DEAN B. MAHIN
INTERNATIONAL ENERGY PROJECTS

POST OFFICE BOX 591, FRONT ROYAL, VIRGINIA 22630

TELEPHONE (703) 636-2126

PN-AAU-635
44162

Report on a Survey of

BIO-ENERGY ACTIVITIES OF U.S. EDUCATIONAL INSTITUTIONS

And Proposals for

INTERNATIONAL BIO-ENERGY TRAINING PROGRAMS

Submitted to

BIORESOURCES FOR ENERGY PROJECT
FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

Pursuant to

USDA CONTRACT 53-319R-1-145

MAY 10, 1981

CONTENTS

SUMMARY AND RECOMMENDATIONS

Survey Process 1

Summary Conclusions on the Capacities of U.S. Institutions to Conduct Bio-Energy Training..... 2

General Recommendations on the Conduct of Bio-Energy Training Programs... 4

PART ONE: THERMOCHEMICAL CONVERSION OF WOOD AND OTHER BIOMASS

I. Overview of University Activities 6

II. Location of an A.I.D. Training Program on Wood Energy and Thermochemical Conversion..... 6

III. Outline of a Proposed A.I.D. Training Program on Industrial Energy from Wood and Other Biomass..... 9

IV. Appendix One: Thermochemical Conversion Projects at U.S. Universities:

A. Direct Combustion: Wood..... 11

B. Direct Combustion: Other Biomass..... 12

C. Thermal Gasification..... 13

D. Pyrolysis..... 15

E. Other Wood Energy Research..... 16

PART TWO: PRODUCTION OF METHANE THROUGH ANAEROBIC DIGESTION OF BIOMASS

I. Overview of University Activities..... 17

II. Location of an A.I.D. Training Program on Methane Production..... 17

III. Outline of a Proposed A.I.D. Training Program on the Production and Use of Methane From Biomass..... 20

IV. Appendix Two: Methane Projects at U.S. Universities:

A. University Experiements with Farm-Scale Digesters..... 23

B. Basic Laboratory Research on Digestion Processes..... 26

PART THREE: ALCOHOL FUELS

I. Overview of Alcohol Fuels Activities of U.S. Universities & Colleges... 29

II. Location of an A.I.D. Training Program on Alcohol Fuels..... 30

III. Outline of a Proposed A.I.D. Training Program on Alcohol Fuels..... 34

IV. Appendix Three: Alcohol Fuels Activities of U.S. Institutions

A. Basic Research on Ethanol Production..... 37

B. Research on Use of Alcohol and By-Products..... 40

C. University Experiments with Farm-Scale Alcohol Fuel Stills..... 41

(continued on next sheet)

D. Economic Studies on Alcohol Production..... 42
E. Examples of Alcohol Fuels Taining at Community and Technical Colleges..... 43
F. Educational Programs by Universities and other Institutions..... 44

SUMMARY AND RECOMMENDATIONS

Introduction

This report contains the results of a survey and evaluation of the capacities of U.S. educational institutions to provide training on bio-energy sources, systems, and technologies for participants from developing countries and recommendations regarding the development of such programs.

This initial section of the report contains an outline of the survey process, a number of general conclusions, and recommendations concerning principles which should govern the development of specific training programs. Each of the subsequent parts of the report deals with a major bio-energy sector (thermochemical conversion of wood and other biomass, the production of methane gas through the anaerobic digestion of biomass, and the production and use of alcohol fuels). Each of these sections includes a summary of the activities of U.S. educational institutions in the bio-energy sector, recommendations concerning the location of an A.I.D. training program in that sector, an outline of a proposed training program in FY-1982, and an appendix providing detailled information on university projects in the sector.

Survey Process

The information and conclusions in this report were mainly derived from a three-phase survey process:

1. The survey began by assembling information on bio-energy projects at U.S. educational institutions from the following sources: (a) the contractor's own extensive files; (b) the Bio-Energy Directory; (c) documents listing research grants and contracts under the DOE Biomass Energy Systems program, the DOE/SERI alcohol fuels research program, the DOE Appropriate Technology Small Grants program, and the DOE/USDA Special Research Grants program; and (d) programs and/or proceedings of the following conferences: Bio-Energy Congress (1980), International Solar Energy Society conferences (1979 and 1980), Mid-America Biomass Conference (1979), International Conferences on Energy Use Management (1977 and 1979), American Society of Agricultural Engineers Energy Symposium (1980), American Farm Bureau Federation Energy Ideas Symposium (1980), a DOE workshop on energy projects in agriculture (1980), and several local and regional energy workshops.

2. Letters describing the survey and requesting additional information were sent to nearly 100 persons at universities, other educational institutions, and organizations sponsoring bio-energy research. While some of these were individual letters, most persons received a printed letter. There were about sixty responses which included letters, reports, articles, and other printed materials as well as appointments during

the field trips described below. The appendices to each section of this report also include a number of other university projects on which basic information was available from the sources listed in the previous paragraph.

3. After the receipt of most of these responses, seven institutions were selected for field visits in consultation with officers of A.I.D. and the Bioresources for Energy Project. Visits were made to Cornell University (March 23), Purdue University (March 26), the Institute of Gas Technology (March 27), the University of Minnesota (March 30), the University of Nebraska (April 1), the University of Arkansas (April 3), and the Georgia Institute of Technology (April 23).

Summary Conclusions on the Capacities of U.S. Institutions to Conduct Bio-Energy Training

This report describes bio-energy projects and programs carried out by a total of 61 educational institutions; 21 of these are in the Middle West, 17 in the Northeast and Middle Atlantic area, 12 in the South and Southwest, and 11 in the Mountain States and the West Coast. Taken as a whole, these university bio-energy projects represent a substantial effort by the academic community in the U.S. to develop technologies and systems for energy production from biomass. However, several factors limit the capacity of most of these institutions to conduct educational programs related to bio-energy for participants from developing countries:

1. Most of these university bio-energy activities are research projects funded by the Department of Energy and other Federal agencies. Only a few of these institutions have also provided educational programs (academic courses for students or workshops for the general public) which have focussed on any aspect of bio-energy. Educational programs have been most common in the alcohol fuels sector, but most of these programs have been offered by two-year community and technical colleges rather than by universities engaged in bio-energy research. The fundamentals of the basic bio-energy conversion processes (anaerobic digestion, fermentation, and thermochemical conversion) are taught in a number of traditional chemistry, chemical engineering, microbiology, and other courses at major universities; however, only a very few universities have courses which give substantial attention to total bio-energy systems including problems and issues associated with the development of these systems. Several community colleges have developed two-year associate degree programs on alcohol fuels, but the survey did not reveal any degree program at a four-year institution on the use of biomass for energy production. There will thus be rather few opportunities for persons from developing countries to obtain useful bio-energy training through individual placements as undergraduate or graduate students at U.S. universities. It appears that most A.I.D.-sponsored training in bio-energy technologies and systems will have to be provided through special programs for groups of participants.

2. The bio-energy projects of U.S. universities, like most energy research in the U.S., have been designed to contribute to the solution of American energy problems. Many of the research projects have involved complex, capital-intensive processes to use large volumes of residues produced by highly mechanized U.S. agricultural and forestry operations. Even the "farm-scale" alcohol fuels and bio-gas plants developed by a number of U.S. educational institutions require levels of technical skill and/or types of equipment which are beyond the reach of almost all farmers in the developing world. However, some of the bio-energy work of U.S. institutions may be quite relevant to the needs of some developing countries. Much of the basic scientific work on biomass conversion has universal applicability. Some of the medium- and smaller-scale conversion systems being developed in the U.S. may be useful in quite a few countries. The initial challenge of any A.I.D. bio-energy training program will be to help decision-makers in developing countries chose the conversion technologies, equipment, and feedstocks which will be the most appropriate in each of their countries. Regretably, American universities are not very well prepared to meet this challenge.

3. No university research project identified by the survey dealt substantially with bio-energy applications or systems in developing countries or, indeed, in any country other than the U.S. None of the university faculty members responding to the request for information about their bio-energy activities cited or sent papers on bio-energy activities or potentials in other countries. Both the type of funding available for bio-energy research and the backgrounds of the persons conducting bio-energy research have precluded a significant international dimension in the bio-energy projects of U.S. universities. Most of these projects have been carried out by faculty members and graduate students in technical disciplines who have had little or no international experiences. The survey identified only a few individuals who have both substantial bio-energy experience and a demonstrated interest in developing countries; the survey indicated that none of these individuals has as yet engaged in research or writing which dealt with bio-energy in developing countries.

4. A program designed to help decision-makers make the best possible decisions concerning total bio-energy systems would need substantial inputs from a number of disciplines and departments. The full utilization of a university's experience with bio-energy technologies, with developing countries, and with international educational programs would require a type of inter-departmental cooperation which is rare on American campuses. None of the universities visited during the survey seemed to have an adequate institutional mechanism for the conduct of such an inter-disciplinary

program within the bio-energy sphere. Three of the universities had offices which had been established to coordinate energy projects, but the Cornell office has no director at present, the Nebraska office has only an acting and part-time director, and the Minnesota office is primarily involved with the coordination of a large program on energy production from wetlands. The limited responses to the survey by the international offices in the colleges of agriculture at Cornell, Purdue, Illinois, and Missouri suggest that these offices would not be the ideal focal points for the coordination of such programs on their campuses.

The preceding paragraphs are not intended to convey the idea that no American institution is capable of organizing a useful educational program on any aspect of bio-energy for participants from developing countries. The limitations outlined above can be overcome or at least minimized if they are clearly recognized at the outset and compensating elements are built into the plan for each training program.

General Recommendations for the Conduct of Bio-Energy Training Programs

The following principles should be applied to the development and operation of each of the bio-energy training programs recommended in the subsequent sections of this report:

1. The program should make the maximum use of all of the relevant resources of the host university. The contract with the university should be negotiated with a senior university official representing the entire university who can stimulate the participation of all appropriate university departments and elements. The contract should include a specific committment by the university to mobilize all of its applicable resources to carry out the bio-energy program. There should be a contractual provision for a university planning committee which would include representatives of the various disciplines and university offices which could contribute to the bio-energy program.

2. The program should also provide for substantial exposure to the relevant bio-energy activities of other U.S. institutions through the use of visiting lecturers in the program at the host university and through field trips to other institutions by the group of participants. Each contract should contain funds for honoraria and travel expenses for at least five visiting lecturers from other institutions who can provide strong coverage of important topics which have received only limited attention at the host university and/or a wider view of bio-energy options. Each program should include visits by the participants to a number of other institutions and companies; if the host university lacks experience in planning and coordinating such visits, professional programming services should be arranged by sub-contract. The total program should be planned to avoid excessive

exposure to a particular technology or system developed at the host university and should include balancing exposure (through visiting lecturers and visits to other institutions) to those advocating other systems or options.

3. The maximum effort should be made to focus each program on the use of biomass for energy production in the developing countries. An officer of A.I.D. or the Bioresources for Energy Project and/or a qualified consultant should meet with the university planning committee to assist with the development of this important international dimension of the program. In the use of the university's own resources and in the choice of visiting lecturers and field visits, priority should be given to those activities which would contribute to the international focus of the program. Priority in selection of participants should be given to individuals who can make useful presentations on the bio-energy projects undertaken or planned in their countries and who can derive the maximum benefit from a full exchange of experience with their counterparts from other countries. Each program should provide ample opportunities for these presentations by the participants and for discussions within the group and with qualified Americans of the various issues, problems, and constraints which may arise in the development of bio-energy projects in the participants' countries. Additional suggestions for the internationalization of the proposed programs are contained in the outlines of these programs in the subsequent sections.

4. The maximum effort should also be made to make these "first generation" bio-energy programs helpful to officials and executives who must make the difficult choices between feedstocks, conversion technologies, and types of plants and systems. Each proposed program has been based on a common conclusion, derived from previous experience with energy officials from developing countries, that the greatest immediate need is to help decision makers obtain the background information and comparitive economic and technical data they need to make the best possible decisions about bio-projects and programs. In-depth training of engineers or technicians to operate a particular type of digester, alcohol plant, or thermochemical conversion system will be appropriate only after a decision has been reached to acquire such a plant or system. The proposed programs would provide opportunities for discussion with the participants of more specialized types of "second generation" bio-energy training programs which may be necessary at a later stage in the development of the bio-energy resources of developing countries.

PART ONE

THERMOCHEMICAL CONVERSION OF WOOD AND OTHER BIOMASS

I. OVERVIEW OF UNIVERSITY ACTIVITIES

The survey identified twenty-one universities which have conducted research and development projects involving energy production through the thermochemical conversion of wood and other biomass. However, only a few institutions have carried out educational programs in this sector.

Most American activity in this sector relates to the direct combustion of wood for space heating in residences or other buildings. Since only a few of the developing countries have space heating problems, no effort has been made to develop a comprehensive list of the universities and community/technical colleges which have carried out research or educational programs related to wood heating. However, the survey information indicates that the most extensive university activities involving wood heating are those at Georgia Tech, the University of Maine, and Oregon State. Two universities - Georgia Tech and North Carolina State - have major programs to assist southern industries to develop systems for the burning of wood as an industrial fuel. The only university projects revealed by the survey for the direct combustion of biomass other than wood were experiments with the burning of cornstalks at Iowa State, Purdue, and the University of Georgia; an industrial project assisted by Georgia Tech which will burn peanut hulls along with wood residues; and a University of Maine study on burning poultry litter to heat broiler houses.

Fourteen universities have carried out research projects on advanced thermochemical conversion systems. Eleven institutions have studied the thermal gasification of wood and/or other biomass. Georgia Tech has worked on gasifiers using wood pellets and wood chips, while the University of Missouri at Rolla has developed a gasification process for sawdust. Other major gasification research projects - at Kansas State, West Virginia University, Texas Tech, the University of California at Davis, and the University of Florida - have tested some wood residues but have concentrated on the gasification of agricultural residues. The survey also included smaller gasification projects at Michigan State, Cornell, the University of Pennsylvania, and Texas A & M. Four universities - Georgia Tech, Princeton, M.I.T., and the University of Arkansas - have operated major research projects on the pyrolytic conversion of various feedstocks.

II. LOCATION OF AN A.I.D. TRAINING PROGRAM ON WOOD ENERGY & THERMOCHEMICAL CONVERSION

The survey results indicate that the U.S. institution which is best qualified to provide a comprehensive educational program on the use of wood for energy and on

thermochemical conversion processes is the Georgia Institute of Technology. The range of Georgia Tech's activities in this sector is much wider than that of any other educational institution. No other university is extensively involved with each of the three types of thermochemical conversion (direct combustion, gasification, and pyrolysis); details of these Georgia Tech projects are provided in the sections of the appendix to this section on combustion, gasification, and pyrolysis. No other university has had comparable U.S. government funding for activities designed to promote the industrial use of wood, and thus no other institution has been able to accumulate a comparable pattern of experience with feasibility studies, demonstration projects, publications, and workshops on the use of wood in industry.

Despite this impressive array of technical and extension activities, there appear to be some significant limitations on Georgia Tech's capacity to conduct an educational training program for participants from developing countries:

1. The Engineering Experiment Station at Georgia Tech, which conducts all of the institution's bio-energy activities, is essentially a large research organization similar to SRI, Battelle, and other non-profit research institutions; it works closely with private industry and seems to draw most of its staff from the private sector. Bio-energy research projects are carried out by full-time research engineers and technologists, rather than by professors and graduate students as a most universities. Although EES can draw on members of the G.I.T. academic faculty, it would be expected to pay honoraria comparable to those the individuals would receive for lectures or consulting work at other institutions.

2. The international activities and experience of EES personnel seem to be more limited than in an earlier period. From 1973 to 1979 the EES Office of International Programs carried out a number of international projects; many of these were related to the development of small-scale industries in developing countries and were funded under a five-year "211(d)" institutional support grant from A.I.D. However, there have been few such activities since the end of the A.I.D. grant in 1979. Last fall the Office of International Programs was abolished and coordination of international projects was assigned to another EES component, the Technology Applications Laboratory; the Laboratory's Associate Director also serves as chief of the reorganized international division. Present international energy activities consist primarily of a solar desalinization project in Haiti, an energy conservation project in Korea, and sporatic requests for assistance to A.I.D. missions on the development of alternate energy and energy conservation programs under an Indefinite Quantity Contract with the Office of Energy of A.I.D.

3. The Wood Energy Systems Division of EES has no international experience. Two overseas pyrolysis projects were the responsibility of a separate EES unit. Moreover, only the Division staff member who was born in India had significant civilian

experience overseas before coming to Georgia Tech. Since the large DOE-funded State Demonstration Program in Wood Energy is now winding down and DOE funding for biomass projects in 1982 is expected to be only about half that in 1981, the staff of the Division (currently eleven professionals and four support staff) may have been substantially reduced by 1982.

Despite these limitations, Georgia Tech remains the best qualified institution, on balance, to conduct a training program on wood energy and thermochemical conversion systems. A number of these limitations could be minimized by the application of the general principles outlined in the previous section and by supplementing a program at Georgia Tech with other activities as outlined in the next section.

III. OUTLINE OF A PROPOSED A.I.D. TRAINING PROGRAM ON INDUSTRIAL ENERGY FROM WOOD AND OTHER BIOMASS

A. Scope of Training

This training program would concentrate on the use of wood and other biomass as industrial fuels through thermochemical conversion processes. The program would provide (a) a comprehensive review of the present state-of-the-art and available equipment and systems for the various types of thermochemical conversion processes including direct combustion, gasification, and pyrolysis; (b) an examination through classroom briefings and field visits of current projects in the U.S. for the use of wood and other biomass for electric power generation and for the production of steam, hot water, or other process heat for various types of industries; and (c) substantial discussion within the group and with qualified Americans of the current and future use of wood and other biomass for power generation and industrial purposes in developing countries.

B. Participants

This program would be designed for participants from (a) countries with major forested regions which can expand the use of wood in industry and/or for power generation without creating severe environmental problems or reducing the supply of wood fuel for household use, and (b) countries which now produce large quantities of forestry or agricultural residues which could be converted to energy through thermochemical conversion processes.

This "first generation" program would be designed for executives, planners, and other decision-makers of energy ministries, electric power agencies, technology agencies, and industries which are or could be major users of energy from wood or other biomass. Nominees should be currently involved in projects for the use of biomass for energy and/or in positions of responsibility related to the development of alternate sources of energy. Each participant should also have (a) a university degree in engineering or the physical sciences and/or considerable practical experience with combustion systems and (b) sufficient verbal facility in English to permit full participation in seminars and discussions.

C. Program in the United States

The program would consist of several distinct but related elements:

1. Seminars and field trips at the Georgia Institute of Technology, Atlanta (Monday, February 15 through Friday, February 26).

   The Georgia program during this period would include:
   (a) An initial day devoted to brief presentations by each participant on the available biomass and current and possible future uses of biomass for industrial energy in his or her country.
   (b) Presentations by Georgia Tech personnel of the state-of-the art, available equipment and systems, and present operating projects in each of the thermochemical conversion categories.
   (c) Discussion by Georgia Tech personnel and visiting lecturers of economic, financial, environmental, and institutional problems associated with the use of wood and other biomass for energy production.
   (d) Review of the production, preparation, transportation, and storage of wood and other biomass with foresty experts from the Virginia Polytechnic Institute, North Carolina State University, and/or Georgia Forestry Commission.
   (e) Field visits to several wood energy projects in central and south Georgia which will not be included on the itinerary for the pre-conference tour described in Section 2 below.

2. Georgia-North Carolina Pre-conference Tour of Industrial Wood Energy Projects
(Monday, March 1 through Friday or Saturday, March 5 or 6)

During this period the participants in the A.I.D. training program would join a bus tour of industrial wood energy projects in northern Georgia, North Carolina, and possibly southern Virginia which will be offered to all American and foreign participants in the Forest Products Research Society's subsequent conference in Washington. Tentative plans include about two days in northern Georgia (an industrial wood combustion system at Aragon, a gasification system at a state institution in Rome, a wood heating system at a school at Blairsville, and a sawdust-to-steam plant at a textile mill at Ravun Gap); two days in North Carolina (a wood energy project at Salisbury or High Point, a wood pelletization facility at Goldston, the North Carolina State University's industrial wood energy program, and a meeting with North Carolina energy officials); and possibly a stop at a wood energy facility in Virginia enroute to washington on Friday or Saturday.

3. Sixth International Industrial Wood Energy Forum, Washington
(Monday, March 8 through Wednesday, March 10)

The Forest Products Research Society has sponsored five other meetings during the past few years on the industrial uses of wood. The Society is making a special effort to maximize international participation and content in the 1982 meeting. Topics covered will be similar to those for the 1981 Forum which included wood energy policies, fuel preparation and firing, gasification, pyrolysis, wood-fired cogeneration systems, hog fuel boiler systems, and emission controls. The Forum will also include exhibits by more than one hundred companies who manufacture equipment for the handling and preparation of wood fuels and for direct combustion, gasification, cogeneration, and emission control systems.

4. Additional Washington Activities
(Thursday, March 11, and Friday, March 12)

Washington activities arranged for the A.I.D. group following the International Wood Energy Forum might include:
(a) a briefing on DOE's bio-energy programs;
(b) a review of current A.I.D. bio-energy projects with officers of the Office of Energy, the Bioresources for Energy Project, and A.I.D. regional bureau energy officers;
(c) a discussion of wood energy activities with Forest Service officers;
(d) a review of the financing of bio-energy projects with representatives of the World Bank and Inter-American Development Bank; and
(e) an evaluation session to review the entire program during the previous four weeks.

5. Optional Team or Individual Visits
(Monday, March 15, through Friday, March 19)

Many of the participants will be busy officials and planners who may not be able to remain in the United States for longer than four weeks. However, some participants might benefit from opportunities to make one or two brief stopovers in the U.S. along their homeward routes. Asian participants might visit facilities in the Pacific Northwest or California, Latin American participants might be interested in additional southern stops, and African or Middle Eastern participants could stop in the Middle Atlantic or New England areas. The project budget might provide for such stops by about half of the participants.

IV. APPENDIX ONE: THERMOCHEMICAL CONVERSION PROJECTS AT U.S. EDUCATIONAL INSTITUTIONS

A. Direct Combustion: Wood

TECHNOLOGY APPLICATIONS LABORATORY, ENGINEERING EXPERIMENT STATION, GEORGIA INSTITUTE OF TECHNOLOGY, Atlanta, Ga. 30332

Ken Maddox, Associate Director (404) 894-3475
William Bulpitt, Chief, Wood Energy Systems Div. (404) 894-3448

(1) Designed and constructed two mobile demonstration trailers displaying woodstoves and central wood-burning furnaces (Georgia Forestry Commission).
(2) Conducted studies of thermal efficiency of residential fireplaces (DOE).
(3) Developed a wood heating appliance code and information service, conducted three two-day training seminars for woodstove inspectors, and published "Safe and Warm Wood Heat" (34 pages) (TVA).
(4) Under $1,652,489 DOE-funded State Demonstration Program for Wood Energy, conducted feasibility studies on the possible use of wood as an industrial fuel by 18 industrial plants, selected three companies for DOE-funded demonstration projects, and supervised design and construction of these projects.
(5) Organized several seminars on wood energy for industry representatives and published 360-page "Proceedings of Georgia Tech Wood Energy Seminars" and 100-page "Case Studies of Wood Energy" (DOE State Demonstration Program).
(6) Conducted feasibility for a wood-fueled district steam and generating facility at a 500-acre industrial park at LaGrange, Ga. (DOE)
(7) Conducted studies of regional potentials for the use of wood energy in Georgia (for the Coastal Plains Regional Commission), West Virginia (for the Benedum Foundation), and Alabama (Appalachian Regional Commission)
(SEE ALSO GASIFICATION AND PYROLYSIS SECTIONS)

SCHOOL OF FOREST RESOURCES, NORTH CAROLINA STATE UNIVERSITY, Raleigh NC 27650

Michael P. Levi, Extension Forest Resources Officer (919) 737-3386

(1) $91,000 DOE 77-80 grant to provide information on the economic and technical feasibility of burning wood as a fuel in the wood products industry and other industries. Program included test burns of wood pellets and whole tree chips at two commercial installations and other wood combustion tests.
(2) Published 150-page "Decison-makers Guide to Wood Fuel for Small Industrial Energy Users" under SERI imprint, February 1980.
(3) Organized two workshops on wood as an industrial fuel in 1979 and a workshop on "Wood: An alternate Energy Resource for Appalachian Industry and Institutions", April 7-8, 1981, under a grant from the Appalachian Regional Commission.

DEPT. OF AGRICULTURAL ENGINEERING, UNIVERSITY OF MAINE, Orono, Maine

John G. Riley, Associate Professor (207) 581-7852

(1) 1973-75 New England Regional Commission grant to design and build a 200,000 BTU/hr fully automated furnace burning chipped forest residues for use in small institutional heating plants.
(2) Designed following wood chip heating systems: (a) 500,000 BTU/hr system for plant manufacturing roof trusses, 1977-78; (b) 600,000 BTU/hr system for vocational school in Ellsworth, Maine, 1978-79; (c) 200,000 BTU/hr system for TVA in Kentucky, 1979; and (d) 500,000 BTU/hr system for Union County high school in Blairsville, Ga., 1979.
(2) Designed scaled-down wood chip heating system for residential use, 1979-80

DEPT. OF MECHANICAL ENGINEERING, UNIVERSITY OF MAINE, Orono, Maine

Richard C. Hill, Professor

(1) Designed and tested a wood heating furnace using stick wood which is now manufactured by three companies.
(2) Built two wood chip fired residential heating systems.

ENERGY RESEARCH AND DEVELOPMENT INSTITUTE, OREGON STATE UNIVERSITY, Corvallis, O

David C. Junge, Associate Professor and Director (503) 754-4902

1976-80 research project funded by DOE ($498,000), Weyerhaeuser Co. ($150,000) a others to develop a data base on the combustion characteristics of wood residue

DEPT. OF MECHANICAL ENGINEERING, AUBURN UNIVERSITY, Auburn, Ala.

Timothy Maxwell, Professor

Lecturer on efficiency and safety of wood heating stoves at three Wood Heating S sponsored by Wood Energy Institute and Wood Heating Alliance.

SOUTHERN MAINE VOCATIONAL-TECHNICAL SCHOOL, South Portland, Maine

William Warren, Dean of Instruction (207) 799-7303

Established Energy Testing Laboratory which has developed a national role as a safety testing center for wood heating equipment.

B. Direct Combustion: Other Biomass

DEPT. OF AGRICULTURAL ENGINEERING, IOWA STATE UNIVERSITY, Ames, Iowa 50011

Wesley F. Buchele, Professor (515) 294-3917

(1) Supervised Senior Design Team in the 1975-76 design and construction of incinerator-type biomass furnace for burning cornst. ks; furnace was used for co drying experiments.
(2) 1978-81 DOE grant to design and test a concentric vortex biomass furnace; continuing research has produced three prototypes and substantial interest by manufacturers in commercialization of this type of biomass furnace.

COOPERATIVE EXTENSION SERVICE, UNIVERSITY OF GEORGIA, Athens, Ga.

Walter C. Hammond

1979-81 DOE Appropriate Technology grant to demonstrate drying of corn and gra by burning large bales of corn stalks in a specially-designed residue burner.

DEPT. OF AGRICULTURAL ENGINEERING, PURDUE UNIVERSITY, W. Lafayette, Ind. 479

J. R. Barrett

Designed a prototype biomass furnace using a new concept, channel gasification; conducted experiments with corn cobs as fuel and using the exhaust for direct d of corn.

DEPT. OF AGRICULTURAL ENGINEERING, UNIVERSITY OF MAINE, Orono, Maine

John C. Riley, Associate Professor

1977-78 experiments with various techniques for the direct combustion of poultry litter as a means of heating broiler houses.

C. Thermal Gasification

TECHNOLOGY APPLICATIONS LABORATORY, ENGINEERING EXPERIMENT STATION, GEORGIA INSTITUTE OF TECHNOLOGY, Atlanta, Ga. 30332

William Bulpitt, Chief, Wood Energy Systems Division (404) 894-3448

(1) Conducted research over several years on the development of a 10' tall updraft gasifier fueled with densified wood pellets, including the use of the low-BTU wood gas in textile drying, in agricultural applications, and in internal combustion engines.
(2) Survey of wood gasification possibilities in Georgia and practical test programs on gasifier operational problems (DOE State Wood Energy Demonstration Program)
(3) Supervised contractor selection, construction, and operational testing of a large gasification system using total tree chips at the Northwest Regional Hospital in Rome, Ga. (Georgia Forestry Commission).
(4) Feasibility study on the use of commercial-ready wood gasification systems at the American Cyanimid complex in Savannah, Ga.
(SEE ALSO DIRECT COMBUSTION AND PYROLYSIS SECTIONS)

SCHOOL OF ENGINEERING, UNIVERSITY OF MISSOURI AT ROLLA, Rolla, Mo.

V. J. Flanigan, Professor of Mechanical Engineering (314) 341-4572

$830,000 79-81 DOE grant to operate largest fluidized bed gasifier in DOE's thermo-chemical gasification program. Project uses 6' x 25' gasifier donated by Adolph Coors Co. to produce low-BTU gas from sawdust, but system can be adapted to use corncobs, wood chips, garbage, and other biomass. Project is staffed by a 26-person inter-disciplinary team of professors, graduate engineers, and students.

DEPT. OF CHEMICAL ENGINEERING, TEXAS TECH UNIVERSITY, Lubbock 79409

Steven R. Beck (806) 742-3553

(1) 1974-77 research (by J.E. Halligan, W. J. Huffman, and R. L. Peterson) on the development of a counter-current pyrolysis reactor to convert feedlot cattle manure to ethylene and amonia synthesis gas, with funding of about $200,000 from EPA and other sources.
(2) $296,000 DOE 77-79 grant for development of above process through experiments with a ½ ton/day fluidized bed gasifier. Potential feedstocks include manure, wood, cotton gin grash, corn stover, and other agricultural stalks.

DEPT. OF CHEMICAL ENGINEERING, WEST VIRGINIA UNIVERSITY, Morgantown WV 26506

Richard C. Bailie, Professor (304) 293-3280 (Leaving university in May 1981 to work full-time on gasification projects for Environmental Energy Engineering Co.)

(1) SERI 1978-79 grant to test a small Swedish wood gasifier with charcoal briquetts, unprocessed charcoal, hardwood and softwood blocks, and wood pellets and to use the gas produced in an internal combustion engine. (Continued on next page).

(2) Sub-contract with Gilbert Commonwealth Associates, a DOE contractor, to provide experimental data on biomass feedstock characteristics and conversion efficiences for a study for DOE of thermochemical conversion processes.

DEPT. OF AGRICULTURAL ENGINEERING, UNIVERSITY OF CALIFORNIA, Davis, California 95616

John Goss, Professor

(1) $285,000 California Energy Commission 76-79 grant to design, construct, and field test a large-scale, down-draft gasifier to convert agricultural and forestry wastes to low-BTU gas. First phase included laboratory studies of gasification characteristics of 12 agricultural and forestry residues in a laboratory-size gas producer. A mobile gasifier was built and tested at three field locations. Gas was used in a steam boiler, an air heater, and a 60 KW electric generator. Laboratory and field tests indicated good potential for gasification of wood chips, corn cobs, fruit pits, almond and walnut shells; slagging problems were encountered with rice straw, cotton stalks, and cotton gin trash.
(2) $125,00 USDA/DOE 80-82 grant for retrofitting a producer gas unit on a portable gas-powered farm irrigation power plant.

DEPT. OF CHEMICAL ENGINEERING, KANSAS STATE UNIVERSITY, Manhattan, Kansas 66506

Walter P. Walawender, Professor (913) 532-5584

(1) 1979-80 research supported by Kansas Agricultural Experiment Station of gasification of carbonaceous materials (including cane, manure, sewage sludge, and rubber tires) in a 9" internal diameter fluidized bed reactor.
(2) Subsequent preliminary tests on corn stover, milo stover, and wood wastes and experiments with use of the gas from the reactor to operate an internal combustion engine.

CENTER FOR BIOMASS ENERGY SYSTEMS, INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES, UNIVERSITY OF FLORIDA, Gainesville 32611

Wayne H. Smith, Director (904) 372-8576

$746,296 State-funded woody biomass research program in 1980 included projects on the use of wood-fueled gasifiers for heating and power sources and the testing of Swedish and Russian gasifiers with corn cobs, peanut hulls, wood, and other feedstocks.

DEPT. OF AGRICULTURAL ENGINEERING, MICHIGAN STATE UNIVERSITY, E. Lansing, Mich. 48824

John Posselius (517) 355-4720

Built and tested an updraft producer gas generator fueled with charcoal and designed to power a 4 to 6 HP gasoline engine.

COLLEGE OF ENGINEERING AND APPLIED SCIENCE, UNIVERSITY OF PENNYLVANIA, Philadelphia 19104

E. K. Pye

Built small mobile gasifier fueled with wood chips and demonstrated use of medium-BTU gas as a truck fuel.

DEPT. OF AGRICULTURAL ENGINEERING, CORNELL UNIVERSITY, Ithaca, NY 14853

Wesley W. Gunkel, Professor

Built an experimental gasifier and conducted tests with wood chips, corn stalks, soybean stems, rice straw, and peanut shells. Used producer gas to operate 25 HP gasoline engine.

DEPT. OF AGRICULTURAL ENGINEERING, TEXAS A & M UNIVERSITY, College Station, Tex. 77801

Wayne A. Lepori, Professor

$29,663 USDA/DOE 80-82 grant on "Cleanup of Gasses Produced from Gasification of Agricultural Biomass."

D. Pyrolysis

ENERGY AND MATERIAL SCIENCES LABORATORY, ENGINEERING EXPERIMENT STATION, GEORGIA INSTITUTE OF TECHNOLOGY, Atlanta, Ga. 30332

James A. Knight (404) 894-3635

(1) 1969-79 research and experimental work on the development of a vertical bed pyrolytic reactor for the conversion of agricultural and forestry residues into char, oil, and gas.
(2) 1972-80 research projects on the pyrolysis of cotton industry wastes, poultry manure, tropical forestry materials, explosive contaminated waste, whole tree chips, and carpet wastes.
(3) 1978 EPA grant for the development of a prototype mobile system for the pyrolysis of agricultural and/or silvicultural wastes.
(4) Designed, fabricated, and installed a pilot plant at a local brick kiln in Ghana for the pyrolysis of wood sawdust and chips.
(5) Designed and installed a pyrolytic converter using rice husks in the Philippines.

DEPT. OF MECHANICAL AND AEROSPACE ENGINEERING, PRINCETON UNIVERSITY, Princeton NJ 08544

Michael J. Antal, Jr. (609) 452-5136

(1) 1979-81 research program, funded from various sources at about $300,000 per year, on the production of a hydrocarbon rich synthesis gas from organic matter by steam pyrolysis/gasification.
(2) 1979 experiments with the flash pyrolysis of biomass at the Odeillo solar furnace in France, with subsequent research on flash pyrolysis in 1980.
(3) Comprehensive report on "Thermochemical Conversion of Biomass: The Scientific Aspects" for the Office of Technology Assessment, 1979.
(4) Graduate level course on "Fuel Conversion" which emphasizes biomass pyrolysis as a source of fuels and chemicals.

ENERGY LABORATORY AND DEPT. OF CHEMICAL ENGINEERING, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Cambridge, Mass. 02139

William A. Peters, Manager of Fuel Conversion Research (617) 253-3433

(1) $100,000 foundation grant for research on the pyrolysis of biomass, 1978-80.
(2) $112,000 DOE/SERI grant for 1979-81 studies of the yields, compositions, and rates for formation from the pyrolysis of various forms of biomass.

DEPT. OF CHEMICAL ENGINEERING, UNIVERSITY OF ARKANSAS, Fayetteville, Ark.

J. Turpin (501) 575-4951

$440,000 DOE 77-79 project to develop a scale-model rotary kiln pyrolysis converter and obtain pyrolytic conversion data for Ozark region biomass including wood wasttes, rice hulls, cotton gin waste, and particle board scraps.

D. Other Wood Energy Research

SCHOOL OF FORESTRY AND WILDLIFE RESOURCES, VIRGINIA POLYTECHNIC INSTITUTE, Blacksburg, 24061

William B. Stuart, Assistant Professor (703) 961-7674

(1) 1979-81 DOE grant to study the procurement, harvesting, drying, and transportation of woody biomass for energy production. Experiments with crushing and baling of logging residues and short rotation forestry material as an alternative to chipping.

(2) Chairman of International Energy Agency working group on harvesting and transportation of woody biomass for energy, including supervision of development of a harvester for short rotation willow production.

(3) Proposal for graduate course on wood and energy for 1981-82 academic year.

PART TWO

PRODUCTION OF METHANE GAS THROUGH ANAEROBIC DIGESTION OF BIOMASS

I. OVERVIEW OF UNIVERSITY ACTIVITIES

At least 24 U.S. universities have had research or experimental projects on the production of methane through the anaerobic digestion of biomass. Fifteen institutions have built and operated farm-scale digesters, and nine other institutions have conducted laboratory research on the digestion of various feedstocks and/or on the microbial processes of anaerobic digestion.

Most of the university experience with farm-scale digesters has been with projects using animal manures as feedstocks. Faculty members at Cornell, Penn State, Washington State, Georgia Tech, and North Dakota State have worked with digesters on dairy farms. Iowa State seems to be the only university with a farm-scale digester using manure from beef cattle, but the University of Illinois and Colorado State have conducted extensive laboratory research on the digestion of manure from beef cattle. Faculty at the universities of Missouri, Nebraska, Minnesota, and Florida have experience with digesters using swine manure. Projects for the digestion of poultry wastes are being carried out by Georgia Tech, North Carolina State, Tarleton State in Texas, and the University of Puerto Rico. The University of California at Davis has tested a large mobile digester at a dairy farm, a hog farm, and a poultry farm.

There have been fewer projects for the anaerobic digestion of agricultural crops and residues. The University of Arkansas seems to be the only university with personnel who have had experience with the digestion of agricultural residues (hay, grasses, and corn stover) in a farm-scale digester. However, Cornell's digestion research now emphasizes agricultural residues, especially corn stover and wheat straw. There have been a number of laboratory experiments with the digestion of other feedstocks including cattails (Florida, Minnesota), water hyacinths (IGT, Florida), grape skins (SUNY at Fredonia), duckweeds (Louisiana State), kelp (IGT), citrus peels (Florida), and tomato wastes (University of California at Davis).

In addition, researchers at the University of Illinois, IGT, UCLA, Stanford, Colorado State, Montana State, and the University of Florida have conducted laboratory studies on the scientific parameters of anaerobic digestion with various types of feedstocks, pretreatment techniques, and digester operating conditions.

II. LOCATION OF AN A.I.D. TRAINING PROGRAM ON METHANE PRODUCTION

A number of factors point to the conclusion that Cornell University is the institution which is best qualified to provide an educational program on the production and use of methane from biomass in developing countries:

1. Cornell has broader experience with methane projects and research than any other U.S. university. Professor William Jewell has received more than a million dollars from the U.S. Government for methane research since 1976 and continues to have the largest budget of any DOE contractor in this sector.

2. While most of the other university methane projects have emphasized equipment and techniques suitable for large American farms, the stated goal of much of the Cornell biogas research has been to develop simple and inexpensive reactors which would be practical and economically feasible for small farms. Comparitive tests at Cornell with more complex completely-mixed reactors and simpler plug-flow reactors demonstrated that the plug-flow reactors were both more economical and more efficient. These reactors were constructed of low-cost materials including flexible liners and earth-supported structures.

3. The Cornell biogas research program is now concentating on the use of crop residues as feedstocks in biogas plants, rather than manures. Most of the work on the digestion of animal manures in the U.S. has been designed for livestock operations in which a large number of cattle, swine, or poultry are confined in a limited space in a feedlot or building. However, most of the livestock raising in the developing world is pastoral, and systems designed for confined animals are not applicable. Therefore, the greatest potential for biogas production in many developing countries is through the use of crop residues as feedstocks. Cornell would be prepared to emphasize the use of these residues in an educational program for AID on methane production.

4. Cornell seems to be the only U.S. university which has conducted a major workshop on biogas production. A workshop on "Methane Technology for Agriculture" in March 1981 was attended by 300 persons.

5. Cornell's total involvement with the developing countries seems greater than that of any other university included in the survey. The university has an impressive array of internationally-oriented courses and degree programs. A brochure on study opportunities at Cornell in international agricultural and rural development lists 40 courses in "International Agriculture". Faculty members teaching courses on soils and crops of the tropics, livestock in the tropics, economic development, and rural sociology in developing countries would all have contributions to make to an inter-disciplinary program on the production and use of biogas in developing countries.

6. Several Cornell faculty members are substantially involved with the development and use of renewable energy technologies in developing countries. David Pimentel, Professor of Entomology, was Chairman of the National Academy of Sciences's Board on Science and Technology for International Development (NAS/BOSTID) at the time of its study on "Energy for Rural Development" in 1976; he is currently chairman.

of a DOE panel which is examining the environmental and social impacts of the extensive use of biomass for energy. Raymond C. Loehr, Director of the Environmental Studies Program in the College of Agriculture, has conducted methane research and is currently chairman of a NAS/BOSTID study on factors affecting the diffusion of renewable energy technologies in developing countries. Harold Capener, Chairman of the Department of Rural Sociology, has extensive international experience and is currently a member of a NAS/BOSTID committee helping the National Research Council of Egypt develop its biogas program.

Less positive factors affecting Cornell's capacity to conduct a methane program for A.I.D. may include some limitations on the time that Professor Jewell would be able to devoted to the planning and conduct of the program, his acknowledged lack of international experience, the apparent absence at present of an adequate mechanism to coordinate an inter-disciplinary program at Cornell, and an academic "star system" which may encourage solo performances by distinguished professors more than inter-disciplinary cooperation and teamwork. However, these problems seem surmountable through the application of the principles recommended on page 4 and 5 of this report to the proposed training program outlined on the following pages.

III. OUTLINE OF A PROPOSED A.I.D. TRAINING PROGRAM ON THE PRODUCTION AND USE OF METHANE FROM BIOMASS

A. Scope of Program

This program would provide a broad view of technologies, equipment, and techniques for the production and use of methane through the anaerobic digestion of a wide range of animal wastes and plant materials. The program would include special efforts to maximize the interchange of experience and ideas among the participants and with interested Americans on both the technical and non-technical aspects of biogas production and utilization.

B. Participants

This program would be designed for participants from (a) countries which already have or are developing programs for the production of methane from animal wastes and (b) countries which produce large quanities of residues from one or more major crops which could be converted to methane through anaerobic digestion.

Appropriate nominees would include (a) individuals in leadership positions in organizations or institutions which are already conducting or sponsoring biogas projects; (b) officials, executives, and planners of energy agencies, technology agencies, and other ministries or agencies which are considering the development or sponsorship of biogas projects. Each participant would be required to have (a) a university degree in agriculture, engineering, chemistry, or the natural sciences or substantial practical experience with the operation of biogas plants and (b) sufficient verbal facility in English to permit full participation in seminars and discussions.

C. Timing

The program should take place in relatively warm weather when most digestion projects are in full operation. The program is not tied to any fixed date such as a conference. An early July starting date would seem appropriate from the standpoint of the schedule of Professor Jewell and the availability of on-campus housing for participants during the summer months.

D. Program in the United States

The proposed program would have several distinct phases:

1. Washington briefings (Day 1 through 4)

Participants would assemble in Washington on a Sunday, Day 1. The subsequent three days would be used for (a) briefings by the project coordinator, get-acqainted sessions, and discussion of any options for individualized activities and/or homeward travel after the group phase of the program; (b) a review of A.I.D. energy programs by an Office of Energy official and team visits to A.I.D. regional bureau energy officers; (c) briefings on DOE and USDA programs for biogas development in the U.S.; (d) a seminar with representatives of the World Bank and Inter-American Development Bank on the financing of biogas projects or programs; and (e) possible visits to, or meetings with, representatives of development oriented organizations including VITA, Overseas Development Council, and the Society for International Development.

2. Virginia-Pennsylvania Field Trip En Route to Ithaca (Day 5 and 6)

On Thursday morning the participants would depart by chartered bus for two-days of field visits to methane facilities which are more or less on the route to Ithaca. These would include (a) a Thursday morning visit to the "Energy Integrated Farm Systems" demonstration project at Foxlease Farm in Loudoun County, Virginia, which will produce methane from cow manure and use it for electricity generation; (b) a Thursday afternoon visit to the large methane production and power generation system at Mason-Dixon Farms near Gettysburg, Pa., and (c) the large research digester operated by the Pennsylvania State University at University Park, on Friday morning. The group would arrive in Cornell on Friday afternoon or evening.

3. Cornell Lectures, Seminars, and Field Trips (Day 9 through 18)

The first week of the Cornell program would be used for a series of lectures and seminars with Cornell personnel and visiting lecturers on the American experience with methane generation through anaerobic digestion. Roughly one day would be devoted to each of the following topics: (a) overview of methane research and biogas projects in the U.S. and summary of Cornell's biogas program; (b) fundamentals of anaerobic digestion and types of feedstocks; (c) types of digester designs and digester operations; (d) use of biogas for heating, cooking power generation, and in other internal combustion engines; and (e) economic, financial, and environmental aspects of biogas production in the U.S.

The first two days of the second week would be used for field visits to several methane projects near Ithaca including (a) Cornell's methane research facility at its Animal Sciences Training and Research Center at Harford, (b) methane production at the Agway Research Farm at Fabius, and (c) the Cornell-operated "Energy Integrated Farm Systems" project at Millbrook Farm which will include methane production. Wednesday might be used for a review of bio-energy options other than methane, including alcohol production, combustion, gasification, pyrolysis, and the direct use of vegetable oils as a substitute for diesel fuel.

4. International Workshop on Bio-gas in Developing Countries (Day 19 and 20)

The last two days of the Cornell program would be used for a workshop designed to stimulate interchange among the participants and with Americans on the opportunities for and limitations on the production and use of biogas in developing countries. Workshop participants would include the members of the A.I.D. group, Cornell faculty interested in methane production and/or the energy problems of developing countries, and a number of Americans and others from other institutions. The project budget would cover the participation of two or three Americans from other universities with a special interest in bio-gas in developing countries. A number of appropriate organizations (AID, USDA, DOE, UN, foundations, World Bank, Inter- American Development Bank, Overseas Development Council, VITA, and the AID-sponsored energy training units at SUNY Stony Brook and the University of Florida) would be invited to send representatives at their own expense.

The workshop format would emphasize inputs from the members of the A.I.D. training group who would be advised in advanced to bring slides or charts to accompany presentations on biogas projects in operation or planned in their countries. There would be sessions (or perhaps simultaneous sub-sessions) on digester designs for developing countries, on the digestion of agricultural residues in tropical countries, on the use of biogas in these countries, and on the

economic, environmental, cultural, and institutional problems which must be resolved if biogas is to contribute significantly to economic development. If it appears that additional time is needed, the workshop can be scheduled to continue through lunch on Saturday. Rapporterurs would summarize the discussion in each section of the workshop, and the project budget would provide for the publication of a summary of the workshop proceedings. Since the A.I.D. group would be splitting up after the Cornell phase of the program, an evaluation session for the entire training program would be scheduled on Saturday morning or afternoon (Day 21).

5. Optional additional team or individualized visits (Day 22 through 27)

Many of the participants who are extremely busy at home will be glad to depart for home after three weeks in the U.S. However, others might profitably use some additional days for professional visits to methane projects of the types which could not be covered in the field trips in Virginia, Pennsylvania, and New York. Asian participants could make one or two stops in the Middle West, California, or Hawaii on their way home. Latin American participants might benefit from visits to projects in North Carolina, Georgia, or Florida. African or Near Eastern participants could participate in some of these visits in the Middle West or South, even though they were not on their homeward routes. Most of these visits would be team visits by several participants, although individual visits might be necessary in a few cases. The project budget might provide for supplementary per diem and travel costs for approximately half of the participants during this period.

IV. APPENDIX TWO: METHANE PROJECTS OF U.S. UNIVERSITIES

A. University Experiments with Farm-Scale Digesters:

DEPT. OF AGRICULTURAL ENGINEERING, CORNELL UNIVERSITY, Ithaca NY 14353

William J. Jewell (607) 256-4533

(1) 1976 NSF/ERDA grant for a comprehensive study of the technical and economic feasibility of generating methane gas from dairies and feedlots.
(2) $280,617 ERDA 76-77 grant to study improved fermenter designs using small-scale laboratory modes and demonstrate the feasibility of new processes in large scale pilot plants.
(3) Continuing DOE funding ($950,000 cumulative through mid-1979) for studies of improved techniques for methane generation in agriculture including comparitive tests of completely-mixed and plug-flow reactors. A full-scale plug flow system has been operated continuously since June 1978.
(4) 1980-84 grant for additional studies emphasizing the storage and use of biogas.
(5) Separate DOE 1980-81 grant for research on "dry fermentation" process for the digestion of wheat straw, cornstalks, and other agricultural residues. Thirty ton/day digester using this process will be built in summer of 1981.

Robert Parsons (607) 256-7654

Organized three-day workshop on "Methane Technology for Agriculture" attended by over 300 farmers, consultants, extension personnel, and others, March 17-19, 1981

L. P. Walker

$766,000 DOE 1980-84 "Energy Integrated Farm Systems" grant for energy demonstrations at Millbrook dairy farm which will include production of methane from cow manure and production of electricity with biogas in Totem generator.

DEPT. OF AGRICULTURAL ENGINEERING, PENNSYLVANIA STATE UNIVERSITY, University Park, Pa.

H. D. Bartlett (814) 865-5419

(1) Pa. Dept. of Agriculture 74-82 funding for design, construction, and operation of 3,500 cu. ft. vertical, double chamber insulatedconcrete silo digester. Floating steel roof serves as gas collector; biogas has been used in a spark-ignition engine.
(2) Publication of "Agricultural Anaerobic Digesters: Design and Operation", 1979, and "Bigas from Manure", 1980.

DEPT. OF AGRICULTURAL ENGINEERING, WASHINGTON STATE UNIVERSITY, Pullman, Wash. 99614

R. E. Hermanson

(1) Participated in the monitoring of the Ecotope Group's 100,000 gallon anaerobic digester at a 180-cow dairy farm in Monroe, Washington.
(2) Presentation on the economics of biogas production from dairy cow manure at a workshop for dairymen, March 1981.

DEPT. OF AGRICULTURAL ENGINEERING, NORTH DAKOTA STATE UNIVERSITY, Fargo, N.D.

Harvey J. Hirning

$398,700 DOE 80-84 grant to establish "Energy Integrated Farm Systems" demonstration which will included generation of methane from manure from a 100-cow dairy farm. Methane will be used to produce electricity for farm use.

DEPT. OF AGRICULTURAL ENGINEERING, IOWA STATE UNIVERSITY, Ames, Iowa

Richard J. Smith (515) 294-3917

(1) Several years of research funded by USDA with small digester using manure from two beef cattle.
(2) DOE 1979-81 Appropriate Technology grant to build and test a digester for 60 head of beef cattle. System was completed by mid-1980; initial data has been collected by a colleague while Smith has been on sabbatical leave in New Zealand in spring of 1981.

DEPT. OF AGRICULTURAL ENGINEERING, UNIVERSITY OF MISSOURI, Columbia, Mo. 65211

James R. Fischer (304) 882-8337

(1) pilot-size digester tested with swine manure, 1974-76.
(2) 37,000 gallon 16' x 19' concrete silo digester constructed at University's 40-sow Swine Research Farm, 1975-76.
(3) Continuous multi-disciplinary research since 1976 has included studies of the bacteriology and biochemistry of anaerobic digestion, the storage and use of methane, the use of fertilizer nutrients in the digested material, and the simplification and cost reduction of digester equipment. Program was the only university-based research on anaroebic digestion funded by USDA through later 1970's.

Eugene L. Ianooti

$99,724 USDA/DOE research grant on "Microbiology of Mesophilic Anaerobic Digesttion of Swine Manure to Methane", 1980.

F. D. Harris

$79,076 USDA/DOE 1980 grant on "Energy Management in a Biogas-Ethanol Production Unit". System to be completed in summer 1981 will include production of electricity from biogas, use of thermal energy from the electric generator for alcohol production, and feeding of residue from the alchol process to swine.

DEPT. OF AGRICULTURAL ENGINEERING, UNIVERSITY OF MINNESOTA, St. Paul, Minn. 55108

Philip R. Goodrich (612) 373-0764

(1) $36,00 Minnesota Energy Agency 77-79 grant to demonstrate feasibility of using methane from anaerobic digestion to provide electric power for a Minnesota farm. Project included operation of a research digester on a medium-sized pig farm and use of bio-gas in 25 KW generator.
(2) Participated in study of electric power use on livestock farms to assess potential for using biogas for power generation on such farms.
(3) Built digesters while on sabbatical leave at a Canadian university, 1979-80.
(4) Member of the National Academy of Sciences Advisory Panel assisting National Research Council of Egypt in development of biogas program.
(5) Accompanied Egyptians from above program on visits to biogas projects in India, Thailand, and the People's Republic of China.

DEPT. OF AGRICULTURAL ENGINEERING, UNIVERSITY OF NEBRASKA, Lincoln, NE 68583

Dennis Schulte (402) 3930

(1) In previous position at the University of Manitoba during 1978-79, participated in extensive research on the anaerobic digestion of swine manure at relatively low temperatures.
(2) Supervisor of methane component of "Energy Integrated Farm Systems" demonstration at UNL Field Laboratory near Mead, Neb. Demonstration will include methane production from the manure from a 10-sow swine facility; methane will be used for space and water heating and for electric power generation. Total demonstration which includes alcohol production from sweet sorghum is funded with $860,000 DOE 80-84 grant and will be operational in summer of 1981.

DEPT. OF AGRICULTURAL ENGINEERING, UNIVERSITY OF CALIFORNIA AT DAVIS, Davis, CA 95616

David J. Hills (916) 752-0102

(1) Extensive 1979-80 laboratory research projects on anaerobic digestion of dairy cattle manure, a mixture of dairy manure and chopped barley straw, and cannerytomato waste solids.
(2) $68,000 California Energy Commission grant to build and test a mobile 6000 gallon digester; field tests from April 1980 to February 1981 included a dairy farm, a tomato cannery, a poultry farm, and a hog farm.
(3) co-author of "Basic Fundamentals of Methane Generation from Agricultural Wastes" (10 pp), UC Davis, 1980.

TECHNOLOGY APPLICATIONS LABORATORY, ENGINEERING EXPERIMENT STATION, GEORGIA INSTITUTE OF TECHNOLOGY, Atlanta, Ga. 30332

Daniel J. O'Neil

(1) Laboratory studies of anaerobic digestion of poultry manure, 1974.
(2) Operated 10,000 gallon digester on a 60,000-bird poultry layer farm from 1976 to 1979 under a grant from the Georgia Agriculture Dept.
(3) Conducted seminar on anaerobic digestion at a workshop in Brazil, June 1980.

Ralph M. Lamade

"Energy Integrated Farm Systems" demonstration at Aubrey Farm, 50 miles N. of Atlanta, will include methane production from dairy cattle manure and use of methane for electricity for farm use.

DEPT. OF AGRICULTURAL ENGINEERING, MICHIGAN STATE UNIVERSITY, East Lansing, Mich.

William T. Rose (517) 355-4720

Published 18-page information paper on "Anaerobic Digestion of Livestock Wastes into Methane Gas."

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH, UNIVERSITY OF PUERTO RICO, San Juan

M. D. Erdman

"Energy Integrated Farm Systems" demonstration will include production of methane from poultry wastes (Manure, wasted feed, feathers, and broken eggs). Methane will be used for electricity production for farm use.

DEPT. OF POULTRY SCIENCE, NORTH CAROLINA STATE UNIVERSITY, Raleigh NC 27650

James C. H. Shih (919) 737-2623

(1) $25,760 N.C. Energy Institute 78-80 grant for laboratory study of potential for methane production from poultry wastes including litter.
(2) $29,550 DOE 80-81 Appropriate Technology grant to demonstrate a low-cost anaerobic digester for methane generation from poultry waste.

TARLETON STATE UNIVERSITY, Stephenville, Texas, 76402

$48,940 DOE 1979-81 Appropriate Technology grant to construct and operate a biogas generator using chicken droppings from a chicken farm; biogas will be used to provide heat for the farm operation and to generate electricity for farm use.

DEPT. OF CHEMICAL ENGINEERING, UNIVERSITY OF ARKANSAS, Fayetteville, Ark. 72701

James. L. Gaddy, Chairman (501) 575-4951

(1) Laboratory studies in 1966-67, during previous position at the University of Missouri at Rolla, to demonstrate feasibility of producing methane from various materials including hay, cornstalks, oak leaves, and municipal solid waste.
(2) $150,000 DOE/SERI grant to conduct tests on the digestion of spoiled hay and cornstalks in 2000 cu.ft., four-tank system at New Life Farm in southern Missouri.
(3) Technical assistance missions for the United Nations on the development of biogas systems using agricultural residues in Mexico (with corn stover) and in Pakistan (using corn and wheat chaff).
(4) Presentation at ASAE National Energy Symposium, 1980, on economics of production of both methane and ethanol from corn stover.
(SEE ALSO ALCOHOL FUELS SECTION).

B. Laboratory Research on Digestion Processes

UNIVERSITY OF ILLINOIS, Urbana, Illinois 61801

Department of Civil Engineering

John T. Pfeffer, Professor of Sanitary Engineering (217) 333-6965

(1) $210,000 National Science Foundation 74-76 grant to study the anaerobic digestion of beef cattle manure using four 0.75 m^3 heated fermentation tanks.
(2) $875,000 cumulative ERDA/DOE 76-81 funding for further study of conversion efficiencies of manure, corn stover, and wheat straw; methane yield was studied as a function of plant species, fiber composition, thermochemical pretreatment or post-treatment, temperatures, liquid recycle, and residence time.

Department of Dairy Science

Marvin P. Bryant, Professor (217) 333-2090

(1) Laboratory research from 1975 to 1978, funded by USDA and Ill. Ag. Experiment Station, on the parameters of thermophilic methane production from beef cattle wastes
(2) $66,000 NSF 1978-79 grant for further study of the microbial ecosystems in the anaerobic degradation of organic matter.

DEPT. OF CIVIL ENGINEERING, STANFORD UNIVERSITY, Palo Alto, CA 94305

Perry L. McCarty, Professor (415) 497-3921

(1) Various studies of anaerobic digestion in 1961, 1964, and 1973.
(2) $86,000 NSF grant and $379,000 DOE 78-80 grant to evaluate thermochemical pretreatment as a method of increasing the biodegradability of organic materials. Research has included evaluations of the biodegradability of various agricultural residues.
(2) Laboratory course in biological wastewater treatment in which students operate methane-producing reactors.

SCHOOL OF PUBLIC HEALTH, UNIVERSITY OF CALIFORNIA AT LOS ANGELES, L.A. 90024

Robert A. Mah, Professor of Environmental Microbiology (213) 82 5-7240

(1) $ 780,000 1974-79 grant from Southern California Edison Co. for studies of microbial processes involved in methane production from urban wastes, sewage, and food processing residues.
(2) Author of more than 20 articles and papers on microbial aspects of methane formation since 1966.
(3) $300,000 1978-80 SCE grant for research on anaerobic digestion of urban solid wastes and sewage sludge to develop optimum waste mixture combinations and digester operating parameters for a demonstration urban waste conversion facility.

CENTER FOR BIOMASS SYSTEMS, INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES, UNIVERSITY OF FLORIDA, Gainesville, Fla. 32611

Wayne H. Smith, Director (904) 372-8576

State-funded IFAS Biomass research program, which total over $3,000,000 in 1980, included following methane projects:
(1) Research on methan production from acquatic plants (Reddy, Sanford Ag. Research Center.
(2) Studies of microbiological aspects of methane formation (Smith, Dept. of Microbiology).
(3) Production of methane from citrus peels (Ingley, Dept. of Mech. Engineering).
(4) Assessment of methane potentials of various biomass feedstocks (LeGrand, Dept. of Agronomy)
(5) Methane production from swine manure, beef cattle manure, and horse manure (Coombs, Shirley, and Ott, Dept. of Animal Science).
(6) Operation of a 4,000 gallon farm-scale methane digester, (Nordstedt, Dept. of Ag. Engineering)

DEPT. OF MICROBIOLOGY, COLORADO STATE UNIVERSITY, Fort Collins, Col. 80523

R. P. Tengerdy

Annual NSF funding at about $35,000 to $40,000 per year from 1976 to 1981 for studies of anaerobic digestion of feedlot wastes and improved methods for biodegrading lignocellulose.

CHEMISTRY DEPARTMENT, MONTANA STATE UNIVERSITY, Bozeman, MT 59717

John Robbins

Continuing research since 1974 with Montana state funding on optimum carbon-nitrogen ratio for production of methane and increased efficiences in digestion processes.

DEPT. OF CHEMICAL ENGINEERING, LOUISIANA STATE UNIVERSITY, Baton Rouge 70803

Dudley Culley. (504) 388-6051

Research program since 1975 on the use of acquatic plants (duckweed) in the diet of dairy cattle has included laboratory studies of methane generation from manure of the cattle fed with duckweeks and the design of a dairy farm methane system.

STATE UNIVERSITY OF NEW YORK AT FREDONIA, Fredonia, NY

Wayne Yunghans

$4,500 DOE Appropriate Technology grant to study the anaerobic digestion of grape skins from New York State wine production.

INSTITUTE OF GAS TECHNOLOGY (ILLINOIS INSTITUTE OF TECHNOLOGY), 3424 State Street, Chicago, Ill. 60616

Donald L. Klass, Vice President (Education) (312) 567-3783

(1) Maintains 4000 sq. ft. of laboratory space and 34 fermenters for research on microbial gasification and liquefaction of biomass and wastes and related problems.
(2) 1973-75 in-hours research on microbiological conversion of waste materials to methane. Research resulted in development of "Biogas" process to convert soild refuse and sewage sludge to synthetic gas.
(3) Conducted one-year training program 1977-78 at IGT for ten engineers from Sao Paul (Brazil) gas company on above biogas process.
(4) Laboratory studies 1977-78 on methane production from water hyacinths, giant kelp, and Bermuda grass.
(5) Sponsored annual mid-winter symposium on "Energy from Biomass and wastes" each year since 1976.

PART THREE

ALCOHOL FUELS

I. OVERVIEW OF ALCOHOL FUELS ACTIVITIES OF UNIVERSITIES AND COLLEGES

The number of U.S. educational institutions which have some involvement with alcohol fuels is considerably greater than the number of instituttions involved with either thermochemical conversion or anaerobic digestion. More than sixty institutions have carried out some kind of research or educational project related to alcohol fuels. However, the alcohol work is high decentralized and fragmented. The survey has revealed no institution which (a) has substantial experience with both research and educational activities related to alcohol fuel production or (b) is conducting a comprehensive multi-disciplinary research program on both the technical and non-technical aspects of alcohol fuels development.

The recent interest in alcohol fuels has been a boon to the chemists, chemical engineers, and microbiologists at American universities. The survey found twenty universities which are conducting some type of laboratory research on some aspect of ethanol production. Most of this research deals with the production of sugars from cellulosic materials through enzymatic hydrolysis or acid hydrolysis; all but a few of these university projects have been funded by federal agencies including DOE, USDA, NSF, and EPA. However, only a handful of these universities are also engaged in educational or demonstration projects on alcohol fuels. Of the twenty institutions conducting ethanol research, only two (the University of Pennsylvania and Georgia Tech) have organized educational workshops on alcohol fuels and only one institution (Iowa State) is operating a farm-scale alcohol still.

Most of the education programs on alcohol fuel production are provided by two-year community or technical colleges. Following a large public response to a pioneer alcohol production workshop at Colby Community College in Colby, Kansas, in 1979, DOE gave $10,000 grants to 29 community and junior colleges to conduct alcohol fuel workshops. Although not all of the recipients of these grants were able to use them to conduct workshops, a forthcoming survey of energy activities of member institutions by the American Association of Community and Junior Colleges will indicate that approximately 30 of these institutions have conducted one or more alcohol workshops. A few of these have developed an on-going series of such workshops and/or have offerred courses or even degree programs to students on alcohol fuel production. The outstanding alcohol fuels programs of six of these instiutions are described in the Appendix to this section; additional information will be available soon from the AACJC energy directory.

Four-year institutions have carried out relatively few educational and demonstration programs on alcohol fuel production. The survey revealed only four universities which have conducted alcohol fuel workshops; these were at the University of Pennsylvania, Georgia Tech, University of Wisconsin Extension, and the University of California at Davis. Two other universities (Michigan State and Washington State) have prepared extensive written materials on alcohol production for distribution through extension channels. Only three universities (South Dakota State, Iowa State, and Eastern Oregon State) were found to be currently operating farm-scale alcohol stills, although four others (Georgia Tech, Ohio State, and the Universities of Nebraska and Minnesota) are funded to build demonstration stills during the coming year.

The survey indicated a rather limited interest in the economics of alcohol fuel production among university economists, although many of the technical people conducting alcohol research or demonstrations have analyzed economic data on their projects or processes. The survey found only four institutions (Purdue, Oklahoma State, South Dakota State, and the University of Florida) where there have been substantial studies by economists of the economic aspects of alcohol fuel production.

II. LOCATION OF AN A.I.D. TRAINING PROGRAM ON ALCOHOL FUELS

The recommendation of an appropriate university to conduct a training program for A.I.D. in the alcohol fuels sector proved to be much more difficult than the recommendation of institutions to conduct programs in methane production and thermochemical conversion systems. The survey included field visits to three Midwest universities which have substantial alcohol fuels activities: Purdue, the University of Nebraska, and the University of Arkansas. While each of these institutions has substantial assets which would be relevant to some segments of an A.I.D. training program, none of these is ideally qualified to conduct a comprehensive program on alcohol fuels.

Purdue is the strongest of the three in the assessment of economic, environmental, land-use, agricultural policy, and foreign trade implications of expanded alcohol fuel production. Purdue was the only university in this group which has personnel actively involved with alcohol fuel issues in developing countries. However, these Purdue assets could be tapped rather easily by inviting one or two Purdue faculty members to another host university to participate in the A.I.D. program as visiting lecturers. Purdue also has the largest university-based research laboratory working on various aspects of the chemistry of alcohol production. However, the director of that laboratory stated that he would not be interested

in participating substantially in any training program unless it was confined primarily to technical training and was developed and managed by his staff. Under these circumstances, it seems best to narrow the choice to Nebraska or Arkansas.

The University of Nebraska at Lincoln is the strongest of the three institutions in research on the utilization of alcohol as a motor fuel and on the use of residual distillers grains as livestock feeds. Nebraska also offers the best opportunities to expose the participants to the on-farm alcohol fuel movement in the U.S., including contacts with gasohol advocates, visits to on-farm alcohol fuel stills, and observation or participation in alcohol fuel workshops organized by community colleges. However, this exposure might be a mixed blessing. The gasohol movement in Nebraska has arisen from the interest of Nebraska corn growers in expanding the market for corn and in using corn to produce alcohol on the farm for farm vehicles. Due to climatic limitations on corn production and the potential threat posed by alcohol production from grains to the food supply for humans and animals, corn will not be widely used as a feedstock for alcohol production in developing countries. Moreover, the type of on-farm alcohol production being developed in the U.S. Corn Belt requires levels of technical capability and capital investment which are beyond the capacities of most farmers or even farm cooperatives in developing countries. A Nebraska-based training program would almost inevitably emphasize on-farm production of alcohol from corn, while most alcohol fuel production in developing countries will probably be in medium-sized industrial units using other feedstocks.

The University of Arkansas has a number of substantial assets for the conduct of an A.I.D. training program on alcohol fuels:

1. The University has two units which are involved with alcohol fuels. The Biomass Research Center directed by George Emert was established in 1979 when the Gulf Oil Company donated patents and equipment to the University for an enzymatic hydrolysis process for the conversion of cellulose to ethanol; Dr. Emert and several collegeagues came to Arkansas from Gulf with the Gulf donations. Dr. James Gaddy, Chairman of the Department of Chemical Engineering, and his colleagues have also conducted research and educational programs in alcohol fuels.

2. The University of Arkansas would be able to provide the broadest program on the prospects for the utilization of cellulosic wastes (including agricultural wastes, forest industry wastes, and urban solid wastes) for ethanol production. The Gulf/Arkansas process can be used for a number of cellulosic feedstocks. Dr. Gaddy has conducted laboratory and economic studies on the conversion of

agricultural residues to alcohol. A considerable emphasis on the prospects for the use of cellulosic feedstocks may be more appropriate in an A.I.D. alcohol fuels training program than a program emphasizing the use of grains as feedstocks. A balanced program on cellulose conversion would be feasible, since Dr. Emert's process involves enzymatic hydrolysis, while Dr. Gaddy has worked primarily with acid hydrolysis.

3. Both Emert and Gaddy have a number of years of experience in industry and are involved in various ways with industrial projects for alcohol fuel production. Thus an Arkansas-based program could include an industry perspective, in contrast to the greater emphasis on on-farm alcohol production in Nebraska.

4. Both Emert and Gaddy are already involved in various ways in the use of renewable energy technologies in developing countries. Emert is working with prospective licensees for the Gulf/Arkansas process in Brazil, Malaysia, and the Philippines. Gaddy has served as a UN consultant on renewable energy projects in Mexico and Pakistan and attended a regional bio-energy seminar in Costa Rica. Both have demonstrated strong interest in an A.I.D. bio-energy program at Arkansas.

5. There are indications of strong support for bio-energy activities by the present University administration. The present President of the University, Dr. James E. Martin, was instrumental in obtaining the Gulf Oil process equipment, and staff for the University while in his previous position as Vice President for Agriculture. In that position, he was also the University contact for cooperation with USDA's Office of International Cooperation and Development on International Training Programs. The extent of the University's committment to bio-energy research is indicated by the construction during 1981 of a new building on the campus to house the Biomass Research Center. Similarly, Dr. Gaddy was brought to Arkansas by the new Dean of Engineering, Dr. J. L. Laddington, who was himself the principal investigator for a bio-energy research project during a previous position at Texas Tech.

6. The University could also provide a strong exposure to bio-energy options other than alcohol, since several Arkansas faculty members have had substantial experience with biogas and thermochemical conversion projects.

As indicated earlier, no institution including Arkansas has all the resources that would be needed for a broad inter-disciplinary program for planners and decision makers on alcohol fuels. Arkansas lacks Purdue's strength in the assessment of economic, environmental, and policy implications of large-scale alcohol fuel production, and could utilize expertise from Nebraska on the use of alcohol in motor vehicles and the use of stillage for livestock feed. A program

at Arkansas (as at any other institution) would have to make fairly extensive use of visiting lecturers to provide some important parts of the desired program. Another possible limitation on the University's capacity to carry out an alcohol fuels program for A.I.D. may be the lack of an appropriate mechansim to coordinate the participation of the two distinct university groups who are now working on alcohol fuels. However, given the apparent high-level interest in bio-energy activities in the University administration, this problem should be surmountable in an acceptable degree. Both Ewart and Gaddy indicated willingness to cooperate, but the issue of project management and coordination was not explored in depth.

Although the conclusion is less clear than in the case of the thermochemical conversion and biogas programs, the University of Arkansas emerges as the institution which has the most to offer A.I.D. for the conduct of a training program on alcohol fuels. A proposal for a training program based at Arkansas has been developed and is outlined in the following section.

III. OUTLINE OF A PROPOSED A.I.D. TRAINING PROGRAM ON ALCOHOL FUELS

A. Scope of Program

This program would be designed to provide information, ideas, and insights which would be helpful to officials of developing countries in making important decisions concerning alcohol fuel production in their countries. It would be about equally divided between activities related to the technical aspects of alcohol production and those related to the non-technical issues and problems associated with the development of an alcohol fuels program. The program would be planned on the assumption that most of the participants would not have had much previous exposure to the technical or non-technical topics covered by the program.

B. Participants

The program would be designed for participants from countries which (a) are already engaged in or planning alcohol fuels projects; or (b) are considering alcohol fuel projects or programs involving the use of agricultural residues as feedstocks or the production of feedstocks on croplands or unused lands. Appropriate nominees would be executives, planners, or advisers who are actively involved in the planning of new energy projects in energy ministries, planning agencies, ministries of industry or agriculture, and technology agencies. Each nominee should have either (a) a university degree in a technical field related to alcohol production (chemistry, chemical engineering, or microbiology) or to feedstock production (agronomy, agricultural engineering) or (b) both a university degree in economics and substantial experience with the economic analysis of major development projects. The presence of both technical people and economists in the group would encourage inter-disiplinary discussion of each topic. All participants would also have sufficient verbal facility in English to permit full participation in seminars and discussions.

C. Timing

Due to the recommended A.I.D. training programs on thermochemical conversion in February-March 1982 and on anaerobic digestion in the summer of 1982, the best timing for this alcohol fuels program would be in the fall of 1981 or 1982. Scheduling the program in the fall of 1981 would require very rapid actions on funding, contractual arrangements, announcement, selection, and programming, and thus may not be feasible. Optimal timing for 1982 might be to begin the program on September 19 or 26, allowing several weeks after Labor Day for final programming details.

D. Program in the United States

The program would consist of several distinct but inter-related phases:

1. University of Arkansas Lectures and Seminars, Fayetteville, Ark. (Sunday, Day 1, through Saturday, Day 14)

Participants would travel directly from their home countries to Fayetteville, assembling there on Sunday, Day 1. The subsequent two weeks would be used primarily for lectures and discussions with University of Arkansas personnel and visiting lecturers. Up to one full day would be used for each of the following topics: (a) feedstocks, plans, and potentials for alcohol production in each of the participants' countries (brief presentations by each participant);

(b) overview of conventional ethanol production technology including basic methods of hydrolysis, fermentation, and distillation; (c) new technological developments in commercial ethanol production and new types of plants and equipment for alcohol fuel production; (d) current processes and future prospects for ethanol production from cellulose including processes using enzymatic hydrolysis and those using acid hydrolysis; (e) availability, characteristics, and suitability of various biomass feedstocks; (f) uses of pure alcohol and alcohol-gasoline blends in motor vehicles and use of alcohol production by-products (distillers grains) as livestock feeds; (g) economic factors in alcohol production including feedstock costs, capital costs, operating costs, economies of scale, and estimated total production costs; (h) impacts of alcohol fuel production on the environment, soil conservation and fertility, land-use patterns, agricultural production, and food supply; (i) impacts on agricultural policies, employment, transportation system, exports, and balance of payments; and (j) other options for energy production from biomass including anaerobic digestion and thermochemical conversion. The campus-based program would also include a field trip to the D&W Refining and Solvents Co's new 2 million gallon a year anhydrous ethanol distillery at Van Buren, Arkansas, approximately 60 miles south of Fayetteville.

2. Midwest Field Trip
(Sunday, Day 15, to Saturday, Day 21)

The field trip would be designed to emphasize (a) visits to current ethanol production facilities, (b) contacts with companies building or planning ethanol plants, and (c) visits to research institutions conducting alcohol fuels research. In addition, the trip might include some seminars with individual experts on topics listed in the previous section in cases where it is easier or cheaper to schedule a meeting along the tour route than to arrange for the expert to come to Fayetteville.

The tour would begin in Fayetteville on Sunday and end in the Chicago area on the following Saturday. Travel would be by chartered bus where necessary but might include one or two segments by scheduled bus. The itinerary would be determined after nominations were received, to reflect the needs and interests of participants. The following is an illustrative possible itinerary:
Kansas City, Mo. (Monday and Tuesday AM): American Agri-Fuels Co. (gasohol marketer, plant operator); "Gasohol" magazine; Missouri Farmers Association (feasibility study for alcohol plant); Pritchard Co. (design and construction of alcohol plants).
Des Moines and Ames, Iowa (Wednesday): Farm Fuels Products Corp., Consolidated Energy Group, and/or Agrifuel Corp. (companies with Federal loan guarantees to build ethanol plants); Iowa State University (farm-scale alcohol still, research on enzymatic hydrolysis).
Cedar Rapids, Iowa (Thursday): Archer Daniels Midland Co. (new 125,000 gallon/day alcohol fuel plant).
Muscatine, Iowa or Peoria, Illinois (Friday): Grain Processing Co., Muscatine (large conventional beverage alcohol plant) or USDA Regional Research Laboratory, Peoria (Federal government ehtanol research program).

The tour would end on Saturday at a motel in the northwest Chicago suburbs near O'Hare airport; this motel would be the site for the final Chicago area phases of the program. This location would facilitate participation by Americans in these phases, as outlined below.

3. Industry Briefings and Seminars, Chicago area
(Monday, Day 23, and Tuesday, Day 24)

This segment of the program would be primarily devoted to a series of sessions

with representatives of U.S. companies which manufacture equipment for alcohol fuels plants or provide design and eingineering services for the construction of such plants. Three of these companies (Brown and Root, A.G. McKee Associates, and Stone and Webster) have Chicago area offices. Other companies located in New York, Philadelphia, Cincinnati, Houston, and San Francisco and several Illinois firms would be invited to send representatives; the feasibility of their participation should be enhanced by the convenient location near the Chicago airport. Each company representative would be alotted a specified time for a presentation on his company's activities related to alcohol fuels including slides on projects and equipment and a question period. Part of Tuesday might be used for meetings with other representatives of Chicago institutions interested in alcohol fuels including the DOE Chicago regional office, the American Farm Bureau Federation headquarters, and Chicago area research institutions.

4. International Workshop on Alcohol Fuels in Developing Countries, Chicago area, (Wednesday, Day 25, and Thursday, Day 26)

This Workshop would be designed to facilitate interchange of ideas and experience between the members of the A.I.D. group and a number of Americans who are actually or potentiall involved with alcohol fuels programs in developing countries. The Chicago location should make participation relatively easy and inexpensive for representatives of institutions and agencies in both the Midwest and Mid-Atlantic regions. Invitations would be extended to development-oriented organizations (World Bank, Inter-American Development Bank, United Nations, Overseas Development Council, foundations, etc.) and Federal and Federally-supported agencies involved with alcohol fuels (DOE, USDA, SERI, etc) to send representatives on their own budgets. The budget for the training program would include travel grants for several individuals from universities or other institutions whose participation would be especially useful.

The Workshop would focus on non-technical problems and issues related to the development of alcohol fuels programs in developing countries. Major topics would include (a) feedstock availabilities and options; (b) economic aspects including financing of alcohol plants and programs; (c) impact of alcohol fuel production on the food supply, exports, balance of payments, employment, transportation system, and environment in a developing country; and (d) social, cultural, and institutional problems associated with alcohol programs. While there would have been introductory discussions of a number of these topics at the University of Arkansas, the International Workshop would provide the primary opportunity for discussion of these problems in developing countries in an internationally-oriented meeeting.

Most sessions would open with brief presentations by several panelists including both Americans and participants from developing countries. Participants might be divided into smaller groups for more intensive discussion of some topics. Rapporters would summarize each session, and the budget for the training program would provide for the publication of a summary report of the Workshop proceedings.

An evaluation session for the entire training program would be scheduled at the motel near Chicago immediately following the International Workshop, on either Thursday evening or Friday morning. Participants would begin their homeward travel from Chicago later on Friday.

IV. APPENDIX THREE: ALCOHOL FUELS ACTIVITIES OF U.S. UNIVERSITIES AND COLLEGES

A. Basic Research on Ethanol Production:

UNIVERSITY OF ARKANSAS, Fayetteville, Ark. 72701

Biomass Research Center

Dr. George H. Emert, Director (501) 575-2654

(1) During five years with Gulf Oil Co's biochemical research program, directed $11 million research program which developed a process for the enzymatic hydrolysis of cellulose to glucose and subsequent fermentation to ethanol.
(2) Biomass Research Center established in 1979 when Gulf donated cellulose conversion process to University of Arkansas. Current Center staff includes 22 professionals to be housed in new building on campus by end of 1981. Some of current research is funded by DOE/SERI as part of alcohol fuel research program.
(3) Center is designing a 50 ton/day plant to be built in Pine Bluff, Ark., beginning in September 1981 which will use the Gulf/Arkansas process to produce ethanol from 75% municipal solid waste and 25% pulp mill waste.
(4) Process technology for converting cellulosic materials into ethanol is available for licensing in the US and other countries. Center has received fourteen visits by representatives of foreign organizations to discuss licensing, and agreements have been reached with organizations in Brazil, Malaysia, and the Phillipines on projects for the conversion of bagasse to ethanol.

Department of Chemical Engineering

Dr. James L. Gaddy, Professor and Chairman (501) 575-3957

(1) Ten years of industrial experience as a process engineer, engineering supervisor, and project manager.
(2) During previous position at University of Missouri at Rolla, $50,000 University of Missouri 1978-80 grant for fermentation studies with immobilized cell reactors.
(3) Continuing laboratory and economic studies on the conversion of cellulosic agricultural resides (especially corn residues) to ethanol; currently planning on-campus alcohol production unit using corn stover as feedstock.
(4) Organizer and lecturer for two-day workshop on Fuel Alcohol Production Technology presented at Alliance for Chemical Engineering meeting in Houston, April 6-7, 1981; program will be repeated in Detroit in August, Montreal in October, and New Orleans in November.
(5) Presentations on ethanol from agricultural residues at ASAE National Energy Symposium, October 1980, and at ICAITI technical workshop on Fuels and Chemicals from Biomass Through Fermentation Processes, San Jose, Costa Rica, February 1981
(6) 1980 study on the use of an acid hydroylsis process for the conversion of peat to ethanol.
(7) Conducted various methane projects (see page 26).

LABORATORY OF RENEWABLE RESOURCES ENGINEERING, PURDUE UNIVERSITY, W. Lafayette, Ind. 49707

Georg T. Tsao, Director (317) 494-6151

55-person Laboratory staff is organized into eight research and support groups on cellulose chemistry, microbiology, energy conservation, enzyme technology, fermentation biochemistry, molecular biology, research and process engineering, and analytical

chemistry. Research activities are funded by grants from NSF, USDA, DOE, SERI, Indiana General Assembly, and six coporations. DOE-funded research ($350,000 cumulativ through FY-1979) has emphasized use of solvents to dissolve cellulose, disrupt crystalline structure, and remove lignin in order to speed up the conversion of cellulose into glucose.

ENERGY AND MATERIAL SCIENCES LABORATORY, GEORGIA INSTITUTE OF TECHNOLOGY, Atlanta, Ga. 30332

Mahendra K. Bery (404) 923-5284

DOE 78-81 contract for the design of a fermentation facility to produce ethanol from cellulosic biomass using an acid hydrolysis process. Conceptual design for a 1000 ton/day processd development unit approved by DOE in June 1979. Phase II includes engineering simulation trials, pilot plant design modifications, tests with one ton/hour steam explosion unit, and large-scale acid hydrolysis with plug flow reactor. Original contract anticipated the construction and operation of a pilot plant by Georgia Tech, but DOE now prefers that plant be built by a private company with Ga. Tech assistance.

Daniel J. O'Neil (404) 428-0953

Conducting feasibility study for Nuclear Assurance Corporation and DOE for a 25-million gallon per year wood-to-ethanol plant based on the process developed by Ga. Tech.

LAWRENCE BERKELEY LABORATORY, UNIVERSITY OF CALIFORNIA, Berkeley, Calif. 94720

C. R. Wilke (415) 843-2740, ext. 5161

$950,000 ERDA/DOE 1976-79 funding for process development studies on the hydrolysis of cellulose, including study of processing characteristics of wheat straw, barley straw, rice straw, corn stalks, and logging residues.

DEPT. OF CHEMICAL & ENVIRONMENTAL ENGINEERING, RENSSELAER POLYTECHNIC INSTITUTE, Troy, NY 12181

Henry R. Bungay

(1) 1977-80 DOE contract to coordinate, analyze, report, and plan research by twelve universities and firms conducting alcohol-related research for DOE and to edit and publish quarterly "Fuels from Biomass" Newsletter on fermentation research.

(2) Paper summarizing status of U.S. research on enzymatic hydrolysis of lignocellulosic materials as US/USSR Symposium, 1979.

(3) Paper on "Research and Development Priorities for Ethanol from Biomass", Bio-Energy '80 Congress, 1980.

DEPT. OF BIOCHEMISTRY AND CHEMICAL ENGINEERING, UNIVERSITY OF PENNSYLVANIA, Philadelphia,, Pa 19104

E. K. Pye (215) 243-8083

(1) Joint DOE alcohol research contract with General Electric Co. and Hahneman Mecial College for study of technical and economic constraints on the development of an integrated process for the biological production of liquid fuels from biomass.

Laboratory research has concentrated on the use of chips of poplar wood as a fermentation feedstock.
(2) Sponsored one-day workshop on "Alernative Liquid Fuels: Gasohol and other Fuels from Biomass, May 1979.

AUBURN UNIVERSITY, Auburn, Ala. 36830

E. P. Chambers

DOE alcohol research contractor studying hydrolysis of hemicellulose with acid catalysts and development of an effective xylose fermenter.

DEPT. OF CHEMICAL ENGINEERING, UNIVERSITY OF CONNECTICUT, Storrs, Conn. 06268

Robert Coughlin

DOE alcohol research contractor studying the problmem of cellobiose inhibition in the enzymatic hydrolysis of cellulose.

DEPARTMENT OF CHEMISTRY & MICROBIOLOGY, RUTGERS UNIVERSITY, New Brunswick, NJ 08903

Douglas E. Eveleigh

DOE Alcohol research contractor studying the production of microbial mutants to increase the effectiveness of enzymatic hydrolysis of cellulose to ethanol.

SCHOOL OF ENGINEERING & APPLIED SCIENCE, COLUMBIA UNIVERSITY, New York, NY 10027

Harry P. Gregor

Research on grants from DOE and private firms on the use ofmembrane technologies to reduce the cost of ethanol production and help treat distillery waste products.

THAYER SCHOOL OF ENGINEERING, DARTMOUTH COLLEGE, Hahnover, NH 03755

Hans E. Grethlein (603) 646-2231

DOE alcohol research contractor studying kinetics, engineering, and economic aspects of an acid hyrolysis process for the conversion of cellulosic biomass (paper, wood, and corn stover) to ethanol.

DEPT. OF NUTRITION & FOOD SCIENCE, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Cambridge, Mass. 02139

Daniel I. C. Wang (617) 253-2126

DOE alcohol research contractor studying the direct conversion of cellulosic biomass to etheanol through the use of anaerobic and thermophilic bacteria.

DEPT. OF APPLIED SCIENCE, NEW YORK UNIVERSITY, New York NY 10003

E. Brenner

$532,000 EPA 1977-80 grant to design a cost effective approach for the continuous conversion of waste cellulose to glucose via acid hyrolysis.

DEPT. OF CHEMICAL ENGINEERING, KANSAS STATE UNIVERSITY, Manhattan, KS 66506

L. T. Fan

$30,792 DOE 79-80 grant for study of pretreatment techniques in enzymatic hydrolysis.

DEPT. OF CHEMICAL ENGINEERING, IOWA STATE UNIVERSITY, Ames, Iowa 50001

Peter J. Reilly (515) 294-5698

(1) $357,000 NSF 1977-80 grant to study enzymatic hydrolysis of agricultural by-rpducts including corn cobs.
(2) Attended ICAITI workshop on Fuels and Chemical From Biomass through Fermentation Processes, San Jose, Costa Rica, February 1981.

FOOD SCIENCES DEPT., UNIVERSITY OF GEORGIA, Athens, Ga. 30602

Romec T. Toledo

DOE 1980 Appropriate Technology grant to develop an improve means of extracting alcohol from mash during fermentation.

UNIVERSITY OF FLORIDA, Gainesville, Fla.

Wayne H. Smith, Director, Center for Biomass Systems (904) 372-8576

State-supported biomass program included following alcohol fuels projects:
(1) Research on the capture, concentration, and conversion to alcohol of dilute solutions of sugars in the waste stream from citrus fruit processing (Braddock, Lake Alfred Ag. Research and Education Center.)
(2) Research on the production of alcohol from bagasse and from the residues of potato harvesting (LeGrand, Dept. of Agronomy).

CROPS RESEARCH LABORATORY, UTAH STATE UNIVERSITY, Logan, Utah 84322

Devon L. Doney

$27,500 USDA 1979-84 grant for laboratory analysis and field tests to evaluate potential for alcohol production from sugar beets, fodder beets, and similar species.

PACE UNIVERSITY, New York, NY

Dr. Cox

$25,000 1980 DOE Appropriate Technology grant for experiments with an enzymatic hydrolysis process to convert cellulose in waste paper to ethanol.

BROOKLYN COLLEGE, Brooklyn, NY

Stephen Cottrell

$25,000 1980 DOE Appropriate Technology grant to study an improved means of extracting ethanol from fermenting biomass through the use of an artificial membrane.

B. Research on Uses of Alcohol and By-Products

DEPT. OF MECHANICAL ENGINEERING, UNIVERSITY OF SANTA CLARA, Santa Clara, CA 995053

Richard K. Pefley, Chairman (408) 984-4325

(1) Continuing research program since 1970 on the use of alcohol and alcohol-gasoline blends in motor vehicles. (Continued on following page)

(2) $84,000 California Energy Commission 1978-81 grant to test alcohol fuel blends in automobile engines: comprehensive report on study due in mid-1981.
(3) Host organization for Third International Symposium on Alcohol Fuels Technology, Asilomar, California, May 1979.

UNIVERSITY OF NEBRASKA, Lincoln, Neb.

Department of Chemical Engineering

William A. Scheller, Professor

(1) 1974-1977 grant from Nebraska Agricultural Products Industrial Utilization Committee to conduct two million mile gasohol road test in cooperation with Nebraska Dept. of Public Roads; subsequent tests with 100% ethanol in vehicles.
(2) 1975 NSF grant to develop a high protein isolate from selected distillers by-products.

Department of Animal Science

Terry Klopfenstein, Professor

(1) Various studies and publications on the use of by-products of alcohol production as livestock feeds.
(2) $100,000 USDA/DOE 80-83 grant to study percipitation of ethanol stillage to improve protein content.

Department of Agricultural Engineering

W. E. Splinter, Professor

Tests on use of "neat" alcohol in tractor engines.

DEPT. OF MECHANICAL ENGINEERING TECHNOLOGY, PURDUE UNIVERSITY, W. Lafayette 47907

Daniel N. McNally

Tests of engine performance with gasohol in farm and garden tractors.

C. University Experiments with Farm-Scale Alcohol Fuel Stills

ORGANIC FUELS PROJECT, SOUTH DAKOTA STATE UNIVERSITY, Brookings, S.D. 57007

Tom Chishom, Associate Professor of Agricultural Engineering

Pilot small-scale fuel alcohol plant with two distillation columns constructed in 1979. Plant uses moldy grains, cull potatoes, unmarketable crops, over-ripe fruits. Research program centered on the pilot plant by multi-disciplinary team from Departments of Microbiology, Animal Sciences, Dairy Sciences, Agricultural Engineering, Mechanical Engineering, and Economics. Technical research includes utilization of alcohol fuels in motorized equipment and vehicles and utilization of alcohol plant by-products as animal feed. (see also listing in "Economic Studies" section and report by George Beinhart, Bioresources for Energy Project, on visit to South Dakota State, spring 1981).

DEPT. OF AGRICULTURAL ENGINEERING, IOWA STATE UNIVERSITY, Ames, Ia. 50011

Wesley Buchele, Professor (515) 294-3917

Built experimental farm-scale alcohol fuel plant with $52,000 1978-80 grant from Iowa state legislature. Additional research in progress with $100,000 USDA/DOE grant for "Continuous On-Farm Corn Alcohol Production." (Problems encountered with distillation column, and satisfactory operation had not been achieved by January 1981).

EASTERN OREGON STATE UNIVERSITY

Terry Edvalson

(1) Built several alcohol distillation systems including six gallon/hour system and a nine gallon/hour system.
(3) Advisory service to farmers developing large alcohol fuel plants.
(3) DOE 1980 Appropriate Te chnology grant to build and operate a small-scale continuous alcohol distillery for research and demonstration purposes.

DEPT. OF AGRICULTURAL ENGINEERING, UNIVERSITY OF NEBRASKA, Lincoln, Neb. 68583

William E. Splinter, Professor and Chairman (402) 472-2824

(1) DOE 80-84 grant for "Energy Integrated Farm Systems" demonstration at Mead, Neb., including alcohol production from sweet sorghum; 25' high, 1' diameter still will produce 25 gallons of alcohol per hour. (Demonstration also includes methane production from swine manure and use of solar energy from adjacent large photovoltaic demonstration).
(2) 1980-81 course on "Engineering in the Food and Energy Interface" which covers use of biomass for energy including alcohol fuels, vegetable oils, and direct combustion.

TECHNOLOGY APPLICATIONS LABORATORY, GEORGIA INSTITUTE OF TECHNOLOGY, Atlanta 30332

Ralph M. Lamade, Research Engineer (404) 894-3412

(1) Operated experimental 25 gallon per hour plant to evaluate ethanol production processes including vacuum distillation, automatic controls, and improved monitoring systems.
(2) DOE 80-84 grant for "Energy Integrated Farm Systems" demonstration at Aubrey Farm, 50 miles N. of Atlanta including farm-scale unit to produce ethanol from grain. Decisions concerning feedstocks and equipment will be made by summer 1981, with construction primarily in 1982. (Program will also include methane production from cattle manure, increased use of wood fuel, and possibly hydraulic rams and/or low-head hydroelectric units.)

DEPT. OF AGRICULTURAL ENGINERING, UNIVERSITY OF MINNESOTA, St. Paul 55108

State legislature appropriation for farm-scale alcohol plant to be built at experiment station at Morris in western Minnesota. (No other details received)

AGRICULTURAL RESEARCH CENTER, OHIO STATE UNIVERSITY, Wooster, Ohio 44691

Wayne Longbrake

$50,000 DOE 1980 Appropriate Technology grant to develop a portable ethanol still for use in classrooms and in farm demonstrations and to conduct demonstration program on the production, and use of alcohol fuels at the Agricultural Technical Institute in Wooster.

D. Economic Studies on Alcohol Production:

DEPT. OF AGRICULTURAL ECONOMICS, OKLAHOMA STATE UNIVERSITY, Stillwater, Okla. 74078

Daryll E. Ray (405) 624-6157

(1) 1979-80 SERI grant for collaborative study with SERI economist Don Hertzmark on the impacts of expanded use of corn for alcohol production on agricultural prices and incomes.
(2) 1980-81 study of economic impacts of use of crops other than corn for alcohol production, including sugar beets, sweet sorghum, and high energy sorghum.

DEPARMTMENT OF AGRICULTURAL ECONOMICS, PURDUE UNIVERSITY, W. Lafayette, Ind. 49707

Wallace E. Tyner, Associate Professor (317) 493-2454

(1) International experience as Peace Corps volunteer in India, subsequent lecture tour on energy topics sponsored by International Communication Agency. Author of book on energy and development in India. Research on leasing systems for gas development in various countries.
(2) Director of study by inter-disciplinary Purdue group on the technical and economic potential for production of energy from agricultural crops and residues under $65,000 grant from Office of Technology Assessment, 1978-79.
(3) Paper on potential for use of biomass for energy in the U.S. for June 1980 FAO conference in Rome covering availability of biomass resources and impacts of biomass energy development on agricultural exports, food aid, and farm policies.
(4) Co-author (with Otto C. Doering) of Purdue Extension publication which emphasizes economic and policy issues associated with alcohol fuel production.
(5) Supervisor of graduate students who are conducting studies of the economics of three types of alcohol fuel plants (farm scale, community/cooperative scale, and commercial/industrial scale).
(6) Current research on impact of increased use of biomass for energy production on the availability and price of food.

Otto C. Doering II, Associate Professor (317) 493-2454

(1) Co-author (with Tyner) of several papers on energy from agriculture including alcohol fuels.
(2) Member of National Academy of Sciences team assisting Indonesian government with survy of biomass availability and other aspects of an Indonesian alcohol fuel program.

DEPARTMENT OF ECONOMICS, SOUTH DAKOTA STATE UNIVERSITY, Brookings, S.D. 57007

Thomas L. Dobbs, Associate Professor (605) 688-4141

(1) Agricultural economist, USAID, in Pakstan (1974-76) and Washington (1976-78).
(2) Member of multi-disciplinary team for SDSU Organic Fuels project which is studying (a) costs of producing fuel grade alcohol from corn and other biomass products, (b) energy balances in production of alcohol fuel, and (c) overall economic feasibility and impacts of fuel alcohol production under various farm, prices, and rural economic circumstances. Research support includes $93,831 USDA/DOE grant for a cost and energy study of on-farm fuel alcohol production.

DEPARTMENT OF FOOD AND RESOURCE ECONOMICS, UNIVERSITY OF FLORIDA, Gainesville

Dr. Kiker

Economic assessment utilizing a mathematical programming model of the potential for use of the resources of the Florida sugar cane industry to produce alcohol fuels.

E. Examples of Alcohol Fuels Training at Community & Technical Colleges

COLBY COMMUNITY COLLEGE, Colby, Kansas 67701

James H. Tangeman, President (913) 462-3984

(1) Conducted ten one-week fuel alcohol production seminars for 581 students between August and December 1979.
(2) Installed 25 gallon per hour still at college in September 1980.
(3) During 1980-81 academic year, offerred two one-week alcohol workshops on consecutive weeks each month; Workshop A is an introductory course, while Workshop B provides additional material on production processes for operators.
(4) Published 356-page "Learning Guide for Alcohol Fuel Production" developed by

college for alcohol fuel workshops.
(5) Two faculty members active in the workshop program (a chemist and a microbiologist) have made eight videotapes on alcohol fuel production including mashing, fermentation, distillation, and microscopic examinations of yeast bacteria.
(6) College offers both a one-year certificate program and a two-year Associate degree program in Alcohol Fuel Production Technology. Special courses include Introduction to Ethanol Production, Plant Operations I and II, Plant Management I and II, Energy Distillation, Law and Regulations, Fermentation Microbiology, and Engine Conversion.

NAVARRO COLLEGE, Corsicana, Texas 75110

Wayne Burkhalter, Project Director, Alcohol Fuels Technology (214) 874-6501

(1) Presented ten three-day workshops on alcohol fuel technology and production between October 1980 and May 1981. About half of the total workshop time is spent in hands-on practice on a working still.
(2) Developing curriculum modules for classroom teaching of alcohol fuels production in secondary schools and post-secondary educational institutions in the state of Texas.

SOUTEAST COMMUNITY COLLEGE, Milford, Nebraska 68405

Robert Klabenes (402) 761-2131

Presented a total of eight four-day alcohol fuel workshops during fall and winter of 1980-81. Program includes hands-on experience with small alcohol plant on Bruce Stutzman farm.

CENTRAL TECHNICAL COMMUNITY COLLEGE, Grand Island, Nebraska 68801

James Dutcher, Instructor (304) 384-5220, ext. 273

Presented a two-day workshop on alcohol fuel production each month from September 1980 to March 1981.

LINCOLN LAND COMMUNITY COLLEGE, Springfield, Illinois, 62708

Robert L. Poorman, President (217) 786-2200

(1) College's extensive energy program includes operation of farm-size alcohol fuel still and presentation of several three-day alcohol fuel workshops.
(2) Currently considering the establishment of an Associate degree program in Renewable Energy Fuels and Technology.

STATE FAIR COMMUNITY COLLEGE, Sedalia, Missouri 65301

Keith Allen, Director, Agricultural Energy Project (816) 826-7100

(1) Experimental and educational use of on-campus alcohol fuel plant.
(2) $40,786 1980 DOE Appropriate Technology grant to add large bale burner for combustion of biomass to provide heat for the fuel alcohol process, heat the building, and dry the distillers grain.
(3) Fuel alcohol production classes offerred to students in the fall and spring semesters of the 1980-81 academic year.
(4) College will offer a two-year Associate degree program in Agricultural Energy beginning in the fall of 1981 which will include fuel alcohol production, crop residue utilization, methane gas from livestock wastes, and solar applications.

F. Educational Programs by Universities & Other Institutions

ENERGY TECHNOLOGY CENTER, UNIVERSITY OF WISCONSIN EXTENSION, Madison, WI 53706

Charles Dorgan, Director (608) 262-2061

Seven-day short course on "Alcohol Production Technology, January 17-23, 1981.

DEPARTMENT OF AGRICULTURAL ENGINEERING, UNIVERSITY OF CALIFORNIA AT DAVIS, Davis, CA.

Co-sponsored (with University Extension) a workshop on "Biomass Alcohol for California" in January 1980 with presentations on alcohol fuel production by Lyn A. Williams (Dept. of Viticulture), on feedstocks for fuel alcohol production in California by Roy M. Sachs (Dept. of Environmental Horticulture), and harvesting cellulosic biomass for alcohol production by George E. Miller, Jr. (Cooperative Extension Service).

DEPT. OF AGRICULTURAL ENGINEERING, WASHINGTON STATE UNIVERSITY, Pullman WA 99614

Henry Waelti, Coordinator of Energy Extension Programs (509) 335-2511

(1) Co-author (with James M. Ebeling) of series of 25 two-to-five page fact sheets on various aspects of the production and use of alcohol fuels.
(2) Currently participating in two year A.I.D. project in Tunisia which includes evaluation of agricultural use of energy and alternative energy sources for Tunisia including biomass utilization.

DEPT. OF AGRICULTURAL ENGINEERING, MICHIGAN STATE UNIVERSITY, E. Lansing, MI 48824

Bill Stout (517) 355-4720

Published a series of information papers on alcohol fuels in 1980 including "Making Ethanol for Fuel on the Farm" (12 pages), "Alcohol Still Analysis" (8 pages), and "Methanol for Fuel" (14 pages).

INSTITUTE OF GAS TECHNOLOGY, 3424 S. State St., Chicago, Ill 60616

Donald Klass, Vice President (312) 567-3783

Sponsored symposia in 1980 and 1981 on "Nonpetroleum Vehicular Fuels" covering technical developments and economic, environmental, and policy questions concerning alcohol fuels and other nonpetroleum vehicular fuels.