements that would improve the quality of petroleum feedstock data. Feedstock flow from point of foreign acquisition or domestic production to consumption at domestic refineries was included. All activities in which feedstocks are produced/acquired, held-handled, or disposed/consumed were considered within the scope of the review	The present system of stand-alone data collection activites has a number of problems including incomplete coverage, unknown accuracy, inconsistent formats, incompatible definitions, dissimilar measurements, and data redundancy. An integrated collection system based on an inventory balance structure is proposed to alleviate these problems. Additionally, costs and respondent burden may be reduced with a consolidated effort.
Petroleum Products Systems Evaluation Task Force Revised Report, EIA (December 1979)	To identify and review DOE requirements for information on the petroleum products industry; to review EIA's existing petroleum product data collection systems; and to recommend an improved framework for meeting such information requirements. Collection systems or forms primarily concerned with natural gas processing were excluded.	Although current surveys appear to satisfy the specific legal mandates of each act, they do not do so in a timely and consistent manner. The sampling frames are outdated and do not have update procedures. In particular, the surveys do not track products through the industry distribution system. To solve these problems, a comprehensive petroleum product information system is proposed.
Requirements Analysis for the Energy Emergency Management Information System, Logistics Management Institute (December 1978)	To determine the user requirements of an energy emergency management information system in terms of its capabilities, services, and data output. This report additionally presents a framework for evaluating (1) designs of an EEMIS and (2) the priorities of its implementation.	Current data collection activities do not cover all areas of anticipated need. State-specific, timely data are largely unavailable. Greater state/EEMIS interaction and cooperation will be required to standardize terminology and procedures for collecting, processing, and retrieving data to provide the capability of forecasting, monitoring, and managing of emergencies.
A Review of Requirements for Coal Production Data, MAXIMA Corp. (June 1981)	To examine the primary information sources of coal production data, the primary uses and requirements for data from these sources, and the rationale for determining to what degree each requirement should be satisfied by EIA. Coal production data are defined here to include both information on the physical processes of production (i.e., extraction from the seam) and on the organizational and economic factors directly affecting such activities.	None of the current 12 relevant federal survey systems fully meet the needs of any of the clustered data sets. However, seven of the individual requirements are met by existing systems. The remaining requirements could be satisfied by modification of three forms and establishment of a mining method survey.

Table 5.3 (continued)

Report title/group/date	Purpose	Conclusions and recommendations
Validation of Information Requirements for Commercial Sector Energy Consumption, BDM Corp. (August 1980)	To provide a baseline of commercial sector energy consumption information requirements for use by OEIV in validating the commercial sector energy data system.	The commercial energy data system should incorporate a number of different collection strategies (i.e., periodic surveys, case studies, etc.) to acquire the variety of data and detail required. However, the principal collection strategy should focus on nonresidential and apartment *buildings* with establishment data collected as possible.
A Review of Requirements for Information on Energy Consumption in the Residential Sector, OEIV, EIA, DOE (April 1980)	To determine DOE requirements for information on energy consumption by the residential sector. In particular, the review is directed toward offices that collect or propose to collect such data, and specifically the Residential Energy Consumption Survey. Emphasis was placed on identifying data needed to understand and predict energy consumption within the housing unit. Transportation energy consumption associated with the residential sector was excluded because the uses and users of information on transportation were presumed to be distinct from those concerned with housing. Similarly, a review of data needed for the monitoring and evaluation of specific DOE consumption-oriented regulatory or conservation programs (i.e., natural gas curtailment) was beyond the scope of this effort.	Current data sources do not meet these needs because critical data items have either not been collected at all or have not been collected in needed combinations. The EIA's Residential Consumption Survey program will collect many of the consumption-related data items. Nevertheless, this program may be improved by collecting a more complete and balanced set of information. The largest improvements can be achieved by: • renewing efforts to find a usable method to measure air infiltration in residences; • renewing efforts to obtain the year of manufacture, capacity, and eventually, the efficiency of the major appliances; • utilizing this program as the first-stage screener for any future surveys similar to the Consumer Products Survey (Form CS-159) so that joint analysis of the two data sets can be performed; • obtaining a history of the availability of natural gas hookups from the covered utilities; and • renewing efforts to obtain measures of appliance utilization for space heating, air conditioning, and water heating. Successful implementation of these recommendations for the Residential Consumption Survey program should enable it to provide the most essential data for each type of analysis.

Table 5.3 (continued)

Report title/group/date	Purpose	Conclusions and recommendations
Identification of State Energy Data Needs, ORAU (July 1980)	To identify the energy-related data needs of seventeen southern states and two territories. Identification of data requirements is an essential first step in the exploration of methods of federal and state government cooperation leading to better energy data for both levels of government. The study focused on the energy office, public service commission, geological survey, revenue or tax office, and the environmental control agency of each state or territory. This report is part of a more comprehensive effort on southern states' energy data.	The major deficiencies with published federal data frequently mentioned are slow release and aggregate scales. This report did not attempt to make conclusions and recommendations. That area will be covered in another segment of the project.

[a]Acronyms used: DOE, Department of Energy; ORAU, Oak Ridge Associated Universities; OEIV, Office of Energy Information Validation; ORNL, Oak Ridge National Laboratory; FERC, Federal Energy Regulatory Commission; NOIRS, National Oil Imports Reporting System; LNG, liquified natural gas; EEMI, Energy Emergency Management Information System.

associated software represent a powerful inventory of analytical methods to assess data quality. This research resulted in several automatic data editing breakthroughs.[11-19]

Among these advances were an efficient error algorithm for discrete data, a statistical analysis of error localization and imputation procedures, a detailed analysis and upgrading of the Chernikova algorithm, extension of Fourier-Motzkin techniques for the determination of an objective function for error localization, and the preliminary development of a row-generation algorithm for error localization of continuous data. Tests conducted at ORNL showed that the efficient discrete data localization algorithm appears to handle data bases an order of magnitude larger than previous algorithms could handle. The practical significance of this improvement is that this error localization method can now begin to be applied to existing energy data bases, whereas previously it was simply an appealing concept. This result has direct application to those energy data bases now under study at ORNL and on-line at EIA. Aside from demonstrating error localization applications to actual energy data bases and the development of new automatic data editing algorithms, ORNL also conducted tests to determine the performance and usefulness of the developed outlier software with empirical data. The results of the test seem to suggest that among the univariate tests, the extreme Studentized deviate and coefficient of kurtosis were the most effective at locating outliers (with no appreciable increase of false positives, that is, observations suggested to be outliers which were not), and that among the bivariate tests, the adjusted discriminate function and discriminate function were rated first and second, respectively.

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11. G. E. Liepins and D. J. Pack, "Prior Probabilities, Maximal Posterior and Minimal Field Error Localization," *Proceedings of the Computer Sciences and Statistics Thirteenth Symposium on the Interface*, Springer-Verlag, New York, 1981.

12. G. E. Liepins and R. Garfinkel, "Optimal Imputation of Erroneous Data: A Survey," *Optimization in Statistics 1981*, The Institute for Management Sciences, accepted September 1981.

13. G. E. Liepins, "Towards the Quantitative Assessment of Energy Data," *Proceedings of the Third International Conference on Energy Use Management*, Pergamon Press, New York, 1981.

14. G. E. Liepins and D. J. Pack, "An Integrated Approach to Automatic Data Editing," *Proceedings of the American Statistical Association*, Survey Research Methods Section, Detroit, Mich., Aug. 10, 1980.

15. Ref. 11.

16. H. J. Tsao, "On the Risk Performance of Bayes Empirical Bayes Procedures for Classification Between $N(-1, 1)$ and $N(1, 1)$," *Statistica Neerlandica* 34, 197–208 (December 1980).

17. H. J. Tsao, "On the Risk Performance of Bayes Procedures in the Finite State Component Case," Ph.D. Thesis, Michigan State University (December 1980).

18. H. J. Tsao and T. Wright, contribution to the coal section of *Accuracy of Energy Information Administration Data Related to Volumes of Petroleum, Natural Gas, and Coal: An Assessment of the Accuracy of Principal Data Series of the Energy Information Administration*, U.S. Department of Energy, EIA, 1981.

19. H. J. Tsao, "On the Risk Performance of Bayes Empirical Bayes Procedures in the Finite State Component Case," presented at the Annual Meeting of the American Statistical Association, Detroit, Mich., Aug. 10, 1981.

5.3 EVALUATION OF ENERGY CONSERVATION PROGRAMS

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5.3.1 Introduction

The Evaluation Group works on research projects related to the following issues:

1. historical trends and patterns in U.S. energy use (i.e., what changes occurred and why did they occur),
2. role of government and utility conservation programs in improving energy efficiency (i.e., are these programs effective and are they cost-effective),
3. management and use of disaggregate energy consumption data to better address issues 1 and 2.

During FY 1981, the group worked on several projects related to these areas, briefly described below.

5.3.2 Energy End-Use Data

We continued a project (begun in FY 1980) to examine and analyze data collected for the federal Institutional Conservation Program (ICP). The Preliminary Energy Audit (PEA) phase of the ICP involves collection of basic data on energy consumption and related characteristics from institutional buildings (schools, hospitals, local government buildings, and public care institutions). We first reviewed the data management procedures in each state; in brief, we found many deficiencies in the ways that state energy offices designed their data collection forms, validated the data they received, and used the PEA data.[25]

We then obtained PEA data from ten different states; the data include information on almost 15,000 institutional buildings across the United States. We developed a common structure to apply to the data obtained from each state and developed outlier detection tests (both engineering and statistical), which were used to delete outliers we thought were errors. This yielded a clean data base containing information on all these buildings in a machine-readable format.[26]

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20. Group leader.
21. Regional and Urban Studies Section, Energy Division.
22. Computer Sciences Division.
23. Efficiency and Renewables Research Section, Energy Division.
24. Economic Analysis Section, Energy Division.
25. J. L. Blue et al., *State Energy Office Data Management: The Preliminary Energy Audit of the Institutional Buildings Grants Program*, ORNL/CON-55 (October 1980).
26. E. Hirst, J. Carney, and P. Knight, *Energy Use at Institutional Buildings: Disaggregate Data and Data Management Issues*, ORNL/CON-73 (June 1981).

Finally, we developed regression equations for each building type, using this clean PEA data. These equations provide statistically meaningful evidence concerning the effects of various factors (such as fuel prices, floor area, climate, occupancy, and building type) on institutional building energy use.[27]

In a related project, we worked with staff at the Oak Ridge Associated Universities (ORAU) to organize data they had collected during energy audits at 48 hospitals. In brief, the average hospital had a potential energy saving of 20% with an average payback period of one year.[28]

Based on our experience with the PEA data and the ORAU energy audit data, we prepared a report suggesting generic improvements in the way that state and federal agencies collect, organize, and use disaggregate energy consumption data.[29] We also published a 1980 version of *A Pocket Reference of Energy Facts and Figures*.[30] We analyzed data collected by the EIA from 4000 households in terms of energy use and retrofit actions.[31] Finally, Science Applications, Inc. (under subcontract to ORNL), analyzed home energy audit data collected by the Wisconsin Power and Light Company; a final report will be published during FY 1982.[32]

5.3.3 Evaluation of Government and Utility Conservation Programs

We reviewed utility evaluations of their home energy audit programs with respect to both the evaluation methodologies used and the evaluation results.[33] This study was helpful to DOE in developing a plan for evaluation of the federal Residential Conservation Service.

We developed a primer on evaluation of conservation programs. The primer was intended for evaluation practitioners and for program managers (who are users of evaluation results); it will be useful for personnel working on either government or utility conservation programs.[34]

We provided assistance to several divisions in DOE's Office of Conservation and Renewable Energy in preparation of the DOE Sunset Report. This report, which must be submitted to Congress in January 1982, is intended to document the past performance of each DOE program and its likely future accomplishments.

We completed two studies that examine recent trends in U.S. energy use and the role of increased energy efficiency on these trends. One study used the ORNL energy end-use models to

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27. E. Hirst, J. Trimble, and R. Goeltz, *Analysis of Energy Use at U.S. Institutional Buildings*, ORNL/CON-78 (November 1981).

28. E. Hirst et al., *Analysis of Energy Audits at 48 Hospitals*, ORNL/CON-77 (July 1981).

29. J. L. Blue and E. Hirst, *Disaggregate Energy Consumption Data: Federal/State Cooperation*, ORNL/CON-72 (May 1981).

30. J. Blue and J. Arehart, *A Pocket Reference of Energy Facts and Figures*, Oak Ridge National Laboratory (December 1980).

31. E. Hirst, R. Goeltz, and J. Carney, *Residential Energy Use and Conservation Actions: Analysis of Disaggregate Household Data*, ORNL/CON-68 (March 1981).

32. S. Grady, *Analysis of the Results of the Wisconsin Power and Light Home Survey and Audit Program*, Science Applications, Inc. (to be published).

33. L. Berry et al., *Review of Evaluations of Utility Home Energy Audit Programs*, ORNL/CON-58 (March 1981).

34. E. J. Soderstrom et al., *Evaluation of Conservation Programs: A Primer*, ORNL/CON-76 (July 1981).

analyze historical trends by sector.[35] The other examined the need for and the role of federal conservation programs and their effectiveness.[36,37]

Our analysis of historical trends included development of simple econometric models of national energy use as functions of gross national product (GNP), average energy price, and time.[35] These models were used to project energy use from 1973 to 1980 under three sets of assumptions:

1. Real GNP grows at its 1960–1973 rate (4.2%/year), and real energy prices remain at their 1973 levels.
2. The GNP follows its actual path, and energy prices remain at their 1973 levels.
3. Both GNP and energy prices follow their actual paths.

These three projections and the values of actual energy use are shown in Fig. 5.1. Relative to historical trends (i.e., a business-as-usual projection), energy use in 1980 was reduced by 20 EJ.

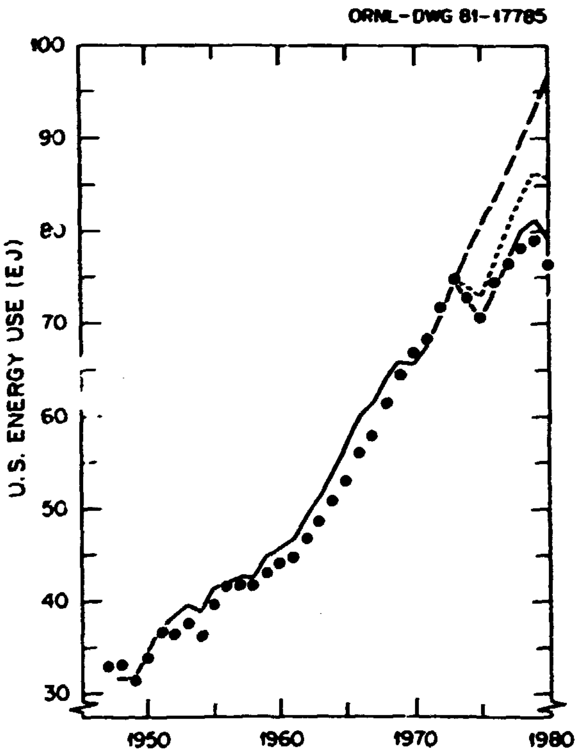

Fig. 5.1. U.S. energy use, 1947–1980. The top projection (dashed line) assumes that the gross national product grows during the 1973–1980 period at its 1960–1973 rate (4.2%/year) and that real fuel prices remain constant at their 1973 values. The middle projection (dotted line) assumes that the gross national product follows its actual path and that fuel prices are constant. The bottom projection (solid line) assumes that both the gross national product and fuel prices follow their actual paths during the 1973–1980 period. The dots are actual energy use.

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35. E. Hirst et al., *Energy Use from 1973 to 1980: The Role of Improved Energy Efficiency*, ORNL/CON-79 (December 1981).

36. E. Hirst et al., *Improving Energy Efficiency: The Effectiveness of Government Action*, Oak Ridge National Laboratory informal report (April 1981).

37. E. Hirst, W. Fulkerson, and R. Carlsmith, "The Role of Government Action in Improving Buildings Energy Efficiency," *ASHRAE J.* 23(6): 25–28 (June 1981).

Half of this difference was due to slower growth in GNP between 1973 and 1980 (i.e., the difference between the top two projections). About 80% of the remaining 10 EJ was due to changes in energy prices (the difference between the bottom two projections). Finally, about 2 EJ (the difference between the bottom projection and actual energy use) was due to other factors not included in these simple models. These other factors include errors in the models and data, structural changes in the economy, and the effects of government and utility energy conservation programs. Additional work in FY 1982 is exploring these changes in more detail, with particular emphasis on the role of federal conservation programs.

During the last quarter of FY 1981, we began several projects that will be completed during FY 1982. These include

1. evaluation of the federal State Energy Conservation Program,
2. evaluation of the federal Energy-Related Inventions Program,
3. development of an evaluation plan for the Bonneville Power Administration residential conservation programs, and
4. assistance to Electric Power Research Institute (EPRI) on evaluation of utility conservation programs.

5.4 BUILDINGS AND INDUSTRIAL ENERGY DEMAND ANALYSIS GROUP

R. W. Barnes[38]

S. M. Cohn D. B. Reister[39]
D. M. Hamblin T. A. Vineyard
G. R. Hadder

5.4.1 Overview of 1981 Activities

During FY 1981, work was peformed by this group for six principal offices of DOE. These offices are listed below, together with the major activities accomplished for each.

1. Office of Energy Use Analysis, EIA. Journal article on the Oak Ridge Industrial Model (ORIM).[40] Updated drafts of the ORIM documentation.[41] Improvements to the ORNL residential model.[42]
2. Office of Coal Utilization, Fossil Energy (FE). Survey of industrial attitudes toward coal use. Data base characterizing the industrial steam market.[43]

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38. Group leader.

39. On loan from Institute of Energy Analysis.

40. R. Barnes et al., *The Oak Ridge Industrial Model (ORIM) — A Component of the Midterm Energy Forecasting System (MEFS)*, draft report (September 1981).

41. D. Reister et al., *The Oak Ridge Industrial Model Volumes I, II, and III*, ORNL/CON-56 (forthcoming).

42. D. Hamblin and T. Vineyard, "COMMENT: An Evaluation of the ORNL Residential Energy Use Model," draft report (October 1981).

43. G. Hadder, "Industrial Boilers: Population Characterization and Investment Factors," draft working paper (December 1981).

3. Office of Policy Planning and Evaluation, Conservation and Renewable Energy (CE). Solar/conservation baseline projection.[44] Natural gas price deregulation study.[45] Cost performance report on residential solar heating.[46]
4. Office of Buildings and Community Systems, CE. Constrained optimization model of residential energy demand. Reestimation of residential model parameters.[42] Tax credit analyses for heat pump water heater.[47]
5. Office of Technology Assessments Environment (EV), now called Office of Environment Planning of Enviromental Protection, Safety and Emergency Preparedness (EPSEP). Study of the impact of the energy and enviromental legislation on the petroleum and chemical industries.[48,49]
6. Office of Data Standards, EIA. Industrial energy consumption data requirements study (technical assistance to the study contractor).

Funding was cut off midway through 1981 for much of the CE work. This resulted in cessation of the integrated buildings energy conservation forecasting system that was being developed for the Systems Analysis Division of Buildings and Community Systems.

There was a substantial change in emphasis in 1981 on the market analysis for coal technologies sponsored by the Office of Coal Utilization. In prior years, we had been developing a computer model to estimate the market penetration. The emphasis in 1981 was shifted to interviews and subjective estimates together with development of a data base describing the characteristics of the industrial steam boiler population.

Also in 1980–1981, a number of reviews of our ORNL residential sector models were made by outside agencies. In response to these reviews and to our own interests, intensive effort was concentrated on correcting the primary shortcomings identified in the model.

In summary, during 1981 there were two major thrusts to our work. One was improving our capabilities for energy demand analysis by improving our data bases and the algorithms used within our models. The other major effort was in developing fuel demand analyses reflecting the changes in perspective within the administration and in DOE relative to expectations for future energy prices and to the continuation of various conservation programs.

In the two following subsections, results from three of our 1981 activities are highlighted.

5.4.2 Industrial Sector

As part of a continuing effort to evaluate the market penetration potential of future, industrial coal-using options, two information systems were established in 1981. The first system of direct data characterizes the industrial boiler population. The second system of corollary data contains

44. R. Barnes et al., *Projection of Energy Use in the U.S. Economy, 1980–2000, Reference Case, 1981* ORNL/TM-8245 (forthcoming).

45. R. Carlsmith, ORNL, communication to M. Savitz, DOE, "Effect of Higher Prices on Conservation Program Impacts," April 1981.

46. F. Zehr et al., *The Performance and Economics of Residential Solar Space Heating*, ORNL/CON-70 (forthcoming).

47. S. Cohn et al., *A Commercial Energy Use Model for the Ten U.S. Federal Regions*, ORNL/CON-40 (March 1981).

48. D. Phung and R. Barnes, "The Petroleum Refining Industries in the 1980's: Impact of the National Energy Plan and Related Legislation," *Mater. Soc.* 5(4), (1981).

49. D. Nguyen and R. Barnes, *Impacts of Recent Energy and Environmental Legislation on the U.S. Chemical Industry*, draft report.

subjective opinions from 50 industrial representatives on factors that influence boiler investment and serve as the driving force for change in the boiler population.

Relative to mid-1981, we found that the dominant opinions and concerns of industry representatives included the following.

1. Investments in energy systems are constrained by limited capital availability and by competition for capital from nonenergy projects.
2. There is interest in advanced coal-burning technologies, particularly Fluidized Bed Combustion (FBC). However, FBC is not considered to have been adequately demonstrated.
3. Energy conservation and waste heat reuse programs are decreasing plant steam requirements. As a result, investment in new boiler installations will be postponed or reduced. This subjective opinion is confirmed by direct data on industrial (SIC categories 20–39) boiler sales (Fig. 5.2). After a precipitous sales drop from 28.0×10^6 kg/h in 1974 to 12.7×10^6 kg/h in 1975, annual sales have continued to decline at an average rate of approximately 1.6×10^6 kg/h.
4. New boiler systems will be multiple-fuel-fired to mitigate the consequences of shortages of a single fuel.
5. Uncertainty about environmental regulations will constrain investment in coal-burning systems.
6. Few existing non-coal-fired boilers will be converted to coal use.
7. An increasing fraction of new boilers will be coal fired.
8. In general, federal involvement in energy-related enterprises is unwelcome. There is, however, strong support for federal participation in the advancement of coal-burning technology.

A significant coal utilization issue is identification of opportunities and mechanisms for consumption of abundant coal resources in lieu of scarcer fuels. Our direct and corollary data systems will provide a foundation for estimation of the market penetration potential of those technologies that support the substitution of coal for other fuels in industrial markets.

5.4.3 Buildings Sector

Solar heating cost performance study

The performance and economics of residential solar space heating were analyzed for 17 cities in the United States. Specifically, the active systems evaluated consisted of air and liquid flat plate collectors with single- and double-pane glazing. The passive systems include Trombe wall, water wall, direct gain, and sunspace systems. Water heating is included with the active systems because most of the equipment needed for solar water heating is integral with the space heating systems. However, the passive solar systems do not lend themselves readily to heating water.

The solar systems analyzed were applied to an average-sized, single-family house designed to meet the thermal integrity requirements of the Department of Housing and Urban Development Minimum Property Standards. Simple payback, discounted payback, and discounted 20-year life cycle costs were computed for each combination of system type, collector (or glazing) area, backup fuel, and city. The auxiliary heating systems are sized to match peak heating requirements. Therefore, the installed costs of the conventional and auxiliary systems are equivalent. Life-cycle-costs scenarios were constructed using federal and state income tax credits, financing charges, a range of discount rates (0, 2, 6, and 10%), and two separate estimations of fuel escalation rates.

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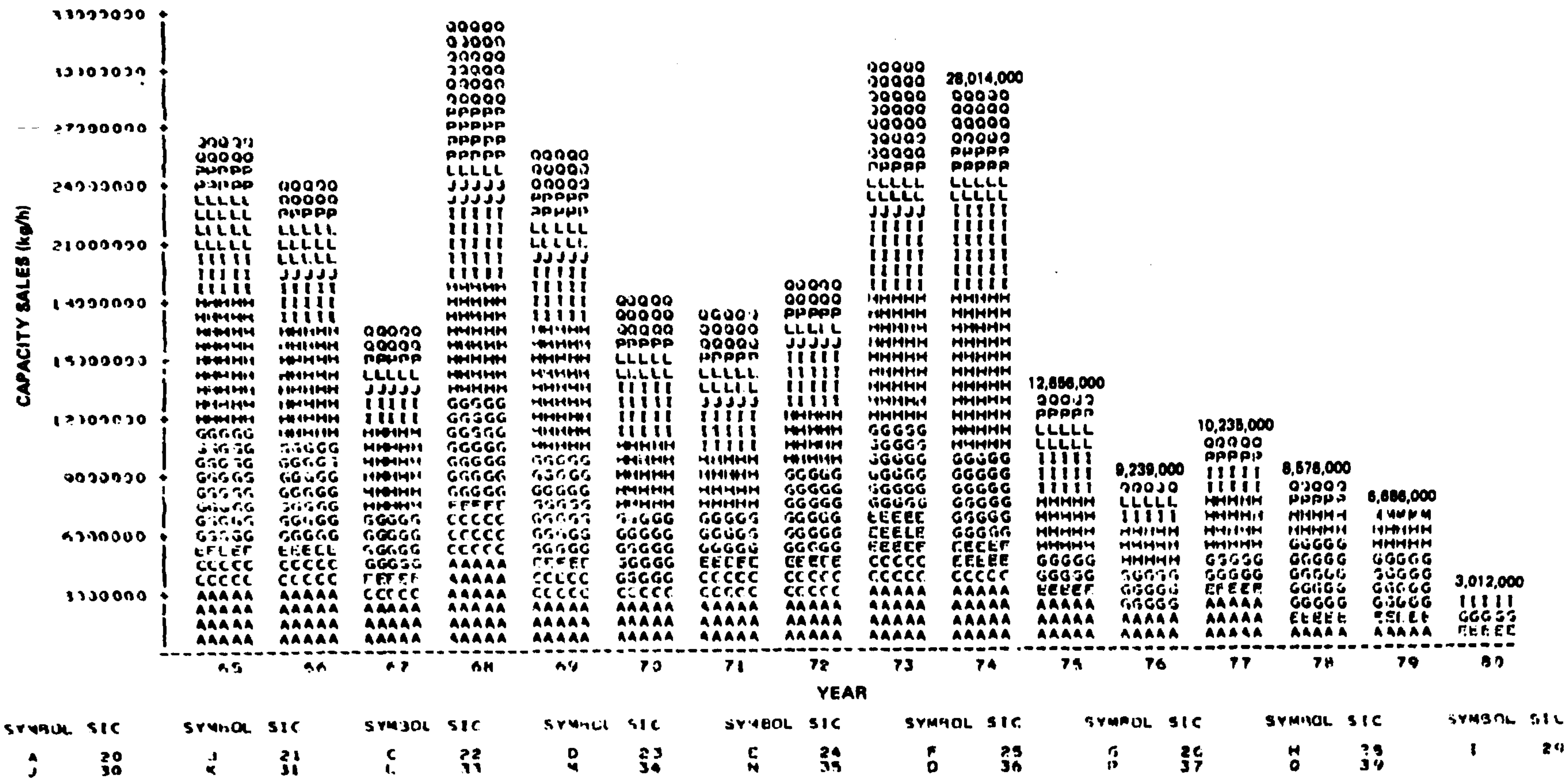


Fig. 5.2. Industrial boiler capacity sales by SIC category. Source: American Boiler Manufacturers Association Data: 1965 1977; Federal Survey Data: 1978–1981.

Figure 5.3 presents the cost-performance data for the four collector types and six collector areas in each of three cities representing a broad range of heating loads. The performance curves for water wall, Trombe wall, and direct gain systems for various collector glazing areas are presented in Fig. 5.4. In the passive solar cases, water wall systems perform as well as or better than other systems. In contrast, Trombe walls with night insulation demonstrate the poorest performance.

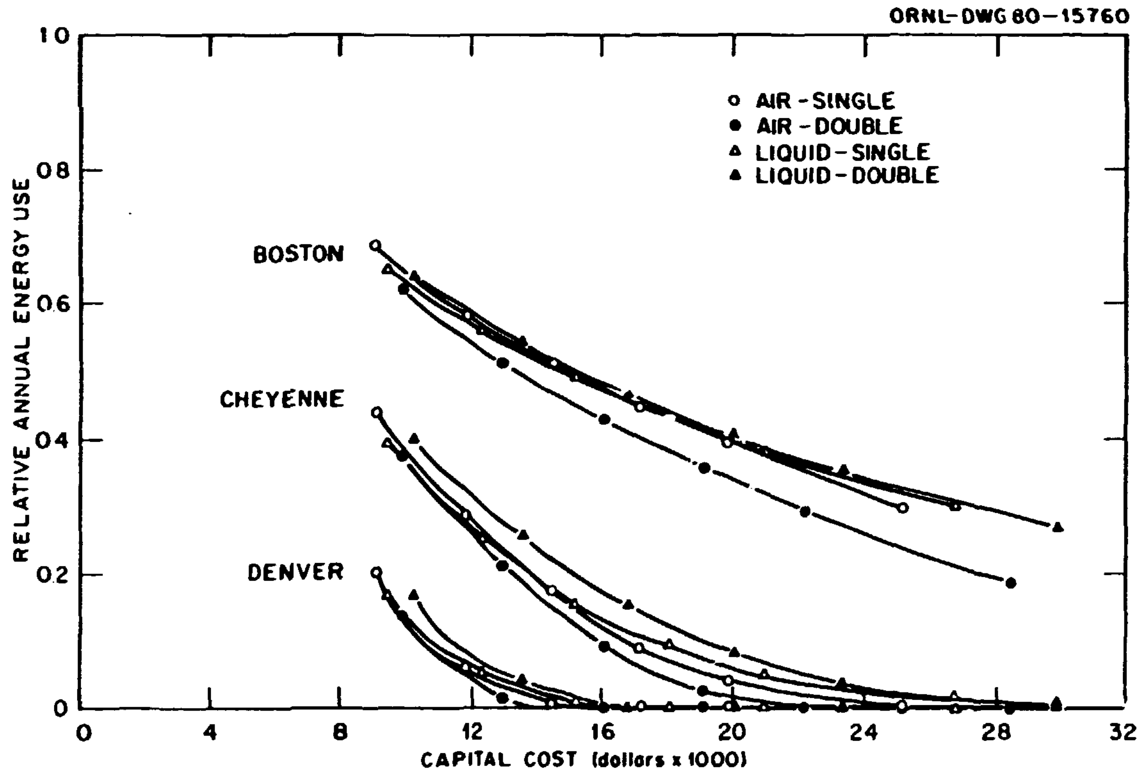


Fig. 5.3. Fraction of conventional heating energy required vs solar system capital cost for active systems. Note: "Relative annual energy use" refers to the fraction of purchased energy needed as a backup for the solar system relative to the purchased energy for a conventional system supplying the full heating load. The terms "air" and "liquid" refer to a system with fluid flowing through the collectors. The terms "single" or "double" refer to the number of glazing plates over the collector aperture.

Table 5.4 gives a comparison of discounted payback periods for a common type of active solar heating system with electricity backup. The values in parentheses include currently available tax credits. With natural gas or fuel oil as the backup fuel, longer payback periods occur. Note that payback periods of less than 20 years occur infrequently. Similarly, Table 5.5 presents discounted payback periods for a Trombe wall (passive) system with electricity backup. The first line for each city pertains to systems with night insulation, while the second line relates to systems without night insulation. The values in parentheses include federal and state tax credits. Boston, Denver, New York, and Philadelphia exhibit payback periods near 20 years or less. Essentially, we find that very high solar insolation levels or very high electricity rates are required to have acceptable payback periods even with tax credits.

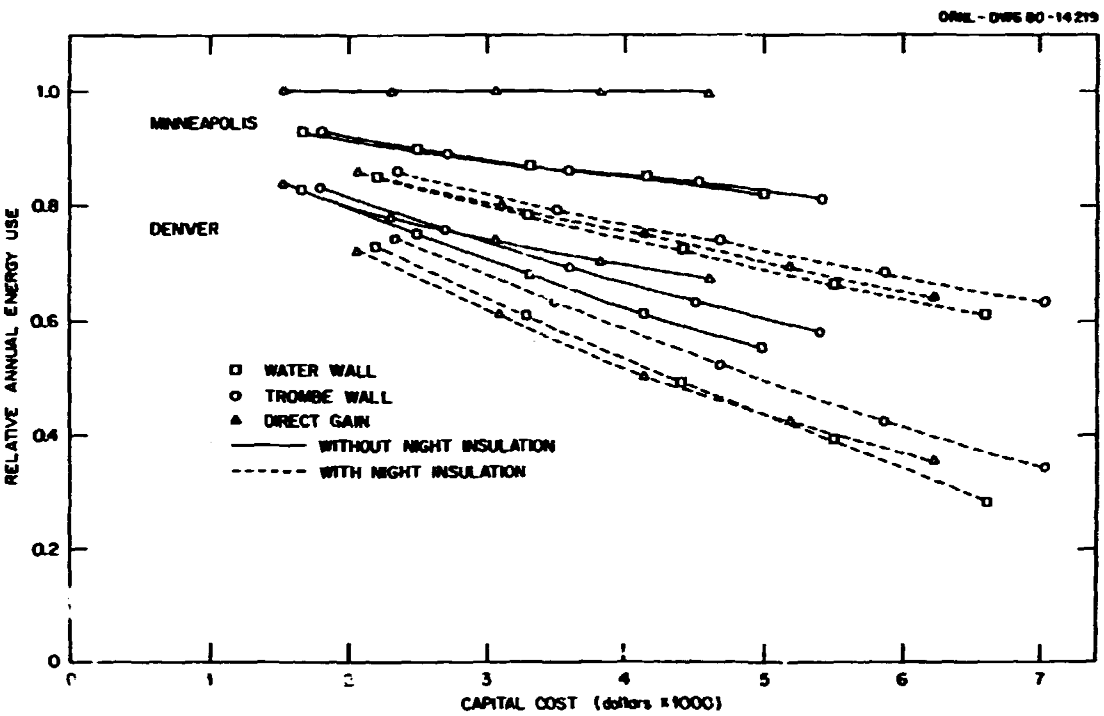


Fig. 5.4. Fraction of conventional heating energy required vs passive solar system capital cost. Note: "Relative annual energy use" refers to the fraction of purchased energy needed as a backup for the solar system relative to the purchased energy for a conventional system supplying the full heating load.

Table 5.4. Discounted payback periods (years)[a] for liquid single-glazed active solar systems with electricity backup for discount rates of 10 to 0% and for collector areas of 20 and 40 m^2

	10%		6%		2%		0%	
	20 m^2	40 m^2	20 m^2	40 m^2	20 m^2	40 m^2	20 m^2	40 m
Minneapolis			(49)		53 (22)	60 (37)	36 (18)	40 (28)
Cheyenne					48 (28)	60 (43)	33 (22)	39 (31)
Boston			(18)	(45)	27 (13)	31 (20)	21 (11)	24 (17)
Chicago					46 (28)	57 (43)	33 (23)	39 (31)
Seattle								
New York			(36)		33 (18)	41 (28)	25 (15)	29 (22)
Omaha					68 (36)	95 (63)	41 (27)	50 (40)
Denver	(40)		(16)	(122)	24 (12)	36 (24)	20 (11)	27 (19)
Kansas City					59 (32)	82 (55)	38 (25)	46 (36)
Philadelphia			(33)		31 (18)	38 (28)	24 (15)	28 (22)
Washington					50 (29)	65 (47)	34 (23)	41 (33)
Atlanta					45 (28)	64 (48)	33 (23)	42 (35)
Knoxville					64 (40)	88 (68)	42 (30)	53 (45)
Dallas			(35)		31 (20)	43 (24)	24 (17)	32 (27)
Phoenix			(26)		33 (16)	63 (42)	25 (14)	41 (31)
San Diego					58 (25)	118 (63)	38 (21)	60 (42)
Miami					69 (44)	125 (97)	45 ([illegible])	67 (58)

[a]Blanks indicate nonconverging payback periods. Items enclosed in parentheses are payback periods with tax credits considered.

Table 5.5. Discounted payback periods[a] for Trombe wall with electricity backup for discount rates of 10 to 0% and for collector areas of 10 and 30 m^2

	10%		6%		2%		0%	
	10 m^2	30 m^2	10 m^2	30 m^2	10 m^2	30 m^2	10 m^2	30 m^2
Minneapolis[b]			(45.3)	(83.6)	34.7 (20.9)	40.2 (24.2)	26.3 (17.4)	29.4 (19.7)
					57.6 (38.3)	64.9 (43.2)	38.3 (28.4)	41.5 (31.2)
Cheyenne					42.1 (33.0)	47.5 (37.1)	29.9 (24.9)	32.6 (27.3)
					55.0 (46.5)	65.0 (54.7)	36.1 (32.2)	40.2 (36.0)
Boston			35.4 (11.8)	66.0 (21.5)	18.5 (9.2)	21.9 (14.1)	15.4 (8.4)	17.9 (12.3)
			86.9 (17.3)	(46.1)	22.7 (12.3)	30.8 (20.2)	18.4 (10.9)	23.6 (16.8)
Chicago					37.1 (20.8)	43.3 (34.8)	27.6 (23.3)	31.1 (26.3)
					47.3 (40.9)	61.6 (53.3)	33.2 (29.8)	40.1 (36.3)
Seattle					141.4 (113.3)	171.7 (137.0)	67.3 (60.0)	74.6 (67.0)
					158.6 (136.6)	235.9 (200.8)	71.6 (66.6)	86.6 (81.3)
New York					29.1 (22.4)	32.5 (24.9)	22.2 (18.1)	24.2 (19.7)
					49.9 (40.8)	49.8 (40.8)	32.5 (28.5)	32.5 (28.5)
Omaha					9.7 (38.0)	63.8 (48.1)	31.1 (27.5)	38.9 (32.5)
Denver			(12.8)	(45.2)	25.3 (9.9)	31.1 (20.2)	20.2 (8.9)	23.8 (16.8)
			(13.5)		31.0 (10.2)	39.6 (26.4)	23.7 (9.3)	28.6 (21.0)
Kansas City					44.0 (33.8)	55.3 (42.0)	30.5 (25.2)	35.5 (29.6)
					61.2 (50.7)	85.7 (69.5)	37.9 (33.6)	46.0 (41.0)
Philadelphia			88.7 (35.7)	(56.5)	23.4 (18.7)	27.4 (21.8)	19.0 (15.7)	21.6 (18.0)
					33.3 (28.6)	37.0 (31.8)	25.2 (22.4)	27.4 (24.3)
Washington					48.0 (37.9)	55.8 (44.0)	31.1 (27.0)	38.9 (33.4)
					65.0 (55.3)	77.5 (65.8)	40.6 (36.7)	45.6 (41.2)
Atlanta					46.2 (37.2)	58.4 (47.2)	32.8 (27.0)	38.9 (33.4)
					54.5 (47.3)	69.1 (60.1)	37.0 (33.4)	43.7 (39.8)
Knoxville					54.0 (43.6)	72.3 (58.5)	36.8 (31.5)	45.1 (30.1)
					63.9 (55.5)	87.0 (75.8)	41.4 (37.6)	51.0 (46.7)
Dallas			(68.1)		30.9 (25.6)	41.6 (34.8)	24.5 (20.9)	31.2 (27.0)
					34.2 (30.2)	44.3 (39.4)	26.6 (24.0)	32.8 (29.9)
Phoenix			(42.6)		46.4 (20.1)	100.3 (95.9)	32.5 (16.8)	67.5 (52.7)
			(62.3)		45.4 (22.4)	117.9 (75.1)	34.8 (18.4)	58.1 (45.2)
San Diego					116.0 (47.3)	917.7 (132.8)	57.6 (33.3)	95.8 (65.1)
					118.1 (48.0)	341.[illegible] (105.6)	58.1 (33.7)	87.0 (57.0)
Miami								
					280.9 (242.1)		96.5 (91.4)	

[a]Blanks indicate noncoverging payback periods. Items enclosed in parentheses are payback periods with tax credits considered.
[b]The first line of entries indicates values for systems with night insulation; the second indicates values [illegible]stems without night insulation.

Residential sector model improvement

During the past two years, the ORNL residential energy demand model has been formally reviewed by individuals such as Daniel McFadden;[50] John Herbert;[51] David Freedman, Thomas Rothenburg, and Richard Sutch;[52] and Robert Weatherwax.[53] These critiques have been commissioned by EPRI, EIA, and the National Bureau of Standards. In addition, comments about the model's strengths and weaknesses are being received from various model users and DOE sponsors.

The primary criticisms communicated through the formalized model evaluation process involve aggregation bias, which includes the lack of a housing vintage structure, out-of-date documentation, and insufficient validation. In addition, no feedback loop from energy prices and policies to housing numbers and size, double translation of usage and fuel-and-equipment-switching elasticities, and lack of usage consideration in life cycle cost optimization are considered weaknesses in the model. An additional criticism expressed by the model practitioners and DOE sponsors concerns improving the technology curves.

Most of the issues raised in the formalized critiques and the concerns of the model users and DOE sponsors have been previously recognized by ORNL, and corrections in many of these areas of weaknesses are already under way or completed. For example, the conversion procedures employed to implement fuel-and-equipment-switching simulations were examined and inconsistencies have been eliminated. Likewise, the interest rates employed in fuel-and-equipment switching have been corrected.

A major revision to the model is the joint determination of space-conditioning equipment, water-heating equipment, and thermal efficiency of the housing structure. Simultaneous optimization provides the opportunity to discern shadow prices associated with energy policies that can be characterized as constraints. For example, building energy performance standards (which do or do not permit trade-offs among the shell, space conditioning, and water heating) can be considered directly in the constrained (simultaneous) optimization framework.

Finally, the model structure has been expanded to accommodate an expected fuel price escalation factor in the present worth calculations. An average price escalation factor is computed from the vector of forecast fuel prices input into the model. Other areas in which the model has been improved include associating housing-size–growth-induced increases in equipment capacity with concomitant increases in equipment price, considering usage in efficiency choice, and the elimination of duplicative lags in life cycle cost optimum efficiency choices.

The revised ORNL building sector models have been employed to analyze impacts of the ASHRAE 90A-1980 Standard for building construction.[54] The work was done on a regional basis for EIA, appropriate for analyzing conservation innovations in commercial and multifamily build-

50. D. McFadden, *An Evaluation of the ORNL Residential Energy Demand Model*, Massachusetts Institute of Technology, Energy Laboratory Report, MIT-EL-81-021 (April 1981).

51. J. Herbert, *Selected Comments on the ORNL Residential Energy-Use Model*, EIA, U.S. Department of Energy, TR/OA/80-09 (June 1980).

52. D. Freedman, T. Rothenburg, and R. Sutch, *Analysis Quality Report on Midterm Energy Demand: The Hirst-Carney Model for the Residential Sector*, advance copy, University of California, Berkeley (June 1981).

53. R. Weatherwax et al., *An Assessment of Residential Energy Consumption Data and Their Use in Forecasting Models, Volume III: Data and Models: A Comparison of the ORNL and CEC Model*, Energy and Resources Group, University of California, Berkeley (July 1981).

54. The ORNL commercial sector model also was significantly improved in 1981.

ings, and is reported in CON-82 (forthcoming). Our analysis indicates that the ASHRAE Standards are close to being optimally cost effective for current fuel prices, but they should be updated as future conditions change.

5.5 RESEARCH UTILIZATION

In addition to providing substantive assistance to each of EIA's missions and objectives as a part of that organization's program of support vis-a-vis our nation's overall energy program, the results of the research proposed here will be helpful to ORNL, other national laboratories, and of value to energy data analysts.

The products of this work include

1. data and improved data management tools,
2. analysis and analytic methods,
3. professional publications, and
4. procedures for evaluating publications.

Because of its breadth of scope (covering every aspect of energy data), the program has the potential of providing research results of at least incidental value to any analyst concerned with energy and to many analysts interested in topics other than energy but concerned with issues of data quality, data management, or the communicability of their results.

Program results to date have already been used within EIA to

1. redesign data collection efforts so that the data which EIA collects is more accurate and more useful,
2. clarify data requirements so that the data which EIA collects is more relevant and less burdensome,
3. qualify data presentations so that users of EIA data are less likely to mislead themselves,
4. establish data quality standards so that data series have a high likelihood of being reasonably accurate and useful,
5. exemplarize data quality assessment techniques so that the ORNL-developed methodologies can be generalized to broad sets and whole series of EIA data,
6. develop projections of expected future fuel consumption by end use for EIA policy studies and for their annual report to Congress,
7. provide accurate energy cost information to policymakers so that possible impacts of new legislation may be weighed prior to passage,
8. define the availabilities of specific energy data within the industries so that requests for nonexistent data are avoided, and
9. reduce respondent burden by identifying duplicative and unnecessary data systems and recommending their discontinuance.

Outside EIA our research products in the energy demand analysis area have been used to project future fuel consumption within states, service territories, and regions. ORNL energy demand models are being used by state energy offices, utilities, private consultants, and regional power planning commissions. We are currently providing consulting services (on a full cost-recovery agreement) to private commercial organizations who have contracts to install our energy demand models in regional planning and forecasting systems.

6. Efficiency and Renewables Research Section

J. W. Michel[1]

W. R. Mixon[2]

6.1 INTRODUCTION

During this year, a divisional reorganization resulted in expanding the work of this section to include the electric energy systems program, community systems and cogeneration projects, and projects related to building energy performance standards and solar photovoltaics. Progress is reported in these areas and in the other work of the section, which includes research and development (R&D) activities relative to heat pumps, appliances, the annual cycle energy system, waste heat utilization, geothermal and ocean thermal energy conversion (OTEC) power cycles, and building thermal envelope systems. Most of this work, which includes both subcontracted and in-house R&D activities, is related to energy conservation through efficiency improvements or to developing alternative energy sources.

6.2 HEAT PUMP RESEARCH AND DEVELOPMENT

F. A. Creswick R. D. Ellison P. D. Fairchild

R. C. DeVault W. A. Miller
S. K. Fischer G. T. Privon
W. L. Jackson[3] C. K. Rice
V. C. Mei

This activity provides assistance to the Department of Energy (DOE) in the management of an R&D program to improve the efficiency and reliability of heat pumps for residential and commercial service. This work is implemented by subcontracts with industry and by in-house research on advanced energy-conserving systems, associated technology projects, and supporting studies.

1. Section head.
2. Manager for X-10 groups.
3. Computer Sciences Division.

6.2.1 Heat-Actuated System Development

Two development projects on residential absorption-cycle heat pumps have been carried out through laboratory proof-of-concept experiments. One of these systems, developed by Allied Corporation[4] and Phillips Engineering Company, uses an unconventional organic-working-fluid pair: ETFE (ethyl-tetrahydro-furfuryl ether) is the absorbent and R133a (chlorotrifluoroethane) is the refrigerant. Figure 6.1 shows an early hardware design reliability test unit. Six of these units operated in Michigan throughout the 1980–1981 heating and cooling seasons. Two residential-size state of the art packaged units are being fabricated. These units have a target heating coefficient of performance (COP) of 1.25 (based on natural gas input).

ORNL-PHOTO 4863-81

Fig. 6.1. Field-trial installation of an organic working-fluid residential absorption heat pump developed by Allied Corporation and cofunded by Gas Research Institute and DOE.

The second absorption unit, a heating-only system which is being developed by Arkla Industries, Inc., utilizes ammonia and water as working fluids and employs technology used by Arkla in an existing line of residential gas-fired absorption air conditioners. Figure 6.2 gives a view of the internal components of this system. Laboratory tests of the second prototype unit achieved a heating COP of 1.25 at 8.3°C ambient temperature and 1.12 at −8.3°C. Six preproduction prototypes are being fabricated for laboratory and field evaluation and reliability testing.

4. The Allied, Garrett, and General Electric projects are cosponsored by the Gas Research Institute.

ORNL-PHOTO 4864-81

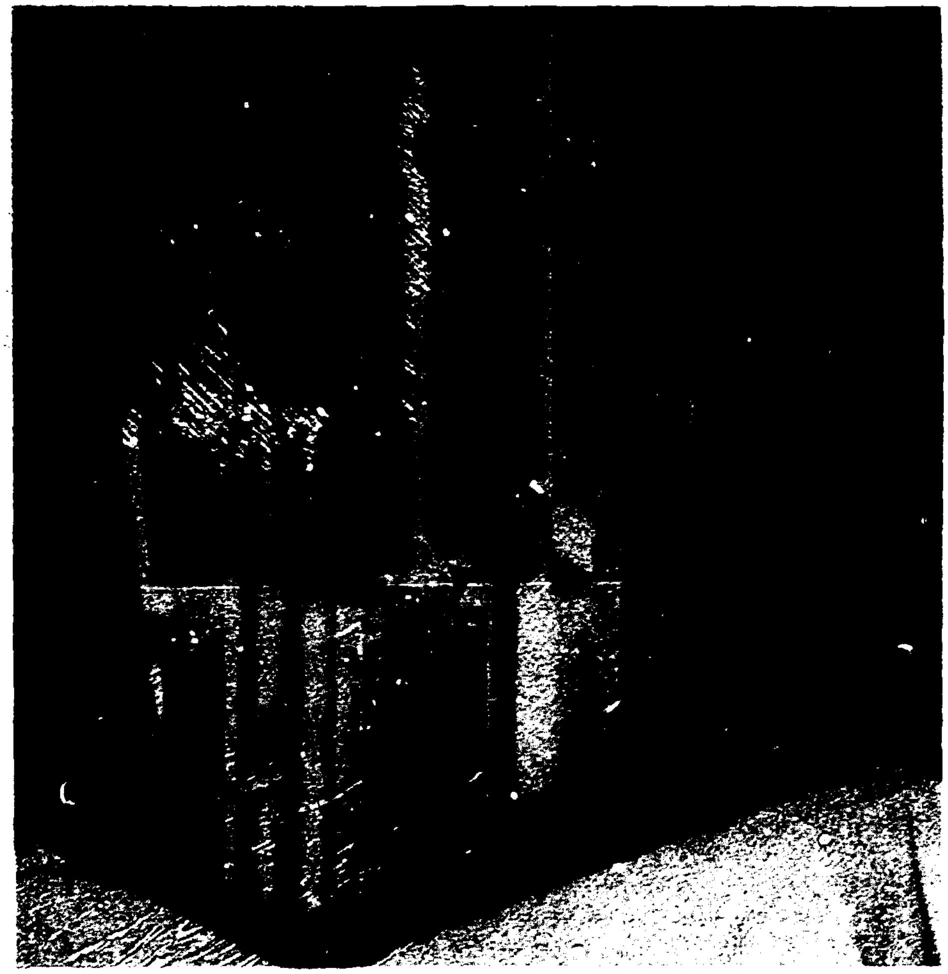


Fig. 6.2. View of the internal components of an ammonia-water residential absorption (heating only) heat pump prototype developed by Arkla Industries, Inc., under ORNL subcontract.

Other heat-actuated systems under development include a gas-turbine-driven unit by Garrett and AiResearch[4,5] (Fig. 6.3), two free-piston–Stirling-engine-driven (FPSE) devices [one by General Electric Company[4,6] and one by Consolidated Natural Gas Company with Mechanical Technology, Inc. (CNG/MTI)], and a free-piston internal combustion engine/compressor by Honeywell, Inc., with Tectonics, Inc. The efficiency targets for these systems are given in Table 6.1.

5. AiResearch Manufacturing Company, *Phase II Brayton/Rankine 10-ton Gas-Fired Space Conditioning System, First Annual Technical Report*, ORNL/Sub/80-24706/1 (to be published).

6. Advanced Energy Programs Department, General Electric Company, *Development and Demonstration of a Stirling/Rankine Heat-Activated Heat Pump*, General Electric Semiannual Report No. COO/2911-8 (July through December 1980).

ORNL-PHOTO 1058-82

Fig. 6.3. Model equipment package for an experimental 35-kW gas-turbine-engine-driven heat pump for light commercial use; system was developed by Garrett Corporation and jointly supported by Gas Research Institute.

Table 6.1. Efficiency objectives for gas-fired heat pump development projects

Unit	Heating COP at 8.3°C ambient[a]	Cooling COP at 35.0°C ambient[a]
Garrett/AiResearch gas-turbine	1.5	1.3
General Electric free-piston Stirling	1.6	0.85
CNG/MTI free-piston Stirling	1.6	1.27
Honeywell/Tectonics free-piston internal combustion engine	Proof of concept	Proof of concept

[a]Target fuel COP values are steady-state ratings (excluding parasitics) for prototype hardware.

6.2.2 Advanced Electric System Development

The advanced electric heat pump under development by Westinghouse Electric Company[7,8] uses high-efficiency fans and fan motors, a novel modulating compressor, and an optimized heat exchanger design to obtain a heating seasonal performance factor that is expected to be at least 30% higher than that of the best available, 1979 single-speed, air-to-air heat pumps, that is, a seasonal COP of 2.6 as compared to 2.0. The compressor design is based on a mechanical stroke-length-change concept that modulates capacity so as to achieve high part-load efficiency and to reduce efficiency losses caused by off-on cycling. The compressor also features improved valving, modified compressor-motor cooling, and direct utilization of reject heat from the compressor shell. These latter attributes have the effect of substantially enhancing compressor performance at low ambient temperatures (Fig. 6.4). This development has progressed through breadboard system tests.

7. S. E. Veyo, *Advanced Electric Heat Pump Component Development and Evaluation, Draft Report*, prepared for ORNL by R&D Center, Westinghouse Electric Corporation, ORNL/Sub/79-24712/2 (to be published).

8. J. C. Kastovich et al., *Advanced Electric Heat Pump Market and Business Analysis, Final Report*, prepared for ORNL by R&D Center, Westinghouse Electric Corporation, ORNL/Sub/79-24712/1 (to be published).

ORNL-DWG 82-7978

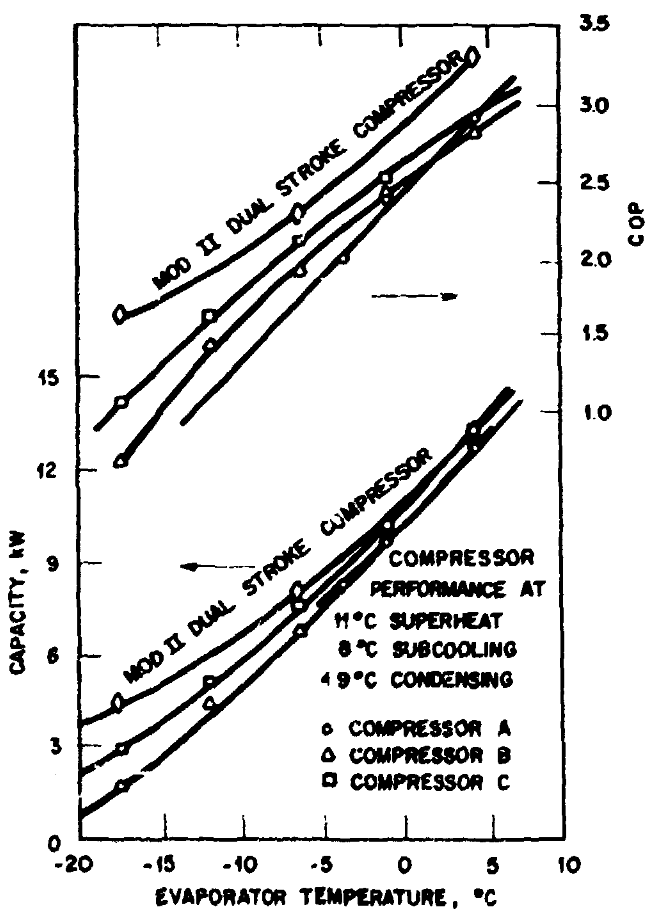


Fig. 6.4. Improvements achieved by the advanced Westinghouse compressor as compared with conventional compressors.

6.2.3 Heat Pump Technology Development

This year, we concluded work on an advanced user-oriented version of the ORNL Heat Pump Computer Model. Recent improvements include a revised treatment of heat transfer with dehumidification, shortened running time, and improved documentation. Earlier versions of this model have been distributed to a number of universities and manufacturing organizations. A heat pump design optimization study was also concluded this year in which our computer model was used as a design tool. This exercise produced some unexpected results (such as a reduction in required compressor size as system design is optimized), which indicate that a heat pump design produced by a methodical, analytical optimization procedure will generally have significantly better performance than one devised by a cut-and-try approach. Details on this mathematical method are available to equipment manufacturers.

In other tests at ORNL, we have been conducting laboratory studies on the performance of a water-source heat pump and have installed a single, vertical heat exchanger in the ground [47 m (155 ft) deep] outside our laboratory for tests using the water-source heat pump as a ground-coupled unit. Also, instrumentation is being installed for cycling-loss and frosting-loss experiments on an air-source heat pump in our environmental chamber.

6.3 ANNUAL CYCLE ENERGY SYSTEM (ACES)

R. E. Minturn[9]

L. A. Abbatiello E. A. Nephew
V. D. Baxter C. A. Sady[10]
J. L. Bledsoe[10]

The experimental work in the ACES program was confined to obtaining additional operating experience on the full ACES, to validating some parameters used to size the radiant/convector panels for minimum ACES installations, and to evaluating a specially designed outdoor air fan coil as an alternative to the radiant/convector panel as a means of collecting or dissipating energy during operation of ACES' several modes. The analytical work reported last year,[11] comparing performance and economics of a number of different heating, ventilating, and air conditioning (HVAC) systems in 115 U.S. cities, was updated[12] to reflect more recent cost information and was extended to include three fossil-fueled systems. A number of utilities and utility organizations were presented with illustrated lectures indicating the value of ACES as an electric load management tool.

Data on the field performance of a high-efficiency, air-to-air heat pump was retrieved from the ACES program data file and used to prepare a report comparing steady-state performance to performance under field conditions.[13] It was found that not only is field performance significantly less

9. Department of Energy National Annual Cycle Energy System program manager.

10. Computer Sciences Division.

11. W. Fulkerson et al., *Energy Division Annual Progress Report for Period Ending September 30, 1980*, ORNL-5740 (November 1981).

12. E. A. Nephew et al., *Performance and Economics of Eight Alternative Residential Heating and Air Conditioning Systems in 115 U.S. Cities*, ORNL/CON-85 (in press).

13. V. D. Baxter et al., "Comparison of Field Performance to Steady-State Performance for Two Dealer-Installed Air-to-Air Heat Pumps," *ASHRAE Trans.* **88**(2) (to be published).

efficient than steady-state performance because of frosting, defrosting, and duty cycling losses but that the absolute efficiency of an air-to-air heat pump in the heating mode may be lower in mild climates than in more severe climates because of increased losses from duty cycling (Fig. 6.5).

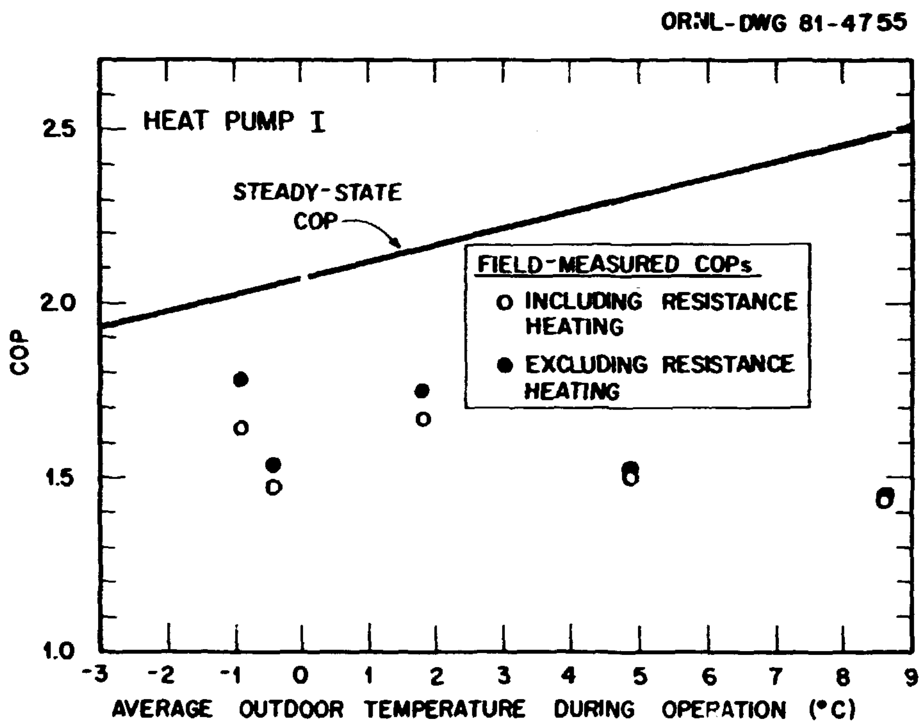


Fig. 6.5. Steady-state (line) and field-measured (points) coefficients of performance (COP) as functions of average outdoor temperature during operation of a middle-of-the-line air-to-air heat pump.

6.4 RESIDENTIAL AND COMMERCIAL APPLIANCES PROGRAM MANAGEMENT[14]

V. O. Haynes

W. L. Cooper, Jr. W. P. Levins
K. E. Heidenreich E. A. Vineyard

During the year, we continued to assist DOE in implementing a national research, development, and demonstration (RD&D) plan[15] to improve the energy efficiency of residential and commercial appliances by contracting and monitoring the progress of hardware projects and analysis and information activities related to consumer products. As part of this activity, in-house RD&D projects are planned and implemented. Table 6.2 shows the variety of appliances and components being investigated.

14. Heat pumps, central space-conditioning equipment, building materials, controls, lighting, and windows are excluded.

15. U.S. Department of Energy, *Technology and Consumer Products Branch Program Plan*, March 1980.

Table 6.2. Residential and commercial appliance projects

Project/subcontractor	Sector	Accomplishments
Heat pump water heater Energy Utilization Systems, Inc. MOR-FLO Industries, Inc.	Residential	Units use about half the energy of a resistance water heater
Refrigerator-freezer Arthur D. Little, Inc. Amana Refrigeration, Inc.	Residential	0.51-m^3 (18-ft^3) refrigerator, tested with 2.04-kWh/d consumption
Motor-compressor Kelvinator Compressor Company	Residential	0.51-m^3 (18-ft^3) refrigerator, tested with 2.9-kWh/d consumption
Gas-fired water heater Advanced Mechanical Technology, Inc. AMTROL, Inc.	Residential	Achieved a 67% service efficiency
Gas-fired water heater Shock Hydrodynamics, Inc. American Appliance Manufacturing Corp.	Commercial	Pulse-combustion unit being developed
Oven Purdue University	Residential	Cooks with 1/4 to 1/2 the energy of a conventional oven
Supermarket equipment Foster-Miller Associates, Inc. Friedrich Air Conditioning and Refrigeration Company	Commercial	Research on a multiple-size, parallel compressor system
Mixed refrigerants University of Illinois	Residential or commercial	Potential energy savings of about 12% estimated for refrigerator-freezers
Insulation Arthur D. Little, Inc.	Residential or commercial	Scoped the opportunities and economics for several applications

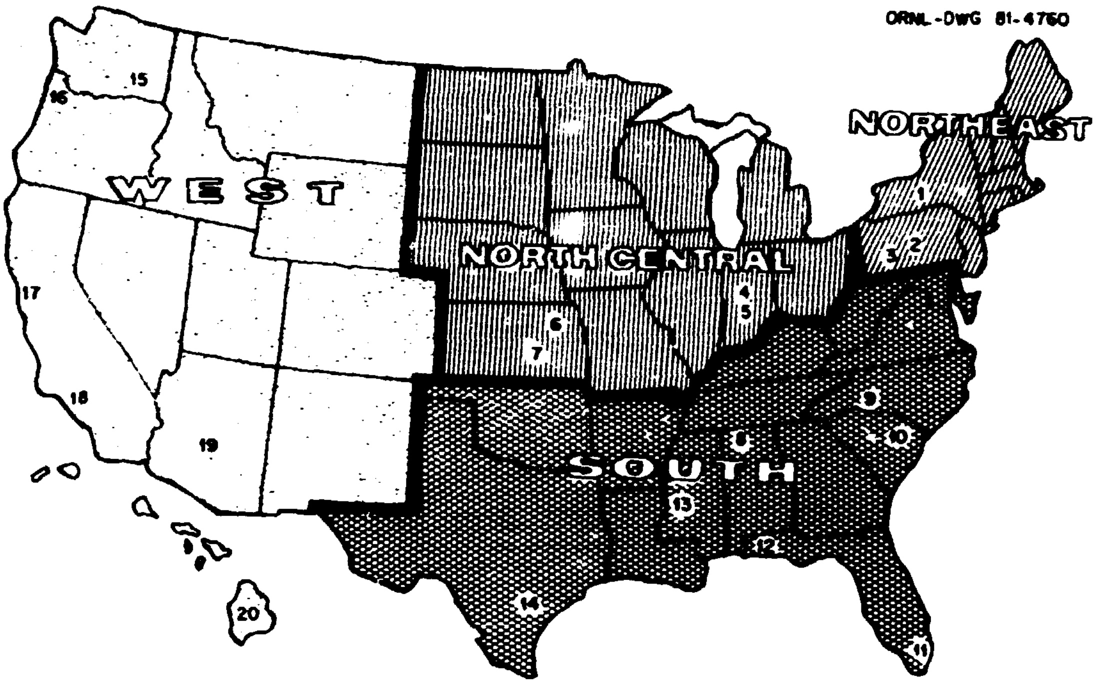
Tests to evaluate the performance of heat pump water heaters under field service were completed.[16] The tests were conducted with the assistance of 20 utilities encompassing a wide variety of climates (Fig. 6.6) and locations in houses, that is, basements, utility rooms, breezeways, and garages. The field tests indicated that these heat pump water heaters can provide hot water with about half the energy a resistance water heater would require.

Two series of tests to evaluate the performance of improved refrigerator-freezers under field service were initiated. One series is an extension of research which increased the energy efficiency by improvements in the refrigeration system and cabinet features.[17] The reference energy consumption of the 0.51-m^3 (18-ft^3) model, obtained using the DOE test procedures, is 2.04 kWh/d. In the other series, the reduced consumption is achieved by use of a better compressor.[18] These compressors reduce the refrigerator energy consumption of the 0.51-m^3 (18-ft^3) model from 3.5 to 2.9 kWh/d (17%) and of the 0.59-m^3 (21-ft^3) model from 3.7 to 3.1 kWh/d (16%).

16. Robert P. Blevins, Barry D. Sloane, and Gary E. Valli, *Demonstration of a Heat Pump Water Heater, Volume 2, Final Report*, prepared for ORNL by Energy Utilization Systems, Inc., ORNL/Sub-7321/4 (June 1981).

17. W. David Lee, *Development of a High-Efficiency Automatic Defrosting Refrigerator-Freezer*, 2 vols., prepared for ORNL by Arthur D. Little, Inc., ORNL/Sub-7255/1 and ORNL/Sub-7255/2 (February 1980).

18. Richard T. Nelson and Parker W. MacCarthy, *Research and Development of Energy-Efficient Appliance Motor-Compressors*, 3 vols., prepared for ORNL by Columbus Products Company, ORNL/Sub-7229/1 (September 1980), ORNL/Sub-7229/2 (December 1980), and ORNL/Sub-7229/3 (September 1980).



REGION		UTILITY	STATE
NORTHEAST	1	NEW YORK STATE ELECTRIC AND GAS	NY
	2	VALLEY RURAL ELECTRIC CO-OP	PA
	3	SOMERSET RURAL ELECTRIC CO-OP	[illegible]
NORTHCENTRAL	4	INDIANAPOLIS POWER AND LIGHT	IN
	5	PUBLIC SERVICE OF INDIANA	IN
	6	KANSAS ELECTRIC COOPERATIVES	KS
	7	KANSAS GAS AND ELECTRIC	KS
SOUTH	8	TENNESSEE VALLEY AUTHORITY	AL
	9	DUKE POWER COMPANY	NC
	10	SOUTH CAROLINA ELECTRIC AND GAS COMPANY	SC
	11	FLORIDA POWER AND LIGHT	FL
	12	GULF POWER COMPANY	FL
	13	MISSISSIPPI POWER AND LIGHT	MS
	14	GUADALUPE VALLEY ELECTRIC CO-OP	TX
WEST	15	BONNEVILLE POWER ADMINISTRATION	WA
	16	PORTLAND GENERAL ELECTRIC	OR
	17	PACIFIC GAS AND ELECTRIC	CA
	18	SOUTHERN CALIFORNIA EDISON COMPANY	CA
	18	ARIZONA POWER SERVICE	AZ
	20	HAWAIIAN ELECTRIC COMPANY	HI

Fig. 6.6. Map showing utility locations for testing the Energy Utilization Systems, Inc. (EUS), heat pump water heater.

Other projects are in progress on high-back-pressure compressors (e.g., used in refrigerated vending machines); bi-radiant ovens; residential and commercial gas-fired water heaters;[19] refrigeration systems for supermarkets; use of mixtures of refrigerants; and advanced insulation for appliances.[20]

19. Andrew D. Vasilakis et al., *Research and Development of a High-Efficiency Gas-Fired Water Heater*, 2 vols., prepared for ORNL by Advanced Mechanical Technology, Inc., ORNL/Sub-7381/1 and ORNL/Sub-7381/2 (May 1980 and January 1980).

20. W. Thompson Lawrence and Frank E. Ruccia, *Development of Advanced Insulation for Appliances, Task 1*, prepared for ORNL by Arthur D. Little, Inc., ORNL/Sub-81/13800/1 (June 1981).

A conference on waste heat recovery from HVAC and refrigeration systems was sponsored in conjunction with several interested organizations.[21]

In-house work continued to gather data on performance of various heat pump water heaters and to establish a base for investigation of improved refrigerator-freezers. A report was also published concerning the effect of forced ventilation on air infiltration into houses.[22] This correlation is shown in Fig. 6.7.

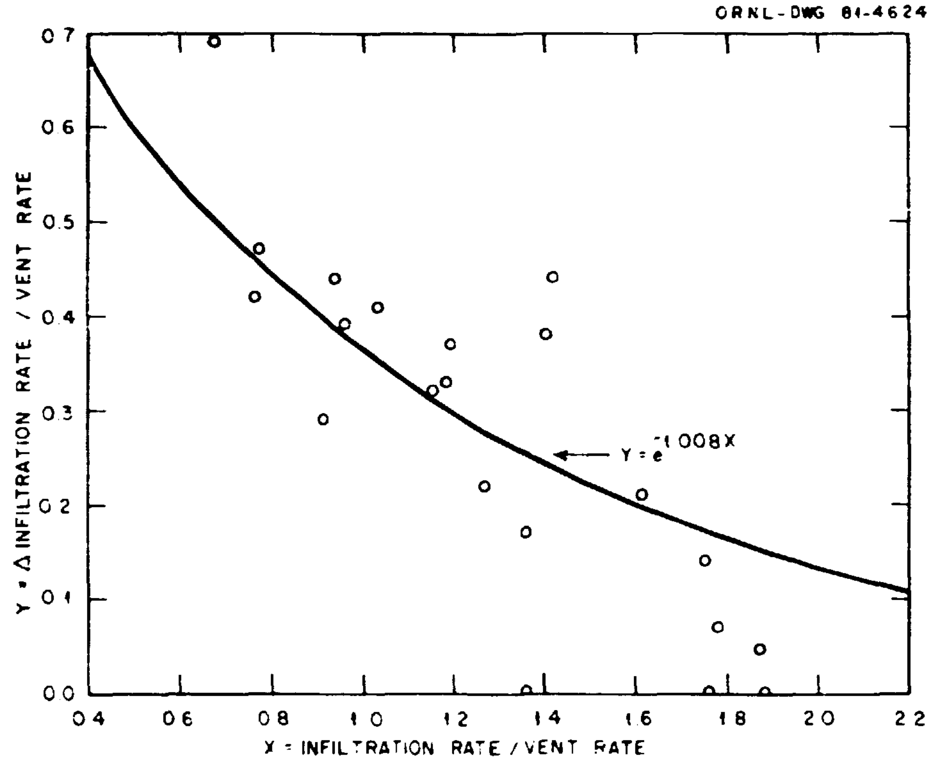


Fig. 6.7. Effect of vented dryer on infiltration rate.

21. *P...edings of the Conference on Waste Heat Recovery for nergy Conservation — Residential and Light Commercial Heat Pumps, Air Conditioning, and Refrigeration Systems*, prepared for ORNL by Purdue University, C NF-800966 (Sept. 15 17, 1980).

22. W. P. Levin', *Effect of Forced Ventilation on House Infiltration*, ORNL/CON-75 (August 1981).

6.5 LOW-TEMPERATURE-HEAT UTILIZATION

H. G. Arnold[23]

N. Domingo[24] R. W. Murphy[24]
G. Grossman[25] H. Perez-Blanco
W. R. Huntley[24] R. C. Robertson
G. H. Llewellyn[26]

6.5.1 Low-Grade-Heat Recovery

The purpose of this project is to develop conversion technology for recovering heat at temperatures below 90°C. The principal accomplishments for 1981 were the completion of feasibility studies and preliminary designs of two industrial heat pumps and two heat-actuated chillers by subcontractors and the cycle analysis, test loop verification, and preliminary design of an absorption heat pump by ORNL staff. One of the chillers (a lithium bromide absorption unit) was built and successfully tested at the subcontractor's installation,[27] and the remaining chiller will be built as detailed designs are finalized in FY 1982.[28] It was determined that the industrial heat pumps, using vapor compression of 60°C water, would not be economical in sizes smaller than 3 kg/s but that potentially economic applications for such equipment are abundant in industry.[29,30] Table 6.3 summarizes the status of subcontracts at the end of 1981.

The ORNL-designed absorption heat pump will be built and tested in 1982 as a proof of concept for advanced absorption cycle configurations suitable for boosting 60°C water to steam temperatures in excess of 120°C.[31] An experimental loop for determining heat and mass transfer coefficients in desorption processes was constructed and began operation in 1981. Initial results are consistent with the computer models for open desorption that were also developed for this project.[32]

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23. Group leader.
24. Engineering Technology Division.
25. On temporary assignment from Technion, Israel Institute of Technology, Haifa, Israel.
26. Engineering Division.
27. Battelle Columbus Laboratories, *Final Report, Compound Absorption Cooling with Low Grade Heat*, Subcontract 7805 (in publication).
28. Foster-Miller Associates, Inc., *Final Report, Design, Test and Demonstration of an Integrated Thermally Activated, Low Temperature, Waste Heat Utilization Chiller System*, Subcontract 41X-28906C (in publication).
29. Mechanical Technology, Inc., *A Theoretical Evaluation of Liquid Injection Cooling of the Rotating Gas in Centrifugal Compressors*, ORNL/Sub-79/24713/1 and ORNL/Sub-79/24713/2 (February 1981).
30. General Electric Company, *Open Cycle Heat Pumps for Industrial Waste Heat Utilization*, Subcontract 86X-24717C (in publication).
31. H. Perez-Blanco and G. Grossman, *Cycle and Performance Analysis of Absorption Heat Pumps for Waste Heat Utilization*, ORNL/TM-7852 (September 1981).
32. H. Perez-Blanco, *Heat Pump Concepts for Industrial Use of Waste Heat*, ORNL/TM-7655 (May 1981).

Table 6.3. Status of subcontracts in low-grade-heat recovery project

Subcontractor	Description of activity	Status
Battelle Columbus Laboratories	Absorption chiller using low-grade heat as energy source (90 kJ/s)	Testing complete: design performance met; final report in publication
Mechanical Technology, Inc.	Open-cycle vapor compression heat pump to produce process steam from low-grade heat	Phases 1 and 2 feasibility studies published; task completed
General Electric Co.	Open-cycle vapor compression heat pump to produce process steam from low-grade heat	Phase 1 feasibility in publication; negotiations in progress to continue; equipment size to be determined
Foster-Miller Associates	Waste-heat-actuated, expander-driven refrigeration cycle (35 kJ/s)	Phase 2 report in publication; construction and test in progress

6.5.2 Geothermal Energy

This geothermal energy project has been involved in a long-term research effort aimed at improving the effectiveness of power plant heat rejection equipment. The major component of this research is the experimental and analytical evaluation of various condenser tube enhancement techniques that might ultimately reduce the size and otherwise improve the performance of geothermal power plant heat dissipation systems. This work was maintained at a laboratory-scale, single-tube level for several years, until appropriate condenser tube surface geometries were determined for the halocarbon and fluorocarbon binary cycle fluids.[33]

This work formed the basis for the design of two condensers that were fabricated and installed in prototype power systems at the Raft River, Idaho [60 kW(e)], and East Mesa, California [500 kW(e)], test sites. The tests at Raft River confirmed the predicted performance and showed that as much as a 40% reduction in condenser costs could be realized. Testing at East Mesa is in progress.

In addition, a task was begun to survey the state of the art in condensers and cooling towers and to select advanced concepts that are suitable for use in the next generation of binary power plants, especially those using binary fluid mixtures. This work will result in a spectrum of advanced heat rejection options to be evaluated in detail for site-specific, advanced plant concepts to be prepared by the Idaho National Engineering Laboratory.

A major accomplishment during 1981 was the completion of an evaluation of water availability and cooling water requirements as a possible constraint to geothermal development.[34] The study concluded that, while it is not possible to forecast such constraints with accuracy due to the legal structure surrounding water rights, water availability is a major factor, if not a constraint, in developing the full potential of a geothermal resource.

33. N. Domingo, *Condensation of Refrigerant-11 on the Outside of Vertical Enhanced Tubes*, ORNL/TM-7797 (August 1981).

34. R. C. Robertson et al., *Water-Related Constraints to the Development of Geothermal Electric Generating Stations*, ORNL/TM-7718 (June 1981).

6.6 POWER SYSTEMS TECHNOLOGY PROGRAM

T. W. Reddoch[35]

R. K. Adams[36]	S. R. Greene[38]	R. C. Muller[36]
P. R. Barnes	W. T. Jewell	M. O. Pace[41]
R. B. Biggs[37]	J. W. Klein	W. P. Poore[38]
H. I. Bowers[38]	M. A. Kuliasha[38]	S. L. Purucker[38]
C. R. Brinkman[39]	J. S. Lawler[40]	D. T. Rizy
W. L. Bryan[36]	F. W. Manning[35]	R. W. Rochelle[40]
G. L. Campen	B. W. McConnell	J. P. Stovall
G. S. Canright[36]	H. McCoy[39]	F. W. Symonds[40]
P. A. Gnadt[38]	J. M. McIntyre[36]	

During FY 1981, activities involving electric utility systems were expanded from the original program in load management to include new source technology integration studies and power delivery technology development. The enlarged collection of activities embraced much of the power system technology needed for the future of the electric utility industry. The program has five major functional categories: technology development, measurements and materials, transmission and distribution, generation planning and operations, and automation and information processing. The program is a blend of in-house studies and subcontracts involving private industry and universities as needed to solve future, complex electric problems. The Energy Division has lead responsibility for the program; however, key roles have been assigned to the Engineering Technology, Engineering, Health and Safety Research, Instrumentation and Controls, and Metals and Ceramics divisions. This report only summarizes the activities for which the Energy Division is directly responsible. A summary of responsibilities and activities for each division is shown in Table 6.4.

A major part of the program is concerned with end-use technologies, including research on distribution automation, customer-side thermal energy storage, and the system integration of dispersed generation sources such as photovoltaic devices or wind machines. Distribution automation involves the use of communication and control between the utility and the distribution network and between the utility and end-use devices in order to use equipment capacity more effectively by reduction in peak demands and to reduce the power losses in lines and transformers by distributing the power flows through the system using a real-time control system. Planning and implementation continues on a large-scale distribution automation and load management experiment to be conducted on the Athens Utilities Board system at Athens, Tennessee, in cooperation with the Tennessee Valley

35. Program manager.
36. Instrumentation and Controls Division.
37. Engineering Division.
38. Engineering Technology Division.
39. Metals and Ceramics Division.
40. University of Tennessee.
41. Health and Safety Research Division.

Table 6.4. Responsibilities of ORNL research divisions in the Power Systems Technology Program

Division	Fundamental categories	Activities
Energy	• Overall program management • Automation and information • Generation planning and operations • Transmission and distribution	HVDC[a] system studies; distribution system design and protection with automation and dispersed storage and generation; load management; harmonics analysis; and wind-turbine-array dynamic interactions
Engineering	• Technology development • Transmission and distribution	High-voltage equipment and HVDC systems
Engineering Technology	• Generation planning and operations • Technology development • Transmission and distribution	High-efficiency motors and large power transformers; reactor cores; ac and dc circuit interruption techniques; high-voltage transmission; load management; generation expansion planning; and generation reliability
Instrumentation and Controls	• Automation and information • Measurements and materials	Low-loss core steel measurements; communication systems for load management; direct load control methods; metal oxide varistor development; and harmonics measurements
Health and Safety Research	• Measurements and materials	Gaseous dielectrics and toxicity of various gases
Metals and Ceramics	• Measurements and materials • Technology development	Solid dielectric materials and large power transformers

[a]HVDC = high-voltage direct current.

Authority (TVA), which will test these concepts.[42–44] A concept plan for the experiment is shown in Fig. 6.8. Research studies are in progress to determine the planning and design considerations associated with distribution systems having automation and control capabilities.[45] Furthermore, a study of the distribution system requirements is in progress to ascertain the design and protection needs for both the accommodation and optimal integration of dispersed generation into electric utility systems.[46] Resolving personnel safety issues and general electric system protection needs is the key for integrating new dispersed systems.

For several years, an important aspect of the program has been the tests that were designed to determine the value of customer-side thermal energy storage systems for load management applications. Heat storage systems were placed in five electric utility systems: Long Island Lighting Company, Niagara Mohawk Power Corporation, Public Service Electric and Gas Company, United

42. W. Fulkerson et al., *Energy Division Annual Progress Report for Period Ending September 30, 1977*, ORNL-5364 (April 1978).

43. W. Fulkerson et al., *Energy Division Annual Progress Report for Period Ending September 30 1979*, ORNL-5638 (June 1980).

44. W. Fulkerson et al., *Energy Division Annual Progress Report for Period Ending September 30, 1980*, ORNL-5740 (November 1981).

45. "Electric Distribution System Planning and Design with Dispersed Storage and Generation (DSG) and Distribution Automation and Control (DAC)," Request for Proposal No. DEDS-19-01, Sept. 4, 1980.

46. D. T. Rizy and T. W. Reddoch, "Distribution System Protection with Dispersed Storage and Generation (DSG) Devices," *Proceedings of the International Conference on Distribution Fusing*, Varennes, Quebec, Canada, Nov. 2–4, 1981.

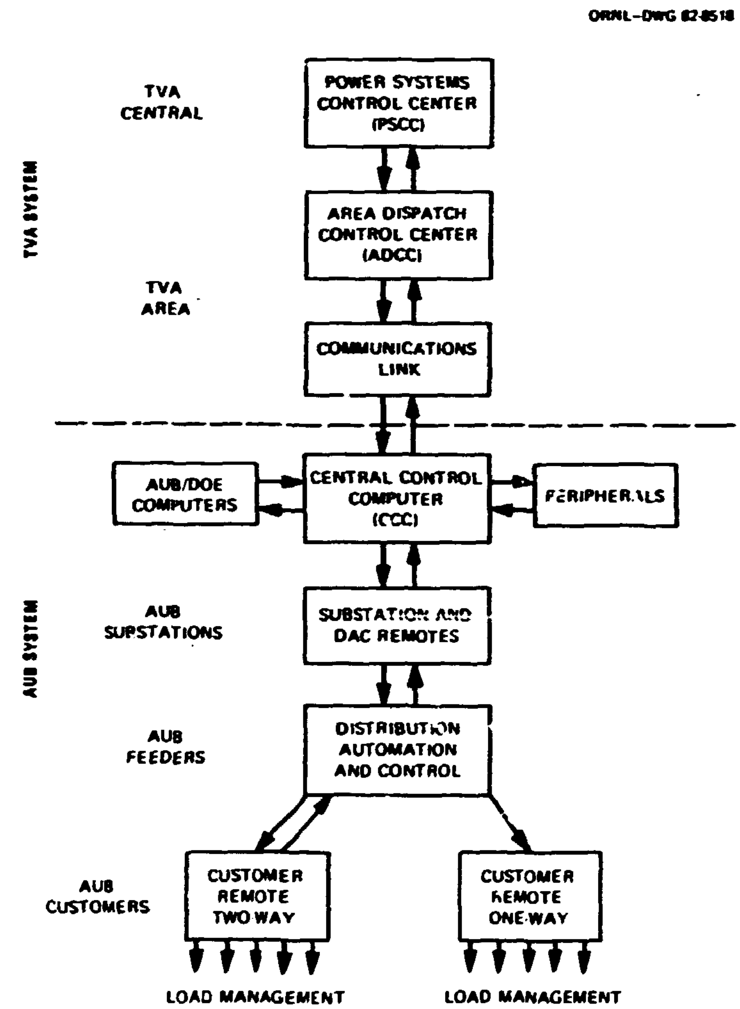

Fig. 6.8. A concept plan for the Athens Utilities Board System for the Automation and Control Experiment.

Power Association, and Virginia Electric and Power Company (Table 6.5).[42–44] Results of installing and operating these heat storage systems indicate that these particular units are not fully commercial hardware.[47] Cool storage systems were installed in the following five utilities: Arkansas Power and Light Company, Long Island Lighting Company, Pacific Gas and Electric Company, Virginia Electric and Power Company, and Wisconsin Electric Power Company. These test results suggest that residential cool storage systems are not ready for commercialization.[48] The electric system benefits of all the thermal energy storage systems are currently under evaluation.

In addition to the electric distribution system requirements for interconnecting dispersed systems, such as photovoltaic installations, the design of appropriate interface hardware, the inverter system, is essential. At the John F. Long photovoltaic house in Phoenix, Arizona, measurements

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47. D. T. Rizy, *Utility-Controlled Customer-Side Thermal Energy Storage Tests: Heat Storage*, ORNL-5796 (February 1982).

48. M. A. Kuliasha, *Utility-Controlled Customer-Side Thermal Energy Storage Tests: Cool Storage*, ORNL-5795 (to be published).

Table 6.5. ORNL heat and cool storage demonstrations

Utility[a]	Location	Thermal energy storage system (manufacturer)	Communications and control system; data collection equipment
AP&L	Little Rock, Arkansas	Cool storage (A. O. Smith)	Radio (Motorola); magnetic tape data collection
LILCO	Mineola, New York	Heat storage (Megatherm); cool storage (Calmac)	Radio (Motorola and Scientific Atlanta); magnetic tape data collection
NMPC	Lake Placid, New York	Heat storage systems: ceramic brick (AEG); pressurized hot water (Megatherm); heat pump with supplemental storage (Carrier); concrete slab storage	Leased telephone lines; on-line data collection
PG&E	Fresno, California	Cool storage (Girton)	Radio (Motorola and Scientific Atlanta); magnetic tape data collection
PSE&G	Newark, New Jersey	Heat storage: ceramic brick (TPI)	Telephone (DARCOM); magnetic tape data collection
UPA	Elk River, Minnesota	Heat storage: ceramic brick (TPI)	Radio (Scientific Atlanta); magnetic tape data collection
VEPCO	Richmond, Virginia	Heat pump system with dual storage: heat storage (Megatherm); cool storage (Carrier)	Leased telephone lines; on-line and magnetic tape data collection
WEPCO	Milwaukee, Wisconsin	Cool storage (A. O. Smith)	Power line carrier (American Science and Engineering); on-line data collection

[a]Acronyms used: AP&L, Arkansas Power and Light Company; LILCO, Long Island Lighting Company; NMPC, Niagara Mohawk Power Corporation; PG&E, Pacific Gas and Electric Company; PSE&G, Public Service Electric and Gas Company; UPA, United Power Association; VEPCO, Virginia Electric Power Company; WEPCO, Wisconsin Electric Power Company; AEG, Allgemeine Elektrizitaets-Gesellschaft; TPI, Tennessee Plastics, Inc.

were taken of various system voltages and currents to determine the performance of a present converter design, including the harmonic output and power factor.[49] Analysis of the data yielded results that were sufficient to provide a sound basis for the conservative modeling of a representative photovoltaic system intertied to a utility. The most important finding of the project was that the particular type of photovoltaic inverter system can be considered as an ideal current source at each harmonic frequency; however, the inverter linking the photovoltaic system to the utility exhibited a poor power factor and produced significantly more harmonics of 60-Hz power than conventional loads. This result suggests that present inverter designs are lacking in their ability to produce high-quality electricity. Improvements will be required before a large-scale intertie to utilities of photovoltaic and other sources will be permitted. As a result, the design of an innovative power converter

49. G. L. Campen, *Results of the Harmonics Measurement Program at the John F. Long Photovoltaic House*, ORNL-5834 (March 1982).

that is low in harmonics, has a good power factor, and has high efficiency is under development at ORNL.[50]

A new effort has been initiated to understand problems caused by intertying large arrays of wind turbines to electric utility systems. The problems are both economic and technical. A class of electric utility operating problems with wind turbine arrays has been defined,[51] and efforts are under way to design control procedures to mitigate them.

Most of our efforts in power delivery activities concentrated on high-voltage direct current (HVDC) transmission. The value of such systems to the electric utility industry is significant and results in improvements in the system stability, effective use of power parks, and long-distance transportation of electric power. There are numerous technical problems to be resolved in HVDC technology; one in particular is commutation technology. (Commutation is the continuous process that converts direct current into alternating current.) A study has been conducted that addresses the critical issues of an alternative commutation technique (force commutation), which could replace line commutation. In line commutation, energy to operate the switching devices is taken as needed from the alternating current source to which the inverter is intertied, but in force commutation, switching energy is taken either from the direct current or the alternating current system and is stored until needed. Force commutation has superior properties to line commutation, especially regarding the effectiveness of HVDC for control purposes.

6.7 BUILDING THERMAL ENVELOPE SYSTEMS

G. E. Courville[52]

K. W. Childs[53] J. N. Robinson[54] R. L. Wendt

ORNL provides technical support and subcontract management for the DOE component of the national plan for Building Thermal Envelope Systems and Insulating Materials. Under this national plan, the Energy Division is responsible for work in Building Envelope Systems, Building Diagnostics, and Innovative Structures.

6.7.1 Building Envelope Systems

A comprehensive multilaboratory program has been organized by ORNL to investigate the dynamic performance of building envelope systems. Of specific interest are the circumstances under which massive materials significantly alter the thermal efficiency of buildings. Wall sections are being analyzed under dynamic temperature cycling in the Portland Cement Association's calibrated hot box, and a new calibrated hot box, designed as an industry standard, is under construction at the National Bureau of Standards (NBS). Whole building field tests are under way at an eight-cell site in New Mexico, a six-cell site at NBS, and at the Joint Institute Dormitory Building at ORNL.

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50. C. Jobbins, *HETUP Utility Interactive Power Converter*, Delta Electronic Controls Corporation, UCC-ND Subcontract 9079.

51. T. W. Reddoch et al., "Operational Concepts for Large Wind Turbine Arrays," *Proceedings of the Fifth Biennial Wind Energy Conference and Workshop*, Washington, D.C., Oct. 5–7, 1981.

52. Group leader.

53. Computer Sciences Division.

54. Deceased.

Results are expected to facilitate the development of techniques to predict and optimize the use of mass in building construction.

An assessment of roofing research documents the lack of roof research in the United States and the potential impact of energy-efficient roofs (a potential of about 1% of total U.S. energy consumption).[55] As a follow-up, ORNL sponsored an international workshop on mathematical modeling of roofs[56] and supported studies by the Army Construction Engineering Research Laboratory and the National Roofing Contractors Association into aspects of adding insulation to roofs. Work continues on a study of the feasibility of a national roofing test center.

6.7.2 Building Diagnostics

Three studies, prepared for ORNL by NBS, National Aeronautics and Space Administration (NASA), and Calspan Corporation, examined the limits of usefulness of residential aerial infrared sensing.[57–59] Results of these studies are shown in Figs. 6.9–6.11. Significant results include the following: (1) measurements of roof temperatures to within 1°C are possible, (2) roof temperature is a good indicator of ceiling insulation levels in adjacent homes, (3) roof temperatures can be used to identify homes with significantly different heat losses, and (4) it is possible to specify microclimate conditions required for good-quality aerial imagery.

An assessment of building diagnostics stressed the need for more accurate building performance analysis and broadly outlined areas where improved diagnostics are needed.[60]

6.7.3 Innovative Structures

A preliminary evaluation of earth-sheltered housing was completed. The impact of climate on earth-sheltered dwellings[61] is illustrated in Fig. 6.12. An ORNL study found that earth-sheltered houses were significantly more costly and that this added cost would not be justified on a life-cycle basis.[62] A summary evaluation of the relationship between earth sheltering and demographic factors is shown in Fig. 6.12.[63]

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55. J. N. Robinson, *The Assessment of Roofing Research: An Interim Report*, ORNL/TM-7640 (July 1981).

56. H. W. Busching and G. E. Courville (eds.), *Proceedings, DOE-ORNL Workshop on Mathematical Modeling of Roofs*, Atlanta, Ga., Nov. 3–4, 1981, CONF-811179 (in press).

57. S. J. Treado et al., "Aerial Infrared Thermography for Residential Energy Analysis," to be published as an NBS Technical Note.

58. J. R. Jack and R. L. Bowman, *Reliable Aerial Thermography for Energy Conservation*, DOE/NASA/20270-1, NASA TM-81766 (August 1981).

59. J. R. Schott, *Aerial Measurement of Heat Loss, Phase II*, NYSERDA report (to be published).

60. G. E. Courville, *Assessment of Building Diagnostics*, ORNL/Sub-80/61602/1 (July 1981).

61. Kenneth Labs, *Regional Analysis of Ground and Aboveground Climate* (to be published as an ORNL report).

62. H. B. Shapira, *Cost and Energy Comparison Study of Above- and Below-Ground Dwellings*, ORNL/CON-91 (in preparation).

63. R. L. Wendt, *Earth-Sheltered Housing, An Evaluation of Energy-Conservation Potential*, ORNL/CON-86 (April 1982).

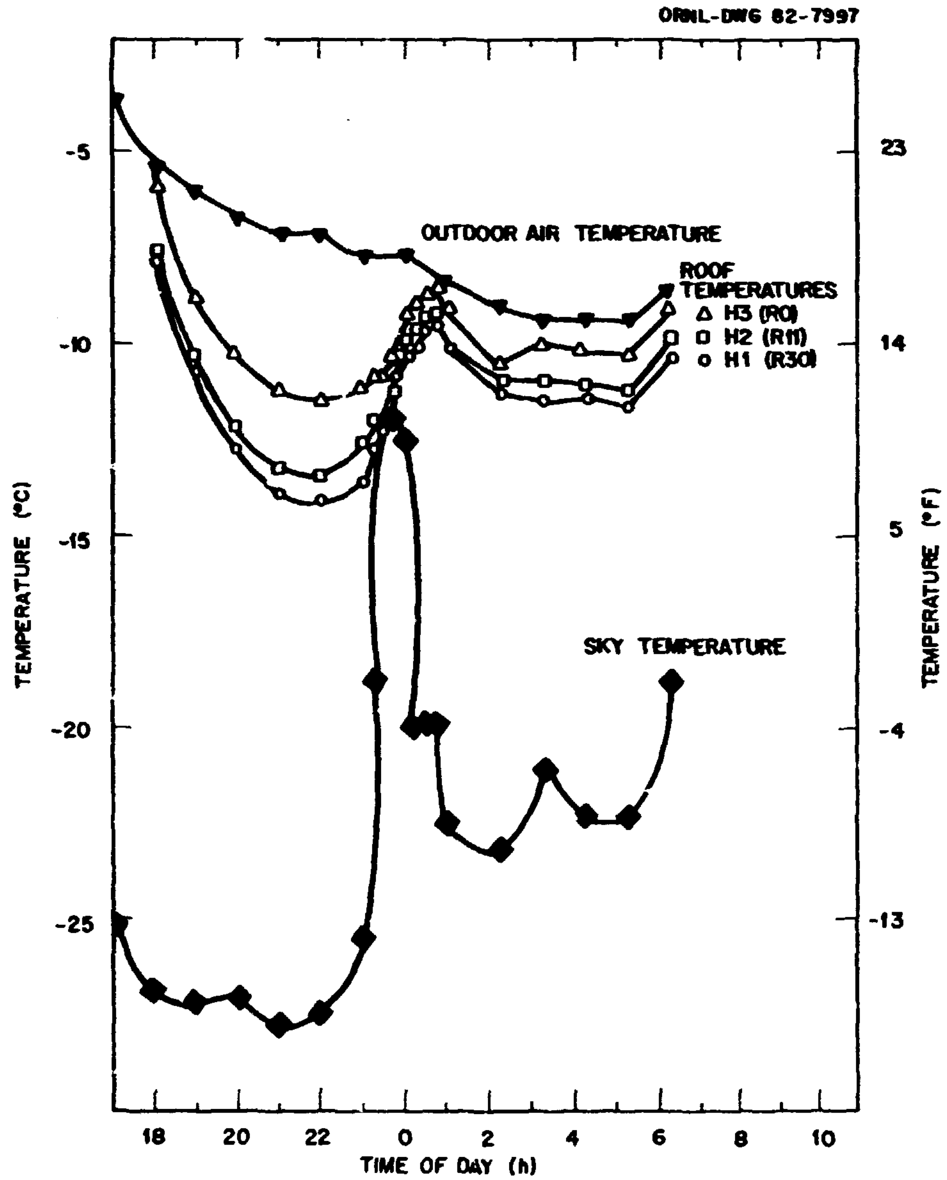

Fig. 6.9. Roof-surface temperature variations as compared with ambient air and sky temperatures for three residences with ceiling insulation levels of R0, R11, and R30. Note the strong effects of radiative coupling between residences and sky: first, in the night, surface temperatures are typically depressed below the ambient; *second, roof temperatures follow* changes *in sky temperatures.* The strong increases near midnight imply cloud coverage. The converging of all roof temperatures under clouds suggests problems with aerial thermography if taken under mixed cloud coverage. Source: ref. 56.

The energy conservation potential of using a large envelope to enclose inhabited structures was investigated. The results from this preliminary effort[64] indicate that energy consumption within enclosed structures in summer-dominated climates would be reduced by approximately 70% and in winter-dominated climates by about 30%.

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64. R. L. Wendt, G. E. Giles, and J. E. Park, *Large Climate-Moderating Envelopes for Enclosed Structures*, ORNL/TM-8018 (1981).

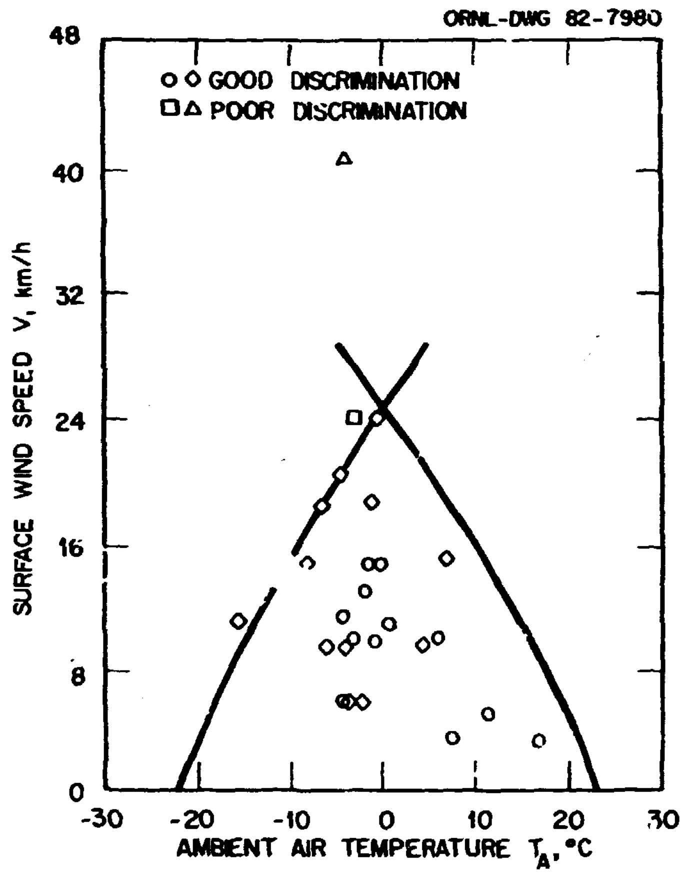


Fig. 6.10. The two curves, one with positive slope and the other with negative slope, bound the values of surface wind speed and ambient air temperature for which good-quality aerial thermograms are available. The area to the left of the positive-slope curve represents poor quality because it is difficult to discriminate between different degrees of insulation. Increasing wind speed helps this discrimination. The area to the right of the negative-slope curve represents poor quality because high ambient temperatures reduce discrimination between roof and surrounding terrain. Increased wind accelerates this problem. Open data points represent flight conditions for surveys, independently judged to have provided good-quality imagery. The two solid points represent surveys with poor imagery. Source: ref. 57.

In an assessment of the energy conservation potential of the use of vegetation, it was found that the proper use of vegetation throughout the United States could result in a net reduction in total U.S. energy consumption of slightly more than 1%.[65]

65. B. A. Hutchison (ed.), *Uses of Vegetation to Ameliorate Building Microclimates: An Assessment of Energy Conservation Potentials* (to be published as an ORNL report).

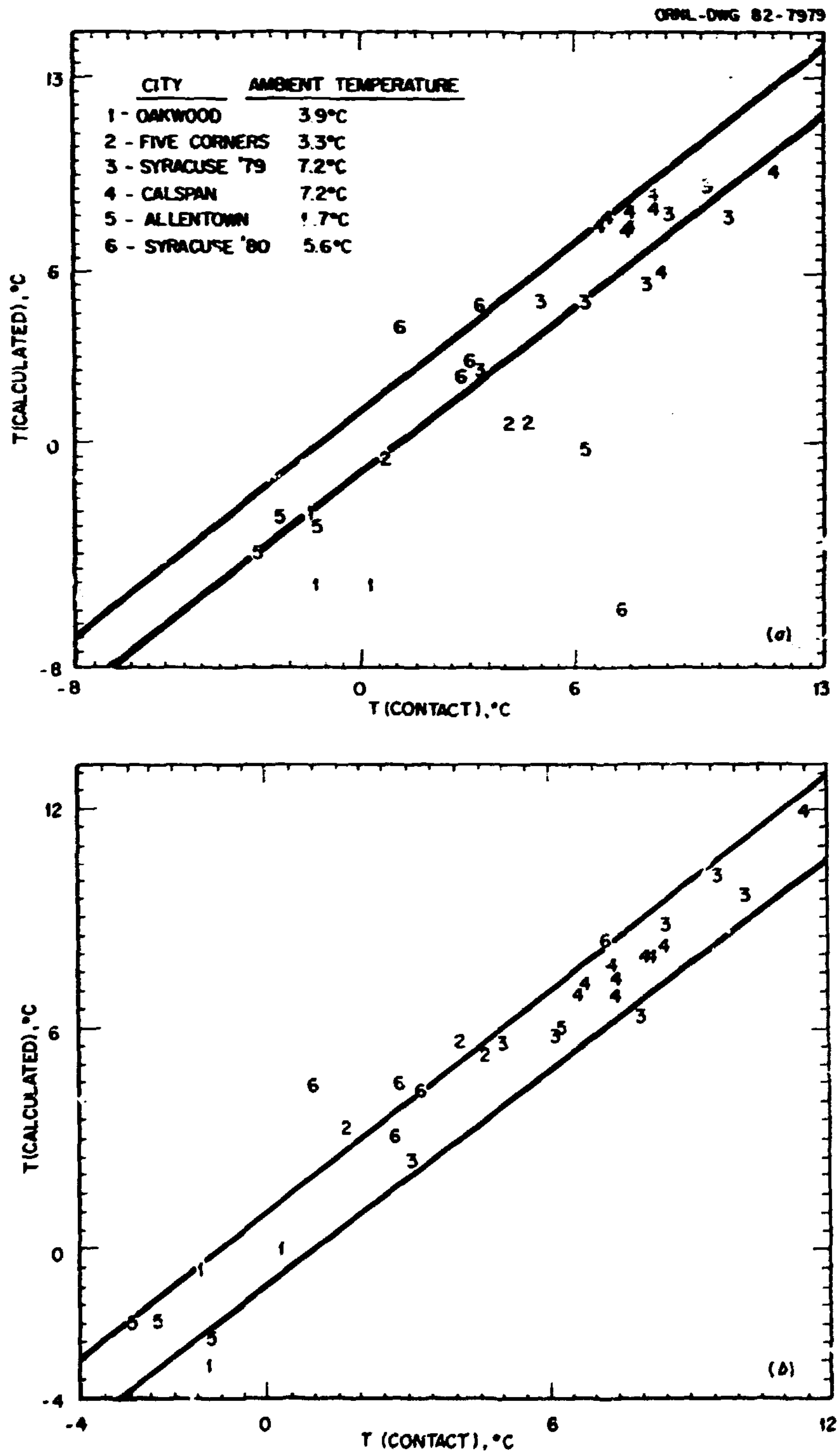
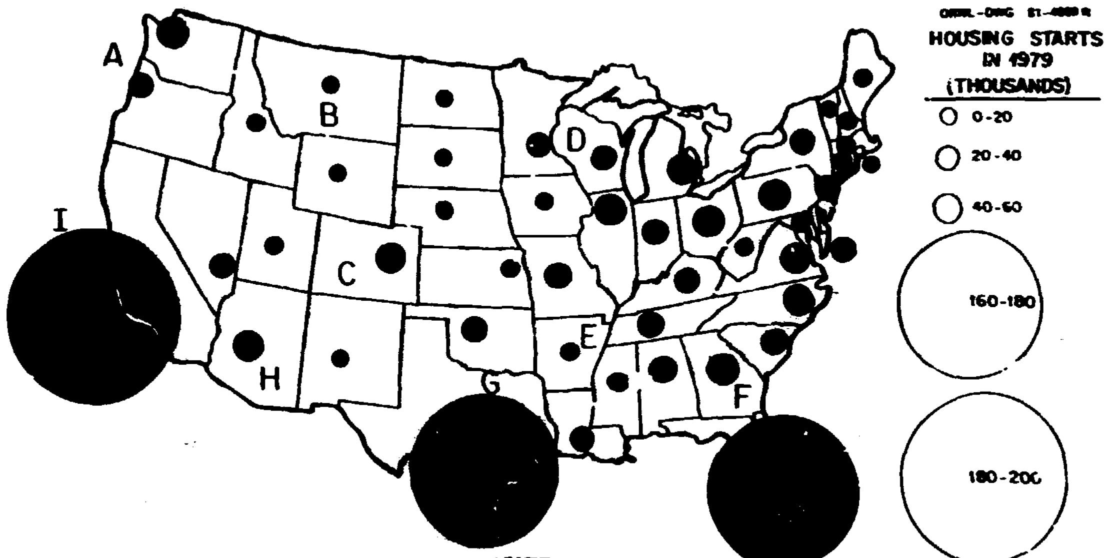


Fig. 6.11. Correlation between apparent roof temperature and contact thermister temperature: (a) calculated from aerial infrared signals with no environmental corrections (the diagonal band represents ±2°F error); (b) calculated from apparent temperatures corrected for surface emittance, atmospheric absorption, and background sky effects. Graph (a) suggests that even uncorrected data is fairly useful. In (b), it is clear that reliable results are obtainable when measurable environmental corrections are made. Source: ref. 58.



LEGEND

A Cold, cloudy winters maximize value of earth-tempering as a heat conservation measure. Cool soil and dry summers favor subgrade placement and earth cover with little likelihood of condensation.

B Severely cold winters demand major heat conservation measures, even though more sunshine is available here than on the coast. Dry summers and cool soil favor earth-covered roofs and ground coupling.

C Good winter insolation offsets need for extraordinary winter heat conservation, but summer benefit is more important here than in zone B. Earth cover is advantageous, the ground offers some cooling; condensation is unlikely, and ventilation is not a major necessity.

D Cold and often cloudy winters place a premium on heat conservation. Low summer ground temperatures offer a cooling source, but with possibility of condensation. High summer humidity makes ventilation the leading conventional summer climate control strategy. An aboveground, superinsulated house, designed to maximize ventilation, is an important competing design approach.

E Generally good winter sun and minor heating demand reduce the need for extreme heat conservation measures. The ground offers protection from overheated air, but not major cooling potential as a heat sink. The primacy of ventilation and the possibility of condensation compromise summer benefits. Quality of design will determine actual benefit realized here.

F High ground temperatures. Persistent high humidity levels largely negate value of roof mass and establish ventilation as the only important summer cooling strategy. Any design that compromises ventilation effectiveness without contributing to cooling may be considered counterproductive.

G This is a transition area between zones F and H, comments concerning which apply here in degree. The value of earth-tempering increases moving westward through this zone, and diminishes moving southward.

H Summer ground temperatures are high, but relatively much cooler than air. Aridity favors roof mass, reduces need for ventilation, and eliminates concern about condensation. Potential for integrating earth-tempering with other passive design alternatives is high.

I Extraordinary means of climate control are not required due to relative moderateness of this zone. Earth-tempering is compatible with other strategies, with no strong argument for or against it.

Fig. 6.12. Comparison of regional suitability of earth-sheltered housing as a means of energy conservation. Housing starts in 1979 show that the major growth in the United States occurs in areas other than where earth sheltering is highly beneficial.

6.8 BUILDING ENERGY PERFORMANCE STANDARDS

G. A. Cristy[66] K. R. Corum[67]
H. B. Shapira R. E. Shelton[68]
D. M. Hamblin G. H. Llewellyn[68]

In November 1979, DOE issued a Notice of Proposed Rulemaking (NOPR) for Building Energy Performance Standards (BEPS). DOE discussed the NOPR quite thoroughly with members of the building community and the general public at four hearings. These hearings generated so many objections on technical and economic issues related to the standards for the commercial and multifamily structures that DOE requested ORNL to establish a new project to expand the data base upon which the standards were based and to resolve the major controversies within the building community.

Three tasks were completed this year:

1. The first commercially available DOE 2.1 program for IBM computers was obtained, debugged, and made operational. A "friendly" processor was developed on the DEC-10 system to make the program readily available to all ORNL and DOE users. The data for 62 Test Reference Year (TRY) stations and 260 Typical Meteorological Year (TMY) stations were processed and packed. A prototypical small office building reflecting 1980–1981 norms was developed as a base case. Various energy-conserving options for the base case were developed and analyzed.
2. A prototypical small office building reflecting 1980–1981 norms was developed as a base case. Various energy-conserving options for the base case were developed and analyzed.
3. A thorough study was made of the existing life-cycle cost (LCC) models available to the general public. No one model was adequate for all users' needs. A new LCC model was developed based on the best models available. The new model was used to compare conservation options for the prototype office building.

The project was terminated at the end of this period with submission of a final progress report which included recommendations for additional research to provide a more complete analysis of commercial and multifamily buildings.

6.9 COMMUNITY SYSTEMS AND COGENERATION

M. A. Karnitz[69]

M. A. Broders L. N. McCold
J. O. Kolb J. T. Meador
C. G. Lawson W. L. Jackson[70]

The Community Systems and Cogeneration Group is providing technical assistance to 12 U.S. cities that are doing preliminary district heating feasibility studies. The ORNL staff is assisting the

66. Project manager.
67. Now with Bonneville Power.
68. Engineering Division.
69. Group leader.
70. Computer Sciences Division.

cities in their efforts to identify potential district heating and cooling projects, assess their economic viability, and develop a plan of action for implementation. The staff is also providing direct assistance to three cities on their municipal refuse-to-energy projects: Detroit, Michigan; Akron, Ohio; and San Juan, Puerto Rico. For example, for the city of Akron, ORNL analyzed the steam district heating distribution system with a pressure-flow computer model. Akron is considering installing a cogeneration turbine, and the amount of electricity that can be produced is linked to the turbine exhaust or district heating supply pressure. The pressure flow modeling of the district heating system has shown that district heating customers can be served with reduced steam pressures, thereby increasing the cogeneration turbine efficiency.

The Community Systems Group completed its work with the St. Paul district heating project. Our involvement in the detailed design verifies that the European-type system can be constructed in the United States using the low-cost design techniques.[71] The St. Paul District Heating Development Company is successfully marketing the hot water service to building owners, and it is anticipated that construction will begin in late 1982. ORNL staff, jointly with the city of Minneapolis, analyzed the feasibility of a hybrid, hot water–steam district heating system. The study showed that it was feasible to develop hot water islands around the existing Minneapolis steam system.[72] There are many old U.S. steam systems, and this analysis showed that at least one system could be expanded using hot water distribution piping.

A movie entitled "An Energy Opportunity — District Heating and Cooling for U.S. Cities" was produced by ORNL.[73] This movie mainly explains the concept of efficient thermal energy production and hot water distribution for local government planners and decision makers.

6.10 SOLAR PROJECTS

6.10.1 Solar Photovoltaic Grant Projects

S. I. Kaplan

J. R. Mullens[74] I. A. Tag

ORNL technical assistance to DOE includes monitoring and evaluating the design, construction, and start-up operation of three photovoltaic (PV) power projects located at institutions of higher learning. ORNL also works closely with other DOE laboratories, coordinating their technical input to the project where their special expertise is required. The three systems are in varying stages of completion; their location, intended composition, and state of completion are shown in Table 6.6.

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71. M. H. Barnes et al., *District Heating/Cogeneration Application Studies for the Minneapolis–St. Paul Area: St. Paul District Heating System Conceptual Design Study and Report: Appendix C, Market Assessment and Economic Analysis of the St. Paul District Heating Demonstration Project*, ORNL/TM-6830/P10, vol. II (January 1982).

72. T. K. Stovall et al., *Minneapolis District Heating Options*, ORNL/TM-7780 (October 1981).

73. *An Energy Opportunity — District Heating and Cooling for U.S. Cities*, 16-min color movie with sound, available in 16 mm and videotape, produced by Oak Ridge National Laboratory (June 1981).

74. Instrumentation and Controls Division.

Table 6.6. Photovoltaic (PV) grant projects

Project	PV cells and concentration	Design output (kW)	Status
Mississippi County Community College, Blytheville, Arkansas	Si, 40×	240	Complete; in start-up phase
Northwest Mississippi Junior College, Senatobia, Mississippi	CdS/CuS, 1×	1	Project suspended
	Si, 5×	50	
	Si, 40×	50	
	GaAs, 400×	50	
Georgetown University, Washington, D.C.	Si, 1×	300	Six bidders selected; request for proposal for design and possible construction to be issued on Dec. 11, 1981

ORNL's specific roles have varied for each project according to its respective stage of completion. For the Mississippi County Community College (MCCC), computer modeling of the solar field is now being finished, and a report will be issued in June 1982.[75] Direct technical assistance in measuring field output and diagnosing the causes of reduced conversion efficiency has been provided by ORNL and by other DOE laboratories through ORNL arrangements. Figure 6.13 shows the morning and afternoon output of 15 PV collector rows at MCCC, supporting a diagnosis that defocusing of the collectors was occurring due to gravitationally induced twist about the tracking axis. Table 6.7 reflects the change in row electrical output when the twisting was manually corrected.

Evaluating design changes and monitoring subcontractor progress were the main ORNL activities performed on the Northwest Mississippi Junior College (NMJC) Project. Technical evaluation services provided for the Georgetown University (GU) project included assistance in evaluating professional qualifications of GU's project consultant candidates and critiques of draft Requests for Proposals to secure and qualify vendors and to obtain design proposals for the roof-mounted PV system.

6.10.2 OTEC Power Cycles Development

F. C. Chen[76]

N. Domingo[77] A. Golshani[77]

The objective of the OTEC Power Cycles Development task is to assist the DOE Energy Systems Division in the development of OTEC advanced power cycle concepts and subsystem components into cost-competitive power conversion options. Besides program technical assistance in

75. J. R. Mullens, *Model of the Solar Power Supply System of the Mississippi County Community College*, ORNL/TM-8262 (to be published).

76. Project manager.

77. Engineering Technology Division.

ORNL–DWG 82-8862R

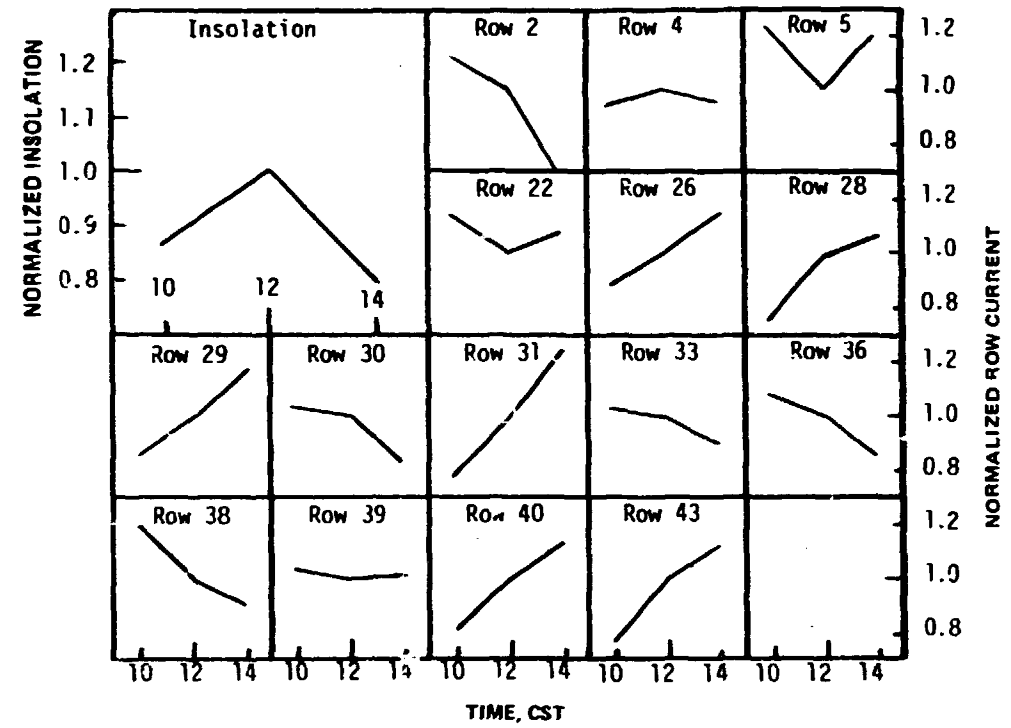

Fig. 6.13. Response of MCCC PV collector rows to morning and afternoon insolation, Sept. 29, 1981.

Table 6.7. Results of manual correction of row twist to overcome insufficient counterbalancing

Row No.	Before correction: Short-circuit current (amp)	Open-circuit voltage (V)	Peak power current (amp)	Peak power voltage (V)	After correction: Short-circuit current (amp)	Open-circuit voltage (V)	Peak power current (amp)	Peak power voltage (V)
27	5.92	409	3.5	295	11.3	411	6.5	295
29	6.61	401	4.2	295	9.8	409	5.8	295
33	7.50	402	3.2	295	9.6	410	5.2	295

which the proof-of-scientific-feasibility experiment of the OTEC mist-lift cycle concept was successfully performed by the subcontractor,[78,79] R&D Associates, the task activities also include in-house gas desorption studies and ammonia condensation tests.

78. C. V. B. Lee and S. Ridgway, "Vapor/Droplet Coupling in Flashing Mist Flow," presented at the ASME 101st Winter Annual Meeting, Chicago, Ill., November 1980.

79. S. L. Ridgway, C. V. B. Lee, and R. P. Hammond, "Experimental Demonstration of the Feasibility of the Mist Flow Ocean Thermal Energy Process," Paper IIA3, *Proceedings of the 8th Ocean Energy Conference*, Washington, D.C., June 1981 (to be published).

Gas Desorption Studies

Vacuum deaeration tests on several types of packings in a column and on the barometric intake system were completed. The test results were documented and published.[80-83] It was found that (1) the vacuum deaeration in a column packed with plastic pall rings is as effective as a corresponding column packed with Raschig rings, while the cost of pall rings is about 2.5 times less than the cost of Raschig rings, and (2) deaeration does occur in a barometric intake pipe, and deaeration up to 27% was observed in the test with high bubble nuclei content. An OTEC deaeration subsystem analysis was also carried out.[84] It was found that both cost and power reductions up to 10% can be realized with a combination of a barometric intake deaerator and a column deaerator packed with plastic pall rings (Table 6.8).

Table 6.8. Comparison of deaeration cost and pumping power for various packings with and without barometric intake systems[a]

Packing	Size (cm)	Case 1[b]		Case 2[c]	
		Deaerator cost ($)	Pumping power (MW)	Deaerator cost ($)	Pumping power (MW)
Ceramic Raschig ring	3.81	2.58×10^6	5.10	2.40×10^6	4.57
	5.08	2.85×10^6	4.68	2.56×10^6	4.23
Plastic pall ring	3.81	1.50×10^6	5.43	1.38×10^6	4.83
	8.90	1.22×10^6	6.26	1.12×10^6	5.49

[a]Warm seawater flow rate = 455×10^6 kg/h; 80% deaeration.
[b]Case 1: Barometric intake deaeration effect not included; packed-column deaeration only.
[c]Case 2: Combined barometric intake and packed-column deaeration.

To provide data on an alternative system for the removal of noncondensible gases, hydraulic air compression tests were performed. Compressor power consumptions at different conditions were obtained in the tests. As shown in Fig. 6.14, for a fixed air flux (J_a), the power consumption decreases as the water flow rate is increased. Based on preliminary test data, a computer model was developed to simulate the performance and to analyze the feasibility of an OTEC hydraulic air compressor.[85]

80. A. Golshani and F. C. Chen, *OTEC Gas Desorption Study — Design of Experiments*, ORNL/TM-7438/V1 (October 1980).
81. A. Golshani and F. C. Chen, "Vacuum Deaeration for OTEC Applications," presented at the International Symposia on Alternative Energy Sources and Technology, San Francisco, Calif., May 20–22, 1981.
82. F. C. Chen and A. Golshani, "OTEC Gas Desorption Studies," Paper IIA6, *Proceedings of the 8th Ocean Energy Conference*, Washington, D.C., June 7–11, 1981 (to be published).
83. F. C. Chen and A. Golshani, "OTEC Gas Desorption Studies," *J. Solar Energy Eng.* **104**: 33 (February 1982).
84. A. Golshani and F. C. Chen, *OTEC Gas Desorption Studies — Deaeration in a Packed Column and Barometric Intake System*, ORNL/TM-7438/V2 (September 1981).
85. F. C. Chen and A. Golshani, "Simulation of a Hydraulic Air Ingestion Process," *Model. Sim.* **12**(1): 55–59 (May 1981).

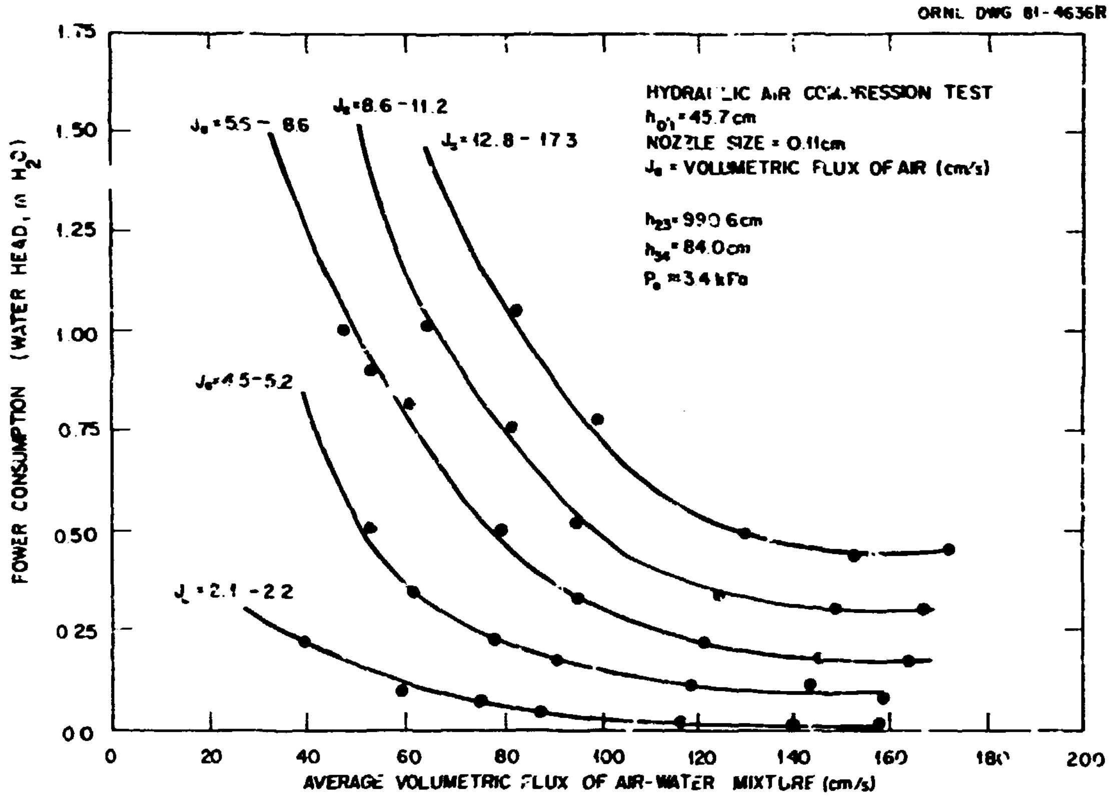

Fig. 6.14. Results of hydraulic air compression tests showing effect of volumetric flux on equivalent power consumption.

Ammonia Condensation Tests

Four single-tube condensation experiments were conducted on the OTEC heat transfer loop.[86,87] Various comparisons were made between fluted tubes tested during these tests and other tubes tested in earlier studies. Also, the effect of tilt angle on smooth tube condensing performance was examined (Fig. 6.15). A horizontal smooth tube yielded condensing coefficients 2.0 and 2.1 times higher than that of a corresponding vertical tube at a given heat flux.

6.11 RESEARCH UTILIZATION

Through subcontracts to industry, much of the work of the section directly involves the ultimate user of the research. This practice is especially significant in the heat pump, appliance, low-grade-heat recovery, power systems technology, and building thermal envelope programs. In the community systems work, we are providing technical assistance on district heating feasibility to 12 cities and providing direct assistance to three cities on their municipal refuse-to-energy projects. We have also produced a sound and color movie for use by local government planners.

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86. N. Domingo and J. W. Michel, "Ammonia Condensation Experiment at ORNL," Paper IIB4, *Proceedings of the 8th Ocean Energy Conference*, Washington, D.C., June 1981 (to be published).

87. N. Domingo and J. W. Michel, "Ammonia Condensation on Smooth and Fluted Aluminum Tubes," *J. Solar Energy Eng.* **104**: 9 (February 1982).

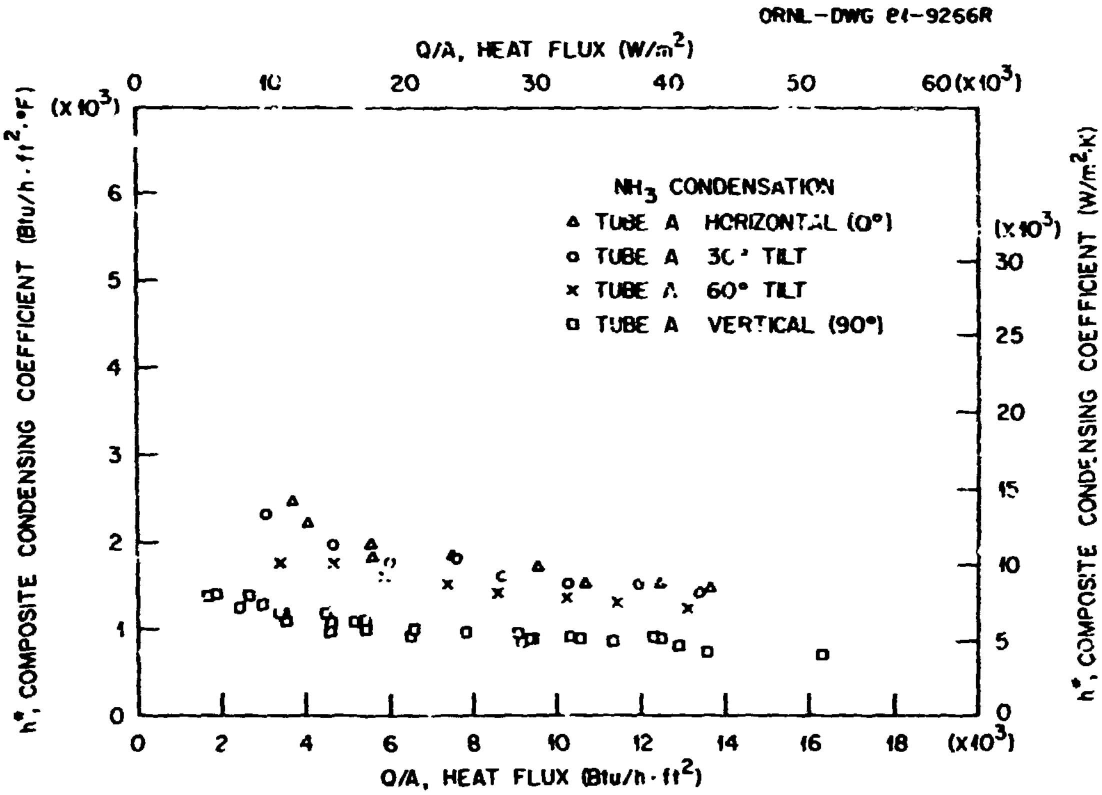

Fig. 6.15. Composite condensing coefficients for ammonia condensing outside smooth tube A [2.5-cm-diam (1-in.) Al-6061 tube].

In addition, wide dissemination of the work, both subcontracted and in-house, is further achieved by the publication of reports and papers, presentations at technical meetings and workshops, and the use of industrial/academic advisory committees and consultants. Also, active participation in work of several technical societies such as American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), American Society for Testing and Materials (ASTM), American Society of Mechanical Engineers (ASME), and Institute of Electrical and Electronic Engineers (IEEE) provide for further industrial interactions and technology transfer.

Finally, the heat pump computer model has now been sent to about 55 users, including 27 industrial firms, and the TECH houses continue to attract large numbers of visitors who tour this facility and learn about ACES and heat pump installations.

7. Integrated Programs

T. J. Wilbanks

When FY 1981 began, three complex multidisciplinary programs were operating under the responsibility of T. J. Wilbanks as Associate Director of the Division: (1) Regional Integrated Analysis, headed by R. B. Honea; (2) Model and Data Validation, headed by A. S. Loebl; and (3) Conservation and Renewable Energy Studies, headed by S. C. Parikh. Two changes occurred on June 1, 1981: the Model and Data Validation Program was incorporated in the Division's new Data and Analysis Section; and the Division's emergency preparedness work, ranging from civil defense to emergency planning for oil supply curtailments, was placed under C. V. Chester as Coordinator, responsible to T. J. Wilbanks. This kind of evolution will probably be common in the Integrated Programs area as certain programs become clear-cut line management functions and other Division activities develop into multisectional, multidivisional programs calling for exceptional management arrangements.

In addition, the Division's Planning Group, consisting of A. M. Perry, Jr., G. Samuels, Jr., and T. J. Wilbanks, continued to play a variety of roles, including Division planning and program development, assistance with Division research projects, and continuation of research and assessment activities of its own.

7.1 ENERGY PLANNING AND POLICY ANALYSIS

W. Fulkerson — G. Samuels, Jr.
A. M. Perry, Jr. — T. J. Wilbanks

Consistent with the Division's long-range plan, studies were conducted on (1) energy emergency planning, a particularly critical issue during FY 1981; (2) CO_2 decision options, related to our interest in clarifying the implications of fossil fuel use; (3) conservation and renewable energy policy; and (4) ways to reach a consensus on energy policies.

7.1.1 Energy Emergency Planning

Two major activities were under way in 1981: an examination of ways to replace oil and gas with alternatives during a petroleum shortage and a survey of behavioral and social aspects of energy emergency planning (other related projects are discussed in Chaps. 4 and 5).

In the fuel-switching study, the focus was on options that could be implemented in a short time with few or no additional requirements for capital investment. Such options include the use of electricity in place of heating oil in the residential and commercial sectors (increased use of lighting, ovens, or portable heaters) and means for utilities to reduce oil and gas consumption by increasing the output of existing coal-fired plants (shutting off precipitators and flue gas desulfurization scrubbers). The study also examined the effect of power wheeling, or power transfers, between utilities on the benefits that may be derived from these options. Because of the interchangeability of oil and gas in many end uses, savings of natural gas were equated with savings of oil.

Based on utility peak load and energy demand projections, the study showed that oil and gas savings would be highly dependent on power wheeling and the degree of public cooperation in using the additional electrical energy only during off-peak periods. In effect, the use of electricity in place of heating oil would result in a net savings of premium fuels only in those regions in which most power generation is by nonoil and nongas equipment. If the transmission system is already heavily loaded to displace oil and gas, the benefits to be gained from this option would be limited to the north central and southeastern areas of the country, with part of the benefit gained at the expense of other areas. The maximum potential net savings would be in the range of 150 to 300 PJ (25 $\times 10^6$ to 50 $\times 10^6$ bbl of oil) during a heating season.

Oil and gas savings would also be affected by price differentials, but the relationship may not be a simple one. A comparison of the current price of heating oil with the average price of electricity in the United States shows little difference in the cost of providing space heat from these two sources during normal conditions. Increasing oil prices associated with an emergency would therefore increase the economic incentive for consumers using oil to switch to electricity in many parts of the country. Although the total cost to the utilities might exceed the total savings by consumers switching to electricity, the increased cost of generation would be shared by all electricity consumers, not limited to those benefiting from the increased load, and the new load could result in increases in the use of premium fuels by utilities that far exceeds the savings in heating oil. It could also drive utility loads beyond their capacity.

One option for dealing with this problem would be to encourage the substitution of additional electricity from coal for electricity from oil and gas, perhaps by suspending certain emission control requirements. Preliminary analyses for 1981 conditions indicate that, with the current transmission system heavily loaded to save oil and gas, shutting off the scrubbers of the 80 to 90 plants equipped with these systems would decrease oil and gas use by the equivalent of 60 to 90 TJ (10,000 to 15,000 bbl/d of crude oil). Shutting off both scrubbers and precipitators would increase the savings to 120 to 185 TJ (20,000 to 30,000 bbl/d).

The importance of public cooperation is only one of many examples of the importance of behavioral and social variables in emergency planning, response, and recovery. For the Committee on Behavioral and Social Aspects of Energy Consumption and Production, National Research Council, the appropriate literatures were surveyed to produce a summary and interpretation of these factors.[1] In addition to identifying a number of dimensions that cause various emergencies to differ in their behavioral implications (e.g., an oil import interruption from a nuclear accident or a coal

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1. Assistance was provided by T. R. Curlee, Economic Analysis Section; A. M. Fullerton and J. H. Sorensen, Regional and Urban Studies Section; and R. Weaver, Information Division.

strike, Table 7.1), the report suggested several principles for energy emergency planning in the United States:

1. Because people respond to an emergency *as they perceive it*, not as an expert or a policy maker may see it, it is essential to develop systems to provide reliable and credible information about the emergency to the public.
2. If economic markets and other decentralized decision-making approaches are to be allowed to operate during a major emergency, certain social needs must be anticipated and provided for.
3. The federal government should seek to minimize uncertainty about the potential uses of available policy instruments.
4. The nation's energy emergency planning effort should not be limited to oil import interruptions alone.

This work continues in 1982.

7.1.2 CO_2 Decision Options

Last year we reported an analysis of the timing of actions that might be needed to limit increases in the concentration of atmospheric CO_2.[2] That analysis was based primarily on scenarios for future world energy demand that were developed by the International Institute for Applied Systems Analysis (IIASA) and on modifications by us of IIASA's scenarios to consider the effect of substituting coal for a major part of IIASA's nuclear contribution. These scenarios, though much lower than those that would result from continuation of historical growth rates (1950–1973), still call for 2.4 to 3.8 times as much annual, worldwide energy use in the year 2030 as in 1980. In 1981, we also considered the effects of both higher and lower scenarios, the former prompted in part by suggestions for greatly expanded use of coal and the latter by a recognition of the possibility that greater gains in energy efficiency may be realized than those postulated by IIASA. The results are presented in Fig. 7.1 in terms of a date, called the action initiation time (AIT), when growth in annual CO_2 production would have to begin to decrease in order to prevent the concentration of atmospheric CO_2 from eventually exceeding a specified maximum value. We assume a uniform deceleration of growth rate after the AIT, followed by an exponential decrease of annual CO_2 production. The curves of Fig. 7.1 represent what we consider to be a rather rapid and hence difficult phasing-out of fossil fuel use (a deceleration rate of 0.2%/year followed by an exponential decline of 2%/year); more or less difficult transitions might change the required AIT by about ten years. Annual CO_2 production increased during the period 1950–1973 at an average annual rate of 4.6%/year, but since 1973 the average rate has been about 2.3%/year.[3]

If we assume that estimated recoverable resources of oil and gas (capable of increasing CO_2 to about 430 ppm) will eventually be used and that restrictions on CO_2 emissions would primarily affect production of coal, oil shale, etc., and if we impose reasonable restrictions on the rate at

2. W. Fulkerson, *Energy Division Annual Progress Report for Period Ending September 30, 1980*, ORNL-5740 (November 1981), pp. 164 65.

3. R. M. Rotty, *Distribution and Cha– in Industrial Carbon Dioxide Production*, paper presented at WMO/ICSU/UNEP Scientific Conference on Analysis and Interpretation of Atmospheric CO_2 Data, Bern, Switzerland, September 14 18, 1981.

Table 7.1. Energy emergencies

Dimension of emergencies	A major interruption of oil supply from the Middle East	A shutdown of nuclear electricity generation because of a nuclear accident	A protracted coal strike	An earthquake in the south central United States that seriously damages major oil and gas pipelines, rail lines, and electricity lines in the region
Causation	External governmental decisions, political instability, or terrorism	Regulator decision to protect public safety	Labor dispute	Natural hazard (act of God)
Immediacy	Import cutoffs lagged 5 to 6 weeks	Immediate effects on electricity supply	End-use energy scarcity lagged up to 90 d	Immediate effects on gas supply to importing regions and on the electricity grid; various lags otherwise
Magnitude	Uncertain; could be serious, but unlikely to be catastrophic	Could be substantial in some locales	Probably no more than discomfort in most places; union control over coal supply apears limited	Possibility of immediate dangers to life and health in the affected area, but energy impacts unlikely to be the major concerns—at least locally
Diffuseness	Affects most sectors of society and economy throughout the United States and in other oil-importing countries	Some geographical focus, but broad social effects in regions impacted	Moderately focused	In addition to the earthquake region, focused on other regions receiving energy shipments through the south central United States
Target	General impacts, but particular impacts on transportation activities and other end-users of oil (heavy industry, some utilities, buildings in some regions)	Impacts electricity users, regions where nuclear power is important, and the nuclear industry	Coal-producing and coal-using regions and sectors	Sectors and groups dependent on energy shipments that are interrupted
Duration	Uncertain; unlikely to be very short, could be quite long	Uncertain and probably contentious; likely to be a political decision	Strike must be fairly long to create an emergency; length of emergency probably not long	Short—until repairs are made and shipments resumed

Table 7.1 (continued)

Dimension of emergencies	A major interruption of oil supply from the Middle East	A shutdown of nuclear electricity generation because of a nuclear accident	A protracted coal strike	An earthquake in the south central United States that seriously damages major oil and gas pipelines, rail lines, and electricity lines in the region
Probability	Opinions differ, but may be fairly high	Opinions differ; probably low, but with a rising probability if/as nuclear power generation grows	Low to moderate; probably varies with national dependence on coal	Low
Credibility	Uncertain, unless the cause and magnitude of the emergency are self-evident; considerable public distrust of some of the key institutions	Probably high, but disputes about the need for the energy action would grow as impacts are felt	Higher in coal-producing than coal-using areas	High
Wieldiness	Causation is hard to control, but the impacts on an import cutoff can be reduced by prior actions: stockpiling, fuel shifts, oil conservation, and domestic energy production	There are ways to reduce the likelihood of the emergency; but the impacts of an emergency, if it occurs, would be hard to handle	The relative lack of immediacy makes this situation more manageable than most	Almost impossible to prepare for or to manage in the very short run; rapid recovery is practicable

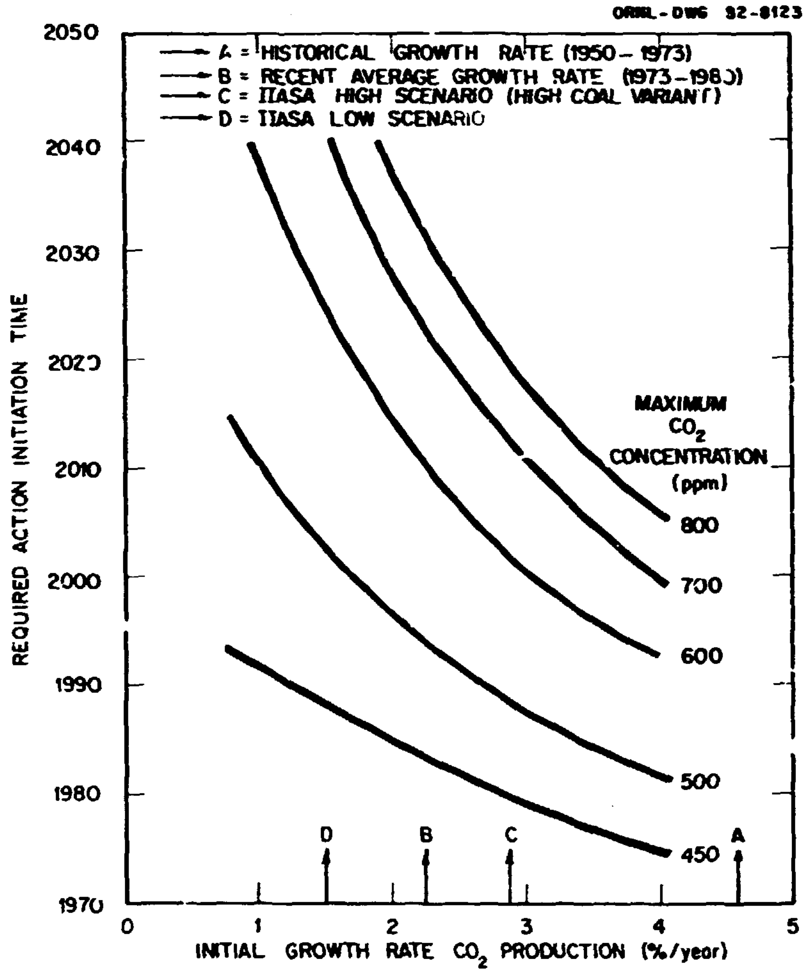

Fig. 7.1. Required action initiation time (AIT) vs initial growth rate of annual CO_2 production and maximum atmospheric CO_2 concentration.

which fossil fuel use can be replaced by other nonfossil energy sources, then peak coal production is roughly related to the maximum CO_2 concentration that will eventually be reached. This correlation is shown in Fig. 7.2 for transition scenarios of various degrees of difficulty and for growth rates of annual coal production ranging from 2 to 4%. For a CO_2 limit of 500 to 600 ppm, annual coal production could probably not exceed two to four times the present level of production. Higher CO_2 limits would evidently allow coal production (or its equivalent in oil shales, tar sands, etc.) to expand much more and to last much longer.

7.1.3 Conservation and Renewable Energy Options

The Division continued its analyses of questions about the potential contributions of conservation and renewable energy options under a variety of conditions. As a contribution to discussions of federal government roles in improving energy efficiency, the Division summarized available information about impediments that slow or prevent consumer responses to market forces, such as imperfect information, problems in obtaining capital, institutional barriers, and certain regulations. Data

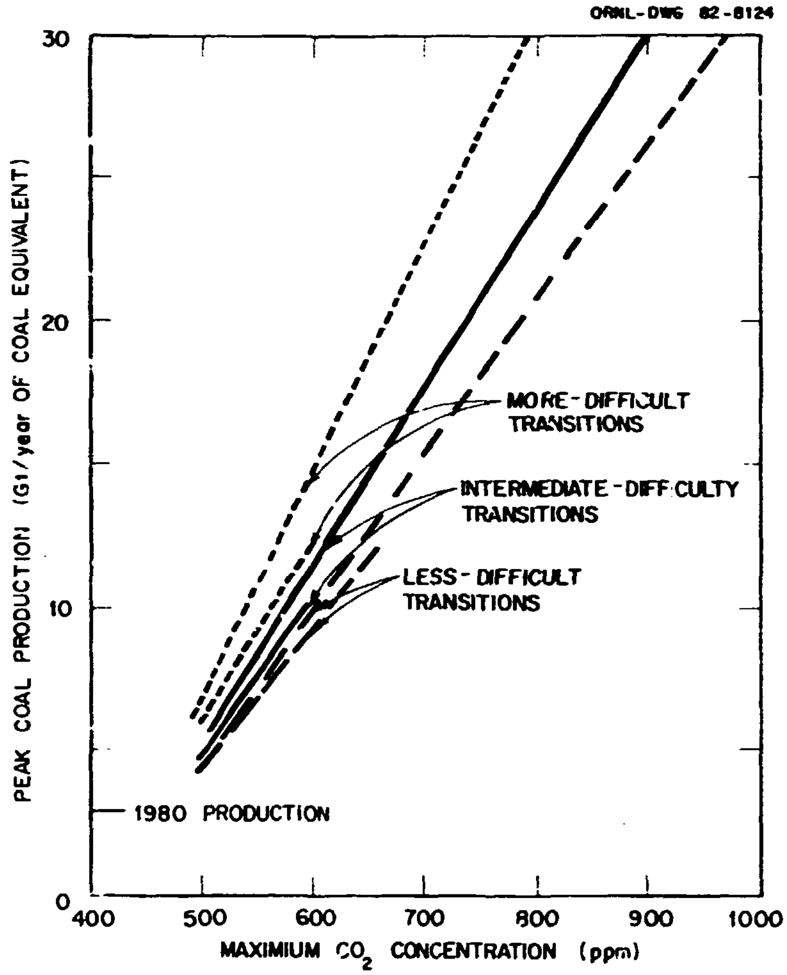

Fig. 7.2. Peak annual coal production vs maximum CO_2 concentration. Initial growth rate of annual coal production ranges from 2 to 4%.

on the effectiveness of government programs in speeding responses to market forces were analyzed, and the results indicated that certain programs have had, and can continue to have, substantial benefits related to energy savings, reductions in the cost of energy services, and reductions in oil imports.[4] Another report argued that the potential of alternative energy systems is greater if options are compared at a local or regional scale than if they are analyzed at a national scale.[5]

7.1.4 Building Consensus for Energy Decisions

Because it appears that a fundamental part of our national energy problem is the difficulty of making and sustaining major energy decisions, we examined some possible strategies for improving

4. E. Hirst, W. Fulkerson, R. S. Carlsmith, and T. J. Wilbanks, "Improving Energy Efficiency: The Case for Government Action," *Energy Policy* (to be published).

5. T. J. Wilbanks, "Decentralized Energy Planning and the Potential of Alternative Energy Systems," *Environment, Energy, and Economics*, ed by J. Henderson (to be published).

the effectiveness of our decision-making structures. One such effort is reported in Sect. 3.2. In addition, the major policy alternatives for making energy technology decisions more effective were outlined,[6] and the potential for making more use of decisions at local and regional scales was examined.[7] Although there are limitations as well as advantages to emphasizing local energy planning and decision making, there are some indications from both theory and experience that consensual decisions are more feasible at smaller social and spatial scales. Experiments in the United States since the mid-1970s with local energy actions need to be studied carefully in order to evaluate both the potential and the possible drawbacks of this approach to meeting national needs.

7.2 REGIONAL INTEGRATED ANALYSIS

R. B. Honea

The Regional Integrated Analysis Program included a number of research projects in FY 1981: several efforts related to the role of the Office of Surface Mining (OSM), Department of the Interior, in solving problems with mined lands; a continuing effort to help the Department of Energy (DOE) improve its locational analysis and regional modeling capabilities for environmental assessments; and an analysis of several issues in rule making for siting nuclear power plants (Sect. 2.2.3).

7.2.1 National Inventory of Abandoned Mine Lands

R. B. Honea

F. P. Baxter[8]

J. Allen[8]	M. L. Green[10]	J. Muncy[3]
F. M. Alvic[8]	D. M. Hester[10]	R. W. Peplies[11]
E. Baldwin[11]	J. Hines[9]	C. H. Petrich
K. Baldwin[11]	R. S. Horne[11]	R. M. Rush
G. Broyles[8]	B. Howard[10]	W. T. Stone[10]
M. Cherry[8]	J. A. Johnson[11]	K. A. Taft[8]
P. R. Coleman[12]	R. W. Klima[8]	C. E. Tanner[10]
C. R Crigger[10]	R. D. Kramer[10]	J. E. Thomas[8]
S. L. Donald[10]	S. A. Laufer[10]	E. P. Tinnel[12]
R. C. Durfee[12]	S. M. Margle[12]	A. H. Voelker
R. G. Edwards[12]	W. J. McDonald[10]	C. W. Weems[11]
J. Farmer[10]	I. S. Messer[8]	B. F. White[10]
N. S. Fischman[11]	G. J. Morris[12]	D. L. Wilson[12]
M. L. Grachis[10]		

6. T. J. Wilbanks, *Building a Consensus about Energy Technologies*, ORNL-5784 (August 1981).

7. T. J. Wilbanks, "Local Energy Initiatives and Consensus in Energy Policy," prepared for the Committee on Behavioral and Social Aspects of Energy Consumption and Production, National Research Council (March 1981); T. J. Wilbanks, "Energy Self-Sufficiency as an Issue in Regional and National Development," *Energy and Regional Growth*, ed by T. R. Lakshamanan (to be published); and T. J. Wilbanks, "Energy Self-Sufficiency vs Interdependency: Implications for Regional Income Distribution," pp. 78 94 in *Regional Development Dialogue*, Vol. 2, 1981.

8. Tennessee Valley Authority.

9. The University of Tennessee.

10. East Tennessee State University.

11. Computer Sciences Division.

12. Lockheed.

During FY 1981, significant progress was made toward completing the national inventory of abandoned mine land problems for OSM.[13] The data entry and storage procedure was revised, based on a pilot test, and several other changes in the process were required because of issues related to the quantity and quality of information to be received from the states. Particularly important was the data validation process initiated this year, seeking to reduce inconsistencies and uncertainties in the data. By September 1981, ORNL had received more than 3000 forms from the states, with the remainder expected early in 1982. Because of the cost of data collection and a number of other factors, about 7000 forms are now expected — compared with the 30,000 originally anticipated.

7.2.2 Locational Analysis and Regional Modeling

D. R. Alvic[14] E. L. Hillsman
P. J. Carroll R. B. Honea
N. G. Dossani[15] J. B. Mills
R. C. Durfee[16] D. P. Vogt

In FY 1981, ORNL assumed an increased responsibility for improving DOE's capabilities for regional environmental analysis. Most of the work concerned (1) improvements in data on manufacturing and electric power plants by county and (2) improvements in models used to forecast the siting of new electric power plants.[17] Such data and models are used by DOE to forecast regional patterns of economic and energy activity in the future, and these forecasts are combined with emission characteristics of individual facilities to estimate future point-source pollution levels.

For example, during the year, DOE asked ORNL to assist in the evaluation of regional economic and environmental implications of the 1981 National Energy Policy Plan (NEPP). As a part of this support, ORNL converted the NEPP's middle-level national electricity and coal use forecasts for 1985 into regional estimates of the conversion of utility and industrial boilers to coal use. To achieve the forecasted national totals, ORNL's analysis showed that more than 28,000 MW(e) of coal-fired electricity generating capacity would have to be added by 1985.[18] Clearly, this could aggravate air quality problems in certain regions of the United States. It is questionable, however, whether a shift to coal of this magnitude is realistic, which suggests that other aspects of the NEPP forecasts might need to be reexamined.

7.3 RESEARCH UTILIZATION

In addition to the utilization of research by sponsors and the communication of work to the research community (Chap. 8), the Integrated Programs area of the Energy Division had several

13. For background, see W. Fulkerson, *Energy Division Annual Progress Report for Period Ending September 30, 1980*, ORNL-5740 (November 1981), pp. 172–78.

14. Lockheed.

15. CONSAD Corp.

16. Computer Sciences Division.

17. E. L. Hillsman and D. R. Alvic, "Issues in Modeling the Future Spatial Distribution of Electric Power Production," draft paper submitted to DOE, September 1981.

18. R. B. Honea, E. L. Hillsman, and D. R. Alvic, *An Analysis of the Electric Utility Sector for NEPP: Some Preliminary Outputs*, draft report submitted to the Office of Environmental Assessment, August 1981.

other notable instances of research utilization. The preliminary data on abandoned mine land problems gathered for OSM were used by several states to proceed with solving urgent problems. The Division's analyses of the impacts of government conservation programs were used by the U.S. Congress and others in considering energy policy and budget priorities.[19] The Division's years of experience with social science aspects of energy issues were recognized by the appointment of T. J. Wilbanks to the Committee on Behavioral and Social Aspects of Energy Consumption and Production of the National Academy of Sciences, National Research Council, which drew heavily on ORNL information and materials during the year.

19. Reference committee off-print containing a version of the paper noted in ref. 4.

8. Publications, Presentations, and Professional Activities

8.1 PROFESSIONAL ACTIVITIES AND AWARDS

Barnes, P. R., Member, Subcommittee of the Passive Solar Section of the International Solar Energy Society (ISES) on Natural Lighting.

Baxter, V. D., Secretary, ASHRAE TG Ice-Maker Heat Pumps.

Blue, J. L., Bibliographer, Association of American Geographers, Energy Specialty Group.

Blue, J. L., Chairman, Committee on the Status of Women in Geography in the Southeast, Southeastern Division of the Association of American Geographers.

Blue, J. L., Regional Representative, Standing Committee on the Status of Women in Geography, Association of American Geographers.

Braid, R. B., Jr., Chairman, Publications Committee, International Association for Impact Assessment.

Broders, M. A., Participating Member of ANSI/ASME Committee on Nuclear Quality Assurance, Design Control Working Group.

Chen, F. C., Chairman of the Simulation of Transport Processes Session of the 12th Modeling and Simulation Conference, Apr. 30, 1981.

Cooper, W. L., Jr., Member, ASHRAE TC 10.5, Refrigeration Warehouses.

Cooper, W. L., Jr., Member, ASHRAE TC 6.6, Service Water Heating.

Cooper, W. L., Jr., Member, ASHRAE TC 7.1, Domestic Refrigeration.

Courville, G. E., Chairman, ASHRAE TC 1.2, Instruments and Measurements.

Courville, G. E., Session Chairman, Thermosense IV, Ottawa, Canada, September 1981.

Courville, G. E., Session Co-chairman, ASHRAE Seminar on Applications of Infrared Sensing, Cincinnati, Ohio, January 1981.

Creswick, F. A., Member, ASHRAE TC 7.6, Unitary Heat Pumps and Air Conditioners.

Davis, R. M., Chairman, Energy Session, Southern Regional Science Association Meeting, Rosslyn, Va., Apr. 15–16, 1981.

Ellison, R. D., Vice-Chairman, ASHRAE TC 8.4, Air to Refrigerant Heat Transfer Equipment.

Fairchild, P. D., Member, Gas Heat Pump Advisory Group, Gas Research Institute.

Fulkerson, W., Consulting Editor, *Environmental Impact Assessment Review.*

Gant, K. S., Plenary Member, Health Physics Society, July 1981.

Greene, D. L., Editor, *Transportation Geography Newsletter*, Association of American Geographers.

Greene, D. L., Member, Committee on Energy Conservation and Transportation Demand, Transportation Research Board, National Academy of Sciences.

Greene, D. L., Member, ORNL Exploratory Studies Program Proposal Review Committee.

Greene, D. L., Secretary-Treasurer, Transportation Special Interest Group, Association of American Geographers.

Grossman, G., Member, National Laboratories Working Group, Department of Energy Heat Pump Program Integration Task Force.

Haynes, V. O., Member, Appliance Advisory Committee, Gas Research Institute.

Hirst, E. A., Associate Editor, *Energy.*

Hirst, E. A., Chairman, Session on Evaluation of Government Energy Conservation Programs, Fourth Annual Meeting of the Evaluation Research Society, Arlington, Va., November 1980.

Hirst, E. A., Member, Editorial Board, *Journal of Environmental Systems.*

Hirst, E. A., Reviewer for *Science*, *Energy Policy*, and *Energy Systems and Policy.*

Kaplan, S. I., Consultant Member of Evaluation Panel, DOE Photovoltaic Application Experiments.

Kaplan, S. I., Member, SOLERAS Photovoltaic Power Project Review Team, Riyadh, Saudi Arabia, Sept. 4–9, 1981.

Kornegay, F. C., Session Chairman, Deposition, Transformations, and Complex Terrain Considerations During Intermediate Range Transport, Symposium on Intermediate Range Atmospheric Transport Processes and Technology Assessment, Gatlinburg, Tenn., Oct. 1–3, 1980.

Levins, W. P., Member, ASHRAE TC 1.2, Instruments and Measurements.

Levins, W. P., Member, Diagnostics Task Group, U.S. Department of Energy.

Loebl, A. S., Assistant Professor (part-time), University of Tennessee, Graduate School of Planning.

Loebl, A. S., Chairman, Session on Energy Data Validation, Survey Research Methods Section, Annual Meeting of the American Statistical Association, Detroit, Mich., August 1981.

Loebl, A. S., Committee Associate, Committee on Energy Conservation and Transportation Demand, Transportation Research Board.

Loebl, A. S., Committee Member, Costa Rican Workshop on Energy and Development, Board on Science and Technology for International Development, National Research Council, National Academy of Sciences.

Loebl, A. S., Member, Board of Directors, Association of Public Data Users.

Loebl, A. S., Rapporteur, Session on Biomass: Energy–Nonenergy Conflict, International Energy Symposium Series II, sponsored by the National Science Foundation, Knoxville, Tenn., 1981.

Loebl, A. S., Senior Research Associate, Center for International Research and Development of the University Research Corporation, Washington, D.C.

McConnell, B. W., Member, Electrical Engineering Power Advisory Committee, Tennessee Technological University.

Michel, J. W., Participant, Panel Discussion on Waste Heat, Utilization of Low-Grade Heat Power Cycles Workshop, May 26–31, 1981, Philadelphia, Pa.

Michel, J. W., Member, Technical Advisory Panel on OTEC Heat Exchangers, Department of Energy.

Michel, J. W., Member, Geothermal Coordinating Committee, Department of Energy.

Michel, J. W., Member, Technical Committee to Plan Activities for the 8th Ocean Energy Conference, Washington, D.C., June 7–11, 1981; Chairman, Session on Open-Cycle Power Systems.

Mixon, W. R., ORNL Representative, International District Heating Association; Member, Public Affairs Committee.

Mixon, W. R., Moderator, Session IV, ASCE Conference, Energy in the Man-Built Environment — The Next Decade, Vail, Colo., Aug. 3–5, 1981.

Perez-Blanco, H., Member, ASHRAE TC 8.3, Absorption Machines.

Perry, A. M., Advisory Editor, *Annals of Nuclear Energy*.

Perry, A. M., Associate Editor, *Energy, the International Journal*.

Perry, A. M., Member, Steering Committee for ONEP (ORNL National Energy Perspective).

Privon, G. T., Member, ASHRAE TC 8.1, Motors and Compressors.

Privon, G. T., Member, ASHRAE TC 8.11, Compressors.

Reddoch, T. W., Associate Editor, Electric Power Systems Research, Distribution Systems and In-Use Technologies Area.

Reddoch, T. W., Member, IEEE Load Management Working Group.

Reddoch, T. W., Member, IEEE Subcommittee on Systems Control.

Rizy, D. T., Member, IEEE Task Force on Dispersed Storage and Generation.

Roop, R. D., Vice-President, ORNL Professional Staff Association.

Rose, A. B., Member, Committee on Energy Conservation and Transportation Demand, Transportation Research Board, National Academy of Sciences.

Row, T. H., Workshop Chairman, Industrial Hygiene and Occupational Medicine in Coal Conversion Projects, Washington, D.C., Nov. 6–7, 1980.

Soderstrom, E. J., Product Reviewer, Policy Research and Analysis Division, National Science Foundation.

Soderstrom, E. J., Reviewer, Institute for Program Evaluation, U.S. General Accounting Office.

Stovall, J. P., Member, IEEE Working Group on Distribution System Design.

Tsao, H. J., Referee, *Biometrics, Journal of the Biometric Society*.

Vineyard, E. A., Member, ASHRAE TC 7.1, Domestic Refrigeration.

Walukas, D. J., Member, Appliance Advisory Committee, Gas Research Institute.

Walukas, D. J., Member, ASHRAE TC 6.6, Service Water Heating.

Walukas, D. J., Member, ASHRAE TC 7.1, Domestic Refrigeration.

Walukas, D. J., Member, ASHRAE TC 9.4, Applied Heat Pumps.

Wilbanks, T. J., Advisory Editor, *Syracuse Geographical Series*.

Wilbanks, T. J., Association Representative to Section *K* of the American Association for the Advancement of Science, Association of American Geographers.

Wilbanks, T. J., Consultant to Cleveland State University on program development in urban studies and policy planning, September 1981.

Wilbanks, T. J., Member, Advisory Committee, Resource Paper Series, Association of American Geographers.

Wilbanks, T. J., Member, Advisory Committee, Social Science–Energy Clearinghouse, Yale University.

Wilbanks, T. J., Member, Committee on Behavioral and Social Aspects of Energy Consumption and Production, National Academy of Sciences/National Research Council.

Wilbanks, T. J., Member, Energy Research Subpanel of the Research and Development Panel, Energy Research Advisory Board.

Wilbanks, T. J., Member, Finance Committee, Association of American Geographers.

Wilbanks, T. J., Member, Selection Committee for Fulbright Fellows in Geography, Council for the International Exchange of Scholars.

Wilbanks, T. J., Member, Working Group on Energy, International Geographical Union.

Wilbanks, T. J., Participant, Workshop on the Scientific Quality of Environmental Impact Statements, Institute of Ecology, March 1981.

8.2 PUBLICATIONS BY ENERGY DIVISION STAFF

Abbatiello, L. A., E. A. Nephew, and M. L. Ballou, *Performance and Economics of the ACES and Alternative Residential Heating and Air Conditioning Systems in 115 U.S. Cities*, ORNL/CON-52 (March 1981).

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8.3 ENVIRONMENTAL IMPACT STATEMENTS AND ASSESSMENTS

U.S. Department of Energy, "Programmatic Environmental Assessment (Documentation)," pp. 52–55 in *Proceedings of Mechanical, Magnetic, and Underground Energy Storage 1980 Annual Contractors' Review*, CONF-801128, November 1980.

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U.S. Department of Energy, *Draft Environmental Assessment: Geothermal Energy, Geopressure Subprogram, Gulf Coast Well Drilling and Testing Activity (Frio, Wilcox, and Tuscaloosa Formations, Texas and Louisiana)* (September 1981).

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U.S. Department of Energy, *Draft Environmental Impact Statement, Defense Waste Processing Facility, Savannah River Plant, Aiken, S.C.*, DOE/EIS-0082D (September 1981).

U.S. Department of Energy, *Draft Environmental Impact Statement, Memphis Light, Gas and Water Division, Memphis, Shelby County, Tennessee*, DOE/EIS-0071-D (October 1980).

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U.S. Department of Energy, *Illinois Coal Gasification Group, Pipeline Gas Demonstration Plant, Cutler, Illinois*, Review Draft Environmental Statement, prepared by ORNL for U.S. Department of Energy, March 1981.

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U.S. Nuclear Regulatory Commission, *Draft Environmental Impact Appraisal of Proposed Amendments for Use of Raffinate, Related to Kerr-McGee Nuclear Corporation Uranium Hexafluoride Facility, Sequoyah, Oklahoma*, Docket No. 40-8027 (September 1981).

U.S. Nuclear Regulatory Commission, *Draft Environmental Impact Statement Related to the Proposed Westinghouse Fuel Fabrication Plant, Prattville, Alabama* (not issued, but completed September 1981).

U.S. Nuclear Regulatory Commission, *Draft Environmental Statement Related to the Decommissioning of the Edgemont Uranium Mill*, Docket No. 40-1341, NUREG-0846 (September 1981).

U.S. Nuclear Regulatory Commission, *Final Environmental Statement Related to the Operation of Bison Basin Project*, Docket No. 40-8745, NUREG-0687 (April 1981).

U.S. Nuclear Regulatory Commission, *Final Environmental Statement Related to the Operation of San Onofre Nuclear Generating Station, Units 2 and 3*, NUREG-0490 (April 1981).

8.4 PATENTS

Grossman, G., "Absorption Heat Pumps for Temperature Boosting — Adaption for Operating Conditions with a Small Temperature Difference Between the Heat Source and Sink," CNID 4143, May 8, 1981.

Grossman, G., and H. Perez-Blanco, "Improvement in the Absorption Heat Pump Cycle for Temperature Boosting," CNID 4108, Oct. 30, 1980.

Mei, V. C., "Highway Vehicle Exhaust Gas Refrigerant System," partially approved by the U.S. Patent Office. [This is work developed prior to employment at ORNL.]

8.5 WORKSHOPS AND SYMPOSIA ORGANIZED BY ENERGY DIVISION STAFF

Energy Session, Southern Regional Science Association Meeting, Rosslyn, Va., Apr. 15–16, 1981, organized by R. M. Davis.

Fifth DOE/ORNL Heat and Cool Storage Demonstration Workshop Lake Placid, N.Y., Oct. 8–9, 1980, organized by D. T. Rizy.

Industrial Hygiene and Occupational Medicine in Coal Conversion Projects, Washington, D.C., Nov. 6-7, 1980, organized by T. H. Row.

Integrated Electrical Distribution Management System (IEDMS) Pre-Bid Conference, Oak Ridge National Laboratory, Oak Ridge, Tenn., July 1981, organized by B. W. McConnell and R. L. Waters (UCC-ND Purchasing).

Joint Institute Dormitory Study Group (symposium of eight experts on earth/building interface to discuss Joint Institute for Heavy Ion Research), Oak Ridge National Laboratory, Oak Ridge, Tenn., Aug. 25, 1981, organized by G. E. Courville.

Thermosense IV, Sept. 1–4, 1981, Ottawa, Canada (cosponsored by DOE, Society of Photo-optical Instrument Engineers, Public Works Canada, and American Society of Photogrammetry), organized by G. E. Courville.

8.6 INVITED SPEAKERS

Date	Subject	Speaker
October 20, 1980	Preliminary Review of Application of Vegetation in Architecture for Cooling	A. W. Spirn, Harvard University, Cambridge
October 21	EIA State-of-the-Data Program Plans and Activities; Guidelines and Procedures for the Conduct of a Data System Requirements Review	John B. Shewmaker, EIA, DOE
October 22	Regional Electricity Model	Martin Baughman, University of Texas, Austin
October 24	Accuracy Assessment and Data Validation Concepts and Methods	John B. Shewmaker and Charles S. Smith, EIA, DOE
November 4	Government, Policy, Technological Innovation, and Alternative Energy Sources: The Sawhill Task Force Report on Innovation	David Roessner, Georgia Institute of Technology, Atlanta
November 6	Energy from the West	Michael D. Devine and Steven C. Ballard, University of Oklahoma, Norman
November 17	Coal Leasing	David B. Pariser, General Accounting Office, Washington, D.C.
December 1	Energy Model Validation and Evaluation: A Comprehensive Validation Methodology	George F. Rhodes, Colorado State University, Fort Collins
December 3	A Multiregion Model of Factor Demands: Preliminary Results	T. R. Lakshmanan, Boston University, Boston

December 4	Theory of Power Pooling under Regulation	John Tschirhart, University of Wyoming, Laramie
December 9	Optimal Exploitation of Energy Resources: Solar Power and Electricity Generation in Below-Sea-Level Basins	Eithan Hochman, University of Southern California (on leave from Ben-Gurion University, Beer-Sheba, Israel)
December 15	Analysis of Coal Production Information Requirements	Joseph J. Bross and Jeffrey P. Price, MAXIMA Corp.
December 11	An Overview of Energy Planning in Brazil	Marisa V. Gallariny, Ministry of Rio de Janeiro, Brazil
December 17	Computer Graphic Applications for Policy Analysis	John Sibert, George Washington University, Washington
January 12, 1981	The Environmental Ozone Issue	Robert B. Hull, Dupont, Freon Products Division, Atlanta, Ga.
January 15	Natural Gas in the Context of the History of U.S. Energy Policy	Edward Erickson, North Carolina State University, Raleigh
January 19	Theoretical Advances in Modeling Economic and Social Behavior: Applications to the Evaluation of Policy-Oriented Models	Pat Burnett, Northwestern University, Evanston, Illinois
February 17	Overview of the Statistical Group Sciences at Research Triangle Institute	D. G. Horvitz and D. L. Bayless, Research Triangle Institute
February 23	Energy, Safety, and Environmental Programs in the U.S. Air Force	Carlos D. Stern, Department of the Air Force
February 27	Policy Considerations for Development of Public Lands	Daniel Beard, George Washington University, Washington
March 9	The Contributions of the Social Sciences to Emergency Planning	Russell Dynes, American Sociological Association, Washington, D.C.
March 12	Hedonic Price Analysis and the Demand for Fuel Efficiency in Automobiles	Allen Goodman, Johns Hopkins University, Baltimore
March 26	Key Environmental Issues at High-Priority Geothermal Areas in the West: A Summary of the LLNL Environmental Overview Program	P. Leitner, St. Mary's College of California
March 27	Water Resources Modelling with Interactive Graphics	Daniel P. Loucks, Cornell University, Ithaca
April 9	Ejector Heat Pumps for Low-Grade Heat Utilization	Z. Lavan, Illinois Institute of Technology, Chicago
April 16	Research and Development of Patents	Jerry A. Hausman, Massachusetts Institute of Technology, Cambridge
April 20	Electric Utilities Load Forecasting: System Load Analysis Method	Gary L. Jackson, TVA, Chattanooga
May 18	Locational Analysis Methods for Higher Order Objectives	G. Joseph Meneley, University of North Carolina, Chapel Hill
May 20	Dynamics of Transportation Development: Financing and Stability	Bruce A. Ralston, University of Tennessee, Knoxville

June 25	Results of the State of the Art Survey of Ground Coil Heat Pump Technology	Robert D. Fischer, Battelle Memorial Institute, Columbus
July 10	Heat Pump R&D Program, West German Federal Ministry for Research and Development	Peter Küppers, Kernforschungsanlage, Jülich
July 17	Delivering Energy Conservation: Primary Factors in the Design of Programs	Julie Elworth, Yale University, New Haven
July 23	Problems in the Cultural Analysis of Public Response to Radiation Hazard	Stephen F. Rayner, Russell Sage Foundation, New York
August 12	The Origin of the Earth's Deep Gases (The Abiotic Theory)	Thomas Gold, Director, Center for Radiophysics and Space Research, Cornell University
September 16	Theoretical Problems in Measuring Economic Responses to Earthquakes	Blaine Roberts, University of South Carolina, Columbia
September 23	Hedonic Demand Analysis of the Used Automobile Market	Allen Goodman, Johns Hopkins University, Baltimore

8.7 PRESENTATIONS BY ENERGY DIVISION STAFF AND SUBCONTRACTORS

Alvic, D. R., and E. L. Hillsman, "Trends in the Outsiting of Electric Power Plants in the United States," presented at the North American Meeting of the Regional Science Association, Milwaukee, Wis., Nov. 14–16, 1980.

Barbier, M. M., K. S. Gant, and C. V. Chester, "Adaptation of Construction Machinery for Large-Scale Environmental Decontamination," presented at the 26th Anniversary Meeting, Health Physics Society, Louisville, Ky., June 21–25, 1981.

Barnes, P. R., "A Review of Utility Issues for the Integration of Wind Electric Generation," presented at the DOE/NASA Workshop on Large, Horizontal-Axis Turbines, Cleveland, Ohio, July 28–30, 1981.

Barnes, R. W., "Conservation Potential in the Industrial Sector," presented at the Bonneville Power Administration's Eighth Annual Energy Management Conference, Portland, Ore., February 1981.

Barnes, R. W., "The Oak Ridge Industrial Model: An Introduction," presented at the Electric Power Research Institute's End Use Modeling and Conservation Analysis Workshop, Atlanta, Ga., November 1980.

Barron, W. F., and P. Kroll, "Modeling the Future Role of an Unconventional Energy Technology: Balancing Engineering and Economic Analyses," presented at the Operators Research Society of America/The Institute of Management Science Joint Meeting, Colorado Springs, Colo., Nov. 11, 1980.

Barron, W. F., "Alcohol Fuel Development: Comparing Ethanol and Methanol," presented at the Third World Energy Engineering Conference, Atlanta, Ga., Oct. 13–16, 1980.

Baxter, V. D., "Annual Cycle Energy System Experimental Performance and Applicability," presented to the Intersociety Energy Conversion Engineering Conference, Atlanta, Ga., Aug. 12, 1981.

Baxter, V. D., "Annual Cycle Energy System," presented to the Paducah, Ky. chapter of AIChE, Apr. 14, 1981.

Bjornstad, D. J., and K. E. Johnson, "An Economic Analysis of Payments in Lieu of Taxes," presented at the Southern Regional Science Association Meeting, Washington, D.C., Apr. 14–16, 1981.

Bjornstad, D. J., J. Mills, and D. N. Stuckwish, "Regional Economic Vulnerability due to Imported Crude Oil Curtailments," presented at the North American Meeting of the Regional Science Association, Milwaukee, Wis., Nov. 15, 1980.

Blue, J. L., "The Importance of Scale in Evaluation of Energy Conservation Programs," presented at the Annual Meeting of the Southeastern Division of the Association of American Geographers, Blacksburg, Va., November 1981.

Boston, C. R., "Synfuels and the NEPA Process," presented at the Seventh National Conference on Energy and the Environment, Phoenix, Ariz., Nov. 30–Dec. 3, 1980.

Boston, C. R., "The Environmental Assessment of Synfuels Projects," presented to the Oak Ridge City Council, Oct. 30, 1980. Invitation resulted from earlier presentation on the same subject to Tennessee State Legislature, Sept. 24, 1980.

Braid, R. B., Jr., "Socioeconomics of Energy Development: Some Observations," presented at the American Rural Health Association, Fifth Annual Institute on Delivery of Human Services to Rural People, Brainerd, Minn., June 12–16, 1981.

Broders, M. A., Taped presentation of "Potential of District Heating: An Historical Overview," presented at the European District Heating and Cooling Briefing, sponsored by the U.S. Conference of Mayors, Heidelberg, Germany, May 2–16, 1981.

Broders, M. A., "Potential for District Heating: An Historical Overview," presented to the District Heating and Cooling Training Workshop, U.S. Conference of Mayors, Washington, D.C., April 1981.

Bross, J. J. (MAXIMA Corporation), and J. P. Price (Resource Dynamics Corporation), "Analysis of Coal Production Information Requirements," presented at an Energy Division Seminar, Oak Ridge National Laboratory, Oak Ridge, Tennessee, and to the Energy Information Administration, Washington, D.C., January 1981.

Cannon, J. B., Testimony concerning Allens Creek Nuclear Generating Station Unit 1 at Atomic Safety and Licensing Board Hearings, Houston, Tex., Mar. 18–20, 1981.

Cannon, J. B., "Fusion's Potential as a Clean and Safe Energy Source," presented at the Atomic Industrial Forum Conference on Industry's Role in the Development of Fusion Power, New York, May 5, 1981.

Carnes, S. A., "Community-Based Assessment and Planning of Energy Futures," presented at the Community Energy Planning Conference, sponsored by the Tennessee Chapter of the American Planning Association, Gatlinburg, Tenn., Jan. 29–30, 1981.

Chen, F. C., "FY-1981 ORNL-OTEC Program," presented at the DOE-CORO program review meeting, Chicago, Ill., Oct. 6, 1981.

Chen, F. C., "ORNL Open-Cycle Deaeration Tests," presented at the OTEC open-cycle component development quarterly review meeting, Columbia, Md., Feb. 23, 1981.

Chen, F. C., "OTEC Alternate Cycles Development," presented at the DOE-CORO program review meeting, Chicago, Ill., Mar. 17, 1981.

Chen, F. C., "OTEC Gas Desorption Studies," presented at the 8th Ocean Energy Conference, Washington, D.C., June 3, 1981.

Chen, F. C., "Simulation of a Hydraulic Air Ingestion Process," presented at the 12th Modeling and Simulation Conference, Pittsburgh, Pa., Apr. 30, 1981.

Chester, C. V., "Incorporating Civil Defense Shelter Space in New Underground Construction," presented at the *Underground Space Conference and Exposition*, Kansas City, Mo., June 8–10, 1981.

Coar, G. (Transportation and Economic Research Associates, Inc.), "Validation of the Mandatory Crude Oil Allocation Program (Buy/Sell) Information System," presented at an Energy Division Seminar, Oak Ridge National Laboratory, Oak Ridge, Tenn., October 1980.

Cohn, S. M., and N. S. Cardell, "Residential Energy Tax Credit Eligibility: A Case Study for the Heat Pump Water Heater," presented at the Southwestern Economic Association Annual Meeting, Dallas, Tex., November 1980.

Corum, K. R., *Conservation Potential in the Commercial Sector*, presented at the Bonneville Power Administration's Eighth Annual Energy Management Conference, Portland, Ore., February 1981.

Creswick, F. A., "Alternate Heat Pump Cycle Studies," presented to the DOE Heat Pump Contractors' Program Integration Meeting, McLean, Va., June 2–4, 1981.

Creswick, F. A., "Gas Heat Pump Development," presented to the 1981 International Gas Research Conference, Los Angeles, Calif., Sept. 28–Oct. 1, 1981.

Cristy, G. A., H. B. Shapira, G. H. Llewellyn, R. B. Shelton, and D. M. Hamblin, "BEPS Project Review," July 21, 1981 (presented to review team from DOE-Headquarters).

DeCicco, S. G., "SRC Demonstration Plants: Alternatives in Pollution Control," keynote paper presented at the 20th Hanford Life Sciences Symposium on Coal Conversion and the Environment, Richland, Wash., Oct. 19–23, 1980.

Dobson, J. E., "Geographic Factors in Federal Coal Leasing Policy," presented at the Annual Meeting, Association of American Geographers, Los Angeles, Calif., April 1981.

Domingo, N., "Ammonia Condensation Experiment at ORNL," presented at the 8th Ocean Energy Conference, Washington, D.C., June 3, 1981.

Fischer, S. K., and C. K. Rice, "Computer-Aided Heat Pump Design and Optimization," presented to the DOE Heat Pump Contractors' Program Integration Meeting, McLean, Va., June 2–4, 1981.

Fischman, N. S., R. W. Peplies, and R. B. Honea, "A Geography of Abandoned Coal Mines: Problems in Identification, Classification, and Implementation," presented at the 1981 Annual Meeting of the Association of American Geographers, Los Angeles, Calif., Apr. 19–22, 1981.

Foster, D. V., L. W. Dowdy, and J. E. Ames (Vanderbilt University), "File Assignment in a Computer Network," presented at the Fifth Berkeley Workshop on Distributed Data Bases and Computer Networks, Berkeley, Calif., March 1981.

Fulkerson, W., and A. M. Perry, "Energy Supply and Demand Implications of CO_2," presented to the ASEV Field and Laboratory Representatives Meeting, Oak Ridge, Tenn., Oct. 3, 1980.

Fulkerson, W., "Energy Supply and Demand Implications of Carbon Dioxide," presented to the Environment, Energy, and Economics Conference, Tuskegee Institute, Tuskegee, Ala., Apr. 3, 1981.

Fulkerson, W., "ORNL's Role for EIA," presented to Albert H. Linden, Jr., Acting Administrator, Energy Information Administration, U.S. Department of Energy, June 3, 1981.

Fulkerson, W., "Overview of the Energy Division," presented to the Electric Power Research Institute, Palo Alto, Calif., May 5, 1981.

Fullerton, A. M., "Age Differences in Depth and Elaboration: Complexity vs. Concreteness," presented at the American Psychological Association, Los Angeles, Calif., Aug. 24–28, 1981.

Fullerton, A. M., "ORNL Tutorial on Human Factors for NRC Operational Aids for Reactor Operators," presented at meeting in Washington, D.C., June 3, 1981.

Fullerton, A. M., "The Relationship Between Depth of Processing and Elaborative Processing: Complexity versus Concreteness," presented at the Southeastern Psychological Association Meeting, Atlanta, Ga., Mar. 26, 1981.

Gallagher, C. A., R. J. Maddigan, and W. S. Chern, "A Comparison of State-Level and Rural Residential Electricity Demand," presented at the American Statistical Association Annual Meeting, Detroit, Mich., August 1981.

Gallagher, C. A., R. J. Maddigan, and W. S. Chern, "The Changing Pattern of Electricity Demand of the Rural Electric Cooperatives," presented at the Western Economic Association Annual Meeting, San Francisco, Calif., July 1981.

Gant, K. S., "Reducing Cancer Deaths by Exposure Management After a Nuclear Attack," presented at the American Civil Defense Association, Radiological Defense Officers' Association, and Southern California Emergency Services National Association Seminar, Anaheim, Calif., Oct. 22, 1980.

Gezen, A. (Transportation and Economic Research Associates), "EIA-149: Natural Gas Supply and Disposition Field Data Validation Study," presented at an Energy Division Seminar, Oak Ridge National Laboratory, Oak Ridge, Tenn., and to the Energy Information Administration, November 1980.

Golshani, A., "Vacuum Deaeration for OTEC Applications," presented at the International Symposia on Alternative Energy Sources and Technology, San Francisco, Calif., May 21, 1981.

Greene, D. L., and E. C. K. Chen, "A Time Series Analysis of State Gasoline Demand, 1975–1980," presented at the Eastern Economics Association Annual Convention, Philadelphia, Penn., Apr. 9–11, 1981.

Greene, D. L., and E. C. K. Chen, "AIRMA Modeling of Regional Gasoline Demand in the U.S.," presented at the Energy Modeling Session, ORSA/TIMS International Conference, Toronto, Ontario, Canada, May 1981.

Greene, D. L., and G. H. Walton, "A Time Series Analysis of Regional Gasoline Demand in the United States," presented at the Association of American Geographers, Los Angeles, Calif., Apr. 19–21, 1981.

Greene, D. L., "A State-Level Stock System Model of Gasoline Demand," presented at the 60th Annual Meeting of the Transportation Research Board, Washington, D.C., Jan. 12–16, 1981.

Greene, D. L., "Regional Issues in Petroleum Supply Emergencies," presented at the Spring Lecture Series, Boston University Center for Energy and Environmental Studies, Boston, Mass., Mar. 18, 1981.

Greene, D. L., "Testimony Before the Interior Appropriations Subcommittee of the Appropriations Committee of the United States House of Representatives," presented at meeting in Washington, D.C., Apr. 8, 1981.

Grossman, G., et al., "Improvements in Absorption Systems for Solar Air Conditioning," presented at the 1981 Annual Meeting of the American Section of the International Solar Energy Society, Philadelphia, Pa., May 28–30, 1981.

Grossman, G., "Absorption Heat Pumps for Upgrading Waste Heat," presented at the ASHRAE Semiannual Meeting, Chicago, Ill., Jan. 25–29, 1981.

Grossman, G., "Air Conditioning and Heat Pump Systems Powered by Solar Energy and Low Grade Heat," invited seminar, presented at Bell Research Laboratories, Whippany, N.J., Oct. 27, 1980.

Grossman, G., "Development of Solar and Low-Grade-Heat-Powered Absorption Chillers for Air Conditioning," invited seminar, presented at the Illinois Institute of Technology, Chicago, Ill., Jan. 30, 1981.

Grossman, G., "Heat Pump Systems for Heating and Cooling Powered by Solar Energy and Low-Grade Heat," invited seminar, presented at the University of Texas, Austin, Apr. 6, 1981.

Grossman, G., "Solar and Low-Grade-Heat-Powered Absorption Chillers," invited seminar, presented at the Solar Energy Research Institute, Golden, Colo., Nov. 12, 1980.

Haaland, C. M., "Radiological Defense Handbooks for FEMA," presented at the Management Conference for the Radiological Defense Officer Program, National Emergency Training Center, Emmitsburg, Md., Sept. 21–25, 1981.

Haaland, C. M., "A Proposed New Handbook for FEMA: Radiation Safety in Shelters," presented at the Health Physics Society Annual Meeting, Louisville, Ky., June 21–26, 1981.

Haaland, C. M., "Assessment of Instrument Requirements Based on Shelter Postures for Nuclear War," presented at the Symposium on the Control of Exposure from Ionizing Radiation in the Event of Accident or Attack, National Council for Radiation Protection, Washington, D.C., Apr. 27–29, 1981.

Haaland, C. M., "Instrument Requirements for Radiological Defense," presented at the Management Conference for the Radiological Defense Officer Program, National Emergency Training Center, Emmitsburg, Md., Sept. 21–25, 1981.

Haynes, V. O., W. P. Levins, and E. A. Vineyard, "Less Fuel, More Heat, ORNL Goal," *Knoxville Journal*, Aug. 18, 1981.

Haynes, V. O., WBIR-TV news release, Apr. 17, 1981.

Hill, L. J., "Forecasting Electricity Demand by States," presented at the Annual Meeting of the National Association of Regulatory Utility Commissioners, San Francisco, Calif., Nov. 18, 1981.

Hill, L. J., "Forecasting Electricity Demand by States," presented at the Annual Meeting of the Western Interstate Energy Board, San Diego, Calif., May 5, 1981.

Hillsman, E. L., P. E. Johnson, and B. E. Peterson, "Predicting Routes of Radioactive Wastes Moved on the U.S. Railroad System," presented at the Sixth International Symposium on Packaging and Transportation of Radioactive Materials (PATRAM '80), Berlin, West Germany, Nov. 10–14, 1980.

Hillsman, E. L., "A System for Location-Allocation Analysis: Solving Multicriteria Optimal Location Problems," presented at the Second Annual Meeting, National Association of Geographers, Tirupati, India, Jan. 10–13, 1981.

Hirst, E. A., "Improving Energy Efficiency: The Case for Government Programs," presented at the Minnesota Energy Agency, St. Paul, Minn., February 1981.

Hirst, E. A., "Disaggregate Data: A New Foundation for Energy Models," presented at the Seminar on Energy Demand Forecasting for the Residential Sector, University of California, Berkeley, May 1981.

Hirst, E. A., "Do Conservation Programs Work?" presented at the Electric Power Research Institute, Palo Alto, Calif., and the Bonneville Power Administration, Portland, Ore., January 1981.

Hirst, E. A., "Do Utility Conservation Programs Work?" presented at the Keystone Center Conference on Improving Electrical Energy Efficiency: California, North Carolina, and Florida, Keystone, Colo., September 1981.

Hirst, E. A., "Energy Conservation Potential in Existing Minnesota Buildings," presented at the Seventh Annual Minnesota Energy Conference, Minneapolis, Minn., February 1981.

Hirst, E. A., "Energy Use and Engineering Audits at State-Owned Facilities in Minnesota," presented at the Third World Energy Engineering Congress, Atlanta, Ga., October 1980.

Hirst, E. A., "Energy Use from 1973 to 1980: The Role of Improved Energy Efficiency," briefing for Joseph Tribble, Assistant Secretary for Conservation and Renewable Energy, U.S. Department of Energy, Washington, D.C., July 1981.

Hirst, E. A., "Evaluating Conservation Programs of the Office of Buildings and Community Systems," presented at the U.S. Department of Energy, Washington, D.C., April 1981.

Hirst, E. A., "Evaluation and Measurement of Energy Conservation Programs," presented at the Solar Energy Research Institute, Golden, Colo., October 1980.

Hirst, E. A., "Future Demand for Electricity: Dealing with Uncertainty," presented at the Fourth Annual Aspen Institute Energy Policy Forum, Utilities in Crisis, a Problem in Governance, Aspen, Colo., July 1981.

Hirst, E. A., "Improving Energy Efficiency: The Effectiveness of Government Action," testimony before the Interior Appropriations Subcommittee, U.S. House of Representatives, April 1981.

Hirst, E. A., "Measuring the Effectiveness of Energy Conservation Programs in the Pacific Northwest," presented to the Pacific Northwest Utilities Conference Committee, Portland, Ore., May 1981.

Hirst, E. A., "Residential Energy Conservation Actions," presented at the National Interim Energy Consumption Survey Data User's Meeting, Princeton University, Princeton, N.J., July 1981.

Hirst, E. A., "Review of David J. MacFadyen's Paper on Housing, Transportation, and Energy Systems Technologies," presented at the Brookings Conference on Housing and Energy in the 1980s, Brookings Institution, Washington, D.C., October 1980.

Hirst, E. A., "The Role of Government Programs to Improve Energy Efficiency in Buildings," presented at the Seminar for Congressional Staff Members, sponsored by the Energy Conservation Coalition and the Federation of American Scientists, Washington, D.C., March 1981.

Honea, R. B., and W. Fulkerson, "The Southeast Region Energy Prospects: A Realistic Appraisal," presented at the 1981 Regional Energy Conference, Atlanta, Ga., Mar. 16, 1981.

Hooker, J. N., "The Effect of a Sudden Fuel Shortage on Freight Transport in the United States: An Overview," presented at the United Parcel Service National Energy Meeting, Knoxville, Tenn., Feb. 25, 1981.

Intemann, P. R., "Land and Resource Use Issues at the Valles Caldera," presented at the 1981 Annual Geothermal Resources Council Meeting, Oct. 26–29, 1981, Houston, Tex.

Johnson, K. E., Prepared Written Testimony Concerning Alternatives to the Proposed Allen's Creek Nuclear Generating Station, presented to the NRC Board, Feb. 9–13, 1981.

Kaplan, S. I., "Experience from DOE Photovoltaic Grant Projects," presented at the 1981 Annual Meeting, American Section, International Solar Energy Society, Philadelphia, Pa., May 26–30, 1981.

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Air Conditioning and Refrigeration Foundation, Inc.
AiResearch Manufacturing Company of California
Allied Chemical Corporation

American Consulting Engineers Council Research and Management Foundation
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Brookhaven National Laboratory
Cabot Consulting Group
Carl Mays, Corkill-Seddon, Inc.
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City of Carbondale
City of Westland
Coastal Environments, Inc.
Colorado State University
Commonwealth Associates, Inc.
CONSAD Research Corporation
Consolidated Natural Gas Research Corporation
Construction Technology Laboratories
CSI Resource Systems Inc.
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Energy Utilization Systems, Inc.
Evaluation Research Corporation
Foster-Miller Associates, Inc.
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GAI Consultants
Gant Scientific Consultants
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Minnesota Energy Agency
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Southern Five Regional Planning District and Development Commission
St. Mary's College of California
Stevens Institute of Technology
Structured Methods Inc.
Studsvik Energiteknik AB (Sweden)
Synergic Resources Corporation
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TLH Associates, Inc.
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8.10 ADVISORY COMMITTEE

The Advisory Committee for the Energy Division is appointed by Herman Postma, Director of Oak Ridge National Laboratory. The committee members for FY 1981 and 1982 are as follows:

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Group Vice-President
Automotive Products Group
Hoover Universal, Inc.
135 East Bennett Street
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Institute of Government Studies
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Larry I. Moss
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Milton Russell*
Director
Center for Energy Policy Research
Resources for the Future
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Washington, D.C. 20036

William Williams*
American Telephone and Telegraph
430 Mountain Avenue, Room 165
Murray Hill, New Jersey 07974

*Appointment effective 1982.

8.11 FINANCIAL STATEMENT

The following charts provide an outline of the work of the Energy Division. The first chart is a listing of sponsors, expenditures, and commitments of the scientific staff, and the second shows a division of personnel by discipline. Following these listings is an organization chart of the division.

ENERGY DIVISION SPONSORS, EXPENDITURES, AND COMMITMENTS OF SCIENTIFIC STAFF FOR FY 1981

Sponsor	Expenditures (10^3 \$)	Scientific staff (person-years)		Subcontract costs (10^3 \$)
		Energy Division	Other divisions	
Department of Energy work				
Conservation and renewable energy				
Buildings and community systems	11,687	30.6	5.2	7,837
Energy storage systems	153	0.6	0.0	76
Industrial	83	0.8	0.0	16
Solar energy	934	6.2	1.1	199
State/local programs	841	5.1	0.1	234
Transportation	909	4.3	0.1	213
	14,607	47.6	6.5	8,575
Economic Regulatory Administration				
Office of Fuels Conversion	1,512	3.6	1.0	913
Office of Utility Systems	237	1.2	0.0	121
Office of Special Counsel for Compliance	853	1.2	0.0	744
Office of Natural Gas Regulation	46	0.0	0.0	43
Regulations and emergency planning	23	0.0	0.0	17
	2,671	6.0	1.0	1,838
Energy Information Administration	4,118	7.3	0.0	2,974
Energy research				
Office of Fusion Energy	569	1.4	3.5	68
Environment				
Office of Environmental Programs	1,213	4.0	0.1	643
Office of Environmental Protection and Public Safety	146	1.1	0.0	6
	1,359	5.1	0.1	649
Federal Energy Regulatory Commission	123	0.5	0.0	73
Fossil energy				
Division of Planning and Systems Engineering	95	0.0	0.3	52
Office of Coal Utilization	1,916	3.5	3.6	1,108
Office of Major Projects	700	1.0	0.4	519
Office of Plans and Technology Assessments	99	0.4	0.0	20
	2,810	4.9	4.3	1,699

SPONSORS, EXPENDITURES, AND COMMITMENTS (continued)

Sponsor	Expenditures (10³ $)	Scientific staff (person-years)		Subcontract costs (10³ $)
		Energy Division	Other divisions	
Nuclear energy				
Office of Advanced Nuclear Systems and Projects	102	0.7	0.0	1
Policy and evaluation	429	1.1	0.0	239
Resource applications				
Electric energy systems	3,626	5.7	0.6	2,775
Geothermal	533	3.2	1.4	34
Leasing policy development office	616	2.3	0.0	348
	4,775	11.2	2.0	3,157
DOE, Bonneville Power Administration	19	0.1	0.0	0
DOE, Chicago Operations and Regional Office	233	1.0	0.1	36
DOE, Oak Ridge Operations Office	1,284	4.4	1.2	342
DOE, San Francisco Operations Office	110	0.7	0.0	24
DOE, Savannah River Operations Office	290	1.1	0.0	179
	1,936	7.3	1.3	581
Argonne National Laboratory	58	0.5	0.0	0
Battelle Columbus Laboratory, Office of Nuclear Waste Isolation	128	0.8	0.4	0
Battelle Pacific Northwest Laboratory	5	0.0	0.0	0
Los Alamos National Laboratory	7	0.0	0.0	0
Oak Ridge Associated Universities	33	0.4	0.0	0
Savannah River Plant	847	2.7	0.0	415
	1,078	4.4	0.4	415
Total DOE work	34,577	97.5	19.1	20,269
Other federal agencies work				
Nuclear Regulatory Commission				
Office of Nuclear Materials Safety and Safeguards	836	2.4	1.1	299
Office of Reactor Regulation	153	1.2	0.0	0
Office of Regulatory Research	687	2.5	0.0	266
	1,676	6.1	1.1	565
Department of Agriculture				
Rural Electrification Administration	96	0.4	0.0	10
Department of Housing and Urban Development	362	1.9	0.2	131
Department of the Interior				
Bureau of Indian Affairs	[illegible]9	0.3	0.0	4
Office of Surface Mining	[illegible]8	2.4	0.0	378
	807	2.7	0.0	382
Department of the Navy	44	0.3	0.0	0
Environmental Protection Administration	131	0.7	0.1	20
Federal Emergency Management Agency	91	0.6	0.0	0
Tennessee Valley Authority	42	0.3	0.0	0
Total other federal agencies	3,249	13.0	1.4	1,108

SPONSORS, EXPENDITURES, AND COMMITMENTS (continued)

Sponsor	Expenditures (10^3 \$)	Scientific staff (person-years)		Subcontract costs (10^3 \$)
		Energy Division	Other divisions	
Private organizations work				
Electric Power Research Institute	42	0.2	0.0	4
Massachusetts Institute of Technology	5	0.0	0.0	0
United Nuclear Corporation	10	0.1	0.0	0
Total work for private organizations	57	0.3	0.0	4
Total non-DOE work	3,306	13.3	1.4	1,112
Total Energy Division work	37,883	110.8	20.5[a]	21,381

[a]Includes effort (in person-years) from the Plant and Equipment, Instrumentation and Controls, Y-12 Support, and Engineering divisions.

ENERGY DIVISION PERSONNEL BY DISCIPLINE—FY 1981
September 30, 1981

Discipline	Enviromental Impact Section	Regional and Urban Studies Section	Economic Analysis Section	Data and Analysis Section	Efficiency and Renewables Research Section	Programs and Planning	Division Administration	To
Professional								
Social sciences								
Architects					1.0			1
Economists			17.0					17
Geographers		9.0		1.0		2.0		12
Philosophers		1.0						1.
Planners		1.0						1.
Political scientists		3.5						3.
Psychologists		2.0						2.
Science education		0.5						0.
Sociologists		2.5		1.0				3.
Other		1.0						1.
Total social sciences								42.
Physical and life sciences								
Biologists	2.0	0.5		1.0	1.0			4.
Chemists	3.0	1.0						4.
Ecologists	1.0	1.0						2.
Geologists	4.5							4.
Mathematicians				1.0	1.0			2.
Meteorologists	4.0							4.
Physicists		2.0			6.0	1.0		9.
Statisticians				1.0				1.
Total physical and life sciences								31.
Engineering sciences								
Architectural engineers					1.0			1.
Chemical engineers	5.0	1.0		2.0	6.0		1.0	15.
Electrical engineers		2.0			5.0			7.
Engineering physicists					1.0			1.
Engineering scientists		1.0			2.0			3.
Industrial engineers		1.0		1.0				2.
Mechanical engineers	5.0	1.0		2.0	16.0	1.0		25.
Other					1.0	1.0		2.
Total engineering sciences								56.
Clerical and technical								
Accounting clerks							1.0	1.
Administrative assistants							1.0	1.
Data center analysts		2.5	1.0	1.0				4.
Librarians		1.0						1.
Secretaries	4.5	6.0	3.5	4.0	9.0	1.5	3.0	31.
Technicians					3.0			3.
Total clerical and technical								42.
Total	29.0	40.5	21.5	15.0	53.0	6.5	6.0	171.

*Full-time equivalents.

ENERGY DIVISION PERSONNEL BY DISCIPLINE—FY 1981
September 30, 1981

	Enviromental Impact Section	Regional and Urban Studies Section	Economic Analysis Section	Data and Analysis Section	Efficiency and Renewables Research Section	Programs and Planning	Division Administration	Total
			Professional					
					1.0			1.0
			17.0					17.0
		9.0		1.0		2.0		12.0
		1.0						1.0
		1.0						1.0
		3.5						3.5
		2.0						2.0
		0.5						0.5
		2.5		1.0				3.5
		1.0						1.0
								42.5
	2.0	0.5		1.0	1.0			4.5
	3.0	1.0						4.0
	1.0	1.0						2.0
	4.5							4.5
				1.0	1.0			2.0
	4.0							4.0
		2.0			6.0	1.0		9.0
				1.0				1.0
science,								31.0
					1.0			1.0
	5.0	1.0		2.0	6.0		1.0	15.0
		2.0			5.0			7.0
					1.0			1.0
		1.0			2.0			3.0
		1.0		1.0				2.0
	5.0	1.0		2.0	16.0	1.0		25.0
					1.0	1.0		2.0
ces								56.0
			Clerical and technical					
							1.0	1.0
							1.0	1.0
		2.5	1.0	1.0				4.5
		1.0						1.0
	4.5	6.0	3.5	4.0	9.0	1.5	3.0	31.5
					3.0			3.0
ical								42.0
	29.0	40.5	21.5	15.0	53.0	6.5	6.0	171.5*

ENERGY DIVISION

SEPTEMBER 1, 1981

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- J. S. BALDWIN[1]

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FUSION PROGRAMMATIC EIS
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SAVANNAH RIVER DEFENSE WASTE EIS
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- V. C. MEI
- W. A. MILLER
- C. K. RICE
- F. D. FAIRCHILD, PROGRAM [illegible]

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- J. L. BLEDSOE[1]
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- K. W. CHILDS[7]
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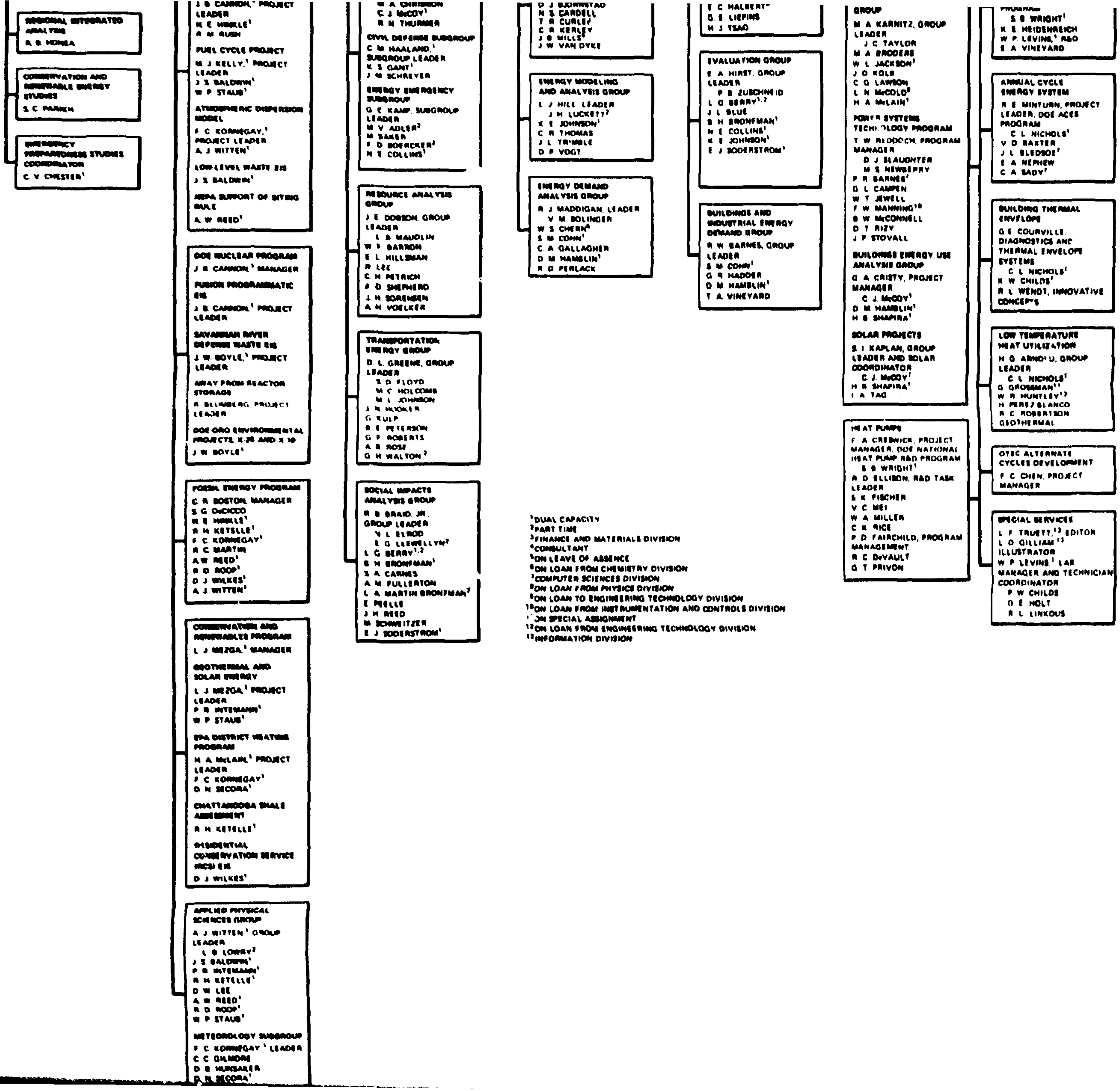
  - C. L. NICHOLS[1]
- G. GROSSMAN[11]
- W. R. HUNTLEY[12]
- H. PEREZ BLANCO
- R. C. ROBERTSON, GEOTHERMAL

OTEC ALTERNATE CYCLES DEVELOPMENT
- F. C. CHEN, PROJECT MANAGER

SPECIAL SERVICES
- L. F. TRUETT,[13] EDITOR

[1]DUAL CAPACITY
[2]PART TIME
[3]FINANCE AND MATERIALS DIVISION



[1]DUAL CAPACITY
[2]PART TIME
[3]FINANCE AND MATERIALS DIVISION
[4]CONSULTANT
[5]ON LEAVE OF ABSENCE
[6]ON LOAN FROM CHEMISTRY DIVISION
[7]COMPUTER SCIENCES DIVISION
[8]ON LOAN FROM PHYSICS DIVISION
[9]ON LOAN TO ENGINEERING TECHNOLOGY DIVISION
[10]ON LOAN FROM INSTRUMENTATION AND CONTROLS DIVISION
[11]ON SPECIAL ASSIGNMENT
[12]ON LOAN FROM ENGINEERING TECHNOLOGY DIVISION
[13]INFORMATION DIVISION