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ANNUAL HIGHLIGHTS OF THE NATIONAL CENTER FOR THE ANALYSIS OF ENERGY SYSTEMS

KENNETH C. HOFFMAN

November 1976

Prepared for the
OFFICE OF THE ASSISTANT ADMINISTRATOR FOR PLANNING, ANALYSIS AND EVALUATION
UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
by the
NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

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UPTON, NEW YORK 11973

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ABSTRACT

The National Center for Analysis of Energy Systems at Brookhaven has been in operation since January 1976. This first 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 1976 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 activities of the Center include:

- long-range forecasting 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.

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INTRODUCTION:

The National Center for the Analysis of Energy Systems (NCAES) was established at Brookhaven in January 1976. The formation of this 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 FY1977 budget for the Center is about \$3.5 million. The staff includes 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 level in areas of special import to energy R&D policy formulation. This work is designed to assist the Energy Research and Development Administration (ERDA) in the formulation and execution of a balanced and diverse energy research and development program that is responsive to the nation's needs. A portion of the program effort is devoted to the development of planning frameworks, analytical models, and data bases that are required to give adequate support to the planning studies. Thus the program involves both operational support to ERDA 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:

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

1. To perform energy technology assessments on a continuous basis to support ERDA planning and budget allocation.
2. To perform special regional and national policy studies in support of ERDA objectives.
3. To explore international aspects of energy in relation to technology and policy.
4. To develop improved data bases and analytical methods for use in energy policy analysis and technology assessment.
5. To provide a central focal point for the coordination and integration of energy data and models through collaborative efforts with universities and industry.
6. To maintain current information on the technical, economic, and environmental characteristics of energy technologies for use by ERDA and other agencies engaged in energy technology assessment.
7. 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.
8. To provide a site and support facilities for workshops and special task groups assembled to address important topics.

HIGHLIGHTS OF 1976:

Application of linked process--econometric models of energy system and economy to ERDA energy forecast (in cooperation with DRI).

Completion of analysis and projections of energy use in the northeast region of the U.S.

Development of regional Reference Energy Systems as technology assessment tool.

Development and application of R&D program analysis to buildings conservation program.

Comparative assessment of health effects of fuel cycles for alternative electric generating plants.

Development of Reference Materials System for the analysis of materials policy.

Analysis of alternative energy storage concepts for utility application.

Assessment of near and long-term role of hydrogen energy systems.

Completion of systems analysis framework for International Energy Agency to be used for planning of cooperative R&D programs (in cooperation with Kernforschungsanlage-Juelich, Federal Republic of Germany).

Completion of a county level energy data base, COENDA.

MAJOR ACTIVITIES PLANNED FOR 1977:

Continued development of long-range energy-economic forecasts.

Study of technical, economic, and social characteristics of decentralized energy systems.

Analysis of environmental policy issues.

Expansion of demand and end use technology detail in analytical models.

Development of regional scenarios for the National Coal Assessment.

ORGANIZATION:

The Center is organized within the Department of Applied Science as shown on the attached charts for the Center and the Department. The Biomedical and Environmental Assessment Division, a joint program between the Medical Department and the Department of Applied Science, is affiliated with the Center. Working groups have been assembled in several areas with specific program responsibilities. These areas are:

1. Policy Analysis
2. Economic Analysis
3. Biomedical and Environmental Assessment
4. Technology Assessment
5. Energy Data and Models

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 ERDA, 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 the Federal Energy Administration and 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 working relationship has been established with the Systems Optimization Laboratory at Stanford University, the energy modeling group at Data Resources, Inc., 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, and the Environment 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.

1. Policy Analysis:

The activities in the area of Policy Analysis have focused on international programs and 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 region.
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.
6. Special studies of international scope dealing with energy technology and policy issues in developing countries.
7. Systems analysis of cooperative R&D programs for the International Energy Agency.

2. 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 macro-economic 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 identification of socio-economic effects of technology implementation.

8. Special studies in areas of net energy or energy accounting.

3. 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, 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.

4. Technology Assessment:

The activity in 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 a 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 (airconditioners, 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 socio-economic 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.

5. 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 to ERDA.

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 governmental, industry, and university groups. The dissemination of the data on energy technologies that are 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, waste, and costs of individual processes and end uses.
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 useful to ERDA.
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.

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.

NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS

DEPARTMENT OF APPLIED SCIENCE
BROOKHAVEN NATIONAL LABORATORY

*JOINT DAS-MEDICAL DEPT. PROGRAM AFFILIATED WITH THE CENTER

Figure 1.

DEPARTMENT OF APPLIED SCIENCE BROOKHAVEN NATIONAL LABORATORY

Figure 2.

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APPENDIX A

SCOPE OF ACTIVITIES FOR FY 1977

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NATIONAL CENTER FOR THE ANALYSIS OF ENERGY SYSTEMS

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A. Planning, Analysis and Evaluation
(for ERDA Assistant Administrator
for Planning, Analysis and Evaluation)

Title: Energy Systems Studies

FY 77: \$1,325,000

Principal Investigator(s):

M. D. Goldberg M. Beller

E. A. Cherniavsky D. J. Behling

FY 78: \$1,600,000

W. Marcuse

Sponsor: Assistant Administrator
for Planning, Analysis, and
Evaluation (ERDA)

The Energy Systems Studies program encompasses a broad range of energy studies for the development of research and development priorities and strategies. The program involves the development and coordination of energy data and analytical models and the application of these techniques to energy systems analysis, technology assessment, and economic analysis. It is carried out within the National Center for Analysis of Energy Systems (NCAES).

The nation's energy system incorporates many competing resources and conversion technologies, and a wide range of substitutability among alternate energy forms is feasible. These options must be analyzed in the context of the social, economic, environmental, and self-sufficiency objectives of the nation so that a balanced and diverse set of priority technical options may be identified and developed. Particular attention must be given to the definition of quantitative objectives for the R&D Program (in terms of cost, efficiency, and environmental characteristics) that will lead to rapid commercialization and implementation of technologies that are developed. The analytical techniques employed in this program were designed to provide a unified and comprehensive framework for planning and analysis. Close coordination has been established with major energy analysis groups in the U.S. and abroad in order to identify and utilize those planning

Title: Energy Systems Studies

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techniques that are applicable to the Energy Research and Development Administration (ERDA) mission wherever they now reside.

The Energy Systems Studies program involves work in four major areas.

Area 1 - Energy Data: Development and maintenance of a comprehensive data base on efficiency, environmental, cost, manpower, and other characteristics of energy technologies. This area also involves the assembly of supply and demand data, and other information pertinent to the overall program, as well as the development of improved data management techniques using interactive programming and graphics.

Area 2 - Energy Models: Coordination and development of U.S. energy system models applicable to the ERDA planning and analysis function. The work in this area involves the maintenance and application of the Reference Energy System (RES) and the Brookhaven Energy System Optimization Model (BESOM) and the evaluation of energy models developed elsewhere that may be applied to ERDA studies alone or in combination with BESOM.

Area 3 - Technology Assessment: Analysis of fuel substitution strategies and the technical characteristics of energy technologies. This work involves the use of the RES as a framework for analysis supported by energy systems (Area 2) and economic modeling (Area 4). Special studies are also performed of implementation opportunities and technological trends in other countries.

Area 4 - Economic Analysis: Analysis of interrelationships between energy and the economy. This work involves the development of economic models that can incorporate technological detail, and their application to ERDA planning activities and special policy studies.

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B. Planning and Analysis (ERDA Program Level)

Title: Systems Studies Support Program - Fossil Energy

FY 77: \$200,000

Principal Investigator(s):
E. A. Cherniavsky

FY 78: \$250,000

Sponsor: Division of Fossil Energy
Research (ERDA)

The purpose of this project is to provide analytical support to the Long Range Strategy Division (LRSD) of the Office of Program Planning and Analysis, ERDA/Fossil Energy. 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. When required, the program includes analysis of the relationship of fossil energy to other energy sources, to the U.S. economy and international trade, and to institutional constraints. The primary users of these data and analysis tools are ERDA and Brookhaven personnel, but access is provided to others, as time and personnel constraints permit.

Title: Assessment of Building and Community Systems
          Conservation Options

FY 77:   \$100,000

Principal Investigator(s):
W. Marcuse

FY 78:   \$200,000

Sponsor: Division of Buildings
          and Community Systems Conservation
          (ERDA)

The purpose of this program is to modify and extend analytical tools originally developed for use in assessing the values of proposed supply technologies to permit their use in assessment of conservation options. The specific tools involved are an energy network diagram known as the Reference Energy System and the Brookhaven Energy System Optimization Model, which is a linear programming model of the U.S. energy system. The extensions will be accomplished mainly by substantially increasing the level of detail in the end use areas. The models will be extended and applied to the Buildings and Community Systems area. Capabilities of the developed models will include (1) cost benefit analysis of specific conservation options, (2) definition of design objectives for new end-use devices, (3) analysis of environmental, resource, and oil import benefits from new technology or policy implementation, and (4) providing a basis for the analysis of social and economic consequences of conservation options.

Title: Assessment of Conservation Options in Industry

FY 77: \$100,000

Principal Investigator(s):
W. Marcuse

FY 78: \$125,000

Sponsor: Division of Industrial
Energy Conservation (ERDA)

U.S. energy policy is directed toward increasing domestically supplied energy through the development of new energy supply conversion options and decreasing energy demand through energy conservation options. Tools and methodological approaches have been developed which have been useful in assessing the value of proposed supply technologies. This program is directed to the extension, improvement, and modification of these tools for use in the assessment of industry conservation options.

The Division of Industry needs analyses of specific projects in order to provide balance of its internal budget allocation and to quantitatively support its program within the AA/Conservation to ERDA AA/Planning, Analysis and Evaluation and to OMB. This program includes both the evaluation of projects on an ad hoc basis using existing methods and the extension of existing models to give more thorough and specialized evaluation of industrial conservation technologies.

Extension of the RES and BESOM for application to projects for residential and commercial buildings and for transportation is being performed under other Schedule 189's. The initial work for industry conservation will be limited in scope but will expand once the tools for assessing buildings options are completed.

The extension of the BNL Reference Energy System (RES) to industry will require a detailed analysis of the main energy flows into and out of all basic unit processes. For each industry a series of conservation technologies will be analyzed, and the resulting influence of these technologies on the energy flows within the industry will be exhibited. These energy flows will then be

Title: Assessment of Conservation Options in Industry

aggregated according to function and temperature regimes across the industrial sector. Careful attention will be paid to the types of waste heat not presently recovered, and to the issue of primary fuel substitution, with the aim of demonstrating the possibilities for conserving oil and natural gas.

Given the existing and expected distribution of capital stock in each industry, and estimates of the rates at which the conservation technologies identified as Industry Projects in the industry Program Approval Document could be introduced to an industry, various conservation scenarios will be constructed. The net effect of these scenarios on the fuel mix demanded by the industrial sector in any given year will then be derived and introduced as possible conservation programs for industry in the form of perturbed Reference Energy System extensions. At this point the interaction with the Brookhaven Optimization Model (BESOM) becomes central in terms of being able to analyze the various national policy implications of the industrial conservation scenarios.

Title: Analysis and Use of Transportation Energy Models

FY 77: \$115,000

Principal Investigator(s):
W. Marcuse

FY 78: \$150,000

Sponsor: Division of Transportation
Energy Conservation (ERDA)

Energy conservation in transportation can result from price increases (of fuel, vehicles, or transportation services), improved technology (improvement in efficiency or substitution of abundant fuel for scarce fuel), decrease in ambience of the same transportation modes (smaller, less powerful cars, carpools, increased seats per aircraft), or shifts to more fuel efficient transportation modes (private auto to train or bus). The role of the Division of Transportation in ERDA is to perform Research, Development & Demonstration (RD&D) directed to discovering developing, and demonstrating energy saving technology. The impact of such programs will be to decrease fuel consumption per passenger mile or per ton mile within a transportation mode or to shift the movement of people or freight from less efficient to more energy efficient transportation modes.

A methodology is needed that will isolate and assess the energy use response to alternative RD&D programs. Such a methodology must concurrently assess the impact of price increases and decreased ambience as well as that of the introduction of new technology. The RD&D program must be assessed against non-technological alternatives such as increased taxes or subsidies, mandatory standards, or regulatory actions.

Title: Analysis and Use of Transportation Energy Models

Models have been used to assess energy R&D and policy alternatives. Two of these are the Brookhaven Energy System Optimization Model, and the SRI-Gulf Energy Model. It is the purpose of this project to select and employ transportation models for the assessment of transportation RD&D alternatives that will be consistent with and can be easily integrated into such models. The models will be modified to permit coupling to more macro-models with a minimum of interface problems.

This program will be carried out in three phases:

- Phase I - Collection, assessment, selection and modification of existing models.
- Phase II - Employment of the models to assess, evaluate, and support transportation RD&D initiatives. During this phase, continuing model modification and data collection activities will be performed side by side with program assessments.
- Phase III - Modification of the models to couple them to macro-energy assessment models and to incorporate system costs.

Title: Systems Analysis Support to Wind Energy
Conversion Program

FY 77: \$100,000

Principal Investigator(s):
H. E. Davitian

FY 78: \$100,000

Sponsor: Division of
Solar Energy (ERDA)

This project provides assistance to the Wind Energy Conversion Branch of the Energy Research and Development Administration (ERDA) Division of Solar Energy in the development of wind energy conversion. This support will be provided specifically in the Systems Analysis subelements of the ERDA Wind Energy Conversion Program, which includes Mission Analyses, Applications/Systems Analyses and Legal/Social/Environmental issues. The tasks and the proposed BNL activity are listed below.

Task 1 - Mission Analysis: Conduct a detailed review of the draft final reports on mission analysis studies conducted by General Electric Company (Contract E(11-1)-2578) and Lockheed-California Company (Contract AT(04-03)-1075), and of reports on other analysis studies as selected by ERDA. Review reports will be prepared and where conflicts or deficiencies are identified in the findings of conclusions of these studies, recommendations will be made regarding analyses to be performed by the contractor to resolve those differences. The final objective of this task is to analyze the contract efforts with respect to results and conclusions that bear on the further development and implementation of wind energy as a national energy resource. A limited amount of independent systems analysis may be performed at Brookhaven as necessary to fill any important voids which are identified in the combined results of the contract studies.

Title: Systems Analysis Support to Wind Energy
Conversion Program

Task 2 - Monitoring and Evaluation of Contract Studies: Assist in the review of individual interim and final reports prepared for ERDA by organizations conducting research on wind energy projects under contract to ERDA or predecessor agencies, as assigned by ERDA. The results of such reviews will be reported in a form appropriate to the subject and scope of the individual project. Brookhaven personnel will participate in review and planning meetings as requested by ERDA personnel.

Task 3 - Other Assistance: Provide systems analysis support in such other areas as are assigned by ERDA. Evaluations of work proposals from contractors, as assigned, will be performed under this task.

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C. Regional Programs

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

FY 77: 895,000

Principal Investigator(s):
P. F. Palmedo

FY 78: \$1,100,000

Sponsor: Division of Biomedical
and Environmental Research
(ERDA)

The objective of this program is the development, testing and application of data, models and assessment tools for regional energy planning. It is part of an integrated multi-laboratory effort aimed at critical energy planning problems requiring analysis at the regional (multi-state) scale. The primary outputs of the program are a series of policy analyses and a set of evaluation tools that can be used by state, local, and regional agencies as well as utilities and industrial groups with interests in energy-related planning. The analyses and methods are being developed in collaboration with those user groups. Three basic programmatic themes have been identified: (1) The siting of energy related facilities, (2) the increased use of coal, and (3) the increased development of domestic oil. The interlaboratory collaboration also aims at the integration of the separate regional studies into national energy policy analyses.

The Brookhaven program focuses on the Northeastern U.S. Eight tasks have been identified in the program, some of which relate to data and models for the entire region; others concentrate on specific key problems of the region; each is related to one or more of the basic programmatic themes. In all cases the applicability to other regions and to a national picture are important considerations. The tasks that are included in the

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

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program are: (1) The analysis of current energy planning activities in the region, interaction with regional users and analysis of possible future regional energy planning institutions; (2) the development of regional energy/environmental and economic data, models and scenarios; (3) the analysis of regional energy conservation strategies; (4) investigations of energy facility siting issues, particularly power parks and site assessment methodologies; (5) urban energy supply options, emphasizing the prediction of health impacts; (6) a study of the potential for, and the environmental implications of, the increased use of coal in the region; (7) studies of offshore and related development, including offshore nuclear plant siting, artificial multipurpose islands and oil and gas development; and (8) support to other laboratories in the program in the areas of health impacts and characterization of emissions.

Title: Study of Load Management Options for Consolidated
Edison Company of New York

FY 77: \$25,000

Principal Investigator(s):
J. Allentuck

FY 78: \$ -0-

Sponsor: N.Y.S. Public Services
Commission (for FEA)

BNL is participating with others under a contract between the FEA and the Public Service Commission of New York State (PSC) in evaluating load management options for Consolidated Edison Company of New York (Con Ed). The objective of load management is to decrease energy consumption and capital investment requirements in electric energy production by increasing the load factor of the time varying system load. This in effect means increasing the ratio of the average to the peak load. It is translated graphically into a flattening of the load curve. Energy savings are accomplished by enabling greater utilization of more energy efficiency base load generating units in place of less efficient peak load generating units. Capital resources are achieved by increased utilization of existing base loaded units and the decrease in the need for additional peak load units.

The approach taken in this study has been to disaggregate the Con Ed daily load curve by end uses; i.e., air conditioning, water heating, space heating, lighting, refrigeration, transportation, etc. and to examine the impact of load management options or use patterns in each end use category. Load management options being considered include storage of "cool," special rate for interruptible service, peak load pricing, florescent tubes adapted for use in existing incandescent receptacles, etc.

Title: Study of Load Management Options for Consolidated
Edison Company of New York

A modified Con Ed load curve is reconstructed on the basis of use changes induced by these options. This modified load curve together with a computer program which models the way in which generators are loaded on the Con Ed system in response to the system load provides usage and fuel consumption of each generator. The impact of a specific load management in terms of machine usage and energy is observed by driving the generation program by a load curve before and after it has been modified by the relevant option.

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D. International Programs

Title: International Energy Agency Systems Analysis Program

FY 77: \$205,000

Principal Investigator(s):
V. L. Sailor

FY 78: \$250,000

Sponsor: Office of International
R&D Programs (ERDA)

Brookhaven National Laboratory has been identified 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 research and development strategy. The Kernforschungsanlage (KEA)-Jülich has been identified as the European site for this program and close coordination will be maintained between the two groups. The Directors of each group will report to the IEA Steering Committee established for the Systems Analysis Program.

E. Biomedical and Environmental Effects Programs

Title: Assessment of Biomedical and Environmental Costs of
Energy Systems

FY 77: \$510,000

Principal Investigator(s):
L. D. Hamilton

FY 78: \$750,000

Sponsor: Division of Biomedical
and Environmental Research
(ERDA)

This program aims at developing a systematic overview of biomedical and environmental 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 effects and environmental effects on animals, crops, and other vegetation and on land, 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 Brookhaven National Laboratory (BNL) Energy Data and Energy Models Groups. That work provides a significant resource for this program and a means of integrating the results of the program into national energy policy analysis.

Title: Assessment of Biomedical and Environmental Costs of
Energy Systems

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: Analysis of Energy and Environmental Policy
Considerations-Environmental Policy Analysis

FY 77: \$200,000

Principal Investigator(s):
L. D. Hamilton

FY 78: \$250,000

Sponsor: Division of Bio-
medical and Environmental
Research (ERDA)

This program will provide the Energy Research and Development Administration (ERDA) with analysis 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 carry out short-term studies to meet policy-making needs in ERDA.

The ERDA/AES environmental policy analysis program has two major tasks: Task 1 is a review and evaluation for the identification of potential conflicts between energy development and production and environmental policies; Task 2 is the analysis of critical issues identified in Task 1 as assigned by ERDA. This Schedule 189 covers Task 1. Revisions will be prepared as required to cover activities under Task 2.

OEP/BNL will undertake Task 1 activities in the following areas:

- . Environmental Aspects of Marine Energy-Related Activities
- . Environmental Impacts of Major Fuel Shifts
- . Health Effects of Energy Production and Use
- . Relationships Between Environmental Effects and Conservation
- . Measures

In addition to these activities, OEP/BNL will maintain continuing surveillance of developments in the Northeast relating to energy and environment and will provide "brushfire" analyses within the core group study areas as requested by AES/OEP.

F. Non-ERDA Programs

Title: Energy Modeling and Data Support

FY 77: \$129,000

Principal Investigator(s):
E. A. Cherniavsky, A. Hermelee

FY 78: Undetermined

Sponsor: Electric Power Research
Institute

The purpose of this program is to provide the Electric Power Research Institute (EPRI) with the capability to employ Brookhaven energy models for their specific analytical needs. In addition to transferring the capabilities that already exist at BNL, effort is provided to enhance the usefulness of the models for EPRI. The Reference Energy System was disaggregated from a national basis to a nine census region model to provide regional detail. A sample assessment of a utility region is being performed.

The Dynamic Energy System Optimization Model is also being modified to meet specific EPRI needs for technology assessment, and will be used for a sample analysis jointly identified by BNL and EPRI. BNL also supplies accelerated transfer of energy models and data bases developed through other funding, but of interest to EPRI.

Title: Energy Data and Modeling Assistance Program

FY 77: \$40,000

Principal Investigator(s):
M. D. Goldberg

FY 78: Undetermined

Sponsor: Council on Environmental
Quality (CEQ)

The Energy Data and Modeling Assistance Program (ENDMAP) is designed to provide access to the Energy Model Data Base (EMDB), and the Energy System Network Simulator (ESNS) to any agency of the Federal government (or their contractees). The EMDB was first developed in a collaborative program with the CEQ, and it and the ESNS model are maintained at the Brookhaven Central Scientific Computing Facility (CSCF). In order to assist Federal agencies which must prepare Environmental Impact Statements or perform other energy-related studies, the ENDMAP was funded by CEQ to encourage use of the EMDB/ESNS system as a basic data source and modeling tool. Training in system use is provided, and qualified users are provided with the necessary files on the CSCF, which they can access via remote terminals at their home locations. Use of English-language interactive programs allow quick training of personnel who do not have deep computer experience. Under the ENDMAP, some analytic work has been carried out by the NCAES in direct support of CEQ needs and also for the Office of Energy R&D Policy of the National Science Foundation, an original cosponsor of the ENDMAP.

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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 system. 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 perhaps 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 capital, labor, energy, and material resources on which the energy system and economy is 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 lifestyles 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 these groups and are available to Brookhaven through collaborative activities. The policy of NCAES is to, wherever possible, 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.

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. Operational. Extensions (also operational) include a time-stepped version which optimizes three years sequentially, and versions which incorporate greater detail in the space heat and air-conditioning sectors, e.g. conservation technologies, different shells, state-specific variations.

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 5-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: Operational on IBM at Multiple Access Incorporated (New York) and Optimum Systems Incorporated (California)

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 (RESOM)
Developed By: Brookhaven National Laboratory
Status: Under development. Completion of operational (on CDC 7600 at Brookhaven National Laboratory) version estimated September 1977.
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 Energy Research and Development Administration's (ERDA'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 Transportation
Status: Operational on Energy Research and Development Administration'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 System
Developed By: Brookhaven National Laboratory
Status: Operational on CDC 7600 at 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, estimated completion September 1977
(on Brookhaven National Laboratory CDC 7600)

Description: A linear programming model of the iron and steel industry has been completed. Other process models are in progress.

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 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.

Data Bases:

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

Developed By: Brookhaven National Laboratory (Calef and Drysdale)

Data Bases: (continued)

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.

2. 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

3. Data Base: Northeast Region State Level Data Base

Developed By: Brookhaven National Laboratory and Subcontractors

Status: Data exist in the Northeast Perspectives Reports, plans underway to computerize data

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

Client: State Energy-Environmental Offices, United States Energy Research and Development Administration. Brookhaven National Laboratory for Policy Analysis.

4. Data Base: 100 Power Plants Data Base

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

Status: Completed, computerized (BNL CDC 7600)

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

ECONOMY

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 macro-economic and inter-industry model. Contains econometrically estimated production functions which incorporate relative price and technological changes over time.

2. 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 sectors is coupled with Brookhaven Energy System Optimization Model (BESOM) to permit interfuel substitution. Operational extensions include incorporation of a capital matrix, and the dual problem. Extensions under development include a reduced form, which will not require iteration between the Input/Output and Brookhaven Energy System Optimization Model, and a multi-regional input/output model.

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

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

Status: Completed

Economy Models (continued)

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

4. 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:

5. 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 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: 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 and not yet incorporated into the Energy Model Data Base.
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-Energy Research Development Administration, New Jersey Energy Center Study. Classical Lagrange Multiplier Optimization Model.
4. Model: County-level Siting Model
Developed By: Peter Meier - Brookhaven National Laboratory - for National Coal Utilization Assessment
Status: Under development.

Environment Models (continued)

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: Completed, 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 system (REPS)

Developed By: Booz-Allen for Environmental Protection Agency

Status: Completed, updated for Energy Model Data Base (EMDB)

Description: Using the most recent National Emissions Data Service (NEDS) emissions inventory, Regional Emissions Projection Systems (REPS) projects emissions production to a selected future year by Air Quality Control Regions (AQCR). User options allow override of any projection algorithm in Regional Emissions Projection Systems (REPS), as well as the addition of any new technology in any region.

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 and to 50 miles.

8. Model: Long-range Trajectory Model

Developed By: Ron Meyers, Rick Cederwall, 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: 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.

Data Bases:

1. Data Base: Energy Model Data Base

Developed By: Brookhaven National Laboratory

Status: Operational on Brookhaven National Laboratory CDC 7600.

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

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

Developed By: Being developed at Brookhaven National Laboratory in conjunction with Committee on Alternative Energy Strategies.

Environmental - Data Bases (continued)

Status: Under development.

Description: Environmental and cost information about nuclear and other technologies.

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

Developed By: Environmental Protection Agency (EPA)

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 Protection Agency (EPA) of all point sources of air emissions as well as area wide activity and associated air emissions. These data are spotty.

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

Developed By: United States 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".

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

Developed By: United States Environmental Protection Agency

Status: Completed, resides on Environmental Protection Agency computer, regularly updated and added to.

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

MATERIALS

Data Bases:

1. Data Base: Reference Materials System

Developed By: Brookhaven National Laboratory

Status: Complete. Report to appear. Not computerized.

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

OTHER COUNTRIES

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 seven 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 Data Base

Developed By: Brookhaven National Laboratory

Status: Under development

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.

POPULATION AND HEALTH

Models:

1. Model: Population Projections by County

Developed By: Brookhaven National Laboratory (Novak)

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 fixed 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: Sam 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: Bozzo

Status: Completed and operative

3. (continued)

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. Eg. compose a group of 1 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: Bozzo

Status: Under Development

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

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).

Data Bases:

1. Data Base: Medical Data Bank (MEDABA)

Developed By: Bozzo

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 characteristics 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 6 million records. Mortality data by age, sex, race by 1969-1971.

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APPENDIX C

PUBLICATIONS LIST

December 1, 1975 - February 29, 1976

Energy Programs
Department of Applied Science
Brookhaven National Laboratory
Upton, New York 11973

I. Energy Systems Analysis

- BNL 20426   Bronheim, Harold, Nathans, Robert, Palmedo, Philip.
BNL/SUNY New York Regional Energy Study. November
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- BNL 20745   Energy Policy Analysis Group, SUNY. A Brief Summary
of the Land Use and Energy Utilization Project.
December 1975. Informal Report.
- BNL 20811-A   Braun, C., Cherniavsky, E. A., Salzano, F. J.
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January 1976.
- BNL 20875   Hoffman, Kenneth C. Energy Modeling--Perspectives
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- BNL 20987   Bezler, P., Curreri, J. R. Piping Dynamic Analysis
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- BNL 50478   Palmedo, Philip F., Editor. BNL Regional Energy
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1975. November 26, 1975.

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- BNL 20162   Powell, J. R., Salzano, F. J., Yu, Wen-Shi, Milau,
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- BNL 20791   Reilly, J. J., Johnson, J. R. Titanium Alloy Hydrides, Their Properties and Applications. December 1975. Paper presented at the First World Hydrogen Energy Conference, Miami Beach, Florida, March 1-3, 1976.
- BNL 20876   Strickland, G., Milau, J., Yu, Wen-Shi. The Behavior of Iron Titanium Hydride Test Beds: Long Term Effects, Heat Transfer and Modeling. Paper presented at the First World Hydrogen Energy Conference, Miami Beach, Florida, March 1-3, 1976.
- BNL 20877   Srinivasan, S., Salzano, F. J. Prospects for Hydrogen Production by Water Electrolysis to be Competitive with Conventional Methods. Paper presented at the First World Hydrogen Energy Conference, Miami Beach, Florida, March 1-3, 1976.
- BNL 20878   Salzano, F. J., Braun, C. Water Electrolysis vs. Thermochemical Production of Hydrogen: A Parametric Assessment. Paper presented at the First World Hydrogen Energy Conference, Miami Beach, Florida, March 1-3, 1976.
- BNL 20899   Powell, J. R., Salzano, F. J., Milau, J. A Closed Brayton Cycle Using Hydrogen as a Work Fluid. Paper presented at the First World Hydrogen Energy Conference, Miami Beach, Florida, March 1-3, 1976. January 1976.
- BNL 20902   Beaufrere, A. H., Salzano, F. J., Isler, R. J., Yu, W-S. Hydrogen Storage via Iron-Titanium for a 26MW(e) Peaking Electric Plant. January 1976. Presented at the First World Hydrogen Energy Conference, Miami Beach, Florida, March 1-3, 1976.

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- BNL 20984   Singh, G., Miles, M. H., Srinivasan, S. Mixed
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- BNL 20993-A   Usher, J. L., Powell, J. R. Comparison of
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- BNL 21015-A   Berlad, A. L., Salzano, F. J., Batey, J. Comfort Range Thermal Storage. February 1976. Abstract of paper to be presented at 1976 ASME Winter Annual Meeting, New York, Nov. 28-Dec. 3, 1976.
- BNL 21037   Benenati, R., Tichler, P., Powell, J. R. Low Activity Blanket with Water Cooled First Wall.
- BNL 21054   Powell, J. R., Reich, M., Hsieh, D., Lehner, J., Danby, G., Prodell, A. Aspects of Safety and Reliability of Superconducting Magnet Systems for Fusion Power Reactors. Paper to be presented at the 9th Symp. on Fusion Technology, Garmisch-Partenkirchen, Germany, June 14-18, 1976.
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Department of Applied Science
Brookhaven National Laboratory
Upton, New York 11973

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- BNL 21079   Beller, Morris. Reference Energy System Methodology. April 1976. Paper presented at the 81st National Meeting of the American Institute of Chemical Engineers, Kansas City, Missouri, April 13, 1976.
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A = Abstract

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