BNL 50969

ANNUAL HIGHLIGHTS OF THE NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS

KENNETH C. HOFFMAN

December 1978

NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS
DEPARTMENT OF ENERGY AND ENVIRONMENT

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

UNDER CONTRACT NO. EY-76-C-02-0016 WITH THE
UNITED STATES DEPARTMENT OF ENERGY

DISCLAIMER

BNL 50969
UC-13
[General, Miscellaneous, and Progress
Reports (Nonnuclear) - TID-4500]

ANNUAL HIGHLIGHTS OF THE NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS

KENNETH C. HOFFMAN

December 1978

NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS
DEPARTMENT OF ENERGY AND ENVIRONMENT

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

NOTICE

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Price: Printed Copy $7.25; Microfiche $3.00

May 1979 700 copies

ABSTRACT

The National Center for Analysis of Energy Systems at Brookhaven has been in operation since January 1976. This annual highlights report outlines the scope of activities of the Center involving the integrated analyses of technological, economic, environmental, and social aspects of energy at the regional, national, and international levels. The objectives of the Center and major accomplishments of 1978 are described along with a list of active projects and publications. The energy data bases and analytical models used in the course of policy analyses are also described.

The major ongoing activites of the Center include:

- analysis of energy-economic relationships,
- regional energy and environmental policy,
- comparative health effects of alternative energy systems,
- technology assessment and energy R&D priorities,
- development of energy-economic-environmental models and data bases,
- R&D strategies for International Energy Agency, and
- energy technologies for developing countries.

The multidisciplinary approach used in the Center and the close interaction with other analytical groups in universities and industry provide a unique perspective on the energy situation. This perspective is given emphasis in the 1978 highlights report.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

TABLE OF CONTENTS

	Page
Abstract	iii
List of Tables	vii
List of Figures	vii
Introduction	1
Objectives	2
Highlights of 1978	3
Technology Assessment Program	4
Economic Analysis Programs	8
Environmental Programs	14
International Perspective	18
Regional Activities	27
Major Activities Planned for 1979	28
Organization	29
Relationship to Other Activities	29
Scope of Activities	31
Regional Studies	31
Economic Analysis	32
Biomedical and Environmental Assessment	32
Technology Assessment	33
Energy Data and Models	34
Energy Model Evaluation	36
International Projects	37
Appendix A: Scope of Activities for FY 79	39
Regional Studies	41
Economic Analysis	47
Biomedical and Environmental Assessment	59

TABLE OF CONTENTS (CONT'D)

		Page
	Technology Assessment	63
	Energy Data and Models	69
	International Projects	81
Appendix B:	Data Bases and Analytical Models Developed by and/or Available to the Center .	91
Appendix C:	Publications and Abstracts of the Center . .	115

LIST OF TABLES

Table No.		Page
I	Resource Use Summary - 2000	5
II	Summary of Economic Effects of Higher Energy Prices in the BNL/DJA Energy-Economic Model	10

LIST OF FIGURES

Figure No.		
1	U.S.-Long Term Energy Supply	7
2	The Energy-GNP Ratio, 1947-2000: An Indicator of Energy-Economy Interactions in the BNL/DJA Model System	12
3	Air Quality-Health Assessment Approach	16
4	Pareto-Optimal Surface	21
5	Technology Map - Country "A" - Year 2000	23
6	Cost-Security Trade-off Possibilities for Several IEA Member Nations	23
7	Projections of Oil Consumption in Peru; Reference Case and Various Energy Strategy Impacts	26
8	Brookhaven National Laboratory National Center for Analysis of Energy Systems	30
B-1	Policy Considerations	93
B-2	Reference Energy System	93

INTRODUCTION

The National Center for Analysis of Energy Systems (NCAES) was established at Brookhaven in January 1976. The formation of the Center gave recognition both to the need for detailed interdisciplinary studies of the relations between the technological, economic, social, and environmental factors of energy systems and to the previous work done by the Brookhaven groups in these areas of energy systems analysis. The staff provides expertise in the areas of science, technology, economics, planning, health and safety, information systems, and quantitative analysis. In order to relate the technological aspects of energy to other policy areas including economics and the environment, work is performed when appropriate for other federal agencies and for state and regional agencies, regulatory bodies, and planning groups.

The emphasis of the programs at the Center is on planning studies at the regional, national, and international levels in areas of special import to energy analysis. This work is designed to assist several offices in the Department of Energy (DOE) including: Energy Information Administration, Assistant Secretary for the Environment, Assistant Secretary for Policy and Evaluation, Assistant Secretary for Conservation and Solar Application, Assistant Secretary for International Affairs, Office of Energy Research, and Economic Regulatory Administration. A portion of the effort is devoted to the development of planning frameworks, analytical models, and data bases that are required to give adequate support to the energy studies. Thus the program involves both operational support to DOE and original research in energy systems analysis. Individuals associated with the Center have engaged in a number of major panel and committee activities in the energy area. The research component of previous programs on which the Center is based has led to the development of analytical methods and data bases that are widely used at the federal level as well as by industry and universities. These unique analytical techniques emphasize technological detail and are employed in support of the planning studies.

OBJECTIVES

Special objectives of the National Center for Analysis of Energy Systems are:

1. To perform energy technology and policy assessments on a continuing basis to support DOE.
2. To develop techniques for energy-economic analysis.
3. To analyze biomedical and environmental impacts of energy strategies.
4. To perform special regional and national policy studies.
5. To explore international aspects of energy in relation to technology and policy.
6. To develop improved data bases and analytical methods for use in energy policy analysis and technology assessment.
7. To assist in the coordination and integration of energy data and models through collaborative efforts with universities and industry.
8. To cooperate with and assist other federal agencies, regional planning and regulatory agencies, universities, and industry groups in the analysis of special problems of mutual interest and in the dissemination of information and analytical methods.
9. To provide support and facilities for workshops and special study groups assembled to address important topics.

HIGHLIGHTS OF 1978

- Completed a study of decentralized energy technologies and their implementation in the U.S. energy system.

- Prepared a series of long-term energy projections for the Energy Information Administration.

- Initiated work on an Energy Emergency Management Information System based on the Reference Energy System.

- Completed, in collaboration with participating IEA member nations, the development of a new energy system market allocation model, MARKAL. The model was applied to a comprehensive multiobjective assessment of new energy technologies.

- Participated in DOE Developing Countries Studies of Egypt and Peru and completed the analysis of alternative future energy systems for those countries.

- Performed comparisons of major energy-economic models used for mid- and long-term energy projections.

- Developed industry process models for steel, aluminum, pulp and paper, and glass for use in policy analysis.

- Evaluated transport of energy pollutants and health effects of the production and utilization of coal for the National Coal Utilization Assessment.

The above is only a sampling of the work of the National Center for Analysis of Energy Systems during 1978. Although many of these achievements involve individual projects for specific program offices in the Department of Energy, the range and scope of the assemblage of individual projects are extremely broad. The integration and coordination of the technical, economic, environmental, and international projects provide a unique perspective on the U.S. and global energy situation. In this report we have drawn these results together into a set of perspectives on the energy situation.

Technology Assessment Program

For several years, the Technology Assessment Group has conducted a series of analyses of the prospects for and potential benefits of new technologies that are now in the research and development stage. The technical and economic characteristics of new energy technologies are subject to large uncertainties; however, assuming technical and economic success of the R&D, certain features of the future energy system for the U.S. seem clear.

To analyze long-term supply and conversion options, three possible cases utilizing technologies for enhanced energy supply were examined:

1. Large-scale electrification based upon coal and nuclear fuels.
2. Large-scale enhancement of fossil supplies of conventional oil and gas as well as synthetics from coal.
3. Large-scale use of renewable resources--solar energy and biomass, and process heat from cogeneration.

These represent alternative boundary cases in that they each stress individual groups of technology to their limits. The most likely forecast would comprise a combination of these cases.

Scenarios for each of the above cases were prepared using the Reference Energy System format, in which constant levels of services required in the economy were assumed for all cases. Judgmental estimates of technology penetration were employed. Prospects for improving the efficiency of energy use, and changes in service levels as a function of price, are discussed in the section on economic perspectives. Technology assessments indicate that the opportunities for technical improvements in the efficiency of energy use are large, but will be governed largely by energy pricing and regulation.

The maximum electrification scenario assumes that the role of electricity could be increased from the base case level of 43 percent of primary inputs in the year 2000 to 47 percent, and relies heavily on both nuclear and coal-fired central station plants to meet the demands of the increasingly

electrified economy. Major areas of emphasis are all-electric homes, some use of electricity for industrial process heat, availability of industrial heat pumps, and large-scale adoption of residential heat pumps.

The maximum fossil scenario assumes the continuation of the present end-use consumption patterns dominated by fossil fuels and emphasizes the role of the supply enhancement programs for oil, gas, and shale oil and the use of coal-based synthetics. The degree of electrification falls to 38 percent from the base case level of 43 percent of total primary inputs. The "gas option" is, of course, a recently rediscovered long-range option. If substantial supplies of methane are available at prices of $3 to $5 per million Btu, then this fuel could capture much of the nation's urban and industrial markets with significant environmental benefits. This would also dampen further the demand for imported oil.

The decentralized scenario is aimed at the maximum use of decentralized and renewable resources by the year 2000. This case emphasizes solar, geothermal, biomass, and waste heat recovery to reduce dependence on conventional fossil fuels, and substitutes direct burning of fossil fuels for electricity in the industrial sector. Electrification falls from the base case level of 43 percent to 37 percent in terms of primary inputs.

Table I summarizes the fuel use patterns for the three cases. The

TABLE I

Resource Use Summary - 2000

(Quadrillion Btu)

	Base	Elect.	Fossil	Decentr.
Total Primary Inputs	138.5	141.3	135.7	129.7
Oil: Domestic	18.8	18.8	22.8	18.8
Imported	26.9	26.6	22.0	28.5
Shale	3.0	3.0	5.0	3.0
Coal	32.6	32.1	33.3	26.3
Gas: Domestic	17.7	17.9	21.1	17.9
Imported	1.3	0.1	2.7	3.7
Nuclear	28.5	31.6	20.0	17.8
Electricity-Central (Hydro/Geo/Solar)	7.7	9.2	6.8	10.2
Electricity-Noncentral	2.0	2.0	2.0	3.4

Notes: Coal includes wood; domestic gas includes biomass.

electrification scenario uses the greatest input fuel quantity because of the conversion, transmission, and distribution losses associated with the use of electricity. The lower oil impact levels of the fossil case result from increased domestic supplies obtained from enhanced recovery, increased shale oil production, and coal synthetics. The decentralized case uses the lowest total fuel input because of the use of renewable resources and waste heat.

In summary, despite significant differences in fuel mix resulting from the choices of supply options, the U.S. energy system will still rely heavily upon fossil fuels and nuclear power through the year 2000. Beyond that time frame, detailed analysis at BNL indicates that future energy supplies will be heavily based upon a triad consisting of fossil fuels (primarily coal-based), nuclear, and renewable resources (solar and geothermal). The resource base for this long-term triad supply strategy is shown in Figure 1.

The three scenarios described above have drawn on previous work performed involving detailed analyses of intensive electrification and the future role of coal. A supporting study of decentralized systems has also been recently completed. The latter study examines the viability of decentralized systems both as the primary source of the nation's energy (in the long term), and as a component of the existing energy system (in the near and mid term).

The issue of decentralization of the energy system is a topic of considerable policy debate. The issue is largely a question of the structure of society and patterns of urban development, but does have significant energy policy implications. Centralization of the energy system toward large utility networks and a global liquid fuel system was driven largely by the economies of scale, increased reliability, and, in the case of utilities, the benefits of load diversity. While these aspects of centralization have been of great benefit to the consumer, there is another side to the coin that must be studied. Centralization has, in many instances, moved the easily perceived risks and environmental issues to locations remote from

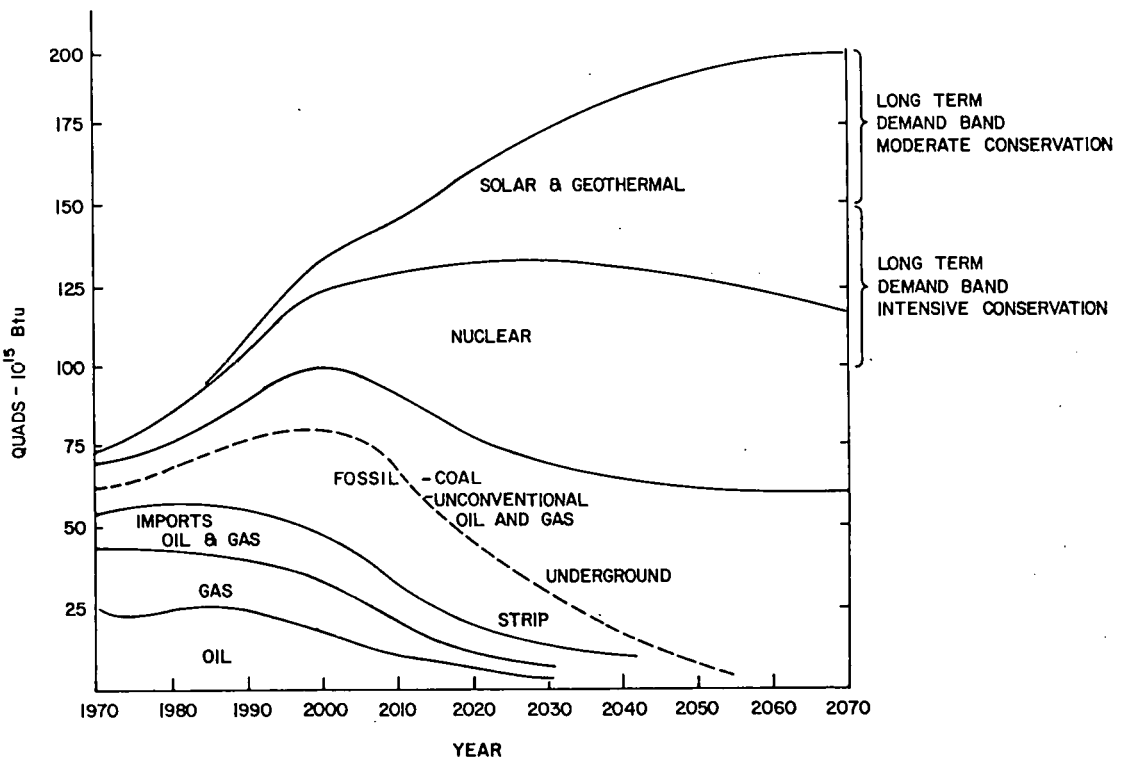


Figure 1. U.S.-long term energy supply.

the consumers. Thus certain groups of people, or regions, suffer the consequences of energy use, while others realize the benefits. Also, the scale of infrequent failures is enlarged. These are legitimate problems that do raise questions about the appropriate scale of centralization of the energy system.

NCAES studies indicate that the appropriate degree of centralization is directly connected to population density. There are appropriate scale technologies for rural, suburban, and urban applications. In terms of electric generation, the range of 10 to 50 kw seems an appropriate option in rural areas, 1 Mw to 50 Mw in suburban areas, and 50 to hundreds of Mw in industrialized or urban areas. These scales of technology are most appropriate for the coupled production of heat and power cogeneration.

Several technologies have been identified that promise alternative options. For the near term these include oil- and gas-fired total energy systems which provide electricity and heat at the local level. For the longer term the fuel cell and photovoltaic devices seem to promise decentralized technologies that could have revolutionary impact on the energy system. They are modular in construction and free of the economies of scale that prevail in other technologies.

Note that this discussion of decentralized options has, until now, avoided the terms "soft" or "hard." We believe that the introduction of these terms relates more to social perspectives and does little to raise the level of dicussion of energy policy. The real question is one of the scale of technology, and matching that scale to the population density in a region. The "soft" technology description has been applied to solar technologies. In this regard we find a need for further R&D on a wide variety of promising solar technologies. In particular, the use of passive solar through improved architectural design to exploit and store solar energy should be given the highest priority.

Economic Analysis Programs

It is extremely important to place energy in the context of economic and social development. Energy, after all, is utilized not for its own characteristics but for the comfort, mobility, employment, and productivity

that it provides. As the availability, or price, of energy changes relative to other inputs to the goods and services that are consumed, substitution of these other inputs may take place. The last 50 years have seen the substitution of capital and energy for labor, thereby increasing the "productivity" of labor. It appears that the future holds open the possible substitution of capital for energy through the development and implementation of more efficient systems that use energy to produce goods and services.

Energy-GNP Relationships: The role of energy in the U.S. economy was explored using the combined Brookhaven National Laboratory/Dale W. Jorgenson Associates (BNL/DJA) model system for energy use and energy-economy interactions. The BNL component of the system is a technological model of energy extraction, conversion, and end use; and it represents the economic and technical characteristics of the future substitution possibilities among new and conventional energy technologies and energy sources. The DJA model depicts production and spending throughout sectors of the economy within a flexible framework of transactions between industries which permits substitution among capital, energy, labor, and product (GNP). Three alternative energy projections were analyzed within this system. These futures were intended to reflect the uncertainty which characterizes the planning and policy process and resulted from the combination of several energy price forecasts with an invariant set of energy policies. The price trajectories were of different intensities and, with no assumed policy response, yielded different levels of energy prices; they are labeled the Low, Medium, and High price cases.

The long-term, equilibrium, economic impacts of higher energy prices are significant, though clearly not catastrophic given sufficient adjustment time. Higher energy prices, irrespective of the sources of this escalation, have an effect on the structure of economic activity, the levels of production and income, and the stucture and level of prices. Increased energy prices slow the growth of productivity and of the economy, and accelerate price inflation. The energy prices, energy use, and GNP impacts are summarized in Table II. Future real GNP is reduced, implying a real

TABLE II

Summary of Economic Effects of Higher Energy Prices
in the BNL/DJA Energy-Economy Model

	1985	1990	2000
Crude Oil Prices			
(1975 dollars/barrel)			
Low Price Case	12.31	13.36	17.11
Medium Price Case	12.92	16.56	27.14
High Price Case	16.69	24.57	35.43
Average Prices of Primary Energy			
(1975 dollars/million Btu)			
Low Price Case	1.76	1.80	2.09
Medium Price Case	1.79	2.09	2.84
High Price Case	2.07	2.69	3.77
Primary Energy Input:			
(Quadrillion Btu)			
Low Price Case	98.10	113.79	136.46
Medium Price Case	97.51	106.22	118.86
High Price Case	93.04	97.35	104.81
Real GNP			
(Billions of 1972 dollars)			
Low Price Case	1779.40	2075.60	2785.80
Medium Price Case	1776.50	2039.30	2696.30
High Price Case	1757.40	2003.30	2617.70
Energy-GNP Ratio*:			
(10^3 Btu/1972$)			
Low Price Case	55.10	54.80	49.00
Medium Price Case	54.90	52.10	44.10
High Price Case	52.90	48.60	40.00

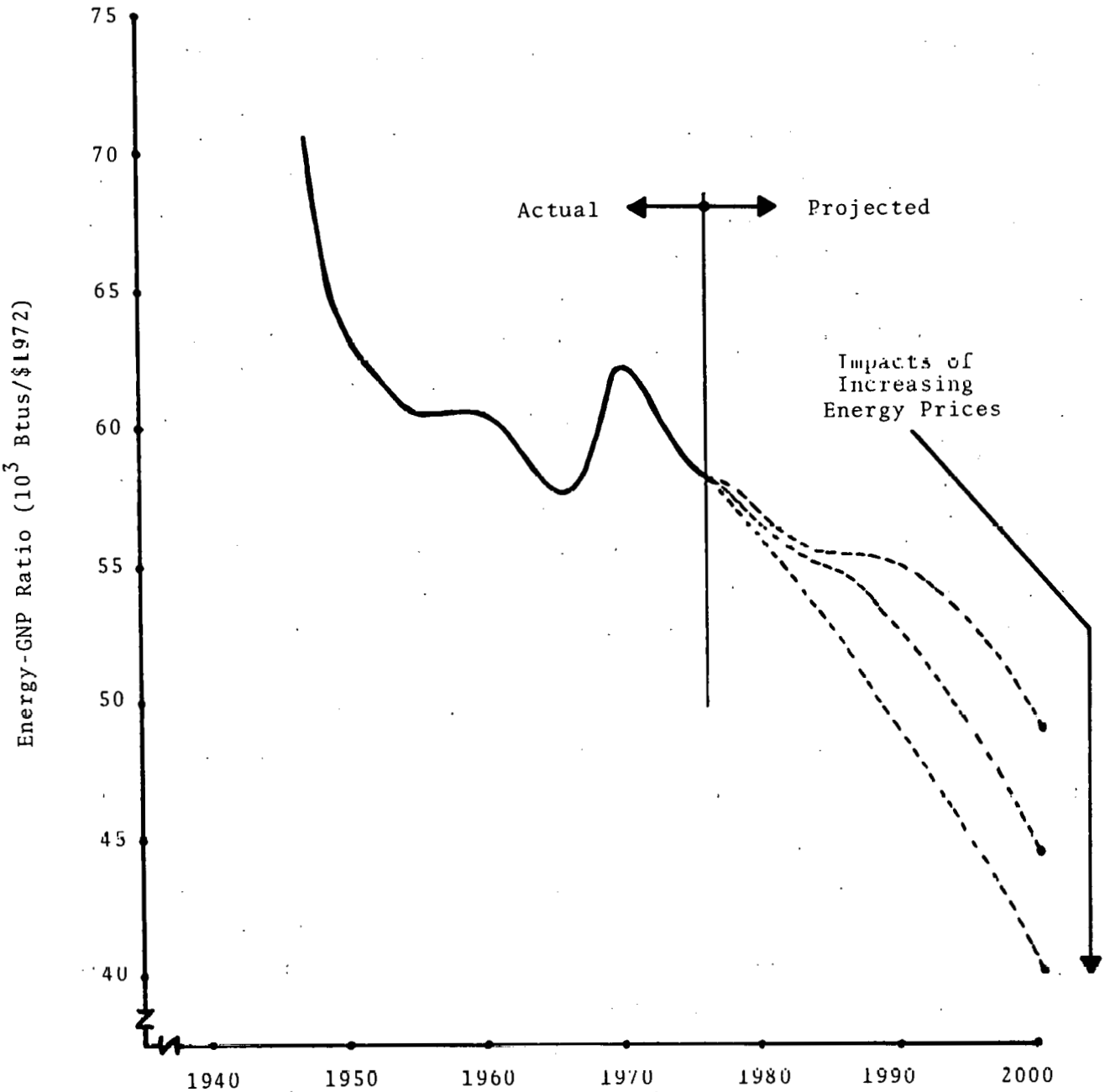
*The actual 1976 Energy-GNP Ratio is 58.4 x 10^3 Btu/1972$.

economic cost in terms of income and production foregone. By 2000, the difference in real GNP between the High and Low price cases is $168 billion, in constant dollars of 1972 value. The cumulative real income and production loss are still more substantial. Over the 1977 to 2000 period, the total real GNP foregone in moving from low to high price conditions is $1560 billion, in constant 1972 dollars; this total real GNP foregone exceeds the entire U.S. real GNP for 1977. Thus, while higher energy prices resulting from policy measures or other causes can be absorbed in the economy without precluding continued positive economic growth, there are real and significant economic costs associated with such price increases, even aside from balance of trade effects. These results are based on a smooth price transition with sufficient warning and time to adjust. The impacts of unexpected sharp price changes or curtailment of supply would certainly be much more serious and disruptive.

One indicator of the overall economic efficiency of energy use is given by the ratio of total primary energy consumed annually to the annual flow of real gross national product (Figure 2). This ratio is projected to decline over time (even in the Low Case) as spending and production patterns move away from energy-intensive activities, and as efficiencies in energy conversion and end use improve. Under the higher energy prices, the decline in the energy-GNP ratio is accelerated as the energy input is reduced to a greater extent than real GNP.

The aggregate energy-GNP relationships outlined above are highly pertinent to energy policy. While the discussion has emphasized aggregate relationships, the analysis focuses in great detail on specific energy use sectors in industry, and on consumer sectors. These sectors are also examined in detail using a series of end-use models, and are discussed below. Future work must give more attention to impacts on questions of equity among income groups and between regions (geographical and urban-suburban-rural).

Conservation Opportunities in Buildings: The amount of energy consumed in heating, cooling, ventilating, and lighting residential and commercial buildings makes the building sector one of the most important areas for



*Defined as the ratio of Btu of primary energy (fossil equivalent) consumed to gross national product (GNP) measured in constant 1972 dollars.

Figure 2. The energy-GNP ratio, 1947-2000: An indicator of energy-economy interactions in the BNL/DJA model system.

conservation programs. A program investigating the use of energy in buildings was designed to provide guidance in program evaluation and management to DOE. The effect of energy prices and policy options on energy demand in buildings, and on the market penetration of conservation technologies, was assessed. Several insights were obtained from the analyses. In the near to intermediate term, the potential for net savings is largest in the residential retrofit market, and reductions in oil demand can be obtained from targeting programs toward the residential retrofit market in the Northeast. Since the residential sector is undercapitalized, new conversion technologies for conventional fuels and solar technologies do not reduce aggregate demand in the near term significantly, though the savings per unit is large. Policy initiatives that address the capital or "first cost" problem, particularly tax credits, have a larger near-term impact than energy price increases. Standards have considerable long-term impact by reducing fuel consumption in new construction; but near-to-intermediate-term net effects are small. The potential for energy savings in the commercial sector is principally in new buildings while energy management and controls are important in existing commercial buildings.

For the economy, implementing conservation measures in buildings shifts household expenditure from energy supply industries to industries producing conversion devices. The latter are typically more employment intensive and the net employment benefits appear to be positive.

Conservation Opportunities in Industry: A set of industry-specific process models have been developed for technology assessment and policy evaluation. As the models are completed, they are exercised to demonstrate their capabilities and to gain useful insights into industrial energy conservation potentials and pitfalls.

In exercising models of the steel and paper industries, a number of such insights have emerged that dictate the use of comprehensive methods for policy analysis. First, because of process interdependencies, the energy impact on an industry from the introduction of a new technology can be quite different from that calculated from a piecemeal or micro approach. For example, several conservation technologies for the paper industry were found to provide

two to three times the energy reductions found from a simple process calculation. Second, policy stimulants directed towards only a subgroup of conservation options may actually result in increasing energy demand. Analysis of selected investment tax credits for cogeneration in the paper industry predicted increased fuel demands due to energy price subsidization and the resulting disincentive to purchase other conserving technologies.

Application of industry process models has also raised issues that are, as yet, unresolved. Implications from use of the steel model are that the majority of conservation technologies currently under discussion are already economic in the postembargo environment. However, technological uncertainty will play an important role in their rates of market penetration. Relative energy price insensitivity of the steel model infers that there is great potential for new inventions and/or more fundamental process changes that are on the technology horizon instead of the usual marginal technology changes currently under discussion. This indicates a need to direct more conservation research and development toward longer-term projects. Lastly, a policy option of disallowing corporate income tax deductions for energy purchases was found to greatly reduce industrial energy consumption.

Environmental Programs

A number of alternative resources and technologies have been discussed from the technical and economic perspectives. An important determining factor in the implementation of these systems at the regional level is in the environmental problems that they pose. In support of the National Coal Utilization Assessment (NCUA) and other DOE policy studies, the environmental and health effects of coal-intensive scenarios have been explored. The environmental assessment techniques developed for these coal-related studies have stressed air quality and health impacts, and use a number of models developed in the environmental sciences program at Brookhaven to map the transport and conversion of sulfur compounds through time and space linked to the damage functions developed in the Biomedical Environmental Assessment program. The sequence of analytical steps in this assessment

methodology is depicted in Figure 3. The study incorporated changes in the 1977 Clean Air Act, which will likely require universal application of Flue Gas Desulfurization (FGD) for new coal-fired facilities beyond 1982, and the stringent requirements for solid waste disposal mandated by the Resource Conservation and Recovery Act (RCRA). Solid waste disposal problems, therefore, received major attention in these assessments.

The thrust of the conclusions of the work on the environmental impacts of increased coal utilization is illustrated by the major findings of an assessment of a 1985 and 1990 scenario developed for the 1977 National Energy Plan:

- The ability to maintain acceptable levels of air quality, while at the same time increasing levels of coal utilization, is vitally dependent on meeting state implementation plans for existing sources of pollution, at least over the next 10 to 15 years.
- The geographical distribution of changes in SO_2 emissions and in population-weighted SO_2 and SO_4 concentrations exhibits considerable variation. Relative to the 1975 base year, for example, Federal Region III (Pennsylvania, Maryland, Delaware, Virginia, and West Virginia) experiences a 10 percent decrease in 1990 population-weighted SO_4 concentration; whereas Region IX (Arizona, California, and Nevada) experiences a 46-fold increase.
- Solid waste disposal problems in the utility sector are amenable to current environmental engineering solutions, although RCRA-imposed costs may be significant. In the industrial sector, however, environmentally acceptable waste disposal may involve such a significant level of engineering and electric difficulty as to represent a real constraint to increased coal use.

The study utilized an atmospheric transport model developed in the environmental sciences program at Brookhaven to map the transport and conversion of sulfur compounds.

An analysis of the impacts on the energy system of various potential sulfate air pollution standards was completed by the Biomedical and Environmental Assessment Division. The form and magnitude of potential standards

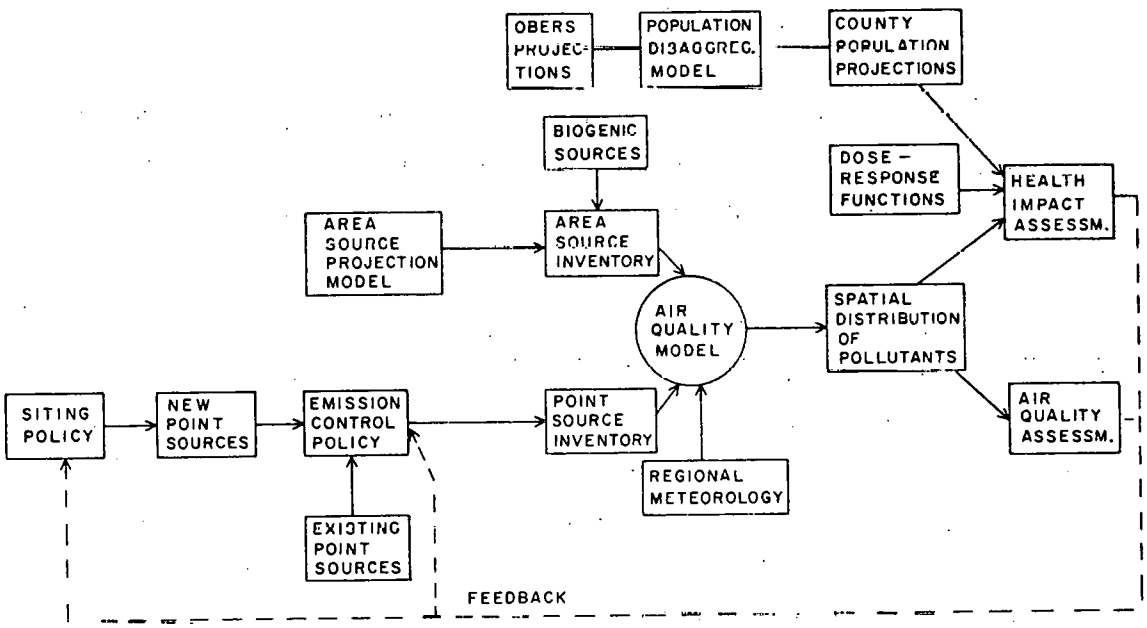


Figure 3. Air quality-health assessment approach.

will affect the required efficiency of SO_2 removal and, thus, the mix of technologies employed. While the least stringent potential standard considered would have minimal impact on the energy system beyond that imposed by existing and proposed SO_2 standards, the most stringent potential standards considered could have large impacts. Precombustion treatment of coal (such as solvent refining) may be unable to meet requirements, and both pre- and postcombustion controls may be necessary. In the extreme case, it may not be physically possible to meet potential ambient sulfate requirements, resulting in limits on new construction and shifts away from coal. Finally, the need for emission controls to meet ambient sulfate standards varies geographically, creating problems of equity in enforcement.

The probabilistic approach to estimating health effects of air pollution from coal-fired power plants developed in collaboration with Carnegie-Mellon University was extended to include comparison with control costs, and an optimization analysis was done to find the best pollution control levels under different assumptions of risk aversion and life value.

New relationships linking socioeconomic factors and air pollution from energy sources to cardiovascular mortality were found using the Medical Data Base developed in BEAD over the past several years. Important differences in the pattern of occurances of acute myocardial infraction and chronic ischemic heart disease shed new light on effects of air pollution. Associations were seen between socioeconomic factors, air pollution, and malignant neoplasms, but expected differences by anatomical site were not found.

A data base of 65 water quality parameters at the county level was constructed for counties east of the Mississippi. An analysis of 139 counties, for which complete water quality data were available, demonstrated that the county aggregation technique does not impair the ability of the data to describe physical and chemical characteristics of natural waters. Energy and economic data were incorporated into the data base and an analysis was conducted in which 25 percent of the variance in water quality was explained by a postulated model linking water quality with residential and industrial factors.

International Perspective

Personnel in the Center have provided assistance to energy planning groups in several countries and international agencies. Techniques such as the Reference Energy System and the energy model have been transferred under DOE sponsorship. In addition major analytical efforts have been mounted for the International Energy Agency and for the DOE study of energy futures for developing countries. In these studies the possibility of implementing substitutes for oil depends largely on the indigenous resource base and the availability of capital and specialized labor. Country-specific studies are clearly necessary to a better understanding of options to resolve the world oil problem of high prices and possible limited supplies. It is impossible to generalize about the feasibility of reductions in oil use, conservation, or nuclear power without examining the specific resources and options available to individual countries.

International studies of developed countries illustrate the great potential for energy conservation. A few years ago, it was the conventional wisdom that energy was used wisely in Europe and Japan because of the higher prices that existed in those countries over an extended period of time. Comparisons with U.S. consumption patterns indicated that improvements of perhaps 20 percent in the use of energy per unit of GNP could be made in the U.S. by adopting some of the technology and policies of these countries. The studies indicate, however, that opportunities of this same magnitude exist even in other developed countries. This indicated an even greater possibility in the long run for energy conservation in the U.S. to reduce the energy required per unit of GNP over the long term when new and more efficient capital stock can be deployed. Many of the potential improvements will require aggressive research and development programs on improved processes and devices that use energy.

Following is a more detailed review of progress in the international programs.

IEA Project: The NCAES serves as host to a multinational energy systems analysis study conducted under the cognizance of the International Energy Agency (IEA). The primary objectives of the program are to develop an

international R&D strategy and to identify new energy technologies which merit cooperative research and development effort by the IEA member nations. The program is conducted jointly with the Kernforschungsanlage (KFA) in Jülich, West Germany. During the past year the participating countries and agencies working at BNL have included the Commission of European Communities (CEC), Canada, Ireland, Japan, Norway, Sweden, and the United States.

For the past year the efforts of the project have concentrated on the quantitative characterizations of new technologies and the development of a model with which to assess the market potential of those technologies. The technology characterization effort has required the development of a common set of economic and technical ground rules, used by all participating countries. More than a hundred new energy technologies have been characterized. The data have been subjected to expert review both at BNL and KFA, and externally by national experts from government and industry. New technologies in 34 generic categories, both energy supply and end use, are included in the assessments, and have been evaluated from the perspective of reducing the cost of energy, replacing oil imports, and increasing the use of renewable energy sources.

In order to assess the possible impact of new energy technologies a computer model, MARKAL (acronym for "market allocation"), has been developed. MARKAL is a demand-driven multiperiod LP-model of very flexible structure which can readily be applied to national or regional energy systems of diverse complexity and composition. A more detailed description of MARKAL appears in Appendix B.

The analysis employed a series of multiobjective assessments of energy options using the MARKAL model. Three principal objectives, as follows, were considered with a 45-year time horizon that carries through the transition period from an oil-based energy system to one employing alternative technologies and resources.

- Cost: Minimize total discounted system cost (referred to as the "P indicator"). This is assumed to represent support of economic growth.

. Security: Minimize total imports of crude oil and refined oil products (referred to as the "S indicator").

. Renewables: Maximize the use of renewable energy resources (referred to as the "R indicator"). This was done by minimizing net heat release to the environment assuming that the net heat burden on the environment from renewables is zero.

Clearly all these objectives are desirable and involve trade-offs among security, environmental, and economic goals. Several such trade-off studies were performed in which each of the three primary indicators, P, S, and R were given varying degrees of emphasis. For example, a PSR scenario emphasized system cost as most important, oil imports as second in importance, and renewable resources as the least important. The four basic scenarios studied were PSR, SPR, SRP, and RSP. To conduct these assessments the following procedures were used:

1. the indicator for the first objective was minimized;
2. holding that value constant, the second indicator was minimized; and finally,
3. holding the first two indicators constant, the third indicator was minimized.

The resultant values for the three indicators can be displayed on a 3-dimensional graph, Figure 4. The points shown correspond to the intersection of a 3-dimensional surface representing feasible and efficient solutions (Pareto-optimal solutions) with the 3 planes of global minima. Each point on the surface has a different mix of technologies in the solution.

In the figure the Pareto-optimal surface is convex, intersecting the three planes of global minima at the six points shown. These six points of intersection are generally extreme points not necessarily of practical interest. However, various trajectories along the Pareto-optimal surface can be explored by obtaining additional solutions in which trade-offs are made among the three indicators. For example, the trade-off between cost and oil imports can be explored by allowing successive increases above the global minimum for oil imports and minimizing costs at each point. Such a trade-off

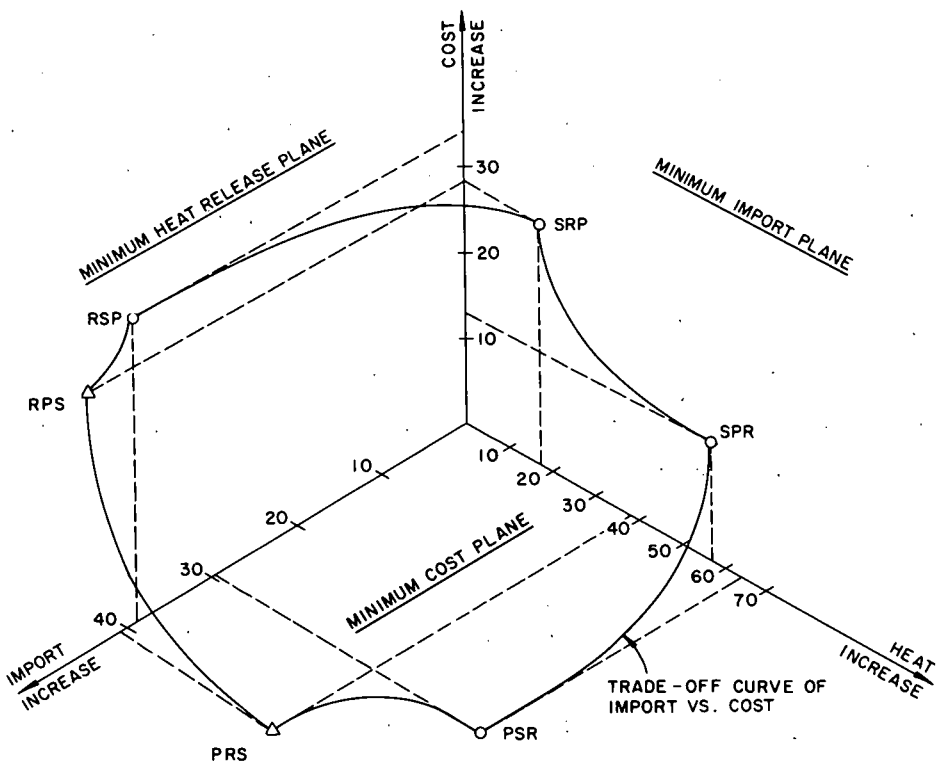


Figure 4. Pareto-optimal surface.

curve is illustrated in the graph. These parametric runs require minimal computer time since they start from an optimal basis.

The impact of individual technologies for points lying in the three planes of global minima can be illustrated on a technology map, Figure 5. The map is a 3-dimensional graph on which the marginal values (dual activities) for each technology are plotted. Technologies lying the greatest distance from the origin have the greatest value for the given objective. For example, in the case shown in Figure 5, heat pump and electric auto both are effective in reducing cost and oil imports, but not in reducing heat release to the atmosphere. On the other hand, geothermal and wave-generated electricity release no heat, but they do not reduce oil imports (inasmuch as they replace coal or nuclear-generated electricity) and they produce less cost savings.

The use of multiobjective analysis for the IEA project is still in its early stages and much exploration remains to be done. However, the early results provide interesting insight into the range of potential benefits to the energy system and economy of new energy sources and technologies now under development. This information is being integrated into a research and development strategy for IEA member nations.

One of the early results of the RD&D strategy analysis was the definition of a conceptual framework for comparing different IEA countries' incentives and abilities to develop and implement new technology to reduce oil imports. This involved the comparison of multiobjective function trade-offs between Total Energy System Cost and New Oil Import using the MARKAL model.

Figure 6 shows these trade-offs normalized to unity for Reference Case Cost and Oil Import for a range of IEA countries with differing oil dependencies and breadth of new technology options to reduce oil imports.

This framework is now being further developed to use these multiobjective function trade-offs to identify isoincentive points--points of oil import saving and the technologies producing these savings where the economic incentive to produce them is the same in differing IEA countries. One obvious such set of points is the set corresponding to strategic stockpiling under IEA

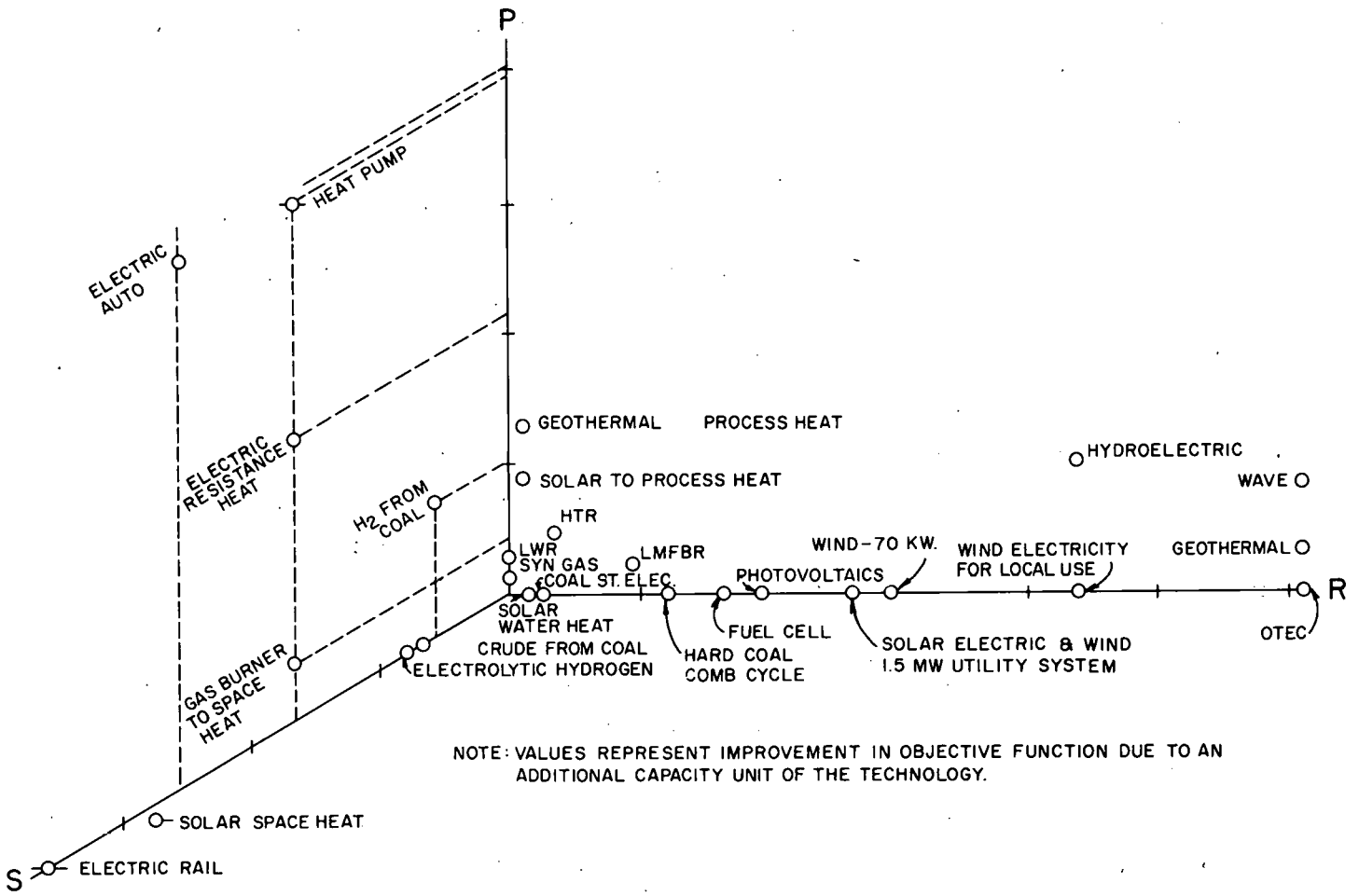


Figure 5. Technology map - country "A" - Year 2000.

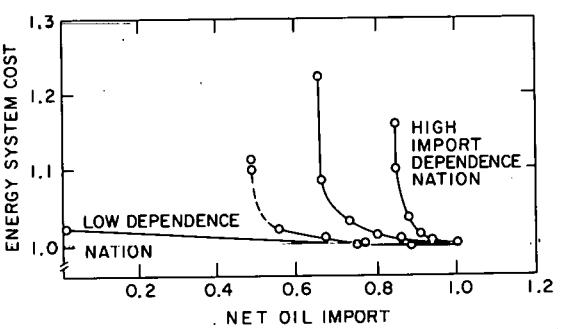


Figure 6. Cost-security trade-off possibilities for several IEA member nations.

agreements. However, other points will correspond to sets of specific technologies and where a technology is common to several countries it will obviously be a prime candidate for further IEA RD&D cooperation--the main objective of the cooperative IEA project.

Developing Country Energy Program: In 1974 members of the staff of the Policy Analysis Division had identified the energy problems of the oil-importing developing countries as significant to U.S. energy and foreign policy. Preliminary work on these issues started in 1975. In late 1977 and 1978, when energy assistance to developing countries became a recognized national concern, the Center undertook several major studies in this area.

A study was carried out for the Agency for International Development (AID) of the overall energy situation in the developing countries and the range of solutions available to them. The report was submitted to Congress by AID in response to a request by the President in the Foreign Assistance Act. In a subsequent report, a variety of programmatic areas for U.S. energy assistance to developing countries were identified, including development and demonstration of new technologies, training programs, and assistance in energy planning. Two other programs were initiated for AID, one studying energy aspects of food production in Senegal and the Dominican Republic, the other carrying out a training course in energy management for developing country planners. The course, given in the Fall of 1978 with the State University of New York at Stony Brook, attracted 27 planners from 21 different countries.

The National Center was also a major contributor to the Department of Energy's International Energy Development Program. That program was requested by the President in September of 1977 to assist developing countries in meeting their future energy needs with indigenous resources and appropriate energy alternatives. Two major collaborative energy analysis studies were carried out in the first year of the program; one with Egypt, and the other with Peru. BNL designed the analytical approach that was used for both and played a major role, particularly in the Peru study. For Peru, a major concern was to identify resource and technology alternatives to substitute for a marginally adequate future domestic oil

production. Figure 7 shows the results of that analysis in which oil demand, corresponding to various alternative strategies, is compared to the range of possible future production estimated by the U.S. Geological Survey (USGS).

International Model and Data Assistance Activities: The energy resource shortages and the spiraling costs of energy in many international communities have induced the formation of small energy systems analysis groups charged with the task of performing comprehensive energy systems analysis. Since the complexity of the energy-economic systems analysis often requires the use of an integrated methodology, one of whose components is the energy system representation, BNL has repeatedly been requested to provide technical support in the acquisition of the Reference Energy System and the Brookhaven Energy System Optimization Model (BESOM) as an important starting point. In keeping with the policy of DOE and NCAES of supporting cooperative research relationships with other domestic and international energy systems analysis groups, a FORTRAN version of BESOM and instructions for its use and interpretation were made available to Greek personnel at their computing facility in Athens. In addition, they requested that BNL provide guidance in the generation of a "Reference Case" set of scenarios and recommend long-term courses of action. The scenarios were generated, and the inputs and outputs of BESOM carefully analyzed for each of the reference year scenarios. The planning group in Greece was urged to actively participate in the IEA program either at Jülich, Germany, or BNL. Current energy concerns for Greece focus on the desire for accelerated GNP growth through the year 2000 while recognizing the domestic resource shortages.

The Federal Nuclear Research Institution of Switzerland requested that NCAES staff provide technical assistance in the use and interpretation of BESOM. The FORTRAN BESOM and optimizer package was provided and used for the following purposes:

1. to provide the Swiss Energy Department (EAEW) with a tool for energy policy analysis;
2. to analyze the potential role of nuclear energy (including district heating) in the Swiss energy system; and

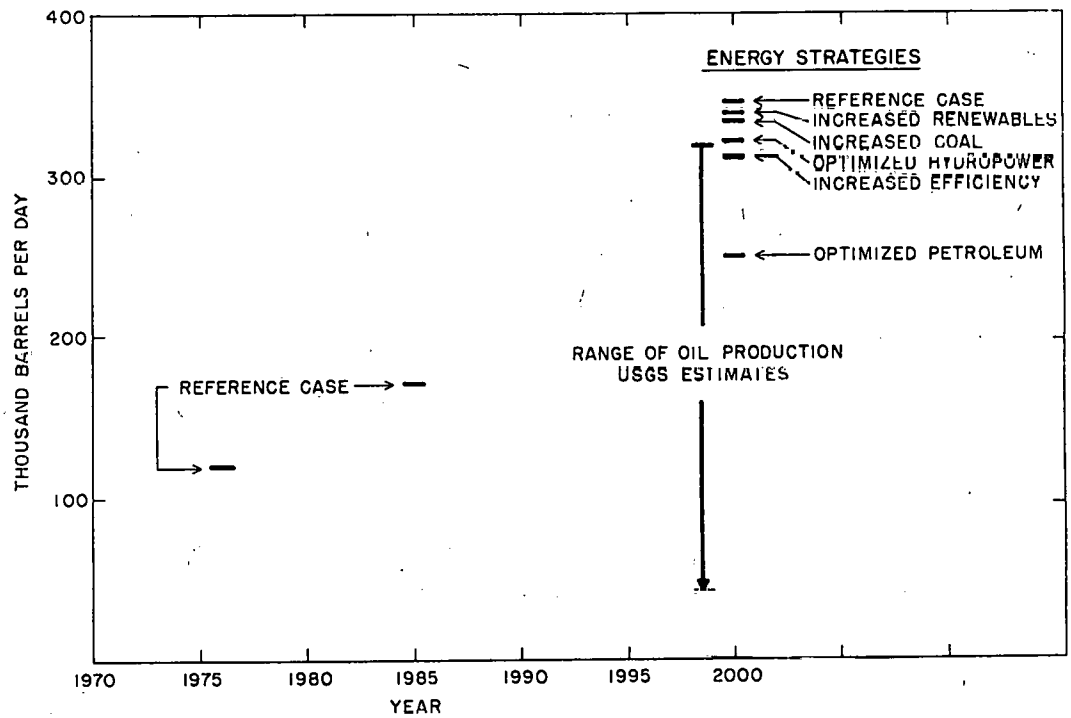


Figure 7. Projections of oil consumption in Peru; reference case and various energy strategy impacts.

3. to assess its R&D programs.

Regional Activities

Analysis of regional energy systems continued during the past year with emphasis on the Northeast and selected utilities.

The Reference Energy System methodology and associated models were transferred to the energy planning group of the Tennessee Valley Authority (TVA). There, the system will be used to project the demand for electricity in the context of the overall energy system of the region, and to investigate a balanced investment strategy between supply-oriented and end-use-oriented options.

The first phase of a New York State Energy Information Analytical System (NYSEIAS) was completed. The NYSEIAS provides a county level data base of energy production, conversion, distribution, and consumption of energy. State aggregate data of energy consumption at a high level of end-use disaggregation is provided for 1976 and projected to 1985. In additon, 1976 and 1985 Reference Energy Systems for NYS are provided in the Energy Systems Network Simulator (ESNS) formulation. A short-term price response model for estimating energy demand fluctuations as a consequence of price changes was included. Finally, a model of energy demand variations with changes in climate for different regions of the state is given. The system, based on the BNL computers, will be accessible from terminals at the NYS Energy Office in Albany, New York.

MAJOR ACTIVITIES PLANNED FOR FY 1979

Technology Assessment

- Design of the Energy Emergency Information System (EEMIS) based on the Reference Energy System.
- Completion of technoeconomic studies on the integration of solar energy in the U.S. energy system.

Economic and Conservation Analysis

- Comparison of model structure and behavior of major energy-economic models.
- Incorporation of selected industrial process models in general equilibrium energy-economic model framework.

Regional Studies

- Completion of survey of siting analyses employed by electric utilities.
- Transfer of Energy Information Analytical System to the New York State Energy Office.

International Programs

- Development of analytic methods for energy-economic analysis in developing countries and techniques for estimating the use of noncommercial fuels.
- Completion of the research and development strategy analysis in support of the International Energy Agency.

Biomedical and Environmental Analysis

- Assessment and development of information base on health effects of energy-related emissions.
- Assessment of air quality and health impact of national energy strategies.

Energy Data and Models

- Completion of evaluation of features of long range energy models employed by DOE-Energy Information Administration for long term analysis.
- Initiation of energy-economic model evaluation and validation program.

ORGANIZATION

The Center is organized within the Department of Energy and Environment as shown on the attached organization chart (Figure 8). The Biomedical and Environmental Assessment Division, a joint program between the Medical Department and the Department of Energy and Environment, is affiliated with the Center. Working groups have been assembled in several areas with specific program responsibilities. These areas are: (Figure 8)

1. Regional Studies
2. Economic Analysis
3. Biomedical and Environmental Assessment
4. Technology Assessment
5. Energy Data and Models
6. International Projects

Each of these working groups draws on the collective skills and capabilities of the staff including chemical, electrical and mechanical engineers, physicists, chemists, physicians, ecologists, epidemiologists, economists, applied mathematicians, and computer specialists. The staff has long-term experience in energy research and development. Many consultants from industry and the academic community are engaged on a continuing basis and contribute to the program as the need arises.

RELATIONSHIP TO OTHER ACTIVITIES

The programs now included in the Center have provided analysis and support for DOE, the National Science Foundation Office of Energy R&D Policy, the Office of Science and Technology, and the Council on Environmental Quality. Collaborative work is in progress with other agencies, federal and state.

Personnel from the Center have participated in special energy panels and studies sponsored by the National Academy of Sciences, the NSF Science and Technology Policy Office, and the Department of Commerce. A close

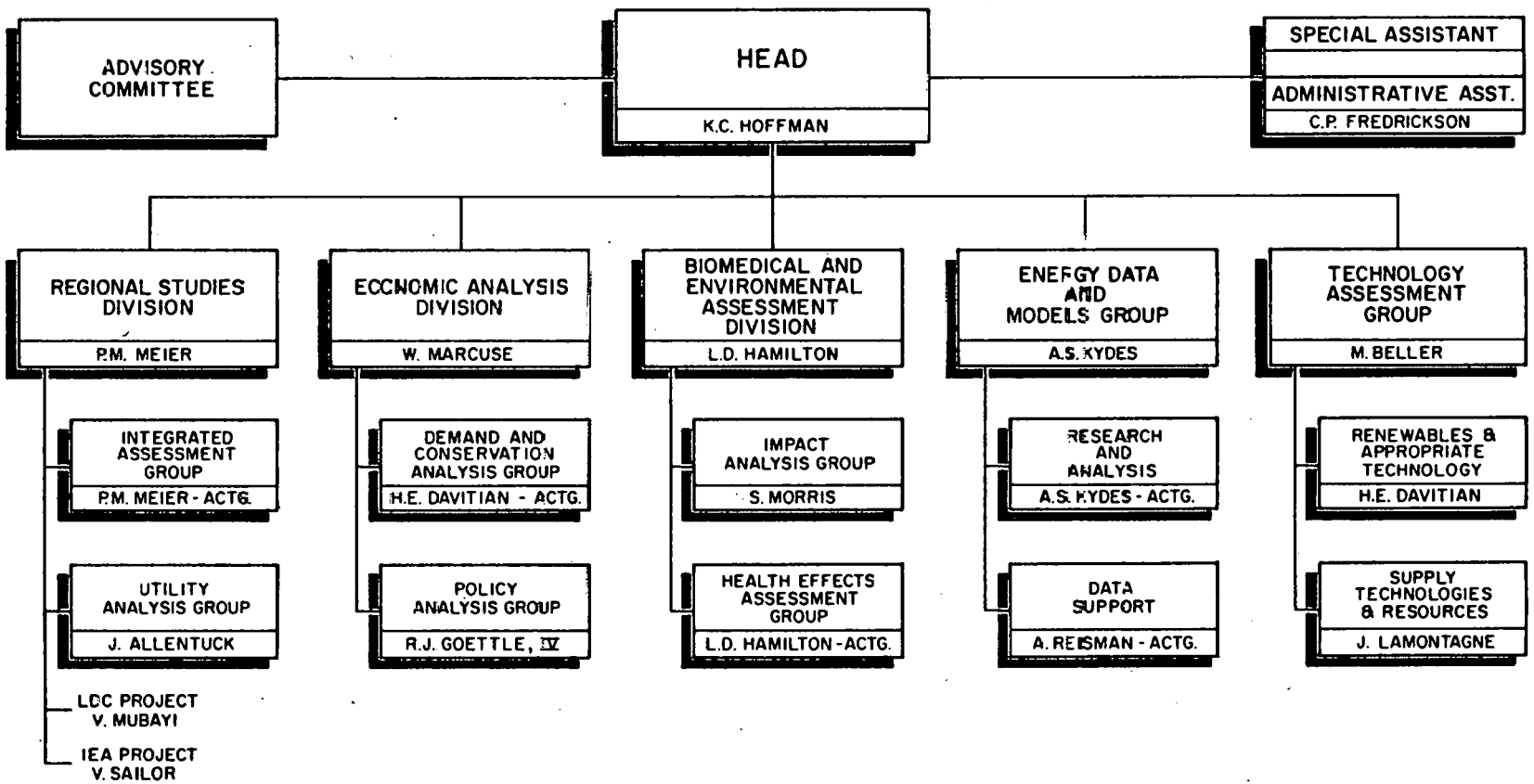


Figure 8. Brookhaven National Laboratory, National Center for Analysis of Energy Systems.

working relationship has been established with energy groups at Stanford, Princeton, Harvard, MIT, the University of Illinois Center for Advanced Computation, the Electric Power Research Institute, and several other universities and institutions.

Extensive interactions and collaborations have also been established with the International Institute of Applied Systems Analysis in Austria, the International Energy Agency, the Commission of European Communities, and the Environmental Directorate of the OECD. These relationships provide useful points of contact for the international aspects of the Center's programs.

SCOPE OF ACTIVITIES

The activities and responsibilities of the major groups in the Center are outlined below. These activities are closely integrated and specific studies generally involve personnel from several groups working under the direction of a Principal Investigator or Program Manager.

Regional Studies

The activities in this area have focused on regional studies including detailed study of the use of energy in urban areas. The scope of the regional energy/environmental study has been expanded to cover the Northeast region of the U.S. with particular attention to the urban/megalopolis. The energy/environmental studies are performed in the context of planning for the social and economic development of the region and provide detailed insight into problems of implementing technologies once they are developed.

Specific studies in this activity include:

1. Energy demands and environmental implications in the New York City and Northeast regions.
2. Forecasting of regional energy demands and strategies.
3. Energy implications of regional development and patterns of land use.
4. Development of analytical models for regional energy/environmental planning and land use.
5. Siting of major energy-related facilities with analysis of environmental implications.

Economic Analysis

Comprehensive energy planning and analysis requires detailed study of the economic characteristics of energy technologies and of the relationship of energy to the social and economic structure of the nation. The objective of the economic analysis activity is to analyze these relationships ensuring that the technological realities of the energy system are reflected in economic modeling and analysis. Support is provided to the technology assessment work in economic analyses used for projections of energy demand and in the analysis of the economics of new technologies.

Specific activities in the area of economic analysis include:

1. Economic analysis of interfuel competition and role of energy in various sectors of the U.S. economy.
2. Model development involving input-output and macroeconomic models that are used for economic analysis and planning.
3. Analysis of shadow prices and cost-benefit characteristics of new technologies.
4. Cost studies of advanced technologies under conditions of changing cost of inputs to production.
5. Projections of level of economic activity and related energy requirements.
6. Identification and analysis of nontechnological alternatives to technical solutions.
7. Studies of commercialization and the nontechnological alternatives to technical solutions.
8. Special studies in areas of net energy or energy accounting.

Biomedical and Environmental Assessment

The biomedical and environmental impacts of energy supply and utilization must be considered explicitly in analysis and planning at both the national and regional levels. The objective of this assessment work is to identify all of the externalities, or social costs, associated with the

extraction, conversion, transmission, and use of alternative fuels and energy sources. Some of these externalities are easily identified and quantified; others are not well understood. The assessment provides information on biomedical and health effects to an overall assessment of energy technologies and policies in which social, economic, and environmental factors must be balanced. The work also serves to identify information gaps on the spatial transport, conversions, and biological damage associated with pollutants or externalities that must be resolved through research in such areas as atmospheric dynamics, health effects, and ecology.

Specific activities in biomedical and environmental assessment include:

1. Assembly of quantitative information on pollutants and other externalities associated with specific fuel cycles and energy conversion technologies.
2. Analysis of transport and damage associated with various pollutants.
3. Analysis of morbidity and mortality in areas of different air quality, including identification of life-shortening effects.
4. Studies of site-specific impacts of energy systems and of other special policy topics.

Technology Assessment

The activity of this area is intended to provide a continuous assessment of the state of development and likely impact of new energy technologies and to perform studies of interfuel substitution. The scope of the assessments includes technologies and processes for all fuels and energy forms and all activities from extraction to end use as indicated on Reference Energy Systems (RES). The RES indicates reference or existing technologies with which new technologies must compete. Impacts of new energy technologies are measured against Reference Energy Systems that project the technical structure of the energy system along with costs and environmental impacts through the year 2000. A unique feature of the methodology is the inclusion of the load structure of specific electrical demands and the incorporation of

end-use technologies (air conditioners, combustion devices, engines, etc.) at the same level of detail as energy supply technologies. The latter is frequently a limiting factor in the rate of implementation of alternative energy systems and in energy conservation.

Future scenarios of the implementation of groups of technologies and new resources are developed. The socioeconomic and environmental consequences are analyzed in detail and impact analyses are performed.

Specific responsibilities in this area include:

1. Projection of future energy demands and fuel mix as represented in the Reference Energy System.
2. Optimization studies to determine the most effective utilization of new technologies and to evaluate interfuel substitution strategies.
3. Estimates of likelihood of success and implementation of new technologies.
4. Development of technological strategies for the implementation of new energy systems.
5. Process analysis of new energy technologies and energy intensive production activities.
6. Special studies in energy intensive activities such as materials, agriculture, and transportation.

Energy Data and Models

The energy data and models activity provides a central capability to coordinate and integrate energy data bases and analytical modeling. Close coordination is maintained with university and industry groups developing data and models of interest for energy policy.

A comprehensive data base, the Energy Model Data Base (EMDB), is maintained at Brookhaven. This data base was developed under the auspices of the Council on Environmental Quality, Energy Research and Development Administration, National Science Foundation, and Environmental Protection

Agency. The EMDB is available to government, industry, and university groups. The dissemination of the data on energy technologies contained in the EMDB provides a uniform and consistent basis for energy policy studies performed by these diverse groups. It also ensures that differences in policy recommendations may be attributed to the viewpoint of the group and not to differences in supporting data obtained from the data base. The data and models activity also supports the studies performed within the Center at Brookhaven:

Included in the EMDB are:

1. Technical efficiencies and fuel requirements of 400 energy supply processes and 200 end uses.
2. Emissions (air and water), occupational hazards, wastes, and costs of individual processes and end use.
3. Labor, material, and water requirements of supply processes.

Individual data elements (efficiencies, emissions, cost) may be extracted from the data base for each process. This information may be aggregated to provide a summation of elements associated with a given energy trajectory (e.g., coal to iron and steel production), a subsystem (e.g., all uses of coal), or the complete Reference Energy System as projected for some future planning period.

Responsibilities of the energy data and models activity include:

1. Coordination and integration of energy data and models.
2. Maintenance, verification, and update of the Energy Model Data Base.
3. Maintenance and development of the energy system models used in the energy programs.
4. Assistance to federal, state, and local government agencies, universities, and industry in the use of data and models when such assistance is related to a Brookhaven program.

5. Special data and analysis tasks in support of other programs within and external to the Center.

6. Model evaluation activities.

A tabulation of energy data bases and analytical models developed by or available to the Center through collaborative agreements is given in Appendix B. The policy of the Center is to rely wherever possible on the developer to perform analyses with his data base or model. This policy is based on the belief that the group which developed the model is in the best position to understand and interpret the policy implications of a particular model. Thus, any requests for information and/or analyses with data bases or models developed elsewhere should be made directly to the developing group or institution.

Energy Model Evaluation

The Energy Data and Models Group has been engaged in data and model evaluation and refinement programs in an effort to improve the information quality of energy-economic data for decision making. The Model and Data Assessment Program was initiated in FY 1978 to examine selected features of the Decision Focus Inc. (DFI) model being implemented for Energy Information Administration (EIA). Areas of principal responsibility consist of (a) evaluation, documentation and standarization of the data in the DFI model; (b) analysis of the DFI market penetration representation and comparison to existing literature; (c) analysis and refinement of the DFI resource representations; (d) algorithmic analysis to speed the convergence; and (e) demand representation analysis. BNL is also coordinating a modeling exercise involving EIA and non-EIA models for incorporation in the Assistant Administrators Report (AAR).

- Technological Data Assessment:

  The technological data validated include capital construction costs, operating and maintenance costs, conversion efficiences, and technological change limits. The major focus of the data validation effort is on data used in the LEAP model. A parallel effort assessed the data used in the Project Independence Evaluation System (PIES). The validated data for the two models are presented in a common, well-documented format.

- Market Penetration Analysis:

  BNL has performed a literature survey on market penetration analysis and its relation to that implemented in the DFI model.

- Resource Supply Analysis:

  The first part of this task focused on the resource supply representations of the PIES model and the LEAP model. The presentation of the investment decisions and their consequences on oil and gas development were addressed. On the basis of this study, BNL has proposed a new version of oil and gas supply models within the current LEAP framework. This version incorporated the data and resource development formulation of the PIES resource models which emphasized the geological survey and engineering judgments on the resource discovery, reserve additions, and enhanced recovery. The result of this task is a more modular representation than the current LEAP oil and gas supply model in the areas of exploration, development, and enhanced recovery.

International Projects

The analytical methods developed at NCAES have been applied to energy planning and analysis in a number of countries, developed and developing. In these programs NCAES cooperates with other centers of energy analysis in the U.S. and overseas. Specific activities of these projects include:

1. Assistance to international groups in the use of energy data and models for planning studies.
2. Special studies dealing with energy technology and strategies for developing countries.
3. Systems analysis in support of the development of a long-term R&D strategy for the International Energy Agency.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

APPENDIX A

SCOPE OF ACTIVITIES FOR FY 1979
AT THE
NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

I. REGIONAL STUDIES

Title: Assessment of Impacts of Energy Production on Local, Regional and National Scales
Regional Energy Studies

FY 79: $905,000

FY 80: $975,000

Principal Investigator(s):
P. M. Meier

Sponsor: Assistant Secretary for Environment

The objective of this program is to support energy environmental policy decisions of the DOE Assistant Secretary for Environment. This is accomplished by technology specific policy analyses, environmental assessments of DOE scenarios and regional analyses designed to bring the regional and State perspective to national energy planning efforts. This program is a joint effort with five other national laboratories, with Brookhaven assigned the Northeastern U.S. for regional analysis, and lead laboratory responsibilities for air pollution emission studies, long range air quality modeling, health effects assessment, and solid waste impacts.

In 1978 three assessments received major emphasis. The National Coal Utilization Assessment (NCUA) provided a detailed, comprehensive assessment of the environmental and socioeconomic impacts of increased coal utilization in the U.S., using a scenario based on the Administration's 1977 National Energy Plan. The Regional Issue Identification Assessment (RIIA), to continue into FY 79, will provide a systematic overview of regional and State energy-environmental issues to be used as a basis for considering the interregional equity issues so important to implementing national policy. Finally the Regional Characterization Program, designed to support basic data needs, emphasized the preparation of a comprehensive regional databook for the Northeast.

Title: Nuclear Siting Methodology Evaluation

FY 79: $95,000

Principal Investigator(s):
Peter M. Meier

Sponsor: Nuclear Regulatory Commission

The BNL Regional Energy Studies Program is developing for the Nuclear Regulatory Commission a procedure for evaluating nuclear power plant siting methodologies. The procedure will be based on analyses of the theoretical foundations of available methods and the results of applying these methods to various regional and site-specific data sets selected to test them under different conditions. Analyses will include estimation of the relative successes of different methods under different conditions, comparison of the results obtained by different methods applied to the same site information, and studies of the influence of personal knowledge and bias of decision makers on the results obtained by each method. Evaluation of the methods will be based on the results of applications of the methods by individuals experienced in siting decision.

The objective of the analysis is to determine some of the problems associated with the methods under specific conditions, to determine whether or not the methods used in fact make a difference under all conditions (or under any conditions), and to develop a scientific basis for evaluating results obtained using the different methods and for rejecting those methods that do not achieve the desired results.

Title: New York State Energy-Information Analytic System - Second Stage Implementation

Fy 79: $60,000

Principal Investigator(s): Jack Allentuck

Sponsor: New York State Energy Research and Development Authority

---

This work comprises the preparation of a reference case view of the state's energy supply-demand picture for the year 1994, and the estimation of energy supply and demand in the presence of four alternative policy constraints prepared by New York State Energy Office staff. The transfer of a methodological approach and data base to the State Energy Office is also included. The work will build on the data base and analytical system developed in the first stage implementation of an energy information and anlaytic system for the state completed in 1978.

The effort has two primary purposes. The first is to provide New York State energy planners with an analytical framework and accompanying data base able to portray the state's energy supply-demand situation in 1995. The reference case is not intended to be a prediction of the future, but rather to provide a basis for discussing impending energy problems in the state and for judging the impacts of energy policy. The second purpose is to transfer a capability to New York Energy Office staff to conduct an analysis of state energy policies employing this methodology and data base.

In addition to the reference case, scenarios to be evaluated include:

A. A nuclear moratorium, i.e., no nuclear power plants reach commercial operation beyond those currently possessing a construction permit.

B. Maximum penetration of technologies employing renewable energy sources.

C. An increased availability of natural gas.

D. Maximum penetration of electricity into the space and water heating markets.

Title: Electricity Demand Curtailment Study

FY 79: $100,000

Principal Investigator(s): Jack Allentuck

Sponsor: DOE/Economic Regulatory Administration

The regulatory assistance function of the Economic Regulatory Administration (ERA) of the Department of Energy embraces planning at the federal level to mitigate the consequences of electric supply inadequacy of substantial duration and/or extent of impact. In the formulation of a federal role, it is essential to assess existing state and federal authorities and plans regarding electric demand curtailment during extended periods of such supply inadequacy.

With the cooperation of representatives of state government, the electric utility industry, and public interests groups, an assessment of existing plans for electric demand curtailment will be made. The assessment is to be made in the context of scenarios representative of possible events resulting in power supply inadequacies. On the basis of these assessments, policy recommendations as to the most appropriate federal role will be formulated.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

II. ECONOMIC ANALYSIS

Title: Analysis of Architectural and Engineering Systems

FY 78: $65,000

FY 79: $75,000

Principal Investigator(s):
S. Guterman, W. Marcuse

Sponsor: Office of Conservation and Solar Applications

This task is directed toward acquiring and analyzing data for use in improving the process of selection of RD&D projects for inclusion in the Architectural and Engineering Systems (AES) program. AES will be provided with data for new projects along with updated data for current projects. Building inventory data, new construction estimates, and energy use estimates will be updated and expanded to improve the information available to AES management. The analytical capabilities developed at Brookhaven National Laboratory will be used to perform an annual analysis of the AES program. The Brookhaven Building Energy Conservation Optimization Model (BECOM) will be used to identify optimal portfolios.

Title: Analysis of Buildings and Community Systems

FY 79: $ 50,000

FY 80: $125,000

Principal Investigator(s): S. Mulherkar

Sponsor: Division of Buildings and Community Systems

This program is designed to provide guidance for management of conservation technology projects in the residential and commercial buildings area. Key questions to be answered are: What is the impact of national energy legislation? What national and regional effects do higher energy prices have on the penetration of retrofit and new building technologies? What is the potential savings from implementing conservation policy such as building codes and standards? What is the optimal portfolio of projects to be funded, given a budget constraint?

The tool used is the Brookhaven Building Energy Conservation Optimization Model (BECOM) which is tied to the Brookhaven Energy System Optimization Model (BESOM). Economy-wide and interindustry effects are obtained by coupling with the Brookhaven I-O and calibrating to the Hudson-Jorgenson Long-term Interindustry Transactions model.

Title: Assessment of Conservation Options for Industry

FY 78: $117,000

FY 79: $100,000

Principal Investigator: D. Pilati

Sponsor: Office of Industry Conservation

This program is primarily directed towards developing a set of mathematical programming (or process) models for each of the energy-intensive industries. These models are to be used to evaluate the potential market penetration of new energy-conserving process technologies, the impacts of proposed industrial energy conservation fiscal policies, and the impact of industrial conservation on the consumption and mix of fossil fuels.

To date, these models have not incorporated the notion of technological, institutional, and commercial risk. As such, they tend to overpredict the market penetration of new technologies that are perceived as risky by the private sector. This limitation is to be corrected under this program. As an adjunct to this effort, additional analyses will be undertaken to quantify perceived risks better.

Title: Conservation and Solar Policy and Program Analysis

FY 79: $775,000

FY 80: $850,000

Principal Investigator(s):
H. Davitian, W. Marcuse

Sponsor: Office of Conservation Policy and Programs

In this program, BNL is providing and coordinating a broad range of support activities to the Assistant Secretary for Conservation and Solar Applications (ASCSA). These activities include analyses of the impacts on resource use patterns, the economy, the environment, national security, employment, and equity for existing and proposed policies which, at the point of end use, affect energy consumption. The thrust of the analyses will be to indicate how policy initiatives sponsored by DOE, in general, and by the ASCSA, in particular, can aid in encouraging energy conservation and the use of solar energy in a manner consistent with other federal goals. The analytical framework of these analyses is a hierarchical system of economic and energy models including detailed sector models of energy consumption. In addition to these analytical activities, the BNL effort will include programmatic review and consultation activities.

Title: Economic, Policy and Planning Analysis, Program to Assess the Potential for Geothermal District Heating

FY 79: $445,000

FY 80: $225,000

Principal Investigator(s): J. Karkheck, R. Tessmer, Jr.

Sponsor: Economic Policy and Planning Office, Division of Geothermal Energy

---

The purpose of this study is, first, to develop and apply techniques for estimating the economic feasibility for meeting energy demands with geothermal heat sources and the extent and nature of such markets. Secondly, this study will identify and examine institutional factors which might affect adoption of such technology. Relevant factors include the monopoly and regulation aspects of existing public utilities, formation and regulations of competitive public utilities (i.e., geothermal), and behavioral constraints or reactions to such things as unfamiliar home heating equipment and pipe laying.

The term "district heating," as it is used here, refers to the supply of direct heat from geothermal sites by a utility to multiple users. Potential markets for district heating include residential and commercial demand for water heat and space conditioning, industrial and commercial demand for low temperature process heat, and agricultural/fishery demand for low temperature process heat and drying. In order to evaluate the economic feasibility and extent of these markets, this activity encompasses supply (bringing heat to the consumer), demand (retrofitting and/or end-use capital equipment), and competing conventional technologies.

Title: Industry Process Models for Energy Use Analysis

FY 78: $125,000

FY 79: $ 75,000

Principal Investigator:
D. Pilati

Sponsor: Energy Use Analysis, EIA

This program is directed towards developing a set of mathematical programming (or process) models for each of the energy-intensive industries. Once developed, the models will be used to analyze the energy use impacts of alternative future energy prices and policy options.

Each model is being developed in conjunction with support by Industry Conservation. The final products are user oriented with matrix generation and report writing capabilities. Each model is dynamic in nature and can assess the use of technologies, energy, labor, and materials over a 25-year time horizon.

Title: Regulatory Issues Associated with Solar Energy Commercialization

FY 79: $165,000

FY 80: $180,000

Principal Investigator(s): W. Marcuse, H. Davitian

Sponsor: Barriers Incentives Branch, Conservation and Solar Applications

---

This study focuses on regulatory issues related to the use of electricity to provide backup for solar heating and hot water systems in residences. A method for estimating the long-run marginal cost of electricity used as backup is being developed and applied to several actual utilities. The results have important implications for the rate making process. In addition, the information developed can be used to estimate the impact of regulatory and tax policies on the economics of solar systems, on the energy resource use patterns, and on environmental quality.

Title: Energy Strategy and Integrated Analysis

FY 79: $355,000

Principal Investigator(s):
R. J. Goettle IV

FY 80: $370,000

Sponsor: Office of Analytical Services (Policy and Evaluation)

The Energy Strategy and Integrated Analysis Program encompasses a broad range of studies in support of the development of energy policy priorities and strategies. The program involves the coordination and integration of national and regional data and models, and their application to comprehensive analyses of the economic, technical, and environmental effects of alternative energy technology and policy options. Among the applications are integrated energy and economic analyses of the consequences of higher energy prices, alternative supply strategies, and conservation initiatives; probabilistic benefit-cost analyses of policy effectiveness and the value of information; comparative scenario and projection analyses; strategic, multiobjective, supply and demand studies related to energy and energy RD&D policies and technological change. These studies employ that combination of assumptions, data, and methodologies which is determined to be consistent with the issue(s) under consideration.

Also under this program, advanced analytical approaches to policy issues are developed and employed with the active participation of the larger scientific community. Such activities at the Center have resulted in the integration and application of several unique energy and economic models and data bases. Consistent with the objective of employing only "state-of-the-art" methodologies in the policy studies for this program, models and data bases developed elsewhere are applied under contracts managed by the Center.

Title: Special Purpose Vehicle Project

FY 79: $100,000

Principal Investigator(s): J. R. Wagner

FY 80: $150,000

Sponsor: Division of Transportation, Energy Conservation

This program is designed to assist TEC in analyzing policies which affect selected components of the nation's stock of transportation vehicles. Currently the program consists of two studies.

The Highway Fleets Study will identify, quantify, and project those characteristics of corporate/governmental highway fleets that affect the market penetration of alternative technologies. The study has three basic objectives: (1) Development of a statistical profile of fleet vehicles, and identification of factors affecting technological penetration rates; (2) development of a systematic framework for estimating the rate at which new technologies can penetrate the fleet vehicle market; (3) generation of a formal set of scenarios to illustrate the relationships between technological options, the requirements of fleet vehicles, and technological penetration rates.

The Recreational Transportation Study is designed to develop a method for estimating the equity and energy consumption impacts of policy options affecting recreational transportation. Objectives which have been identified include: (1) Estimates of the number of recreational vehicles (including highway vehicles, airplanes, and boats) by type of household; (2) estimates of vehicle energy intensities; and (3) estimates of vehicle utilization rates.

Title: Urban Energy Policy Study

FY 79: $275,000

Principal Investigator(s): W. Marcuse

FY 80: $300,000

Sponsor: Conservation and Solar Applications/Policy and Evaluation

---

This program represents a policy-oriented study of energy use and feasible energy system improvements in urban areas. It includes an economic evaluation of alternative end-use and supply technologies as they apply in different community applications. In addition, the study includes the identification of institutional barriers to the implementation of energy system improving technologies. The objectives of this study are to:

1. Identify which specific technologies, both supply and end-use, are appropriate to different types of community applications.
2. Identify institutional barriers to the implementation of technological alternatives.
3. Recommend policies that will lead to the utilization of technologies which will decrease energy consumption, improve environmental conditions, and reduce dependence on imported energy supplies.

The study will classify different types of urban environments, identify energy use targets, and recommend appropriate policy initiatives. In so doing the study will identify opportunities for linking energy initiatives with urban capital projects and other federal, state, and local programs for cost reductions. Finally, the study will, through conducting a series of case studies, develop a set of specific policy options and recommendations directed toward the realization of energy opportunities for conserving non-renewable energy resources, reducing environmental emissions, and improving the economic climate in the nations cities.

The study will produce systems and methodologies useful to both local community leaders and federal personnel. It will provide local

community leaders with a system through which they can identify current, and plan future, energy consumption in their areas, as well as identify what technologies will be most effective in modifying that consumption. The study will also provide the Department of Energy and other federal agencies with a management tool to evaluate alternative policy initiatives and provide a rationale for the most effective alternatives.

III. BIOMEDICAL AND ENVIRONMENTAL ASSESSMENT

Title: Assessment of Health Effects of Energy Systems - Assessment of Biomedical and Environmental Costs of Energy Systems

FY 79: $790,000

FY 80: $875,000

Principal Investigator(s): L. Hamilton

Sponsor: Division of Technology Overview/Environment

This program aims at developing a systematic overview of biomedical and enviornmental costs of energy production and use. All forms of energy are being considered. Starting with a compilation of residuals from the energy system, the various pathways to man are traced. This task entails definition of transport mechanisms including chemical conversions and various links through the biosphere to man. An evaluation is then made of effects. The initial focus is on biomedical and environmental effects on animals, crops and other vegetation, and on land, that are known to affect man. This evaluation relies on available information: epidemiological data, field and laboratory studies carried out on appropriate animals and vegetation, and basic biomedical research designed to elucidate molecular and cellular mechanisms underlying biological responses to various residuals. By taking account of the magnitude of energy flow through the system and of the populations exposed, total effects are calculated. The basic framework of the evaluation is provided by the national energy system models and data base in use and under development by the National Center for Analysis of Energy Systems (NCAES) at Brookhaven. That work provides a significant resource for this program and a means of integrating the results of the program into national energy policy analysis.

Integrated assessment activity in this area is designed to serve two purposes: (1) guide the allocation of resources in the biomedical research program, and (2) provide information on biological and environmental costs required to make decisions regarding alternative energy systems.

Title: Environmental Policy Analysis - Analysis of Energy and Environmental Policy Conditions

FY 79: $565,000

FY 80: $630,000

Principal Investigator(s): L. Hamilton

Sponsor: Assistant Secretary for Environment

This program will provide the Department of Energy (DOE) with dissections of relationships among technical, environmental, health, economic, and societal factors as they affect environmental regulation, energy, and environmental R&D policy, or the commercialization of developed energy systems. The program entails longer-term policy analyses to diagnose incipient energy/environmental problems and short-term studies to meet policy-making needs in DOE.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

IV. TECHNOLOGY ASSESSMENT

Title: EEMIS - Support for Energy Emergency Management Information Systems Program

FY 79: $1,000,000

FY 80: $ 675,000

Principal Investigator(s): M. Beller, A.S. Kydes, R. J. Goettle

Sponsor: EEMIS Program Energy Information Administration

The objective of this program is to provide analytical support to the Energy Emergency Management Information System (EEMIS) Project Office in the Energy Information Administration. This support is based upon the application and expansion of the Reference Energy System, developed at BNL, to meet the basic EEMIS objectives of detection, prevention, and management of energy emergencies. Additionally, specifications for ancillary modeling requirements will be outlined, drawing upon existing models or as yet undeveloped techniques to assist in the data management and analysis process.

The operation of EEMIS is conceived to be a real time system monitoring energy use. For example, it could present a month-to-month, state-by-state view of energy use patterns from the supply side to energy-demand consumption sectors. It would include the status of energy forms in storage, production, and possibly transit. It would permit the determination of the possible onset of an energy emergency (shortfall). Or, it could respond to unpredicted crises (embargo, natural disaster) by presenting substitution or rerouting alternatives. EEMIS would have submodels associated with it which would do simple energy forecasts, and which might also provide economic assessments associated with energy policy decisions in response to emergencies.

To encompass this capability, an energy management structure will be formulated which specifies the types of data and formats required to meet the program objectives.

Title: Energy Case Studies - Fossil Energy

FY 79: $150,000

Principal Investigator(s): J. Lamontagne

FY 80: $150,000

Sponsor: Office of Fossil Energy

The objective of this program is to provide data and analytical support to the U.S. Department of Energy's Energy Technology Office of Fossil Energy Programs' Division of Program Control and Support. This support involves the continuing assembly, qualification, updating, and application of data bases and analytical tools that describe the technical, environmental, and economic characteristics of fossil energy technologies and fossil energy resources.

Data support includes definition and review of parameters for use with fossil energy related models; technical information regarding fossil energy resources and conversion processes; and related data characterizing factors such as water availability, land use, and institutional constraints. Data base extension involves exploration of current sources to define data resources available to satisfy perceived program control and support needs.

Analytical support includes the analysis of the role of fossil energy systems in the context of the U.S. energy system; and analyses of fossil energy extraction, transportation, conversion, and utilization. Models used in these analyses range from engineering descriptions of advanced energy conversion processes and their associated technical and economic characteristics to national and regional models simulating energy supply and demand.

Computer support is utilized to accomplish the physical transfer of data bases and analytical models from one location to another and to develop software for any direct access, interaction, or graphic display required by DOE, BNL, or other users of the data base and analytical models.

When required, the relationship of fossil energy to other energy sources, interactions with the U.S. economy and international trade, and impacts of institutional constraints on fossil energy supply and utilization are explored.

Title: Energy Research - Technology Assessment for the Office of Energy Research

FY 79: $90,000

FY 80: $90,000

Principal Investigator: M. Beller

Sponsor: Office of Program Analysis Energy Research

The objective of this program is to provide analytical support to the Office of Energy Research in terms of impact assessments of selected RD&D programs and assistance in the development of coordinated plans involving groups of technological and policy options. Additionally, specific evaluation tasks of interest to the Office of Energy Research will be performed as required. The program will also maintain an updated file of technological information maintained to support the analyses generated in these assessments.

The functions of the Office of Program Analysis (PA) require it to conduct independent analysis, evaluation, and review of energy R&D programs, particularly with respect to their role within national energy supply, as well as to conduct independent benefit-cost analyses of selected technologies in order to advise the director on relative priorities of R&D programs. To accomplish these tasks PA requires access to and use of data and quantitative capabilities existing at the National Center for Analysis of Energy Systems at Brookhaven National Laboratory which has assembled and employs analytical models and data bases that are extensively used by federal agencies, universities, industry, and international research centers. The tools at BNL are uniquely suited for examining the role of new technology in the context of economic, tax, and other national energy policy variables and for integrating the work of individual technology studies into an overall energy systems analysis.

Title: Energy Storage Systems Analysis

FY 79: $100,000

FY 80: $100,000

Principal Investigator(s): M. Beller, R. Leigh

Sponsor: Division of Energy Storage Applications Analysis Branch

---

The objective of this program is to provide analytical support to the Division of Energy Storage in terms of impact assessments of selected technologies and specific assignments requested as they pertain to energy storage programs. Additionally, studies of storage applications, with particular emphasis on solar technologies, will be performed. The general approach is to study energy storage options as functions of fossil fuel prices and availability, device cost, and availability of off-peak power supply and cost. The national impacts of storage technologies commercialization, in terms of total cost, electric and nonelectric fuels supply mix, electric load factors, and environmental emissions, will be determined. The results will be applicable to guiding DOE RD&D programs and to assisting in energy policy formulation. Opportunities for fuel savings attainable by the use of storage devices in all sectors of the energy system will be explored.

Specific studies completed or currently under way include an examination of the economically optimal sizing of energy storage systems when device lifetime depends on detailed nature of the loads being served, a study of the optimal number of glazings to be used in Trombe walls (a "passive" energy storage device), and an ongoing study of breakeven costs of various energy storage devices in the context of residential solar total energy systems. Future studies will include further development of these topics and studies of the role that energy storage techniques can play in commercial and industrial process heat and in seasonal and diurnal residential thermal storage for space heating.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

V. ENERGY DATA AND MODELS

Title: Energy Model Evaluations Standards General Systems Studies

FY 79: $270,000

Principal Investigator(s): A. S. Kydes, R. J. Goettle, L. L. Juang

FY 80: $420,000

Sponsor: Energy Information Administration

This project is intended to develop generic standards, diagnostic procedures, and information systems for the evaluation of Energy Information Administration (EIA) model systems. The EIA has established many large scale mathematical and statistical procedures for projecting and analyzing energy production, consumption, prices, and associated impacts. The systems, based on complex mathematical, technological, and statistical techniques, are to be subjected to extensive, continuing reviews and critiques aimed at determining and improving their validity, accuracy, and abilities. These systems will always be in a state of change. It is important for the Department of Energy to specify generic standards and procedures that will regularly be applied to the latest version of each system to determine its current validity and applicability and to suggest improvements and state-of-the-art extensions.

The National Center for Analysis of Energy Systems at BNL will establish a continuing activity which will be tasked to develop the aforementioned methods for the general evaluation activities of EIA. The ultimate test of the results of this effort will be their application to a specific analysis system selected by EIA.

The goal of this research is to develop rigorous analytical methods for ascertaining the degree of confidence in model results and the circumstances under which systems may be used. Model evaluation, the procedure by which model applicability and utility is determined, is comprised of two components: verification and validation. The focus of verification activities is the confirmation that the system behaves and is structured as its developer intended. Here, the procedural approach is to systematically assess the scope, assumptions, structural derivations, and functional representations contained in the model system.

Title: Energy Model Evaluations Standards General Systems Studies

---

Model validation concerns the determination of the degree of accuracy and plausibility of the model, and serves to quantitatively identify potential limits of applicability to model use. For validation, the procedural approach stresses model performance, sensitivity, comparison to alternative methodologies, and other factors which significantly influence confidence in the results. Whether accuracy or plausibility become the validation criterion is dependent on the model and its specific application.

Title: Energy Modeling Support
General Systems Studies

FY 79:

Principal Investigator(s):
A. S. Kydes, R. J. Goettle

FY 80: $245,000

Sponsor: Energy Information Administration

The analysis and forecasting activities, which are part of the mission of the Assistant Administrator for Applied Analysis in the Energy Information Administration (EIA) of the Department of Energy, require access to a large number of models and methodologies. The objective of the Energy Modeling Support Program is to provide for theoretical investigation and practical development of special features for incorporation into EIA models.

Area 1 - Energy-Economic Coupling

The analysis of U.S. and world energy markets and economies requires the use of existing models and data bases capable of addressing the interrelationships between the nation's energy system and its economic system. Of particular interest are analyses regarding the macroeconomic consequences of energy price/availability variations, federal supply strategies, and federal conservation initiatives.

Area 2 - Multiobjective Analysis

Analysis of how good a particular energy system configuration is must be done in accordance with certain criteria. Configurations may be judged by how well they meet social, economic, or environmental objectives; often these objectives conflict. The purpose of multiobjective analysis is to provide a coherent and consistent framework for evaluating energy/economic systems.

Area 3 - Market Penetration

Forecasts of the future include new technologies which are not completely developed and whose rate of introduction is uncertain. Market penetration analysis can help resolve some of the uncertainty and provide a basis for estimating implementation levels.

Title: Energy Modeling Support - General Systems Studies

Area 4 - Treatment of Uncertainty

Projections of the future are by their nature uncertain; systematic ways of treating uncertainties are needed. One aspect is the current behavior of producers and consumers in light of their perception of the likelihood of alternate futures. Another aspect is the sensitivity of model outputs to variations in inputs.

Title: International Model and Data Assistance Activity - General Systems Studies

FY 79: $83,000

FY 80: $73,000

Principal Investigator(s): A. S. Kydes, J. Rabinowitz

Sponsor: International Affairs

The International Model and Data Assistance Program enables NCAES to further its policy of establishing cooperative research relationships with international energy system analysis groups. The program's primary purpose is to assist these groups in their energy systems analysis by providing BNL models and data bases when requested, and giving preliminary advice and consultation in model use and interpretation. A secondary objective is the exchange of energy technology and systems information which may enhance BNL's approach to energy systems analysis capabilities. This assistance will also include, when appropriate, discussions with personnel sent to BNL by their home country sponsor. A users' guide will be developed for the transportable FORTRAN versions of BESOM and ESNS. An information system will be initiated and maintained to record all requests submitted under this program.

Title: Model and Forecasting - Model Evaluation Program

FY 79: $277,000

Principal Investigator(s):
A. S. Kydes, E. A. Cherniavsky

FY 80: $100,000

Sponsor: Energy Information Administration

The data and analysis functions of DOE/EIA will require access to a wide variety of data sources and models dealing with energy, economic, and environmental issues. Brookhaven has been engaged in the survey and analysis of pertinent data and models. The objective of the Model Evaluation Program is to provide for the validation and verification of relevant energy data and models. Evaluation may be performed on the complete model or on certain model features.

This program deals with the detailed evaluation of selected energy models. Under this program, the first efforts will focus on performing a critical evaluation of the Decision Focus, Inc. model, or Long-Range Energy Analysis Package (LEAP).

The purpose of Task 1 is to review the technological data on primary energy conversion, distribution, and end-use consumption; and to correct and verify them as a basis for EIA forecasting.

The purpose of Task 2 is to develop an algorithm to solve economic equilibria in a computationally more efficient way than the current procedure.

The purpose of Tasks 4-6 is to develop supply and demand representations and incorporate them in the Long-Range Energy Analysis Package (LEAP). These representations are to be calibrated to existing models that have been subjected to peer review and have gained acceptance.

Title: Modeling and Forecasting - Energy Data Base Program

FY 79: $420,000

Principal Investigator(s): A. Reisman

FY 80: $200,000

Sponsor: Energy Information Administration

The data and analysis functions of the Energy Information Administration (EIA) in the Department of Energy will require access to a wide variety of data sources including information relating to the technological, economic, and environmental aspects of energy production and use. Brookhaven National Laboratory (BNL) has been engaged in the survey, analysis, and acquisition of pertinent data; and has gained relevant experience in making these data accessible to both in-house and outside users.

The Energy Data Base, developed at BNL, contains data on over 800 energy supply processes and over 200 energy utilization processes. With each process is associated a vector of environmental emissions, social impacts, and costs. The vector contains 7 air pollutants, 13 water pollutants, 45 toxic trace pollutants, 18 types of radioactive emittants; health data on occupational deaths, injuries, days lost; land use and makeup water figures; cost data; and labor and materials requirements for construction of energy supply facilities. Each number in the data base is referenced, and footnotes explain the derivation of underlying assumptions. A "hardness" number gives a subjective evaluation of how good each datum is.

The Energy Data Base has provided data inputs for a variety of models requiring technical detail. In addition, users have often wished to extract individual data elements, which is facilitated by the interactive use of the System 2000 data base management package; or to investigate the effects associated with a single supply trajectory, e.g., gas from coal. Interactive software has also been developed that permits easy access to such information.

Under this program it is proposed to update and extend the Energy Data Base, and to continue support user access to the data. Work will be undertaken

to verify and validate relevant data and to improve the usefulness of these data by filling in gaps in process characterization and by providing, whenever possible, ranges of values for each coefficeint. A study will also be done of the utility of the Energy Data Base format as the framework for an Energy Information System.

Title: Research in Applied Mathematical Sciences
Basic Research Topics in Modeling Support

FY 79: $60,000

FY 80: $350,000

Principal Investigator(s):
A. S. Kydes, R. J. Goettle

Sponsor: Office of Basic Energy Sciences

The importance of monitoring and advancing the state of the art in mathematical, statistical, and computer science research and its impact on the information quality of energy systems anslysis has been recognized as a legitimate basic research activity to be supported by the Office of Basic Energy Sciences in the Department of Energy.

Area 1 - Multiobjective Analysis

The scope of energy systems analysis has broadened to include not only energy-economic interactions and their implications for policy planning but also social concerns (e.g., environmental degradation), security requirements (e.g., levels of oil imports), and interactions with energy use and the economy. The quality of an energy system configuration can no longer be judged solely by a single criterion; it has become essential to identify and employ approaches and a systems framework which facilitate the evaluation and characterization of an energy system by multiple criteria. The purpose of multiobjective analysis is to provide a coherent and consistent analytical framework for evaluating energy/economic/environmental systems.

Investigation of multiobjective analysis techniques is a long-standing activity of the National Center for Analysis of Energy Systems. In the past year efforts have focused on four approaches which are employed in conjunction with linear programming models.

The first methodology determines a "best case" by indirectly eliciting the decision makers' utility function through a series of questions about preferred trade-offs.

The second approach is the automation of multiobjective analysis by explicit specification of alternative utility functions (possibly nonlinear).

Experiments were performed with three different utility function representations. These were found to agree well with judgmental "best case" selections.

A third area is the hierarchical multiobjective analysis. In this framework, the decision maker ranks the objectives (e.g., security, cost, environment) which are represented by linear functions, and given weights to the subordinate objectives. The method allows the decision maker to look at a variety of solutions that maintain consistency between different rankings, and to examine sensitivity of the solution to choice of weighing factors.

The fourth approach ("rim analysis") involves a statistical analysis of the characteristics of alternative solutions which are "near" a preferred solution by using the model as a data source (pseudodata via sensitivity analyses) to generate smooth approximations to the implied relationships among competing objectives.

Area 2 - Software and Algorithmic Development

The translation of the perceived interactions between energy, economy, and environment to an appropriate mathematical structure has often been limited by the quality and availability of "off-the-shelf" software. For example, modelers are reluctant to formulate problems in the form of large-scale nonlinear optimization problems with (non) linear constraints because good commercial codes for such large nonlinear optimization problems are not readily available.

Further, time-phased, regionalized linear programming formulations of energy systems are often severely limited by existing LP software capabilities and associated computing facilities. For example, a regionalized version of the Brookhaven Time-Stepped Energy System Optimization Model (TESOM), with five time periods and ten regions would result in an LP containing approximately 10,000 rows and 12,000 columns.

For general equilibrium frameworks, such as that of the Long-Run Energy Analysis Package (LEAP) currently being implemented for EIA by Decision Focus, Inc. (DFI), the regionalized time-phased formulation for the U.S.A. results in a system of approximately 100,000 equations to be solved repeatedly until equilibrium prices and quantities are established. The SOR (successive over relaxations) algorithm is currently being used to solve this problem. The solution procedure could benefit from the use of alternative algorithms, such as Newton-type schemes (with partitioning) which tend to converge super-linearly, and/or the exploitation of the special structure of the problem. Finally, questions regarding the uniqueness of general equilibrium solutions are often tangentially or insubstantially treated.

Area 3 - Decision Analysis Under Uncertainty

The energy dilemma is revealed as a situation in which an imbalance exists among perceived energy supplies and availabilities, fuel choices and behavioral uses, energy-using and energy-producing capital stocks, energy prices and the costs of energy production. Energy is required (demanded and consumed) to obtain the current mix of goods and services available in our economy. In turn, the current mix of goods and services is determined by those private and public decisions which affect the structural and technical organization of our combined production, distribution, and consumption activities.

The purpose of this research is to systematically investigate various aspects of consumer, producer, and public policy decision problems (objective functions; decision variables, parameters, and sequences; expectational considerations; risk preferences; etc.) so as to establish a better understanding of more atomistic private and public reaction processes which, in turn, provides a clearer assessment of the integrated transitional direction.

VI. INTERNATIONAL PROJECTS

Title: Developing Country Energy Project: Technical Support of Country Studies

FY 79: $360,000

FY 80: $220,000

Principal Investigator(s): Vinod Mubayi, A. Kydes

Sponsor: Office of International Programs Support, Special Regions Policy

---

In this task, Brookhaven National Laboratory (BNL) will give technical support in the general area of energy supply-demand analysis to the Department of Energy (DOE) and contractors responsible for carrying out country energy assessments in individual developing countries. BNL will provide technical advice on the methodology of structuring the assessments to ensure consistency among individual approaches, on energy demand projection methods, and on integration of resource and technology options with future demand scenarios.

BNL will also provide training in analytical techniques and methodologies related to energy assessment and in the implementation and use of energy system models developed at the Laboratory. This training will be offered both to contractor personnel carrying out individual country studies and to designated analysts from appropriate institutions in developing countries.

In addition, under this task, BNL will continue to assist DOE in overall program formulation as well as evaluate, for DOE, its individual country studies carried out by contractors.

Title: Developing Country Energy Project: Methodologies Development

FY 79: $190,000

FY 80: $200,000

Principal Investigator(s): Vinod Mubayi, S. Kyle

Sponsor: Office of International Programs Support, Special Regions Policy

---

The development and extension of methodologies for Less Developed Countries (LDCs) energy system analysis will be an important focus of work within the Developing Country Energy Project at Brookhaven National Laboratory (BNL). This activity will provide useful input to future country assessments and will also greatly contribute to refining and further continuing the analytical part of the pilot project initiated in Egypt and Peru. The main areas of focus in this task are: (i) Energy-Economic Model Development: A model framework will be developed to provide for a more accurate and consistent incorporation of economic factors into energy demand projections. Initially, the model will be tested for Peru and Egypt. (ii) Noncommercial-Commercial Fuels Transition Analysis: A methodology will be developed to improve our understanding of the transition from consumption of noncommercial fuels to commercial fuels, expecially petroleum based ones. The methodology will incorporate regional and ecological factors affecting fuel mix patterns and the influence of alternative developmental strategies on the transition. The methodology will first be developed for Peru where some important work on noncommercial fuels has been done by the United Nations Development Program (UNDP), Ministry of Energy and Mines Project on Energy Balances. (iii) Electric Capacity Expansion/Siting Model: It is proposed to investigate the possibilities of linking an electric capacity expansion model, such as the Wien Automatic Systems Planning (WASP) Model, with the energy facility siting model developed at BNL (see BNL report 23388). This will provide a more accurate description of the costs and benefits of alternative electrification strategies.

Title: Developing Country Energy Project: Country Follow-on Activities

FY 79: $150,000

FY 80: $380,000

Principal Investigator(s): Vinod Mubayi, A. Doernberg

Sponsor: Office of International Programs Support, Special Regions Policy

---

The objective of this program is to provide support for the Department of Energy's follow-on activities in those developing countries where energy assessments under the pilot program have been completed. Activities for follow-on in developing countries are in five areas. (i) Transfer energy models developed at Brookhaven National Laboratory (Less Developed Country-Energy Systems Network Simulator (LDC-ESNS), and Brookhaven Energy System Optimization Model (BESOM) to host country, including training and model verification in qualified institutions. (ii) Design the structure of a multi-region national analysis and complete an analysis for a designated region of Peru to be performed by Peruvians. (iii) Develop an energy information system for Peru. (iv) Perform an investment analysis of alternative energy strategies identified under the pilot program. (v) Analyze the trend of noncommercial to commercial fuel consumption in rural areas, and identify technologies which will enhance the efficiency of energy utilization.

Title: General Systems Studies
IEA, Systems Analysis Program, Phase II

FY 79: $487,000

FY 80: $485,000

Principal Investigator(s):
Vance L. Sailor

Sponsor: U.S. Department of Energy

Brookhaven National Laboratory (BNL) has been serving as the U.S. site for the systems analysis program of the International Energy Agency (IEA). The objective of this program is to develop data and perform analyses of the impact of new energy technologies on the energy systems of member IEA nations and thereby establish a basis for a cooperative IEA research and development strategy. The Kernforschungsanlage (KFA), Jülich, has been serving as the European site for this program, and close coordination has been maintained between the two groups. The directors of each group report to the IEA Steering Group for Energy R&D Strategy established for the Systems Analysis Program.

The program budget covers the BNL appointee and support staff to the program as well as materials, supplies, computing services, overhead, and management expenses associated with the activity at BNL. A more detailed work plan has been developed for the activity by the Steering Group and has been reviewed and updated at about 3-month intervals. The work plan was expanded and accelerated by actions taken by the IEA Committee on Research and Development and the Steering Group at their meetings on September 15-16, 1977. A number of national representatives, assigned to the IEA Systems Analysis staff by member IEA nations, arrived at BNL in May 1976. The salaries, living expenses, and travel of these representatives are covered by their home countries and are not included in this budget.

The BNL staff appointee selected by the Steering Group serves as the program director. Two other BNL staff appointees serve as the United States representative and his assistant. An additional two BNL appointees provide

computer modeling and data base services for the project. The support staff (also BNL employees) report to the director and provide assistance in the work plan. BNL expert consultants provide special technical services.

During FY 78 a computer model, MARKAL, was developed and tested. MARKAL is a multiperiod, demand-driven, LP model covering the time span from 1980 through 2020. The model has been applied to the participating countries for several alternative sets of assumptions (scenarios) specified by the Steering Groups. As results are obtained, the Steering Group will select special cases for sensitivity analysis and more intensive study with differing sets of assumptions.

During FY 79, reports will be prepared summarizing the results for each individual country and for the IEA as a whole. These reports will provide a quantitative basis for the development of an IEA cooperative R&D strategy by the IEA Committee on Research and Development.

Title: Energy Management Training Program

FY 79: $300,000

FY 80: $300,000

Principal Investigator(s): Robert Nathans

Sponsor: U.S. Agency for International Development

In the course of developing countries work conducted at Brookhaven National Laboratory over the past two years one major issue was identified: the inability of developing countries to acknowledge, understand, and analyze the variety of resources, technologies, and policies which play a part in energy development. Therefore, the Agency for International Development (AID) requested that Brookhaven National Laboratory and the Institute for Energy Research at the State University of New York at Stony Brook design, develop, and present a review course in energy policy analysis for developing countries. This course [the Energy Management Training Program (EMTP)] reviews both current and emerging energy technologies and resources, as well as the regulatory and incentive policies which both inhibit and encourage their use. The economic and environmental implications of the development of these energy technologies and resources are discussed, as are the interpolicy implications (for example, the relationship between energy growth and economic development).

Funding for this program is derived through an agreement (PASA) between the Agency for International Development and the U.S. Department of Energy. Its operation involves the solicitation of candidates, by mail, through participation in international meetings, and through international travel. Selection is made by EMTP staff with concurrence by the EMTP Advisory Panel and AID, Washington. Travel for the participants (with some few exceptions) is at their expense. Housing and stipend costs while in attendance at the course are provided under the contract. Management and operation of the course (for Fiscal 1978) were the responsibilities of the Institute for Energy Research (under subcontract to BNL). Operating costs for the course are borne primarily by the Institute for Energy Research.

Title: Studies of Energy Needs in Food Systems

FY 79: $373,000

FY 80: $168,000

Principal Investigator(s): J. Brainard

Sponsor: U.S. Agency for International Development

Improvements in the agricultural sector--particularly in the production, processing, distribution, and preparation of food--are central to national development and improvement in the well-being of the rural poor. Traditionally such improvements have been tied directly and indirectly to increased energy use: directly through increased consumption of energy by machinery used in the agricultural and food system; and indirectly through use of inputs, such as fertilizers, pesticides, and herbicides, that require large amounts of energy for their manufacture. Recent events affecting the cost and availability of energy, however, have focused attention on the need to understand more fully the way energy is used, directly and indirectly, in the agricultural and food system in order to assess the opportunities for (1) increasing the efficiency with which energy is used, and (2) employing alternative energy sources that are less dependent on high-priced fuels.

In response to this need, the U.S. Agency for International Development (USAID) is supporting a number of studies of the relationships between the agricultural, food, and energy systems of developing countries. This overall project will consist of two parts. The first is a series of country-specific studies intended to yield an extensive information base covering the use of energy in all major agricultural activities, and in the production, distribution, and preparation of selected, nutritionally important foods. The country-specific studies will also seek to identify feasible and desirable innovations which could contribute in the near and long term to the alleviation of the most significant problems associated with the use of energy in the agricultural and food system.

The second part of the project will be an overview assessment and intercomparison of all the country-specific studies and results. A primary

purpose of that assessment is to improve the basis on which U.S. assistance policy is made. In order to make full use of the results of each of the country-specific studies in the overview and comparison effect, AID has contracted with a consortium of institutions led by Brookhaven National Laboratory and including Tufts and Cornell Universities and the State University of New York at Stony Brook to provide this overview assessment and the required coordination between studies. To that end, the consortium will assist AID in monitoring and evaluating the progress of the studies.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

APPENDIX B

DATA BASES AND ANALYTICAL MODELS DEVELOPED BY AND/OR AVAILABLE TO THE CENTER

The work performed in NCAES includes technical, economic, environmental, and policy analysis of all aspects of the energy systems. In this work, a mix of quantitative and nonquantitative information must be utilized. Depending on the policy issue to be addressed, the analysis and interpretation of quantitative information can comprise anywhere from 10% to 90% of the policy study. To assist in this portion of the work, a number of data bases and analytical models have been assembled at the Center.

The scope of the assemblage of data and models is shown in Figure B-1. This figure illustrates the relationships between the economy, the energy system, and individual technologies that must be addressed in a complete analysis. The basic structure of the Brookhaven energy system models is represented in Figure B-2, The Reference Energy System. The capital, labor, energy, and material resources on which the energy system and economy are based must be considered. Also, environmental and health effects of technologies must be addressed and these factors, combined with the state of the economy, comprise the society and life styles that are uppermost in the planning and analysis hierarchy. The data bases and models listed below address various components of the hierarchical system and the relationships among the components.

Some of the models listed were developed by other groups and are available to Brookhaven through collaborative activities. The policy of NCAES is, whenever possible, to work with the model developer in a collaborative way such that the developer performs the actual runs or analysis with his model. Therefore, anyone interested in a model or data base listed here that was developed elsewhere should contact the developer for any information or possible application.

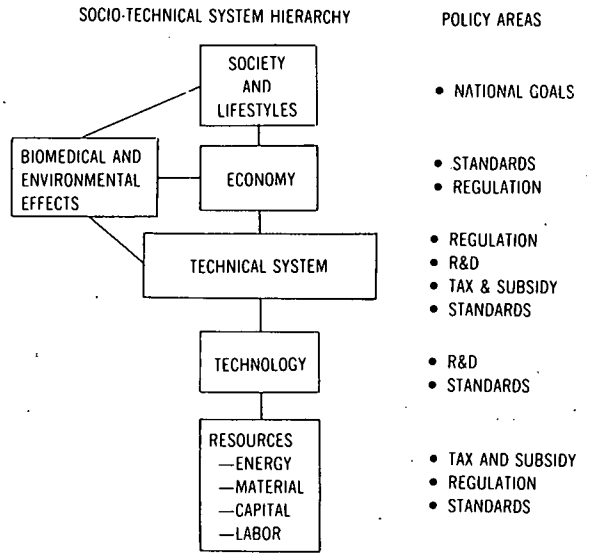


Figure B-1 Policy Considerations

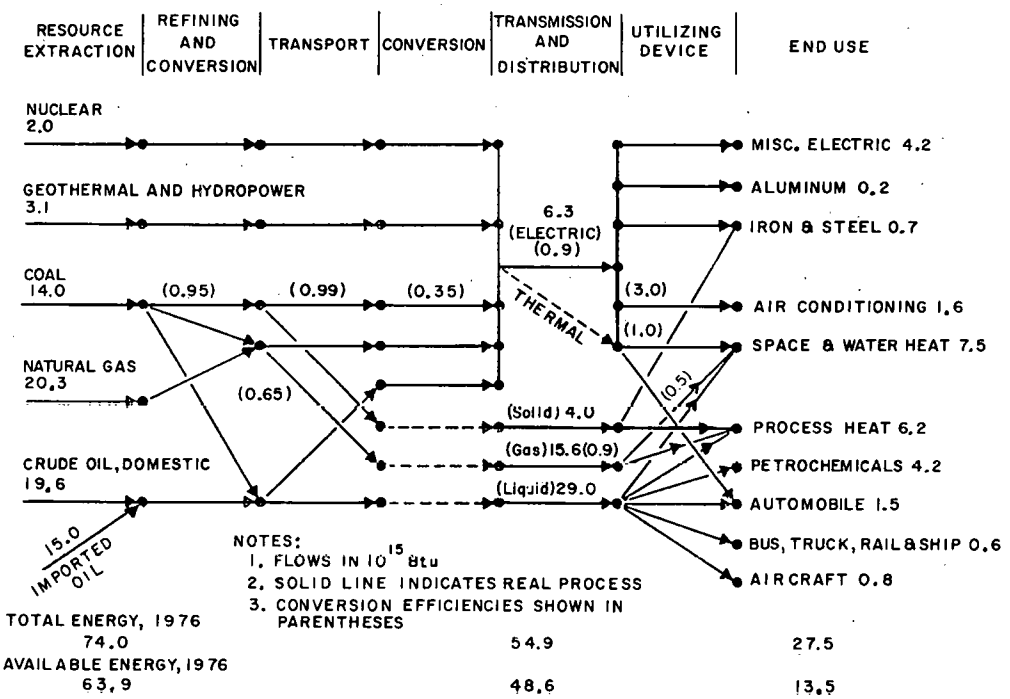


Figure B-2. Reference energy system.

ENERGY SYSTEMS

Models:

1. Model: Brookhaven Energy System Optimization Model (BESOM)

   Developed By: Brookhaven National Laboratory

   Status: Operational on CDC 7600 - Brookhaven National Laboratory

   Description: A linear programming model of the national energy system emphasizing technological detail and interfuel substitution which focuses on a single year at a time.

2. Model: Dynamic Energy System Optimization Model (DESOM)

   Developed By: Brookhaven National Laboratory

   Status: Operational on CDC 7600 - Brookhaven National Laboratory

   Description: A linear programming model of the national energy system emphasizing technological detail and interfuel substitution which optimizes over a time horizon (usually 10 five-year periods).

3. Model: Regional Energy System for the Planning and Optimization of National Scenarios (RESPONS) (also known as the Bechtel Coal Model)

   Developed By: Bechtel Corporation

   Status: A version that will be operational on the Brookhaven National Laboratory CDC 7600 is under development

   Description: A linear programming model of the national energy system with special emphasis on the coal sector.

4. Model: Multi-regional Energy System Optimization Model (M-RESOM)
   Developed By: Brookhaven National Laboratory
   Status: Development is complete and the model is being validated
   Description: A multi-regional (9 census regions) version of Brookhaven Energy System Optimization Model (BESOM).

5. Model: CURVE

   Developed By: T. Muench, M. Wooders, R. McLean of SUNY Stony Brook

   Status: Operational on UNIVAC at SUNY Stony Brook

   Description: Calculates demand for fuel and fuel systems required to heat single family dwelling units.

6. Model: Federal Energy Agency Marketing and Mobility Model

   Developed By: Jack Faucett Associates

   Status: Operational on U.S. Department of Energy's (DOE's) Germantown computer

   Description: Computes size of auto fleet to year 2000 and indicates fuel consumed and vehicle miles traveled.

7. Model: Auto Fleet Submodel

   Developed By: Department of Transporation

   Status: Operational on U.S. Department of Energy's (DOE's) Germantown computer

   Description: Computes size of auto fleet to year 2000, miles traveled, and fuel consumption by grade of fuel.

8. Model: Brookhaven Energy Transportation Submodel

   Developed By: Brookhaven National Laboratory

   Status: Operational on CDC 7600 - Brookhaven National Laboratory

   Description: Calculates energy requirements for the transportation of energy.

9. Model: Industry Process Optimization Models

   Developed By: T. Sparrow at Brookhaven National Laboratory

   Status: Under development on Brookhaven National Laboratory CDC 7600

   Description: Linear programming models of the iron and steel, cement, aluminum, and paper and pulp industries have been completed. Sensitivity of market penetration to capital costs and energy prices may be examined.

10. Model: Energy Supply-Demand Scenario Model

Developed By: Brookhaven National Laboratory from Oak Ridge International Energy Agency (IEA) work

Status: Developed: description exists in Northeast Perspectives Reports

Description: Allows matching of independently developed supply and and demand scenarios. Creates an emissions inventory.

11. Model & Data: Con-Ed Generation Model for Load Management

Developed By: Consolidated Edison Company, modified by Brookhaven National Laboratory (J. Allentuck)

Status: Operational - Brookhaven National Laboratory CDC 7600

Description: Simulates economic dispatch of Con-Ed electric generation. The model is driven by time-varying load curves developed on the basis of aggregating electric demand in the Con-Ed service area by end use.

12. Model: Time-Stepped Energy System Optimization Model (TESOM)

Developed By: Brookhaven National Laboratory

Status: Operational on CDC 7600 - Brookhaven National Laboratory. Report writer is in progress.

Description: A "present trends" time-phased model which optimizes over the changes possible from one time-step to the next. Significant new features include: (1) identification of capital stock by date of introduction, (2) technological characterizations by date of introduction (efficiencies, plant factors, O&M), (3) technological decay rates, and (4) a new market formulation giving an improved simulation capability.

13. Model: Brookhaven Energy Conservation Optimization Model (BECOM)

Developed By: Brookhaven National Laboratory

Status: Operational on CDC 7600 - Brookhaven National Laboratory

Description: Assesses both new and retrofit conservation technologies in nine building types and four regions.

14. Model: Preparation of Reference Energy Systems Through Time (PRESTO)

Developed By: Brookhaven National Laboratory

Status: Completed, operational on CDC 7600 - Brookhaven National Laboratory

Description: Interactive computer programs (based on the Ref-Energy System) that provides a convenient framework for energy flow accounting over time.

15. Model: Regional Process Heat Model (BEPHOM)

Developed By: Brookhaven National Laboratory

Status: Completed, operational on CDC 7600 - Brookhaven National Laboratory

Description: This extension to the BESOM model was developed to permit more realistic analysis of the use of solar and geothermal energy resources in the process heat sector. BEPHOM categories and five temperature regimes were chosen to correspond to four collector/fluid combinations (air, low temperature; air, high temperature; steam, low temperature; steam, high temperature) plus one residual category for which solar is not permitted to compete. A backup supply is required in all solar applications. The following parameters can be varied independently for each region/temperature combination: the capital costs of the collectors, per square foot, the efficiencies of conversion of solar to thermal energy, the number of square feet required per million Btu per year of output, the fraction of solar to backup power.

Data Base:

1. Data Base: Energy Model Data Base

Developed By: Brookhaven National Laboratory

Status: Operational on Brookhaven National Laboratory CDC 7600

Description: Includes (cost, efficiencies, and environmental effects of) new and old technological processes for both supply and utilization.

2. Data Base: County Energy Data Base (COENDA)

   Developed By: Brookhaven National Laboratory (C. Calef, and F. Drysdale)

   Status: Completed, periodically updated and revised, computerized, manipulated by County Energy Budget (COENBU) Program

   Description: Contains county and state level energy, economic, and environmental data. State level data are disaggregated in many instances to provide estimates of county level parameters.

3. Data Base: New York City Data Base

   Developed By: Brookhaven National Laboratory

   Status: Data exist in a series of Brookhaven National Laboratory reports

   Description: Energy and environmental data related to New York City.

   Client: New York City Government

4. Data Base: Northeast Region State Level Data Base

   Developed By: Brookhaven National Laboratory and Subcontractors

   Status: Data exist in the Northeast Perspectives Reports

   Description: Energy and Environmental Data for all states in the Northeast Region.

   Client: State Energy-Environmental Offices, United States Department of Energy. Brookhaven National Laboratory for Policy Analysis.

5. Data Base: 100 Power Plants Data Base

   Developed By: Sam Morris and Granger Morgan, Brookhaven National Laboratory

   Status: Completed, computerized on CDC 7600 - Brookhaven National Laboratory

   Description: Demographic data within 100 miles of 100 power plants in the United States, mostly in Northeast.

Models:

1. Model: Data Resources Incorporated Long-Term Inter-Industry Transactions Model

   Developed By: Data Resources Incorporated

   Status: Operational in conjunction with Data Resources Incorporated on their computer

   Description: Combined macroeconomic and inter-industry model. Contains economically estimated production and utility functions. Permits simultaneous determination of relative prices and input purchase patterns over time.

2. Model: Integrated BNL/DRI Data Base

   Developed By: Brookhaven National Laboratory and Data Resources Incorporated

   Status: Operational on the CDC 7600 at Brookhaven National Laboratory via iterative solution procedure. Linkage equations being programmed.

   Description: The Data Resources Incorporated Long Term Inter-industry Transactions Model is coupled with the Brookhaven Time-Phased Energy System Optimization Model (TESOM) and attached energy supply schedules.

3. Model: Input/Output Model

   Developed By: Brookhaven National Laboratory and Center for Advanced Computation; University of Illinois

   Status: Static and Dynamic Prime Versions operations on CDC 7600 at Brookhaven National Laboratory; dual pricing model 60% complete

   Description: Energy transactions are defined in terms of functional service units. Engineering-based production functions are added for a wide variety of energy supply and conversion technologies. Operational extensions include incorporation of a capital matrix for two period dynamic solutions and a balance of payments routine.

4. Model: Input/Output and Energy System Optimization Model

   Developed By: Center for Advanced Computation, University of Illinois and Brookhaven National Laboratory

   Status: Operational on CDC 7600 at Brookhaven National Laboratory and at Center for Advanced Computation, University of Illinois

   Description: An energy input/output model with 102 producing is coupled with Brookhaven Energy System Optimization Model (BESOM) to permit interfuel substitution. Extensions under development include a reduced form, which will not require iteration between the Input/Output and Brookhaven Energy Systems Optimization Model, and a multi-regional input/output model.

5. Model: Model for the Assessment of Uncertainty and Risk

   Developed By: Peter Love for OECD and International Energy Agency (IEA)

   Status: Completed

   Description: Uses decision analysis and Monte Carlo methodology to assess the uncertainty and risk involved in the assessment of new technologies.

6. Model: Analysis of the Impact of New Energy Technologies in an Overall System

   Developed By: Peter Love for OECD and International Energy Agency (IEA)

   Status: 90% complete

   Description: A methodology for ranking specific technologies within some given system and with estimated upper and lower implementation bounds.

Data Bases:

1. Data Base: New York State Energy-Economic Data Base

   Developed By: SUNY at Stony Brook (Owen Carroll and John Sanborn) and Brookhaven National Laboratory

Status: Under development

Description: Energy and Economic data for New York State. Plan to use a modified Energy System Network Simulator (ESNS) to interface with this data.

Client: New York State Energy Research and Development Administration, New York State Energy Office

ENVIRONMENT

Models:

1. Model: Energy System Network Simulator (ESNS)

   Developed By: Walter A. Sevian, Brookhaven National Laboratory

   Status: Operational on Brookhaven National Laboratory CDC 7600

   Description: A flow model which is a network representation of national or regional energy systems. Extensions include an operational model for nuclear fuel cycle analysis which relies on a data base on nuclear and some nonnuclear technologies, developed by Teknekron. The current working version has 435 supply and end use processes.

2. Model: Radiological and Biological Generic Atmospheric Dose (RABGAD)

   Developed By: Teknekron, Incorporated

   Status: Operational on Brookhaven National Laboratory CDC 7600

   Description: Transport model

3. Model: Energy Center Water Supply Optimization Model

   Developed By: Peter Meier, Brookhaven National Laboratory

   Status: Completed. Results exist in Brookhaven National Laboratory report

   Description: Developed for Nuclear Regulatory Commission--Department of Energy, New Jersey Energy Center Study. Classical Legrange Multiplier Optimization Model.

4. Model: County-Level Siting Model

Developed By: Peter Meier, Brookhaven National Laboratory--for National Coal Utilization Assessment

Status: Operational on Brookhaven National Laboratory CDC 7600 for the three power pools of the Northeast

Description: Performs a county-level disaggregation of regional (census region) scenarios. Sites all power plants. Includes costs of transportation, electricity, fuels, and transmission. Uses Office of the Bureau of Economic Research Service (OBERS) projections, location of existing facilities, and water resources data from United States Geological Survey (USGS).

5. Model: National Residuals Discharge Inventory

Developed By: Consultants to National Research Council

Status: Computerized, exists at Brookhaven National Laboratory CDC 7600

Description: An assessment of residuals generation and discharges and of the costs involved in cleaning up or reducing these discharges. Regional disaggregation to ASA (aggregated subarea, or river basin). Examines Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS). Examined costs of Best Available Technology (BAT) and Best Practicable Technology (BPT) required to clean up these effluents.

6. Model: Regional Emissions Projections Systems (REPS)

Developed By: Booz-Allen for Environmental Protection Agency

Status: Operational on Brookhaven National Laboratory CDC 7600

Description: Using the most recent National Emissions Data Service (NEDS) emissions inventory to establish baseline emission levels, Regional Emissions Projection Systems (REPS) projects emissions production to a selected future year by Air Quality Control Regions (AQCR). SEAS economic forecasts are used to compute the growth factors. The projected emissions are then adjusted to include the effects of present and future control regulations. Many user options and overrides are available.

7. Model: Wind Rose Model

Developed By: Paul Michael, Brookhaven National Laboratory

Status: Under development. (Resides outside NCAES but is being developed at Brookhaven National Laboratory and will be used extensively by NCAES personnel)

Description: Describes a yearly average concentration of a pollutant from a point source up to 50 miles.

8. Model: Long-Range Trajectory Model

Developed By: Ron Meyers, Rick Cederwall, Brookhaven National Laboratory

Status: Operational on Brookhaven National Laboratory CDC 7600 (Resides outside NCAES but is being developed at Brookhaven National Laboratory and will be used extensively by NCAES personnel)

Description: Traces the pollution from a point source, over time, using actual meteorological data in 3 dimensions. Allows the tracing of a pollutant from a specific source over large distances, as well as allowing the incorporation of nonlinear chemistry effects.

9. Model: SECPOP

Developed By: Office of Radiation Programs, USEPA

Status: On cards, but has not been used at BNL

Description: Determines the population distribution around any given point in the U.S. using master Enumeration District List from the 1970 census.

10. Model: ESNS-BESOM Interface (EBIP)

Developed By: Walter A. Sevian, S. Michaile, Brookhaven National Laboratory

Status: Operational on Brookhaven National Laboratory CDC 7600

Description: This program takes the aggregated BESOM Intermediate Energy Form (IEF) outputs along with other totals and, after application of suitable assumptions, disaggregates the IEFs, generates an equivalent ESNS trajectory file, and executes the ESNS model. The outputs of the ESNS model are simply the process-by-process emissions generated by the aggregated IEF solutions to the BESOM model.

11. Model: Energy System Simulator (ESS)

Developed By: Paula Newhouse, Walter A. Sevian, Brookhaven National Laboratory

Status: Operational on Brookhaven National Laboratory CDC 7600

Description: An aggregated activity level version of ESNS that generates energy flows and environmental effects. About 110 processes are included in this network.

12. Model: REESNS

Developed By: Walter A. Sevian, Brookhaven National Laboratory

Status: Under development

Description: Regionalized ESNS model to be developed primarily from BEMIS data when completed. This will be the primary vehicle through which BEMIS data will be available.

13. Model: Air Pollution Linear Rollback Model

Developed By: Environmental Protection Agency

Status: Operational on Brookhaven National Laboratory CDC 7600

Description: A linear adjustment model for estimating urban air quality under various automobile emission control requirements. Health impacts can also be estimated, given a suitable set of assumptions about stationary emission source growth rates.

Data Bases:

1. Data Base: Committee on Alternative Energy Strategies (CONAES)

   Developed By: Brookhaven National Laboratory in conjunction with Committee on Alternative Energy Strategies

   Status: Under development

   Description: Environmental information about nuclear and other technologies. This is basically an ESNS input file which includes all of the Teknekron new technology data plus additional nuclear data from a CONAES subgroup.

2. Data Base: National Emissions Data Service (NEDS)

   Developed By: Environmental Protection Agency

   Status: Developed, undergoes periodic updates. Latest version is available at Brookhaven National Laboratory for use with Regional Emissions Projection System (REPS)

   Description: A county-level compilation by Environmental Protecton Agency (EPA) of all point sources of air emissions as well as area wide activity and associated air emissions. These data are spotty. Also available as a system 2000 data base from the Atmospheric Sciences Division including additional state and local dates. Quality control checks are being implemented.

3. Data Base: Storage and Retrieval of Water Quality and Related Data (STORET)

   Developed By: Environmental Protection Agency

   Status: Completed, resides on Environmental Protection Agency (EPA) computer, regularly updated and added to

   Description: Contains data on "water quality, municipal and industrial waste facility inventory, water quality standards compliance, fish kill, oil spill, construction cost, and other related data."

4. Data Base: Storage and Retrieval of Aerometric Data (SAROAD)

   Developed By: Environmental Protection Agency

Status: Completed, resides on Environmental Protection Agency computer, regularly updated and added to. Also available at Brookhaven National Laboratory, Atmospheric Sciences Division, as a System 2000 data base

Description: Contains air quality and meteorological data and generates air quality data reports.

5. Data Base: Edited Version of Master Enumeration District List with coordinates

Developed By: U.S. Census Bureau

Status: On tape, but has not been used at Brookhaven National Laboratory

Description: The population, longitude, and latitude of the enumeration district population centroid, from the 1970 census.

6. Data Base: Biomedical and Environmental Modeling Information System (BEMIS)

Developed By: Brookhaven National Laboratory and Teknekron, Incorporated

Status: Under development

Description: A critical review of the environment coefficients in the current Brookhaven National Laboratory Energy Model Data Base by Teknekron, Incorporated, with a goal to their reformulation for use in health impact assessment, has resulted in a decision to develop BEMIS. With a revised set of both coefficients and process representation, the BEMIS structure will be used to develop a regional version of ESNS, R-ESNS.

7. Data Base: County Level Data Bank of Future Energy Supply Facilities

Developed By: Walter A. Sevian, Salvador R. Bozzo, Brookhaven National Laboratory

Status: Operational on Brookhaven National Laboratory CDC 7600

Description: This data bank contains all future energy supply facilities to the year 1985 and beyond in some cases. The entries are keyed to the process classifications in the ESNS model, and it is planned to interface this data bank with the ESNS model to meaningfully assign future energy scenario emissions in space.

8. Data Base: Business Patterns Data Bank

Developed By: Walter A. Sevian, Regina Hakoopian, Brookhaven National Laboratory

Status: Under development

Description: County level clusters of industrial facilities will be developed into an information file to be used with the MEDABA medical data base and the ESNS model. This base year will be 1970 and site-specific projections will be accepted.

9. Data Base: WATSTORE

Developed By: U.S. Geological Survey

Status: Completed, resides on USGS computer, regularly updated and added to.

Description: Hydrologic information on surfaces and subsurface waters.

10. Data Base: County Level Water File

Developed By: E. Kaplan, Brookhaven National Laboratory

Status: Water Quality file completed, hydrologic file under development

Description: Water quality and hydrologic data aggregated at the county and river basin level. Data extracted from EPA, USGS, and other agencies.

11. Data Base: Disaggregated Emission Coefficients in the Commercial/ Residential, Industrial, Electric Utility, and Transportation Sectors

Developed By: P. Raskin, R. Rosen, Energy Systems Research, Incorporated

Status: Completed, noncomputerized, report to be published.

Description: In the electrical sector, emission coefficients were disaggregated to account for variations in fuel mix (coal, gas, oil....) and mix of old and new plants. In the industrial sector, emission coefficients are disaggregated for the five major energy consuming industries plus "others." These coefficients were specific to the industry, fuel, process, and age of plants in service. In the commercial/residential sector, emission coefficients are disaggregated by fuel type (oil, gas...) and end use (space heat, water heat, and cooling). In the transportation sector, emissions were calculated only for automobiles. The emission coefficients for the transportation sector are disaggregated by model year.

12. Data Base: Emissions Data Base using FPC Form 67

    Developed By: Federal Power Commission

    Status: Air data variable at Brookhaven National Laboratory in system 2K data base; water data available at Brookhaven National Laboratory on tape.

    Description: Air quality control data for steam electric power plants.

MATERIALS

Data Bases:

1. Data Base: Reference Materials System

   Developed By: Brookhaven National Laboratory

   Status: Complete in report form, BNL 50609, not computerized

   Description: Information regarding materials requirements for various processes, e.g., resource extraction, processing, transportation, etc.

INTERNATIONAL

Models:

1. Model: MARKAL-IEA Market Allocation Model

   Developed By: Brookhaven National Laboratory (International Energy Agency), Kernforschungsanlage

   Status: Completed, computerized; draft documentation is available

Description: MARKAL is a time-phased, demand-driven LP representation of a national (or regional) energy system developed through direct participation of IEA systems analysts stationed at BNL and KFA. The model is a synthesis and embellishment of DESOM and the KFA model and represents a significant advance in dynamic LP representations of energy systems. New features include (1) country independent model structure, (2) the programmed flexibility in the definition and addition of new technologies purely through data inputs, (3) the significantly improved resolution of supply and demand conversion technologies due to participation by international experts, and the automation of a multicriteria, trade-off analysis technique for identifying potentially useful technologies and their impact on factors defining the quality of the energy system.

2. Model: WASP, Electric Generation Capacity Expansion Model

   Developed By: International Atomic Energy Agency

   Status: Operational at Brookhaven National Laboratory CDC 7600

   Description: A group of six interrelated computer code modules developed to meet the needs of electric generation capacity expansion in developing countries. WASP accepts data on the load characteristics, annual peak demand for each year in the study, and a description of the fixed system. It can consider up to 20 candidate expansion plants. Within user-generated constraints, WASP considers all acceptable expansion configurations and carries out a dynamic optimization of alternative expansion plans.

Data Bases:

1. Data Base: Developing Countries Data Base

   Developed By: Brookhaven National Laboratory - LDC Program

   Status: Under development, partly computerized

   Description: Energy production and import data for LDC's as group. More detailed energy and economic data for twelve selected countries, enough to create a Reference Energy System (RES). Detailed technological data for irrigation, using renewable resources (especially biogas).

2. Data Base: International Energy Agency, ESNS Input File

Developed By: Brookhaven National Laboratory

Status: Operational on Brookhaven National Laboratory CDC 7600

Description: A collection of energy, economic, and environmental data for each International Energy Agency (IEA) participating country, as well as for cross-country technology characterization. The Energy Systems Network Simulator (ESNS) program and its associated interactive program have been adapted to interface with the IEA data base. Units are metric. Energy Supply and demand data for each country are stored using APL format so that tabular information for reports is generated quickly and easily.

3. Data Base: IEA Data Base for MARKAL

Developed By: Brookhaven National Laboratory

Status: Completed

Description: All data for MARKAL specified by country.

POPULATION AND HEALTH

Models:

1. Model: Population Projections by County

Developed By: Brookhaven National Laboratory

Status: Under development (working paper #2)

Description: Uses natural rate of increase method with 1950-1970 rates and 1960-1970 rates. Also, a ratio method, a trend method, and a fired rate method. Coded by Federal Information Processing Standard (FIPS) - 1970 and by Inter-Censal Equivalent Area Code (ICEAC).

2. Model: Health Impacts Simulation Model

Developed By: S. Morris, Brookhaven National Laboratory, and Granger Morgan

Status: Under development

Description: A simulation model which uses a probabilistic approach to study health impacts of air pollution from coal-fired power plants. Two versions exist: in one, each parametric is represented by a probability density function while in the other, the mean of the pdf is used. Uses Paul Michael's Wind Rose Model as a base.

3. Model: Interactions Between Income, Pollution, Mortality, Sex, Age, and Race

Developed By: Salvador Bozzo, Brookhaven National Laboratory

Status: Completed and operative

Description: The model uses the Medical Data Bank (MEDABA) files to compose groups of countries which contain enough population to reflect the impact of different levels of pollution and income in the population. For example, compose a group of one million persons living in low income, high pollutant area and contrast with similar groups living in low income low pollutant areas. Examines mortality data with respect to demographic characteristics.

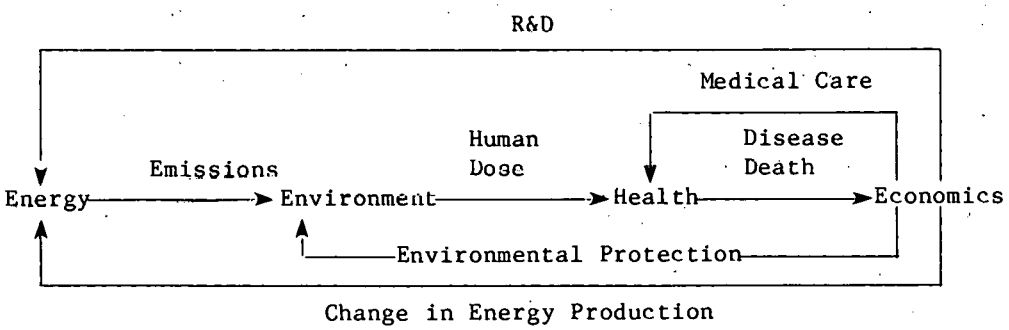
Software to group countries and compute disease-specific mortality rates for each of the groups is operative. This output can be coupled to a graphics package on the DTC 300/S terminal.

4. Model: Comprehensive Model Relating Energy, Environment, Humans, and Economics

Developed By: Salvador Bozzo, Brookhaven National Laboratory

Status: Under development

Description: The interrelationships among energy, environment, human health, and economics are described by the following chain:



Description (Cont'd): An attempt to describe the transfer functions between the different segments of the model is being carried out. Input data are from the Medical Data Bank (MEDABA).

5. Model: CEM Accident Model

Developed By: The Center for Environment and Man, Inc., for Department of Transportation

Status: Operational on Brookhaven National Laboratory CDC 7600

Description: Estimates future auto occupant deaths in relative and absolute terms, using algorithms based on historical data which describes how the frequency and number of auto occupant deaths change with alteration in the number of auto registrations (fleet size), and an accident trend model describing how auto occupant deaths change in relation to variations in the mix of small and large cars (fleet mix).

6. Model: Population Dynamic Model

Developed By: S. Bozzo, K. Novak, Brookhaven National Laboratory

Status: Operational on Brookhaven National Laboratory CDC 7600

Description: Using 1970 census data, 1970 fertility data, 1967-1971 mortality data, and county-level net migration data between 1960-70 the interrelated effects of median family income and SO_x emissions on county-level population dynamics were examined. Age, race, sex-specific results are produced. Modifications and improvements to the model and input data are under way.

7. Model: Mortality Effects Model

Developed By: S. Bozzo, K. Novak, Brookhaven National Laboratory

Status: Operational on Brookhaven National Laboratory CDC 7600

Description: Using a linear combination of diseases, the effects of SO_x emissions and median family income on total mortality and specific causes of death can be computed. Age, race, sex-specific results are produced. Modifications and improvements to the model and input data are under way.

8. Model: Health Impacts Program

Developed By: J. Nagy, Brookhaven National Laboratory

Status: Under development

Description: Integrates health impacts with energy networks by associating health impact coefficients in the correct units with each process in the network. The impacts of each process are calculated and these can be aggregated to any level or by any criteria desired. Deaths, injuries, and illnesses are considered. Uncertainty is accounted for by providing best estimate and upper and lower range of estimates.

Data Bases:

1. Data Base: Medical Data Bank (MEDABA)

Developed By: Salvador Bozzo, Brookhaven National Laboratory

Status: Completed, computerized

Description: Part A: County-level Data. Each county includes Federal Information Processing Standard (FIPS) code, Standard Metropolitan Statistical Area (SMSA) code, State Economic Area (SEA) code, and National Center for Health Statistics (NCHS) code. Geographic characteristics, center of population, complete demographic characteristics by age, sex and race, complete migration chacteristics by age, sex, and race, natality data (1960-1970), quality of life data, energy use data, emission data. Part B: Three magnetic tapes-sequential hierarchical file with six million records. Mortality data by age, sex, race by 1969-1971.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

APPENDIX C

PUBLICATIONS AND ABSTRACTS

January 1, 1978 - December 31, 1978

APPENDIX C

PUBLICATIONS AND ABSTRACTS

NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS
DEPARTMENT OF ENERGY AND ENVIRONMENT
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

JOURNAL ARTICLES AND CONFERENCE PROCEEDINGS

S. R. Bozzo, K. M. Novak, F. Galdos, L. D. Hamilton, "Health Effects of Energy Use: A Temporal Spatial and Factor Analysis Approach," Third Annual NCHS Data Use Conference Proceedings, Phoenix, Arizona, Nov. 13-17, 1978.

P. M. Meier and T. H. McCoy, "Some Extensions of Mills' Method for Urban Population Density Gradient Estimation," Geographical Analysis X, No. 2, 163-73 (April 1978).

P. M. Meier, "Long Range Regional Power Plant Siting Model," J. of the Energy Division, American Society of Civil Engineers 105, No. EY1, 117-35 (Jan. 1979).

K. C. Hoffman, "Energy Modeling--Perspectives and Policy Applications," Studies in the Management Sciences 10, 5-20 (1978).

M. G. Morgan, S. C. Morris, A. K. Meier, and W. R. Rish, "Sulfur Control in Coal-Fired Power Plants: A Probabilistic Approach to Policy Analysis," J. Air Pollution Control Assoc. 10, 993-97 (1978).

M. G. Morgan, S. C. Morris, A. K. Meier, and D. L. Shenk, "A Probabilistic Methodology for Estimating Air Pollution Health Effects from Coal-Fired Power Plants," Energy Systems and Policy 2, 287-309 (1978).

M. D. Rowe, S. C. Morris, and L. D. Hamilton, "Potential Ambient Standards for Atmospheric Sulfates: An Account of a Workshop," J. Air Pollution Control Assoc. 28, 772-75 (1978).

R. G. Tessmer, Jr., "A Comprehensive Areal Model of Residential Heating Demands," Second Lawrence Symposium on Systems and Decision Sciences, Lawrence School of Science, Berkeley, Calif., Oct. 3-4, 1978.

K. C. Hoffman, "Annual Highlights of the National Center for Analysis of Energy Systems," BNL 50772, Dec. 1977.

I. REGIONAL STUDIES

BNL 23246 P. M. Meier, D. Morell, and P. F. Palmedo, "Political Implications of Clustered Nuclear Siting," July 1977.

BNL 23388 P. M. Meier, "A Linear Programming Model for Country Level Electric Facility Siting," June 1977.

BNL 23596 P. M. Meier, R. Stern, and T. H. McCoy, "Coal Utilization in the Northeast, Vol. I: Issues and Siting Scenarios," January 1978.

BNL 23597 P. M. Meier and B. Hobbs, "The Locational Response to Regulatory Policy: A Regional Analysis of Energy Facility Location," September 1978. 1978 Annual Meeting of the New England Regional Science Association, Baltimore, Maryland, May 12, 1978.

BNL 23598 E. N. Ziegler and R. E. Meyers, "Coal Utilization in the Northeast: Vol. III: An Assessment of the Acid Rain Problem," January 1978.

BNL 23600 D. Morell, J. Elliot, M. Messenger, and P. M. Meier, "Coal Utilization in the Northeast, Vol. V: Offshore Siting for Coal Fired Electric Generation Facilities," December 1977.

BNL 23601 E. S. Rubin and E. Medine, "Coal Utilization in the Northeast, Vol. VI: Industrial Energy Use," December 1977.

BNL 23603 T.-Q. Le, E. S. Rubin, and P. M. Meier, "Coal Utilization in the Northeast, Vol. VIII: Solid Waste Management Issues and Impacts," March 1978.

BNL 23943[a] J. Allentuck, "Energy-Economic Modeling for Policy Decision" (Abstract), ANS 1978 Annual Meeting, San Diego, Calif, June 1978.

BNL 24073 P. M. Meier, "Analysis of Nuclear Energy Center Water Supply Systems," December 1977.

BNL 24786 T. Le, P. M. Meier, and H. Rostoker, "The Solid Waste Impacts of Increased Coal Utilization," August 1978 (Draft).

BNL 24788 E. Kaplan, R. Hardy, and J. S. Munson, "New England's Future: Water, Energy and Economic Development," Aug. 1978. Summary of the Workshop on the Impacts of Water Availability on New England Energy and Economic Future, Boston, October 27-28, 1977.

BNL 24867 James S. Munson and Robert Stern, "Regional Energy-Environment Data Book - Northeast Region," October 1978.

BNL 24928[a] William Metz, "Socioeconomic Impact Management in the Western Energy Industry," Sept. 1978. 1979 Environmental Science Meeting, Seattle, Washington, April 30 - May 2, 1979.

---

[a]Abstract

I. REGIONAL STUDIES (Cont'd)

BNL 20594 B. Hobbs and P. M. Meier, "An Analysis of Water Resources Constraints to Power Plant Siting in the Mid-Atlantic States," October 1978.

BNL 50564 J. Zakaria and F. Moore, "Noise Radiation from Energy Center Cooling Towers," December 1976.

BNL 50703 J. S. Munson, J. P. Brainard, and others, "The Energy Situation in the Mid-Atlantic Region," December 1977.

BNL 50708 P. M. Meier, E. S. Rubin, T.-Q. Le, and R. Stern, "An Assessment of the Solid Waste Impact of the National Energy Plan," February 1978.

BNL 50723 E. Beardsworth, and G. Goldstein, "Program Praeto - Preparation of Reference Energy Systems Through Time," August 1977.

BNL 50735 J. Allentuck, J. Applemen, T. O. Carroll, P. F. Palmedo, and R. Nathans, and others, "An Assessment of Energy Research, Development and Demonstration Priorities for New York State," Vols. I and II, November 1977.

BNL 50757 T. O. Carroll, P. F. Palmedo, and R. Stern, "The Future Demand for Electricity in the Nassau-Suffolk Region," December 1977.

BNL 50898 T. von Foerster, "On the Use of Wood as an Energy Source in the State of Maine," September 1978.

II. ECONOMIC ANALYSIS

BNL 22735 W. Marcuse, D. J. Behling, J. Lukachinski, and R. Dullien, "The Long Term Economic and Environmental Consequences of Phasing Out Nuclear Electricity." ORSA/TIMS Joint National Meeting, San Francisco, May 8-11, 1977.

BNL 23853[a] S. C. Carhart and W. Marcuse, "Assessment of Policy and Program Alternatives for Energy Savings in Buildings," January 1978. Joint National Meeting of the Inst. of Management Sci. and Operations Research Soc. of America, May 1-3, 1978.

BNL 23854[a] W. Marcuse, "Transition to a Decentralized Energy Future," January 1978. AAAS Annual Meeting, Washington, DC, Feb. 12-17, 1978.

BNL 23834[a] H. Davitian, "A Study of Solar Process Heat Use in the Year 2000 Incorporating Regional and Temperature Level Characteristics of Process Heat Requirements," January 1978. Annual Meeting of the American Section of the International Solar Energy Soc., Denver, Colorado, Aug. 28-31, 1978.

BNL 23935[a] H. Davitian, "Load Management Applied to Solar Water Heating with Electric Backup," January 1978. Annual Meeting of the American Section of the International Solar Energy Society, Denver, Colorado, Aug. 28-31, 1978.

BNL 24048 P. J. Groncki, J. S. Munson, S. C. Kyle, and M. K. Reckard, "Assessing the Employment Implications of Alternative Energy Supply, Conversion and End Use Technological Configurations: The Case of Firewood Versus Fuel Oil in New England in 1985," February 1978.

BNL 24149 H. Davitian, R. Bright, and W. Marcuse, "Utility Load Management and Solar Energy: Study Background and Outline," March 1978.

BNL 24268 D. A. Pilati and R. Rosen, "Energy Use Modeling of the Iron and Steel Industry," April 1978. 1978 Summer Computer Simulation Conf., Newport Beach, Calif., July 24-26, 1978.

BNL 24285[a] R. J. Goettle IV, and S. S. L. Chang, "Energy-Economy Interactions in an Optimal Control Framework," April 1978. ORSA/TIMS Meeting, Los Angeles, Calif., Nov. 13-15, 1978.

BNL 24328 S. Carhart, "Energy Demand and Conservation Analysis," April 1978. International Conf. on Energy Economy, and Environment, Palermo, Italy, March 28-29, 1978.

---

[a]Abstract

II. ECONOMIC ANALYSIS (Cont'd)

BNL 24345 S. Linke, A. Teshome, and P. D. Yehsakul, "A Study of Transmission and Protection Elements for Wind Energy Generating Systems," Volume II, Appendices, April 1978.

BNL 24365 R. J. Goettle, IV, and R. G. Tessmer, Jr., "Hydrogen Energy: Economic Issues," May 1978. Presented at the Workshop on the Societal Aspects of Hydrogen Energy Systems, Reston, Virginia, June 4-7, 1978.

BNL 24368 R. J. Goettle, IV, "Some Measures of Regional-Industrial Interfuel Substitution Potentials," May 1978. 53rd Annual Conf. of the Western Economic Assoc., Honolulu and Kona, Hawaii, June 20-26, 1978.

BNL 24444 W. Marcuse, "A Hierarchical Decomposition Approach to Environmental Policy Analysis," May 1978. Workshop in Economic Measurement of Energy Related Environment Damages, Colden, Colorado, June 21-22, 1978.

BNL 24445 W. Marcuse, "Internalizing the Externalities of Solar Technology: Methodologies for Incorporating Externalities in the Assessment of Policy Options and Technology Assessments of Solar Energy Initiatives and R&D Programs Using Brookhaven Models," May 1978. Workshop in Economic Measurement of Energy Related Environmental Damages, Golden, Colorado, June 21-22, 1978.

BNL 24708 J. R. Wagner and J. Naughton, "Fleet Operator Study: Geographic Aspects," July 1978.

BNL 24781 P. J. Groncki, "A General Equilibrium Approach to Energy/Environmental Economic Analysis," August 1978. 1978 Annual Meeting of the Allied Social Sci. Assoc., Chicago, Ill., Aug. 29-31, 1978.

BNL 24885 W. Marcuse, D. Pilati, and F. T. Sparrow, "Energy Conservation - Technology Push or Policy Pull?" July 1978. Engineering Foundation Conf., Henniker, New Hampshire, July 27, 1978.

BNL 24993 M. K. Reckard, "Solar System Performance Data for Use in Regional Models," September 1978.

BNL 25038 H. Davitian, R. N. Bright, and W. Marcuse, "Utility Load Management and Solar Energy: Study Background and Preliminary Market Potential Analysis." Systems Simulation and Economic Analysis for Solar Heating and Cooling Conf., San Diego, Calif, June 27-29, 1978.

II. ECONOMIC ANALYSIS (Cont'd)

BNL 25226[a] R. J. Goettle, P. J. Groncki, J. Lukachinski, R. G. Tessmer, and E. A. Hudson, "An Integrated Methodology for Assessing Energy-Economy Interactions," December 1978.

BNL 25291 H. Davitian and R. W. Leigh, "A Method for the Comparative Economic Assessment of Storage Systems," November 1978.

BNL 25494 H. P. Serry, "Underground Piping Systems for District Heating with Particular Application to Geothermal District Heating in Utah," September 1978.

BNL 25501 R. Bright and H. Davitian, "The Marginal Cost of Electricity Used as Backup for Solar Hot Water Systems: A Case Study," December 1978.

BNL 25599 W. Marcuse, "Why Should Energy Models Form a Crucial Policy Input in an Uncertain Political World," April 1978.

BNL 50768 R. G. Tessmer, Jr., P. Groncki, and G. W. Boyce, Jr., "Estimation of Sectoral Prices in the BNL Energy Input-Output Model," January 1978.

BNL 50828 S. C. Carhart, S. S. Mulherkar, and Y. Sanborn, "The Brookhaven Buildings Energy Conservation Optimization Model," February 1978.

BNL 50839 D. A. Pilati and R. A. Rosen, "The Use of the Pulp and Paper Industry Process Model for R&D Decision Making," March 1978.

BNL 50849 H. Davitian, "Wind Power and Electric Utilities: A Review of the Problems and Prospects," April 1978.

BNL 50851 S. Linke, A. Teshome, and P. D. Yehsakul, "A Study of Transmission and Protection Elements for Wind Energy Generating Systems," Vol. I, April 1978.

BNL 50856 J. T. Fraser, "Documentation of the Brookhaven Energy I-O and I-O BESOM Linkage," August 1978.

BNL 50863 S. C. Carhart, "Energy Demand Analysis in the Workshop on Alternative Energy Strategies," April 1978.

BNL 50871 R. G. Tessmer, Jr., S. C. Carhart, and W. Marcuse, "Economic Impacts of a Transition to Higher Oil Prices," June 1978.

---

[a]Abstract

II. ECONOMIC ANALYSIS (Cont'd)

BNL 50887 D. Schneider, "Documentation of an Interactive Program for Projecting Space Heating Energy Demand," January 1978.

BNL 50899 S. C. Carhart, W. Marcuse, and R. G. Tessmer, Jr., "Oil Supplies, Energy Conservation, and Global Stability," March 1978.

BNL 50902 J. R. Wagner, "Brookhaven Energy Transportation Submodel (BETS) Documentation and Results," October 1977.

BNL 50905 J. Karkheck and R. G. Tessmer, Jr., "Methodology for Modeling Geothermal District Heating for Residential Markets," August 1978.

BNL 50918 S. C. Carhart, S. Mulherkar, and J. Schwam, "Energy, Employment, and Environmental Impacts of Accelerated Investment in Conservation and Solar Technology in Buildings," November 1978.

BNL 50922 H. Davitian, R. LaSala, and W. Marcuse, "Solar and Geothermal Energy Utilization in SF-2: A Sensitivity Analysis," December 1978.

BNL 50923 R. J. Goettle, IV, E. A. Hudson, and J. Lukachinski, "Comparative Assessment of Energy-Economy Interactions: Price Versus Growth," October 1978.

BNL 50956 E. A. Hudson and D. J. Behling, Jr., "Energy Conservation Policies: Possibilities, Mechanisms and Impacts," December 1978.

III. BIOMEDICAL AND ENVIRONMENTAL ASSESSMENT

BNL 23579 S. C. Morris, "Comparative Effects of Coal and Nuclear Fuel on Mortality," November 1977.

BNL 23606 S. C. Morris and K. M. Novak, "Databook for the Quantitation of Health Effects from Coal Energy Systems," December 1977.

BNL 23891 S. Silberstein, "Exposure to Indoor Pollution," December 1977.

BNL 24000 A. J. Van Horn and R. Wilson of Harvard Univ., "Factors Influencing the Public Perception of Risks to Health and Safety: A Brief Summary," August 1977.

BNL 24301 S. Silberstein, "Energy Conservation and Indoor Air Pollution," January 1978.

BNL 24302 S. Silberstein, "Analysis of Heating System-Generated Air Pollution," December 1977.

BNL 24488 J. Nagy and C. E. Calef, "ESUSA: U.S. Endangered Species Distribution File, May 1978.

BNL 24852 L. D. Hamilton, "Alternative Sources and Health," March 1977. CRC Forum on Energy, U.S. Electricity Through the Year 2000: Coal or Nuclear? San Diego, California, May 1977.

BNL 50754 S. R. Bozzo and W. A. Sevian, "A Data Bank for the Geographical Allocation of Future U.S. Energy Supply Facilities by Country," May 1977.

BNL 50761 S. Silberstein, "Hazards of Organic Working Fluids," August 1977.

BNL 50762 S. Silberstein, "Outdoor Sources of Indoor Air Pollution," November 1977.

BNL 50814 P. D. Raskin and R. A. Rosen, "The Effect of Energy Conservation on Environmental Emissions: Utility, Residential and Commercial Sectors," 1978.

BNL 50815 P. D. Raskin and R. A. Rosen, "The Effect on Air and Water Emissions of Energy Conservation in Industry," 1978.

BNL 50840 S. R. Bozzo, F. Galdos, K. M. Novak, C. E. Calef, and L. D. Hamilton, "Medical Data Base: A Tool for Studying the Relationship of Energy-Related Pollutants to Ill Health," March 1978.

BNL 50841 D. F. Shreeve, C. E. Calef, and J. Nagy, "The Endangered Species Act and Energy Facility Planning: Compliance and Conflict," May 1978.

BNL 50876 P. D. Moskowitz, J. Brainard, D. Serwer, and L. D. Hamilton, "Preliminary Report on Some Health, Environmental, Economic Costs and Benefits of Energy Conservation and Fuel Substitution," May 1978.

IV. TECHNOLOGY ASSESSMENT

BNL 21958-R[a] N. K. Bhagat and K. C. Hoffman, "Systems Framework for Materials Policy Analysis," April 1978.

BNL 24371 J. Schank, "Multiobjective Analysis in a National Energy System Model." Conf. on Modeling and Simulation, Pittsburgh, April 1978.

BNL 24627 A. L. Hermelee, "Regional Reference Energy Systems: Electric Utility Applications." Energy Modeling and Net Energy Analysis Symp., Colorado Springs, Aug. 21-25, 1978.

BNL 24637 R. W. Pouder and R. W. Leigh, "Glazing and the Trombe Wall." Conf. on American Section Annual Meeting/ISES, Denver, Colorado, Aug. 28-31, 1978.

BNL 25085[a] R. W. Leigh, "The Role of Storage in Solar Total Energy Systems," October 26, 1978.

BNL 25117[a] H. Davitian and R. Bright, "A Comparison of the Total Annual Costs of Solar and Conventional Heating and Hot Water Systems: Effects of Electricity Rate Schedules and Tax Incentives," Nov. 1, 1978.

BNL 25118[a] R. Bright and H. Davitian, "The Marginal Cost of Electricity Used to Backup Residential Solar Heating and Hot Water Systems," Nov. 1, 1978.

BNL 25119[a] R. Pouder, N. K. Bhagat, and H. Davitian, "An Evaluation of Crop Residues for Generation of Electricity," Oct. 30, 1978.

BNL 25194[a] K. C. Hoffman, "Energy Analysis and Policy - Some Observations," Oct. 1978. ORSA/TIMS Meeting, New Orleans, April 30-May 2, 1978.

BNL 25207[a] M. Beller, "The Applications of Energy Systems Analysis to Policy and Technology Studies," Oct. 30, 1978.

BNL 25250 K. C. Hoffman and S. C. Carhart, "Long-Term Strategic Analysis (Towards an Energy Doctrine)," Nov. 1978. International Scientific Forum on an Acceptable World Energy Future, Miami, Nov. 27-Dec. 1, 1978.

BNL 25291-R H. Davitian and R. W. Leigh, "On the Economic Assessment and Optimization of Energy Storage Systems," March 1979. 13th Intersociety Energy Conversion Engineering Conf., San Diego, Aug. 20-25, 1978.

---

[a]Abstract

[R]Revised version.

IV. TECHNOLOGY ASSESSMENT (Cont'd)

BNL 25517[a] K. C. Hoffman, "Future Energy Requirements - the Basis of Energy Policy," December 1978. TVA Conf., Chattanooga, Tenn., July 31, 1978.

BNL 50686 K. C. Hoffman, "Whither Energy - Future Shock or a Greening?" August 1977. A BNL Lecture Series Report.

BNL 50713 A. Doernberg, "Energy Use in Japan and the United States," August 1977.

BNL 50745 A. Doernberg, "Impacts of Selected Energy Conservation Technologies Baseline Demands," September 1977.

BNL 50771 D. Gunwaldsen, N. Bhagat, and M. Beller, "A Study of Potential Coal Utilization: 1985-2000," December 1977.

BNL 50782 K. C. Hoffman, "Proceedings of the Workshop on World Oil Supply-Demand Analysis," April 1978. Workshop held at Brookhaven National Laboratory, June 1-2, 1978.

BNL 50822 M. Beller, "Energy Systems Studies Program," January 1978.

BNL 50892 J. Schank, "An Alternative, Semi-Automated Method for Performing Multiobjective Analyses," August 1978.

BNL 50915 K. C. Hoffman and S. C. Carhart, "Long Term Energy Projections," December 1978. Preliminary.

---

[a]Abstract

V. ENERGY DATA AND MODELS

BNL 24222[a] A. S. Kydes, "A Demand Elasticity Representation Methodology and Calibration," March 1978.

BNL 24223[a] A. S. Kydes, E. A. Cherniavsky, and W. Marcuse, "The Brookhaven Time Stepped Energy System Optimization Model (TESOM)," March 1978.

BNL 24354[a] E. A. Cherniavsky and J. Schank, "An Approach to Hierarchical Multiobjective Analysis," May 1978. ORSA/TIMS Conf., Los Angeles, Calif., Nov. 13-15, 1978.

BNL 23643 K. C. Hoffman, "The Utilization of Energy - Information Requirements for Policy," December 1977. Workshop on Energy Information, Stanford Univ., Calif.

BNL 24819[a] K. C. Hoffman and A. Reisman, "The Reference Energy System - A Framework for Energy Information," April 1978. For presentation at the 1979 ORSA/TIMS Conf., New Orleans, Louisiana, April 30-May 2, 1979.

BNL 24820 K. C. Hoffman and N. K. Bhagat, "The Reference Materials System - A Framework for Substitution Analysis," July 1978. The World Conf. on Future Sources of Organic Raw Materials, Toronto, Canada, July 10-13, 1978.

BNL 24821 K. C. Hoffman, "Technological-Economic Models for Energy Analysis," August 1978. Inst. of Gas Technology Symposium on Energy Modeling and Net Energy Analysis, Colorado Springs, Colorado, Aug. 21-25, 1978.

BNL 50844 A. S. Kydes and E. A. Cherniavsky, "Coal in Transition 1980-2000 Demand Considerations," December 1977.

BNL 50873 A. S. Kydes, "The Brookhaven Energy System Optimization Model - Its Variants and Uses," May 1978.

---

[a]Abstract

VI. INTERNATIONAL PROGRAMS

BNL 23300 Policy Analysis Division,* "Outline of a Study of the Energy Needs, Uses and Resources of Developing Countries and the Implications for AID Programs," August 1977.

BNL 23669 P. F. Palmedo, and V. Mubayi, "Some Considerations on the Role of ERDA in the Development and Analysis of Energy Technologies for Developing Countries," January 1978.

BNL 24260 J. Allentuck, "Capacity Expansion in Electric Generation with Reference to the Developing Countries," April 1978.

BNL 24274 V. Mubayi, J. Allentuck, E. Beardsworth, and P. F. Palmedo, "Some Considerations on the Choice of Countries for U.S. Assistance Under Title V of the Nuclear Nonproliferation Act of 1978," April 1978.

BNL 24952[a] P. M. Meier and V. Mubayi, "A Systems Framework for Interregional Resource Allocation for Energy Supply in Developing Countries: The Case of Coal and Water Resources in India," December 1978. Internat'l. Conf. on Energy and Environment in the Developing Countries, Bangalore, India, Jan. 11-14, 1979.

BNL 25523 P. F. Palmedo and R. Nathans, "A Systems Approach to Energy Planning," November 18, 1978. Caribbean Consultation on Energy and Agriculture, Santo Domingo, Dominican Republic, December 1, 1978.

BNL 25537 P. M. Meier and V. Mubayi, "On the Application of Resource Allocation Models to the Problems of Regional Energy Policy in Large Developing Countries," December 1978. Internat'l. Seminar on Energy, Administrative Staff College of India, Hyderabad, India, January 4-7, 1979.

BNL 50784 P. F. Palmedo, R. Nathans, E. Beardsworth, and S. Hale, Jr., "Energy Needs, Uses and Resources in Developing Countries and the Implications for U.S. Assistance," March 1978.

BNL 50800 P. F. Palmedo, "An Analytical Framework for the Assessment of Energy Resource and Technology Options for Developing Countries," March 1978.

BNL 50836 A. Reisman, and R. Malone, "Less Developed Countries Energy System Network Simulator, LDC-ESNS, A Brief Description," April 1978.

BNL 50890 P. F. Palmedo, R. Nathans, E. Beardsworth and G. Tschannerl, "Programmatic Areas for U.S. Assistance for Energy in Developing Countries," December 1978.

---

*In January 1979 the Policy Analysis Division became the Division of Regional Studies.

[a]Abstract