MASTER

ANNUAL HIGHLIGHTS OF THE ENERGY TECHNOLOGY PROGRAMS

December 1978

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

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

ANNUAL HIGHLIGHTS OF THE ENERGY TECHNOLOGY PROGRAMS

December 1978

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DEPARTMENT OF ENERGY AND ENVIRONMENT

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy (DOE), nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

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 \$5.25; Microfiche \$3.00

March 1979

500 copies

CONTENTS

Preface	iii
Introduction	1
Energy Storage and Conversion Division	
Electrolysis-Based Hydrogen Energy Storage Systems	8
An Electrochemically Regenerative Hydrogen-Halogen Energy Storage System	10
Fuel Cells: Applied Research on Fuel Cell Materials and Electrolysis.....	12
High Temperature Water Electrolysis.....	14
Hydrogen Energy Storage Systems for Automobile Propulsion.....	16
Program Planning for Research Related to Energy Conservation.....	18
New York State Energy Office Oil Retrofit Pilot Program.....	20
Burner-Boiler/Furnace Testing.....	21
Programs Proposed for Initiation in 1980.....	23
Engineering Division	
Solar-Assisted Heat-Pump (SAHP) System Development.....	26
Technical Support--Solar Cooling Subsystems and Systems.....	28
Preliminary Design Review and Technical Monitoring of Solar Demonstration Project in Northeast U.S.	30
Development of Hardware Simulators for Tests of Solar Cooling/Heating Subsystems and Systems.....	31
Fossil Energy Program Development.....	33
Catalytic Process for Conversion of Synthesis Gas to Methanol.....	34
Coal-Fired Heater Workshop.....	36
Coal-Oil Mixture Combustion.....	37
Rotating Fluidized Bed Containing Limestone for Removal of Sulfur from Hot Gases.....	38
Improved Oil and Gas Burners.....	39
Residue and Waste Fuels.....	40
Programs Proposed for Initiation in 1980.....	41
Conservation Program Management Group	
Conservation Program Management.....	44
Space Conditioning, Diagnostics, and Controls Technology for Conservation in Buildings.....	45
Energy Conservation in Residential Buildings.....	47

PREFACE

The Energy Technology Programs in the Department of Energy and Environment are sponsored by two general areas of DOE. The division or group at Brookhaven holding primary responsibility for each program is noted.

CONSERVATION AND SOLAR TECHNOLOGY

- oil- and gas-fired space-conditioning systems (Energy Storage and Conversion Division)
- energy conservation in buildings (Energy Storage and Conversion Division)
- solar-assisted heat pumps and cooling systems (Engineering Division)
- conservation program management (Conservation Program Management Group)

ENERGY TECHNOLOGIES

- energy storage by chemical means (Energy Storage and Conversion Division)
- energy conversion in fuel cells and combustion devices (Energy Storage and Conversion Division)
- fossil energy conversion, combustion, and environmental control (Engineering Division)
- program management (Conservation Program Management Group)

Related fossil energy programs are conducted in the Process Sciences Division and are described in the Energy Sciences program highlights.

The Conservation Program Management Group (CPMG) is responsible for the management of programs in electrolysis-based hydrogen storage systems, hydrogen-halogen energy storage systems; space conditioning, diagnostics, and controls; and conservation in residential buildings.

The individual projects are summarized and the significant accomplishments in 1978 are presented.

Robert J. Isler

INTRODUCTION

The objective of the Energy Technology Programs in the Department of Energy and Environment is to further the development of advanced energy components and systems. Emphasis is on technologies that utilize abundant and renewable sources and offer significant improvements in energy conversion systems and in environmental characteristics. Concepts that advance the state of the art well beyond that required by current or contemplated standards are of primary importance.

The Energy Technology Programs involve an integrated approach in collaboration with universities and industry. The work at Brookhaven is directed towards exploratory research and engineering, and support research. To provide the basis for eventual commercialization of the technologies under development, work is performed by appropriate industrial groups under contract to Brookhaven. Considerable interaction between Energy Technology Programs and Energy Science Programs, Environmental Programs, and the National Center for Analysis of Energy Systems (NCAES) Programs occurs both by inter-division/group participation in technology programs and by consultation.

The Energy Technology Programs are concentrated in the Energy Storage and Conversion Division and the Engineering Division with selected program management activities the responsibility of the Conservation Program Management Group.

The Energy Storage and Conversion Division programs are in two broad areas: electrolysis-based hydrogen energy storage systems and related technologies, and conservation in buildings and community systems.

The objective of the hydrogen energy storage activity is to develop the basic technology for substituting hydrogen, derived from nonfossil inexhaustible resources, as a chemical feedstock and/or fuel and as a storage medium or energy carrier. Related research work in electrolysis and fuel cells broadens the research base of this activity. Application of hydrogen energy storage to vehicular systems continues to be an area of interest.

A burner-boiler/furnace testing program provides technical data on equipment performances to support the DOE R&D program in Space-Conditioning Technology. A closely allied activity is the Brookhaven participation in the Oil Retrofit Pilot Program of the New York State Energy Office.

The Engineering Division programs include work on solar energy, fossil energy, and combustion technology.

The objective of the solar energy technology program is to assist the DOE in the development of cost-effective solar-assisted heat-pump systems. In addition to providing program assistance and technical monitoring, Brookhaven has several in-house research activities: investigating heat-pump impact on solar collector design and cost; determining heat-pump performance capability at source temperatures above 40°F (4.44°C); and experimentally determining the performance capability of storage elements thermally coupled to the ground.

The objective of the fossil energy development program is to utilize the special resources of Brookhaven to generate processes and techniques for increasing the utilization of the nation's coal supply. Areas of interest include hot gas desulfurization, catalysis, and particle monitoring and removal in turbine systems.

Brookhaven has direct responsibility for two combustion projects. One is concerned with the improvement of oil- and gas-fired boilers, furnaces, and industrial process heaters; the other, on residue and waste fuels, deals with wood and waste combustion. Both projects include management and planning activities.

The Conservation Program Management Group at Brookhaven has planning and management responsibilities in several program areas of national scope involving R&D projects carried out in coordination with industry and universities. Its principal responsibilities are a planning role in defining the overall DOE research program in each area and an implementation role involving research projects not only at Brookhaven but also conducted by outside organizations. One activity is directed toward space conditioning, diagnostics, and controls technology for conservation in buildings. An allied activity is concerned with the building envelope and its integration with the total building system.

Investigators in the Energy Technology Programs have ready access to supporting disciplines and techniques in other organizational units of the Department (see organization chart).

This report presents an overview of the program in Energy Technology during 1978. The objective, scope, significant accomplishments in 1978, principal activities planned for 1979, and publications are presented for each program.

HIGHLIGHTS OF 1978:

The mechanism of time variation of overpotential for oxygen evolution on some metals (Ni, Ir, Ru) was shown to be due to a change in the oxidation state and not due to a thickening of the film.

The present work in high temperature electrochemistry reveals that, in addition to ohmic overpotential of the solid electrolyte, other forms of overpotential, e.g., mass transfer can contribute to voltage losses.

Nickel cobalt oxide, nickel boride, and Teflon bonded potassium titanate or Nafion have been identified as potential anode catalyst, cathode catalyst, and separator, respectively for an advanced alkaline water electrolyzer operating at 120-150°C.

The safety analysis of a Hydrogen/Halogen Electric Energy Storage System in urban, industrial, and remote applications was completed. The analysis showed that no additional safety hazards exist than those presently controlled in the chloralkali industry.

A workshop to identify research related to energy conservation in industry was held in November with technical management representatives from twelve industrial areas. Research initiatives for long-term government support in each of the categories were identified as well as institutional mechanisms for affecting said support.

A novel interpretation of carbon oxide reduction reactions related to methanol synthesis was proposed. This oxide mechanism for synthesis gas reactions provides an explanation of experimental observations in syngas reactions. With this mechanism new catalysts can be designed, existing catalyst systems can be defined, and synthesis conditions and side products can be better understood.

A simulator for liquid source and load subsystems was completed and used, in conjunction with a laboratory model solar-assisted liquid/liquid heat pump, to investigate the use of a series solar input to a heat pump to produce heat coefficients of performance (COP) and high seasonal performance factors. Maximum COP's of 9 to 9.5 were measured, which compare favorably with theoretical predictions, and the trend of increasing COP with evaporator temperature was clearly demonstrated.

MAJOR ACTIVITIES PLANNED FOR 1979:

Investigate the effects of crystallite size, orientation, defects, alloying, and support material on electrocatalytic activity.

Examine the performance of perovskite-type oxygen electrodes in high temperature electrochemical cells.

A heat transfer enhancement apparatus for hydrogen storage systems will be constructed and used to evaluate various configurations of heat transfer surface.

The completion of the first full season of operation of the ground energy coupling experiment will allow validation of our three-dimensional underground heat flow model and an estimate of the impact of ground energy coupling on solar-assisted heat pump systems.

The operation of the rotating fluidized bed (RFB) apparatus at temperature, with limestone and alternate sorbent materials, will allow the evaluation of the RFB for the removal of sulfur from hot combustion gases.

The identification of the characteristics of coal-oil mixtures required to ensure long-term storage and handling and stable combustion will make possible the design of the experimental apparatus used to investigate these areas.

DEPARTMENT OF ENERGY AND ENVIRONMENT
BROOKHAVEN NATIONAL LABORATORY

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

ENERGY STORAGE AND CONVERSION DIVISION

ELECTROLYSIS-BASED HYDROGEN ENERGY STORAGE SYSTEMS

FY 1978: \$1,800,000

Principal Investigator: A. Mezzina

FY 1979: \$1,900,000

Sponsor: Chemical and Thermal Branch
of Energy Storage Systems Division
(DOE)

Objective:

The objective of this program is to develop the basic technology for substituting hydrogen, derived from nonfossil inexhaustible resources, as a chemical feedstock and/or fuel and as a storage medium or an energy carrier. Participation by private industry is encouraged to facilitate transfer of the technology relevant to hydrogen systems. The primary thrust is toward near-term commercialization.

Scope:

The program embodies hydrogen research and development activities performed at BNL and projects contracted with private industry, universities, and other research laboratories. The contracts are managed and monitored at BNL, and liaison is maintained with related activities in the public, private, and academic sectors. The R&D projects address technology development in the areas of hydrogen production by water electrolysis, hydrogen storage subsystems for stationary and mobile applications, advanced storage materials development and characterization, near-term end-use evaluations, and engineering systems studies dealing with barriers and incentives associated with hydrogen technology implementation.

Significant Accomplishments in 1978:

1. Initial performance testing of General Electric $2\frac{1}{2}$ -ft² SPE water electrolysis cell stack.
2. Complete performance test program on large-size (4000 lb) carbon steel hydride storage vessel installed in Billings Hydrogen Homestead Project.
3. Completion of characterization of low-temperature manganese-substituted TiCr_2H_x systems leading to a new family of reversible hydrides that can store up to 2 wt % hydrogen.
4. Completion of survey study (IGT) on hydrogen from small hydropower, and initiation of BNL public solicitation for major demonstration project.
5. Construction of major portion of hydrogen technology advanced component test system (HYTACTS) facility, and some testing of representative hydrogen component designs.

Principal Activities Planned for 1979:

1. Completion of test program on GE SPE $2\frac{1}{2}$ -ft² cell stack (12 cells--50 kW), and initial testing of a 200-kW complete system for hydrogen production.

2. Complete initial assessment of hydrogen from small hydropower concept, and, if positive, initiation of design and construction at demonstration site.

3. Experimental work and analytical assessment of hydrogen separation techniques using metal hydrides, including isotope separation and hydrogen separation from mixed gas streams.

4. Characterization of lightweight hydride systems (Mg-based) for automotive storage systems.

5. Initiation of public solicitation for demonstration of hydrogen-powered fork-lift truck application.

Publications in 1978:

BNL Reports

Ku, W. S., Nielsen, D. C., Zemkowki, J., Leich, D. L., Yatcko, P., and Gaebe, G. P. Hydrogen Supplementation System Evaluation Study. Prepared by Public Service Electric & Gas Company, Newark, NJ, BNL Contract No. 403024-S. (BNL 24099)

Lu, P. W. T., and Srinivasan, S. Ruthenium Oxide Anodes for Solid Polymer Electrolyte Water Electrolyzers: Electrochemical and Ellipsometric Studies. (BNL 24914)

Oral Presentations

Isaacs, H. S., Fillo, J. A., Dang, V., Powell, J. R., Steinberg, M., Salzano, F., and Benenati, R. Hydrogen Production for Fusion Reactors Coupled with High Temperature Electrolysis. Symposium on Industrial Water Electrolysis, Seattle, WA, May 1978. (BNL 24777)

Strickland, G. Experience with Hydride Reservoirs Built at BNL. Hydride Storage Reservoir Symposium/Workshop, BNL, June 1978. (BNL 24576)

Rosso, M. J., and Strickland, G. Bulk Hydrogen Storage: Engineering-Scale Tests. DOE Chemical/Hydrogen Contract Review Meeting, Washington, DC, November 1978. (BNL 25264)

AN ELECTROCHEMICALLY REGENERATIVE HYDROGEN-HALOGEN
ENERGY STORAGE SYSTEM

FY 1978: \$325,000

Principal Investigators: J. McBreen
and S. Srinivasan

FY 1979: \$100,000

Sponsor: Battery Branch of Energy
Storage Systems Division (DOE)

Objective:

The objective of this program is to assist industry in developing and demonstrating, in the near term, a cost-effective electrochemically regenerative hydrogen-halogen energy storage system.

Scope:

The hydrogen-halogen activity includes work on the electrochemical subsystem, the halogen storage subsystem, materials, cell studies, and economic assessments. The initial effort is directed at the hydrogen-chlorine system.

The program also includes assistance to DOE in the technical monitoring of the following advanced battery programs: zinc-bromine, zinc-chlorine, redox systems, and air cathodes for chloralkali cells.

Significant Accomplishments in 1978:

1. A safety and cost assessment of the H_2/Cl_2 energy storage system resulting in a firm cost and estimate indicated that equipment is now available for designing and building the reactant storage subsystems.
2. Cell studies carried out at elevated pressures (1 to 10 atm) and temperatures (25° to $95^\circ C$) showed that electric-to-electric efficiency increases with temperature and pressure.
3. Study of the transport properties of Nafion membranes in HCl and HBr indicated that the major contributor to coulombic losses in the H_2/Cl_2 system is permeation of chlorine through the membrane; coulombic efficiencies of about 97% are expected.
4. A non-steady state heat and mass balance analysis was begun for the H_2/Br_2 system.

Principal Activities Planned for 1979:

1. A safety and cost assessment of the H_2/Br_2 system.
2. Completion of cell tests at elevated temperatures and pressures.
3. Completion of electrochemical engineering analysis of the H_2/Cl_2 and H_2/Br_2 systems.

Publications in 1978:

Journal Articles

Chin, D-T., Yeo, R. S., McBreen, J., and Srinivasan, S. An electrochemically regenerative hydrogen-chlorine energy storage system: A study of mass and heat balances. J. Electrochem. Soc. (in press), September 1978. (BNL 24327)

BNL Reports

Spaziante, P. M., Sciolo, G. C., Trotta, R., Perego, A., and McBreen, J. Hydrogen/Halogen Energy Storage Systems. Oronzio de Nora Impianti Elettrochimici S.p.A. Via Bistolfi, 35, 20134, Milano, Italy. (BNL 25212)

Oral Presentations

Yeo, R. S., and McBreen, J. Electrochemical Characterization of Nafion Membranes for Electrochemically Regenerative Hydrogen/Halogen Energy Storage Systems. 153rd Electrochemical Society Meeting, Seattle, WA, May 1978. (BNL 23520)

Chin, D-T., Yeo, R. S., McBreen, J., and Srinivasan, S. An Electrochemically Regenerative Hydrogen-Chlorine Energy Storage System: A Study of Mass and Heat Balances. Electrochemical Society Meeting, Pittsburgh, PA, October 1978. (BNL 24500)

FUEL CELLS: APPLIED RESEARCH ON
FUEL CELL MATERIALS AND ELECTROCATALYSIS

FY 1978: \$225,000

Principal Investigators: S. Srinivasan
H. S. Isaacs, and W. E. O'Grady

FY 1979: \$380,000

Sponsor: Fossil Fuels Utilization of
Fossil Energy (DOE)

Objective:

The objectives of the program are (1) to carry out supporting research in pressing problem areas in first, second, and future generation fuel cells, (2) to work on advanced research concepts, (3) to interact with industry, universities, and other research organizations on basic research necessary for the successful development of fuel cells, and (4) to assist DOE in reviewing proposals and reports, technical monitoring of DOE supported programs, and making future program plans.

Scope:

The activities can be broadly classified under three headings: (1) electrocatalysis of fuel cell reactions, (2) selection and evaluation of materials for solid electrolyte fuel cells, and (3) assistance to DOE in the management and planning of the national fuel cell program.

The research activities consist of screening and evaluation of electrocatalysts including non-noble metal and nonmetallic catalysts, examination of time variation of performance due to sintering or poisoning, investigation of catalyst-support interactions by sophisticated surface techniques, determination of the potential development or organic compound (e.g., methanol)-air fuel cells and analysis of overpotentials, and selection and evaluation of interconnection materials for solid electrolyte fuel cells.

Significant Accomplishments in 1978:

1. Hydrogen adsorption method developed for in situ measurement of surface area of fuel cell electrodes as a function of time.
2. Activities of high-surface-area Teflon-bonded platinum black electrodes regenerated after aging in a fuel cell environment.
3. Increased activity found in underpotentially deposited lead or platinum for methanol oxidation.
4. Aging characteristics determined for platinum in solid electrolyte fuel cells.
5. Technique established for analysis of overpotentials in solid electrolyte fuel cells with air and hydrogen-water mixtures by polarization and ac methods.
6. Measurement initiated on indium oxide cathodes in solid electrolyte fuel cells.

Principal Activities Planned for 1979:

1. Electrocatalysis of fuel cell reactions--studies of the following:
  - a. Mechanism of sintering of fuel cell electrodes and methods for its inhibition.
  - b. Effects of temperature and pressure on phosphoric acid fuel cell performance.
  - c. Electrode morphology and catalysis.
  - d. Electrode kinetics of the oxygen reduction reaction.
2. Solid electrolyte fuel cells:
  - a. Analysis of overpotentials.
  - b. Selection and evaluation of interconnection materials.

Publications in 1978:

BNL Reports

Isaacs, H. S., Srinivasan, S., and Harry, I. L., Editors. Proceedings of the Workshop on High Temperature Solid Oxide Fuel Cells. BNL, May 1977. BNL 50756, August 1978.

Oral Presentations

Olender, H., Tseung, A. C. C., Isaacs, H. S., O'Grady, W. E., and Srinivasan, S. An Electrochemical Method for Regeneration of Active Area of Fuel Cell Electrodes. 153rd Electrochemical Society Meeting, Seattle, WA, May 1978. (BNL 23733)

Isaacs, H. S., Olmer, L.J., and Srinivasan, S. Analysis of Overpotentials in Solid Electrolyte Fuel Cells. National Fuel Cell Seminar, San Francisco, CA, July 1978. (BNL 24578)

O'Grady, W. E., Olender, H., Isaacs, H. S., and Srinivasan, S. In Situ Regeneration of Surfaces of Fuel Cell Electrodes. National Fuel Cell Seminar, San Francisco, CA, July 1978. (BNL 24577)

Srinivasan, S. Fuel Cells for Electric Utility and Transportation Applications. International Society of Electrochemistry, 29th Meeting, Budapest, Hungary, August 1978. (BNL 24690)

HIGH TEMPERATURE WATER ELECTROLYSIS

FY 1978: \$102,000

Principal Investigator: H. S. Isaacs

FY 1979: \$163,000

Sponsor: Division of Advanced Energy
Projects (DOE)

Objective:

The objective of the program is to identify materials for the construction of a steam electrolysis cell with a solid oxide electrolyte to operate in the temperature range 1400° to 1650° C. The water electrolysis for hydrogen production will operate in conjunction with a fusion reactor producing the required high temperature steam and heat for the endothermic electrolysis reaction.

Scope:

The work involves the preparation and testing of anode, cathode, and inter-connection materials for solid oxide steam electrolysis. Measurements are being made on conductivities, compatibility among the construction materials and the hydrogen/water and oxygen environments, oxygen diffusion in these materials, and electronic conduction in zirconia-yttria at temperatures up to 1650° C.

Significant Accomplishments in 1978:

1. High temperature furnaces and testing equipment were set up.
2. Testing of indium oxide up to 1500° C as an anode material showed the high vapor pressure of the oxide to be unacceptable.
3. Testing of compatibility of doped LaCrO_3 -based materials with $\text{ZrO}_2\text{-Y}_2\text{O}_3$ was begun and a reaction produced at 1550° C associated with the dopants Al and Mg was identified.

Principal Activities Planned for 1979:

1. Testing of LaCrO_3 with a range of dopants to eliminate reaction product formation.
2. Testing of compatibility of $\text{Al}_2\text{O}_3\text{-Fe}_2\text{O}_3\text{-Cr}_2\text{O}_3$ spinels and of $\text{ZrO}_2\text{-CeO}_2\text{-CoO}$ and $\text{LaFeO}_3\text{-SrZrO}_2$ perovskites with zirconia in air and hydrogen.
3. Determination of vapor losses of compatible materials.
4. Determination of oxygen diffusion coefficients in compatible materials.
5. Start of cell construction and electrochemical kinetic measurements on $\text{ZrO}_2\text{-Y}_2\text{O}_3$.

Publications in 1978:

BNL Reports

Isaacs, H. S., Fillo, J. A., Dang, V., Powell, J. R., Steinberg, M., Salzano, F., and Benenati, R. Hydrogen Production from Fusion Reactors Coupled with High Temperature Electrolysis. (BNL 24625)

Fillo, J. A., Isaacs, H. S., et al. Synfuels Production from Fusion Reactors. 3rd ANS Topical Meeting on the Technology of Controlled Nuclear Fusion, Santa Fe, NM, May 1978. (BNL 24669)

Oral Presentations

Fillo, J. A., et al. Hydrogen Production from Fusion Reactors Coupled with High Temperature Electrolysis. 153rd Electrochemical Society Meeting, Seattle, WA, May 1978. (BNL 24777)

Dang, V., Steinberg, M., Fillo, J., Isaacs, H. S., Lazareth, O., Powell, J.R., and Salzano, F. J. Hydrogen Production from High Temperature Electrolysis and Fusion Reactors. 13th Intersociety Energy Conversion Engineering Conference, San Diego, CA, August 1978. (BNL 24420)

Isaacs, H. A., and Olmer, L. J. Solid Oxide Fuel Cells and Electrolytes. Electrochemical Society Meeting, Pittsburgh, PA, October 1978. (BNL 24504)

HYDROGEN ENERGY STORAGE SYSTEMS FOR AUTOMOBILE PROPULSION

FY 1978: \$31,000

Principal Investigator: G. Strickland*

FY 1979: \$30,000

Sponsor: Lawrence Livermore Laboratory,
Transportation Systems (DOE STOR funds)

Objective:

Hydrogen is one of the forms of stored energy being considered for use in automobile propulsion systems, either for combustion in a modified engine or for reaction with air in a fuel cell to produce energy for electric propulsion. Brookhaven's role in the program is to develop energy and power projections for hydrogen systems utilizing liquid hydrogen or decomposable metal hydrides. The main objective is to identify the hydrogen system best suited for automobile use in the next decade or two.

Scope:

Brookhaven directs the activities of the panel members and reviews their efforts in preparing input to the LLL vehicular performance model. In preparing the desired information it is essential to review developments in storage and container materials and in container and system design, to develop conceptual designs for evaluation, and to review hydrogen safety. This work involves communication with personnel at various government laboratories, industrial firms, universities, and subcontractors. The output of the Chemical-Energy Storage Panel is included in the LLL report listed under Publications.

Significant Accomplishments in FY 1978:

1. Completed energy and power projections for a liquid-hydrogen energy-storage system and for TiFe- and Mg-based hydride-hydrogen systems.
2. Prepared a preliminary design of a hydride reservoir that can be recharged in 10 minutes.
3. Developed a simple method of analyzing the performance of various energy-storage vehicles.
4. Completed writing of a section on hydrogen safety.

Principal Activities Planned for 1979:

1. Conduct work of Chemical-Energy Storage Panel.
2. Prepare a workshop on presentation of FY 1978 results.
3. Initiate projections for hydrogen-air fuel cell system.
4. Report on hydrogen-fueled vehicle developments and methods of analyzing performance.

---

* Chairman of Chemical Energy Storage Panel

5. Assist in adding hydrogen storage data to the National Energy Storage Data Base.
6. Provide needed support to other study panels.

Publications in 1978:

LLL Report

Behrin, E. Analysis and Comparison of Energy Storage Systems in Automobiles.
September 1978, UCRL-52535 Draft.

Oral Presentation

Strickland, G. Hydrogen Storage Devices for Automobiles. DOE Chemical/
Hydrogen Energy Systems Contractor Review, Washington, DC, November 1978.
(BNL 25263)

PROGRAM PLANNING FOR RESEARCH RELATED TO ENERGY CONSERVATION

FY 1978: \$15,000

Principal Investigator: F. J. Salzano

FY 1979: \$70,000

Sponsor: Office of Energy Research
(DOE)

Objective:

The objective of this program is to consider the need for long-range research programs aimed at improvement in energy utilization and materials substitution in U.S. industry. When research areas are identified, specific program plans will be prepared, and high-priority projects will be identified.

Scope:

This program was initiated by planning and carrying out a Workshop on industrial participants to consider the key issues and recommend specific areas of work and initial projects. The major industrial areas involved include the following:

- . agricultural technology
- . forest products, pulp and paper
- . iron and steel processing
- . glass, cement, and ceramics
- . chemicals and polymers
- . textiles
- . information processing and machine intelligence
- . technological education and engineering practices
- . manufacturing
- . raw materials, exploration, and extraction
- . construction
- . nonferrous metals processing

Significant Accomplishments in 1978:

The Industrial Steering Group was convened, and made plans for a Workshop to be held November 9 and 10, 1978, with industrial and some university participants. The Workshop was held in Reston, VA, and an initial draft report of the Summary Session was prepared and circulated to the participants and Panel Chairmen for review.

Principal Activities Planned for 1979:

1. Individual Panel Chairmen and panel participants will develop specific research proposals in the areas of work identified.
2. The Summary Session Report will be issued.

Publications in 1978:

None.

NEW YORK STATE ENERGY OFFICE OIL RETROFIT PILOT PROGRAM

FY 1978: --

Principal Investigator: F. J. Salzano

FY 1979: \$160,000

Sponsor: Technology and Consumer
Products Branch of the Division of
Buildings and Community Systems (DOE)

Objective:

The objective of this program is to determine technical and marketing measures that reduce the consumption of fuel oil and can be utilized in future expanded retrofit programs.

Scope:

This retrofit program will provide technical information in support of the DOE RD&D program in Space Conditioning Technology with the objective of achieving a significant reduction in oil consumption. The work includes providing technical information to the Program Advisory Committee as a result of the burner-boiler/furnace testing, monitoring fuel consumption ranges of the retrofit options included in the program, and providing general technical guidance in all aspects of the program planning and implementation. BNL input falls in the areas of marketing analyses, determination of oil dealer qualifications, selection of retrofit option lists, and determination of fuel savings.

Significant Accomplishments in 1978:

1. Participation in all program planning and hosting of workshop activities.
2. Assistance to DOE retrofit installation standards group by organization of an industry-represented workshop for their proposed burner installation standard.
3. Establishment of procedures for performance of efficiency analyses requested by the participating oil dealers.
4. Establishment of procedures for monitoring fuel consumption by using actual field data and laboratory-derived fuel savings computations.
5. Testing of equipment recommended by the Program Advisory Committee.

Principal Activities Planned for 1979:

1. Implementation of procedures related to the BNL role.
2. Spot checking of work being performed by the participating dealers.
3. Continuation of all appropriate activities in support of the Program Advisory Committee.

Publications in 1978:

None.

BURNER-BOILER/FURNACE TESTING

FY 1978: \$460,000

Principal Investigators: R. J. Hoppe
and J. E. Batey

FY 1979: \$500,000

Sponsor: Technology and Consumer
Products Branch of the Division of
Buildings and Community Systems (DOE)

Objective:

The objective of this program is to provide technical data on burner-boiler/furnace performance to support the DOE RD&D program in Space Conditioning Technology. The DOE program is directed toward achieving a reduction in oil and gas consumption for space heating of residential and commercial buildings.

Scope:

The work includes development and refinement of test methods based on enthalpy-flow efficiency measurements, and construction and operation of test stands for oil- and gas-fired heating equipment. The testing falls in three general areas: (1) characterization of available commercial equipment, (2) evaluation of modifications to systems and operating procedures, and (3) evaluation of developmental equipment with potential for significantly improved performance on a seasonal basis.

Significant Accomplishments in 1978:

1. A second hydronic test stand was completed and placed in operation. Testing proceeded at an increased pace. Equipment tested included boilers, furnaces, burners, and other items such as stack heat reclaimers.
2. Operation of the forced warm air test, which was delayed for technical reasons, commenced by the end of the year.

Principal Activities Planned for 1979:

1. A capability for testing gas-fired equipment as well as oil-fired equipment will be provided.
2. Characterization testing will be completed, and reports issued, for several generic categories of commercially available heating equipment.
3. Complete steady state and seasonal performance tests will be conducted for several developmental low firing rate oil burners.
4. Emissions monitoring equipment will be used in conjunction with the efficiency testing apparatus.

Publications in 1978:

BNL Reports

Batey, J. E., Allen, T. W., McDonald, R. J., Hoppe, R. J., Salzano, F. J., and Berlad, A. L. Direct Measurement of the Overall Efficiency and Annual Fuel Consumption of Residential Oil-Fired Boilers. Annual Report FY 1977, January 1978. BNL 50853

PROGRAMS PROPOSED FOR INITIATION IN 1980

1. Assessment: Energy Storage for Automotive Application of Hydrogen
2. Development of Alkaline Fuel Cell Technology for Vehicle Application
3. Photoelectrochemical Cells: Electrochemical and Engineering Aspects
4. Electrocatalysis
5. Quantum Calculations on Reactant Catalyst Interactions
6. Material for Electrochemical Energy Conversion and Storage
7. Investigation of Zinc Electrode Reactions
8. Investigation of the Oxygen Electrode Reaction

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

ENGINEERING DIVISION

SOLAR-ASSISTED HEAT-PUMP (SAHP) SYSTEM DEVELOPMENT

FY 1978: \$435,000

Principal Investigators: J. W. Andrews,
J. G. Cottingham, E. A. Kush, and
P. Metz

FY 1979: \$575,000

Sponsor: Solar Heating and Cooling R&D
Branch, Division of Conservation and
Solar Application (DOE)

Objective:

The objective is to develop cost-effective heat-pump systems that achieve high energy efficiency through the use of solar Btu's as thermal input to a heat pump designed for this application. The means by which this goal is to be attained are fourfold:

1. The use of a heat pump to make possible the use of low-cost low-temperature collectors.
2. Optimization of the heat pump for source temperatures above 40°F.
3. Buffering of storage against thermal starvation during periods of high demand and low insulation.
4. Achievement of favorable utility impact by avoiding the need for electric resistance backup, thereby presenting a relatively level load to the utility.

Scope:

BNL provides technical support to the Solar Heating and Cooling R&D Branch of DOE in the solar-assisted heat-pump area. The in-house research projects supporting the development program include: (1) estimation of heat-pump impact on solar collector design and cost, (2) determination of heat-pump performance capability at source temperatures above 40°F, and (3) experimental determination of performance capability of storage elements thermally coupled to the ground.

Significant Accomplishments in 1978:

1. Relationships between collector performance characteristics and required collector area in SAHP systems were elucidated.
2. A heat-pump simulator and laboratory model heat pump were constructed, and testing is in progress. Heating COP in excess of nine was obtained at an evaporating temperature of 95°F.
3. The first generation of the ground-coupling experiments was constructed, and testing was initiated.
4. An air-heating solar collector test facility was constructed, and testing on collector designs identified as promising candidates for use with SAHP's.

Principal Activities Planned for 1979:

1. Further computer studies of collector requirements and modeling of ground-coupled storage.

2. Extensive testing of heat-pump capabilities on the simulator with preparation for testing of prototype SAHP's supplied by DOE contractors.
3. Further modification of the ground-coupled storage experiment and assessment of the impact of this energy coupling technique on SAHP systems.
4. Construction of a liquid-heating collector test facility and testing of low-cost site-built collectors for use with heat pumps.

Publications in 1978:

BNL Reports

Andrews, J., Kush, E., and Metz, P. A Solar Assisted Heat Pump System for Cost-Effective Space Heating and Cooling. March 1978. BNL 50819

Andrews, J., and Lewandowski, A. Survey of Low-Cost Solar Energy Collectors for Use in Solar Assisted Heat Pump Systems. May 1978. (BNL 24381)

Lewandowski, A., Editor. In-House Solar Research and Development Projects Third Quarterly Activity Report. August 1978. (BNL 25096)

Cottingham, J. G. The Cost Effective Potential of Optimally Designed Heat Pumps for the Collection, Storage, and Distribution of Solar Energy. November 1978. (BNL 25195)

Oral Presentations

Andrews, J., Kush, E., and Metz, P. A Solar Assisted Heat Pump System for Year-Round Space Conditioning. 3rd Workshop on the Use of Solar Energy for the Cooling of Buildings, San Francisco, CA, February 1978. (BNL 24329)

Andrews, J., Kush, E., and Metz, P. Heat Pump Development for Solar Assisted Heat Pump Space Conditioning. 3rd Annual Heat Pump Technology Conference, Oklahoma State University, Stillwater, OK, April 1978. (BNL 24353)

Metz, P. The Potential for Ground Coupled Storage Within the Series Solar Assisted Heat Pump System. AS/ISES Annual Meeting, Denver, CO, August 1978. (BNL 24579)

Andrews, J. Development of a Cost-Effective Solar Assisted Heat Pump System. AS/ISES Annual Meeting, Denver, CO, August 1978. (BNL 24517)

Kush, E. The Role of the Vapor Compression Cycle in Solar Energy Utilization. AS/ISES Annual Meeting, Denver, CO, August 1978. (BNL 24573)

Andrews, J. Solar Assisted Heat Pump Overview and Summary of In-House Research. Solar Heating and Cooling R&D Contractors 3rd Annual Meeting, Washington, DC, September 1978. (BNL 24911)

Kush, E. Development of a Solar Assisted Heat Pump for the Heating and Cooling of Buildings. Solar Heating and Cooling R&D Contractors 3rd Annual Meeting, Washington, DC, September 1978. (BNL 24994)

TECHNICAL SUPPORT--SOLAR COOLING SUBSYSTEMS AND SYSTEMS

FY 1978: \$240,000

Principal Investigator: P. C. Auh

FY 1979: --

Sponsor: Solar Research and Development Branch for Heating and Cooling, Division of Conservation and Solar Application (DOE)

Objective:

The objective of the program is to provide technical assistance to the Solar Research and Development Branch for Heating and Cooling in the development of solar cooling technologies.

Scope:

Brookhaven provides technical support in the development of solar cooling technologies by performing various tasks to aid in the identification and development of cost-effective solar cooling technologies, and by assisting in the demonstration program in the solar cooling area. BNL will develop in-house solar cooling research activities.

Significant Accomplishments in 1978:

Brookhaven assisted the DOE office in the development of program plans and prepared two documents for DOE in this area: "Solar Cooling R&D Recommendations," and "Solar Cooling R&D Plan--5 Years."

Brookhaven constructed a solar cooling hardware simulator of residential size and began testing of a commercial absorption chiller. This in-house R&D task has been an integral part of the technical support program in FY 1978, but will become an independent project in FY 1979.

Principal Activities Planned for 1979:

This program was not funded in FY 1979.

Publications in 1978:

BNL Reports

Auh, P. C. An Overview on Absorption Cooling Technology in Solar Applications. 3rd Workshop on the Use of Solar Energy for the Cooling of Buildings, San Francisco, CA, February 1978. (BNL 24325)

Auh, P. C. In-House Solar Research and Development Projects. April 1978. (BNL 24778)

Oral Presentations

Auh, P. C. Thermal Performance and Economics of Solar Space and Hot Water Heating Systems on Long Island, New York. KSEA (Korean Scientists and Engineers Association in America) Symposia '78, Seoul, Korea, July 1978. (BNL 24665)

Auh, P. C. Solar Energy: Its Technologies and Applications. KSEA Symposia '78, Seoul, Korea, July 1978. (BNL 24832)

Auh, P. C. Solar Cooling R&D Overview. Solar Heating and Cooling R&D Contractors 3rd Annual Meeting, Washington, DC, September 1978. (BNL 24924)

PRELIMINARY DESIGN REVIEW AND TECHNICAL MONITORING OF SOLAR
DEMONSTRATION PROJECT IN NORTHEAST U.S.

FY 1978: \$100,000

Principal Investigators: P. C. Auh
and J. W. Andrews

FY 1979: \$50,000 (Est.)

Sponsor: Chicago Operations Office,
Division of Conservation and Solar
Application (DOE)

Objective:

The objective of the proposed program is to assist the DOE Solar Demonstration Program by providing preliminary design reviews and other technical evaluation assistance for solar demonstration projects in the northeastern United States.

Scope:

The scope of work includes the following activities: (1) preliminary design reviews of proposed projects, (2) visits to contractor sites, (3) preparation of project progress reports, (4) analytical work and technical assistance for control schemes, and (5) assistance in proposal evaluation.

Significant Accomplishments in 1978:

1. Preliminary design reviews of the proposed projects.
2. Participation in the extensive Program Opportunity Notice (PON) reviews for the latest commercial demonstration cycle.

Principal Activities Planned for 1979:

Continued technical support to the DOE office.

Publications in 1978:

None.

DEVELOPMENT OF HARDWARE SIMULATORS FOR TESTS OF SOLAR
COOLING/HEATING SUBSYSTEMS AND SYSTEMS

FY 1978: Under Technical Support
Program

Principal Investigator: P. C. Auh

FY 1979: \$50,000

Sponsor: Solar Research and Develop-
ment Branch for Heating and Cooling,
Division of Conservation and Solar
Application (DOE)

Objective:

Large numbers of advanced cooling subsystems and systems are expected to be developed within about three years under present DOE contracts. Independent confirmation and evaluation of the performance of the advanced cooling devices under various realistic operating conditions are of prime importance. The objectives of the proposed simulator work are: (1) to confirm steady state performance data for advanced subsystems and/or systems, (2) to procure unsteady state and part-load performance data to be used for advanced subsystem and system designs, and (3) to validate computer simulation models for subsystems and systems.

Scope:

Brookhaven will develop hardware simulators for tests of solar cooling/heating subsystems and systems. Hardware simulations will be performed to obtain steady state/unsteady state performance under full-load and part-load conditions, and parasitic power measurements.

Software simulations and data reductions will involve use of the available advanced computer programs for model validations of subsystems/systems and the use of existing computer facilities at BNL. To avoid duplication, no in-house development of the computer simulation program will be attempted.

Significant Accomplishments in 1978:

A solar cooling simulator for residential-size subsystems (chillers) was constructed and is operational. A second-generation commercial absorption chiller is under test. A computer control system for hardware simulators is under development.

Principal Activities Planned for 1979:

BNL will continue to develop the solar cooling hardware simulator and to test second-generation absorption chillers of residential size. Emphasis will be on cycling and dynamic testing. BNL will continue to develop the interface for simulation data reduction and operation.

Publications in 1978:

BNL Report

Auh, P. C., and Wilhelm, W. G. Evaluation of Performance Enhancement of Solar Powered Absorption Chiller with an Improved Control Strategy Using the BNL-Built Hardware Simulator. Extended Abstract submitted to 1979 International Solar Energy Society Congress, Atlanta, GA, May 28 - June 1, 1979, October 1978. (BNL 25139)

FOSSIL ENERGY PROGRAM DEVELOPMENT

FY 1978: \$200,000

Principal Investigator: C. H. Waide

FY 1979: \$200,000

Sponsor: Division of Fossil Fuel
Processing (DOE)

Objective:

This program is directed toward the development of projects that utilize Brookhaven's capabilities in meeting the needs of the DOE Fossil Energy Program, both by identifying areas falling within the special capabilities and interest of the BNL staff and by making BNL's resources more readily available to the DOE-FE staff by developing and maintaining a suitable level of communication.

Scope:

The activities of Brookhaven staff members in the development of fossil programs at BNL are coordinated through this program, and consultants are used to provide special expertise. Program activities are developed with the DOE staff at Headquarters and at the Technology Centers.

Significant Accomplishments in 1978:

Increased emphasis in the catalyst area resulted in the development of both a basic research and a technology effort, the former directed toward mechanism studies and the latter toward the development of improved catalysts for production of methanol and higher hydrocarbons.

A study of coal-oil mixture combustion was initiated in October. Plans were made for a workshop on coal-fired heaters. Studies were started on hot-gas cleanup which include particle monitoring and removal in combustion gases at high temperature and high pressure by using various concepts that originated at Brookhaven.

Principal Activities Planned for 1979:

The potential for improved or alternative fossil energy technologies will be considered and, where appropriate, discussions regarding new initiatives will be held with the DOE staff to confirm the approaches suggested. Work on catalysts and particulates will continue.

Publications in 1978:

None.

CATALYTIC PROCESS FOR CONVERSION OF SYNTHESIS GAS TO METHANOL

FY 1978: \$65,000

Principal Investigator: R. Sapienza

FY 1979: --

Sponsor: Division of Fossil Fuel
Utilization (DOE)

Objective:

The objective of this program was to develop more active catalysts for the conversion of synthesis gas to methanol.

Scope:

The approach was based on the use of multi-metallic bifunctional catalysts in a homogeneous analogue of the methanol synthesis reaction. The mechanistic approach suggested by this reaction was used to investigate the homogeneous catalyst system. Elucidation of the mechanism of the reactions would help provide techniques for process improvement.

Significant Accomplishments in 1978:

A catalyst system was identified, operative mechanisms were elucidated, and a proposed mechanism for methanol synthesis based on the experimental work was developed.

Principal Activities Planned for 1979:

This project was concluded in FY 1978. In 1979, a research program will be initiated, to be followed by a restructured technology effort.

Publications in 1978:

Journal Articles

Sapienza, R. S., Sansone, M. J., Spaulding, L. C., and Lynch, J. F. Novel interpretations of carbon oxide reductions. Submitted to Chem Tech Journal, Summit, NJ, August 1978. (BNL 24857)

Oral Presentations

Sapienza, R. S., Sansone, M. J., Spaulding, L. D., and Lynch, J. F. Novel Interpretations of Carbon Oxide Reductions. First International Symposium on Homogeneous Catalysis, Corpus Christi, TX, November 1978. Proceedings to be published by Plenum, New York, in May 1979. (BNL 24857)

Lynch, J. F., Spaulding, L. D., and Sapienza, R. S. An FeTi Methanation Catalyst. American Chemical Society 176th National Meeting, Miami Beach, FL, September 1978. Division of Petroleum Preprints, 1345, Petr 019. (BNL 24477)

Sapienza, R. S., Spaulding, L. D., Lynch, J. F., and Sansone, M. J. Novel Interpretations of Carbon Oxide Reduction Reactions. I. Over Metal Surfaces. II. Over Metal Oxides. American Chemical Society 176th National Meeting, Miami Beach, FL, September 1978. Division of Petroleum Preprints, 1255, 1336, Petr 017. (BNL 24427-24430)

COAL-FIRED HEATER WORKSHOP

FY 1978: --

Principal Investigators: C. H. Waide
and T. Butcher

FY 1979: \$30,000

Sponsor: Division of Fossil Fuel
Utilization (DOE)

Objective:

This project will serve to establish, through the vehicle of a workshop involving industry members, the type and extent of research and development needed to facilitate the use of coal fuel for fired heaters.

Scope:

Industry members will participate in the activity to identify R&D needs and consider the role of industry and government in this area. The results are expected to aid the Division of Fossil Fuel Utilization in developing this program area.

Significant Accomplishments in 1978:

The program was initiated in October 1978.

Principal Activities Planned for 1979:

A workshop will be held, and the results and recommendations will be developed for use by DOE.

Publications in 1978:

None.

COAL-OIL MIXTURE COMBUSTION

FY 1978: --

Principal Investigator: C. R. Krishna

FY 1979: \$100,000

Sponsor: Division of Fossil Fuel
Utilization (DOE)

Objective:

The purpose of this program is to study the combustion of coal-oil mixtures (COM) to determine the effects of mixture makeup and combustor operating parameters. The data generated will aid in the development of confirmation of design procedures for the handling, firing, and combustion of COM.

Scope:

The work will include systematic investigation of the mixtures and their specifications, of burner nozzle and fuel flow, and of the effect of controlled turbulent mixing of the combustion process.

Significant Accomplishments in 1978:

The program was initiated in October 1978. In the initial studies, the stability criteria used for COM were reviewed and the fundamental aspects of COM rheological behavior were investigated.

Principal Activities Planned for 1979:

A design for a combustion experiment, including preliminary design of the necessary equipment, will be developed. Instruments will be selected and ordered. COM stability studies will be continued to provide a basis for the analysis of test data.

Publications in 1978:

None.

ROTATING FLUIDIZED BED CONTAINING LIMESTONE FOR REMOVAL
OF SULFUR FROM HOT GASES

FY 1978: \$ 80,000

Principal Investigators: C. H. Waide
and J. S. Mialu

FY 1979: \$150,000

Sponsor: Division of Fossil Fuel
Utilization (DOE)

Objective:

The objective of this program is to determine the feasibility of using a rotating fluidized bed containing limestone for the removal of sulfur (SO_2) from hot gases.

Scope:

A rotating fluidized bed containing limestone at approximately 1600°F will be built, and its capability for removing sulfur from hot gases will be evaluated. It is expected to improve the utilization of limestone compared with a stationary fluidized bed, and to reduce particle elutriation. Tests will be run, the results will be analyzed, and the conclusions will be reported to DOE with recommendations regarding further consideration.

Significant Accomplishments in 1978:

A device and the necessary auxiliary equipment were assembled and tested at ambient temperatures to verify the design basis. High temperature components were fabricated.

Principal Activities Planned for 1979:

The hot test equipment will be assembled and operated with limestone early in the year. The results of the test program will be evaluated. Assuming the feasibility of the application is demonstrated, future development work will be outlined.

Publications in 1978:

None.

IMPROVED OIL AND GAS BURNERS

FY 1978: \$150,000

Principal Investigators: C. H. Waide
and J. S. Milau

FY 1979: \$ 30,000 (Est.)

Sponsor: Division of Fossil Fuel
Utilization (DOE)

Objective:

The objective of the program is to improve the utilization of oil and gas fuels by modification or retrofit of combustion processes and equipment.

Scope:

Brookhaven manages contract work in the boiler and furnace area for the Division of Fossil Fuel Utilization. Emphasis is on reduction of oil and gas fuel use. The work involves proposal reviews, preparation of procurement requests for DOE, monitoring of contract activities, analysis of results, and supporting the DOE program manager in the development of program plans.

Significant Accomplishments in FY 1978:

Contracts dealing with pulsed combustors, premixed-prevaporized fuel system evaluation, an inventory of combustion facilities, and a study of furnace scaling factors were monitored or initiated. Procurement packages were developed, and program plan drafts were prepared.

A pulsed combustor of commercial origin was tested to confirm the high efficiencies reported and to support the interest in including this type of device in the research program.

Furnace modeling was reviewed, as well as residential and light commercial oil and gas heating equipment.

Principal Activities Planned for 1979:

The management of combustion programs within the Office of Fossil Energy of the DOE is being decentralized, and responsibility for this specific program will reside with the Pittsburgh Energy Technology Center (PETC) of DOE. The planning for this and the extent to which BNL will be involved in the management activity are under consideration.

Publications in 1978:

BNL Report

Krishna, C. R. A Review of Furnace Modeling. June 1978. BNL 50888

Scott, E. Residential and Light Commercial Oil and Gas Heating Equipment.
(Informal Report, in preparation)

RESIDUE AND WASTE FUELS

FY 1978: \$240,000

Principal Investigator: J. E. Manuel

FY 1979: \$345,000

Sponsor: Division of Fossil Fuel
Utilization (DOE)

Objective:

The objective of this program is to provide the DOE Division of Fossil Fuel Utilization with project management support in the development of combustion systems for residue and waste fuels (forest, wood, biomass, etc.).

Scope:

BNL provides management support through activities which include making planning recommendations, reviewing proposals, preparing procurement documents, providing systems analysis support, and monitoring contracts.

Significant Accomplishments in 1978:

The Residue and Waste (RW) five-year subactivity annex (program plan) was developed for input to the Division of Fossil Fuel Utilization Multi-Year Program Plan, and a RW Broadened Program Plan with budgets was prepared.

A Request for Proposal (RFP) was prepared for design and cost studies for a small-scale gas generator power system (SSGGPS) utilizing agricultural residues. This effort was supported by a survey of representative standard engine electric generator sets, and by a market and requirements study, performed by the BNL National Center for Analysis of Energy Systems, to identify the agricultural resource potential and costs, and to define economically desirable system sizes and applications.

Principal Activities Planned for 1979:

Support activities will be continued including systems analysis and contract monitoring. Two new contracts will be included.

Publications in 1978:

None.

PROGRAMS PROPOSED FOR INITIATION IN 1980

1. Catalysts for Conversion of Synthesis Gas to Methanol
2. Direct Sampling of Particulate Mass in Combustion Gas Streams
3. LASH--A Laser Ash Fragmentation System for Combustion Gas Streams
4. Feasibility of Rotating Baffles in a Cyclone to Improve Collection Efficiency
5. Determination of Particle Size Distribution of Time of Flight Particle Spectrometer
6. Removal of Submicron Particles by Means of a Regenerative Fluidized Bed Filter
7. Fracture Mechanics in Coal Liquefaction Vessels and Components
8. Gravitational Effects on Combustion
9. Advanced Gasifier-Combustor for Biomass Fuels

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

CONSERVATION PROGRAM MANAGEMENT GROUP

CONSERVATION PROGRAM MANAGEMENT

FY 1978: \$354,000*

Principal Investigator: G. Dennehy

FY 1979: \$425,000*

Sponsor: Contributing program areas

*These funds are included in the funding shown for the four program areas.

Objective:

The objective is to carry out planning and management responsibilities in four program areas: (1) hydrogen-halogen energy storage system, (2) electrolysis-based hydrogen storage systems, (3) energy conservation in residential buildings, and (4) space conditioning, diagnostics, and controls for conservation in buildings.

Scope:

The principal responsibilities undertaken by Brookhaven in this activity are: (1) a planning role in defining the overall DOE research program in each area, and (2) an implementation role involving research projects conducted not only at BNL but also by outside organizations under contract to BNL.

Significant Accomplishments in 1978:

Approximately 25 contracts were placed with outside organizations in 1978, bringing the total contracts placed since the inception of this program to over 40.

Principal Activities Planned for 1979:

A significant number of subcontracted projects will be completed in 1979. Increased effort will be required in management of the preparation of final reports, dissemination of results, planning for follow-on work, and encouragement of commercialization.

Publications in 1978:

BNL Report

Salzano, F. J., and Bonner, M. F. Program Plan for Fiscal Year 1978 for Electrolysis-Based Hydrogen Storage Systems Programs. November 1977. (BNL 23289)

SPACE CONDITIONING, DIAGNOSTICS, AND CONTROLS
TECHNOLOGY FOR CONSERVATION IN BUILDINGS

FY 1978: \$1,100,000

Principal Investigators: G. Dennehy
and L. M. Woodworth

FY 1979: \$2,000,000

Sponsor: Technology and Consumer
Products Branch of the Division of
Buildings and Community Systems (DOE)

Objective:

The objective of this program is to effect conservation of energy supplies by reducing energy consumption in residential and light commercial buildings through improved technology.

Scope:

This program provides for planning and management of the RD&D effort in three areas of the technology subprogram of Consumer Products and Technology Conservation: space conditioning, building diagnostics, and building systems controls. The Brookhaven responsibilities include preparation of detailed RD&D plans and implementation through in-house work and subcontracts with industry. The responsibility for specific subcontracts includes technical and/or administrative control, depending on the program element, the desire of DOE to maintain management responsibility, and the technical capability of BNL in the specific area.

Significant Accomplishments in 1978:

1. Approximately 20 subcontracted projects were continued or initiated.
2. A final report was issued on a survey of insulation materials.
3. Subcontracts placed included those for development of four distinct technical approaches to oil burners with a low firing rate.
4. Four contracts were placed for development of advanced design high efficiency gas furnaces.
5. Responsibility was assumed for providing technical information and support for a pilot oil retrofit program managed for DOE by the New York State Energy Office.

Principal Activities Planned for 1979:

1. Program Plans will be updated as required by progress on individual contracts and changes in overall objectives.
2. Efforts will be made to encourage entry of at least one low-firing-rate oil burner concept into the commercialization process, under industry initiative and financial support.
3. Two surveys of heating equipment technology will be completed by Battelle Columbus, one for oil-fired and one for gas-fired equipment.

4. Cooperative RD&D projects on gas-fired equipment will be pursued with the Gas Research Institute.

Publications in 1978:

BNL Reports

Dynatech R/D Company. An Assessment of Thermal Insulation Materials and Systems for Building Applications. June 1978. BNL 50862

Hendrick, A. S. Control and Metering Systems for Energy Conservation in Buildings: Emerging Communications Requirements. September 1978. (BNL 24874)

ENERGY CONSERVATION IN RESIDENTIAL BUILDINGS

FY 1978: \$320,000

Principal Investigators: G. Dennehy
and W. Marcuse (NCAES)

FY 1979: \$375,000

Sponsor: Architectural and Engineering
Systems Branch of the Division of
Buildings and Community Systems (DOE)

Objective:

The objective is to provide program planning and analysis, in-house research, and management of RD&D conducted by subcontractors.

Scope:

This program provides support to DOE in the residential buildings area of the Architectural and Engineering Systems Branch RD&D effort. The BNL responsibilities include assistance to DOE in program planning and implementation through in-house work and subcontracts with industry. The projects will fall in the following areas of the AES program:

1. RD&D of new and improved energy efficient technologies related to new buildings.
2. RD&D of retrofit technologies related to existing buildings.
3. Proof-of-concept evaluation and use encouragement of appropriate existing or prototype technologies to maximize their market penetration potential.
4. Development of guidelines and criteria for building design, construction, and operation to facilitate widespread adoption of energy efficiency technologies and practices.
5. Identifying and overcoming institutional (e.g., financial, legal, and socioeconomic) barriers to implementation of energy saving technologies and designs.

Significant Accomplishments in 1978:

1. A contract was awarded to Total Environmental Action, Inc. (TEA) for analysis and design of residential buildings utilizing natural thermal storage to reduce energy consumption.
2. A case study was initiated of the Brownell low energy requirement house, an innovative structure utilizing a very tight thermal envelope, passive solar gain, and thermal storage both in the exposed structure and in a below-grade ducted sand bed.
3. A user manual was prepared for the Interactive System for Calculating Energy Use.

Principal Activities for 1979:

1. The TEA thermal storage study will be completed, including design drawings for a tract-type house with thermal storage. A contractor will be selected for construction of the house, probably at the BNL site.

2. A report on the Brownell case study will be issued, and a second case study of innovative structures will be performed.

3. A data base for threshold criteria analysis will be completed.

Publications in 1978:

BNL Report

Schneider, D. Documentation of an Interactive Program for Projecting Space Heating and Energy Demand (IPPSHED). September 1978. BNL 50887

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK