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UC-61D

Biomass Conversion Task IV 1986-1988 Program of Work

International Energy Agency Bioenergy Agreement

Don J. Stevens

August 1986

Prepared for the
International Energy Agency
Bioenergy Agreement
under a Related Services Contract
DE-AC06-76RLO 1830
with the U.S. Department of Energy

Pacific Northwest Laboratory
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BIOMASS CONVERSION TASK 1V
1986 - 1988 PROGRAM OF WORK
INTERNATIONAL ENERGY AGENCY
BIOENERGY AGREEMENT

Don J. Stevens

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Biomass Program Office

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Richland, Washington 99352

1. EXECUTIVE SUMMARY

Biomass is a major, renewable energy resource throughout much of the world, and extensive research is being conducted on bioenergy technologies. In an effort to improve communications and cooperation in the area of biomass energy, several countries have agreed to a cooperative program of work under the International Energy Agency's Bioenergy Agreement (IEA/BA). Three areas of major importance have been identified including Short Rotation Forestry, Conventional Forestry, and Biomass Conversion.

This document describes a Program of Work for cooperative activities in the area of Biomass Conversion. The background of the cooperation and general descriptions of specific conversion projects are presented. Details of activity funding are also provided. Finally, individual Activity Plans for specific cooperative activities are attached for reference. These plans describe projected work for the period 1986-1988.

CONTENTS

2. PROGRAM OF WORK FOR 1986 - 1988

INTRODUCTION

Biomass materials represent a major and often under-used resource for producing energy. Biomass includes feedstocks such as wood, wood wastes, agricultural wastes, and other cellulosic residues. These feedstocks are renewable and offer the potential for stable national energy sources relatively isolated from international fluctuations in petroleum availability. Biomass is also the only renewable energy technology capable of addressing the future need for transportation fuels.

For biomass to meet its potential as an energy resource, conversion processes must be available which are both efficient and environmentally acceptable. Conversion can include direct production of heat and electricity as well as production of intermediate gaseous, liquid, and solid fuels. While many biomass conversion processes are commercially available at present, others are still in the conceptual stage. Additional research and development activities on these advanced concepts will be necessary to fully use biomass resources.

Ongoing research on biomass conversion processes is being conducted by many nations throughout the world. In an effort to better coordinate this research and improve information exchange, several countries have agreed to a cooperative effort through the International Energy Agency's Bioenergy Agreement (IEA/BA). The background of the IEA/BA cooperative program and the plans for conversion activities in the period 1986-1988 are described below. Specific plans for individual activities are included in Appendix I.

BACKGROUND OF IEA COOPERATION

Initial cooperation on biomass conversion issues began in the late 1970's under the International Energy Agency's Forestry Energy Agreement. Three areas of ongoing cooperation were identified including Growth and Production, Harvesting, and Conversion. The activities in these areas were characterized by cooperative projects on specific topics. The projects included information exchange and coordination of ongoing national research programs.

In early 1986, participating countries made changes which resulted in initiating a new Bioenergy Agreement while phasing out the former Forestry Energy Agreement. In additional to expanding the types of energy feedstocks to be considered, the Bioenergy Agreement also resulted in organizational changes. Specifically, individual Task Annexes for three areas where formulated in which individual countries could choose to participate. These three Task Annexes include Short Rotation Forestry, Conventional Forestry, and Biomass Conversion. The Task Annex for Biomass Conversion is attached as Appendix II. As of July 1986, countries participating in the Conversion Annex include Austria, Canada, Denmark, Finland, Ireland, New Zealand, Norway, Sweden, and United Kingdom. United States has also indicated interest pending legal review of the document.

Many of the cooperative activities initiated under the Forestry Energy Agreement were continued under the Bioenergy Agreement. In the area of biomass conversion, all five projects started under the previous Agreement are continuing. These include cooperative efforts on biomass direct liquefaction, combustion safety, combustion emissions, pretreatments of lignocellulosics, and conversion of C-5 sugars. A list of publications from these activities is attached as Appendix III. In addition, the transition gave the opportunity to start new activities as well. Both the ongoing and new activities are described below:

The 1986-1988 Program of Work for the Biomass Conversion Annex is outlined below. The Program of Work was developed by representatives of the countries participating in the IEA Forestry Energy Agreement with input from leaders of ongoing activities. Suggested areas for cooperative activities were discussed at meetings of the IEA held in Venice in March 1985. Additional input was received from representatives of the national governments following those meetings. The final proposal was adopted at the IEA/BE Executive Committee Meeting in Washington, D.C. in April 1986.

AREAS OF ACTIVITIES

Biomass conversion is a very diverse field and national interests often vary widely. In developing the Program of Work, five major areas dealing with conversion research were identified as having highest priority for cooperative interaction. These are:

(a) Thermal conversion
(b) Biochemical conversion
(c) General conversion
(d) Environmental issues
(e) Voluntary standards.

The cooperative activities consist of information exchange and coordination of national research programs on specific topics. The activities address biomass conversion in a systematic manner, dealing with the pretreatment of biomass prior to conversion, the subsequent conversion of the biomass to intermediate fuels or end-product energy, and then the environmental aspects of the conversion process. In addition, the area of establishing voluntary standards for dealing with biomass conversion has attracted wide-spread interest. These areas are discussed in general below. Detailed Activity Plans are an integral part of this Program of Work and follow the general description.

Thermal Conversion

In the area of thermal conversion, activities on biomass direct liquefaction and combustor safety will be continued. The biomass liquefaction work will focus on methods for refining and upgrading biocrude oils to produce economical products. The activities on boiler safety will continue with emphasis on small-scale facilities. New activities will also be initiated. An international conference on thermal conversion is planned. The meeting would be held in late 1987 which is five years after a similar conference held in Estes Park, Colorado. Activities are also planned to compile a bibliography of world-wide thermal conversion research which would provide information on accessibility of research data. Detailed Activity Plans for these individual activities are attached as part of this Program of Work and can be referenced on the following pages:

Activity	Reference
Direct Liquefaction	p. 15
Combustor Safety and Reliability	p. 25
Thermal Conversion Conference	p. 26
World Wide Data Base	p. 27

Biochemical Conversion

Cooperative work in the area of biochemical conversion will include the highly productive activities on pretreatment of lignocellulosics. A meeting

of participants in this activity is planned in June 1986 which will decide on activities beyond the end of 1986. Work on conversion of C-5 sugars will also continue. The activity will look genetic improvement of an expanded variety of yeasts and will provide an economic analysis of ethanol and other pentose-derived energy products. A new initiative in the biochemical conversion area will extend the current work on feedstock pretreatment and will examine alcohol productions in an integrated manner. This work will be closely interfaced with product utilization activities being undertaken by the IEA Alcohol Fuels Agreement. A new initiative in the area of anaerobic digestion is also planned. This activity will define a series of unit processes for various digestion applications and will evaluate which systems would be most effective depending on desired end result. The Activity Plans for these activities are attached as follows:

Activity	Reference
Pretreatment of Lignocellulosics	p. 39
Conversion of C-5 Sugars	p. 43
Alcohol Fuel Production Systems	p. 46
Anaerobic Digestion	p. 48

General Conversion

In addition to the specific thermal and biochemical technology areas, cooperative activities are planned on general conversion issues which cannot be assigned to one technology approach alone. Cooperative activities will be performed on issues relating to conversion of municipal solid waste (MSW). This activity would coordinate basic chemical and engineering work on MSW systems to better understand mechanisms involved and their effect on process efficiency. The activity would also examine MSW pretreatment steps and would examine related standards issues. The detailed Activity Plan is attached.

Activity	Reference
Conversion of Municipal Solid Waste	p. 56

Environmental Issues

The environmental impacts of biomass conversion technologies are often important issues in determining overall process feasibility. Cooperative activities will be undertaken to evaluate environmental impacts and to conduct research on eliminating undesirable emissions. Cooperative interaction on the

environmental consequences of biomass combustion will continue. Chemical and biological analyses will be made to identify combustion emissions, and standard analysis procedures will be recommended. This activity is expected to be completed in 1988.

Activity	Reference
Combustor Emissions	p. 62

Voluntary Standards

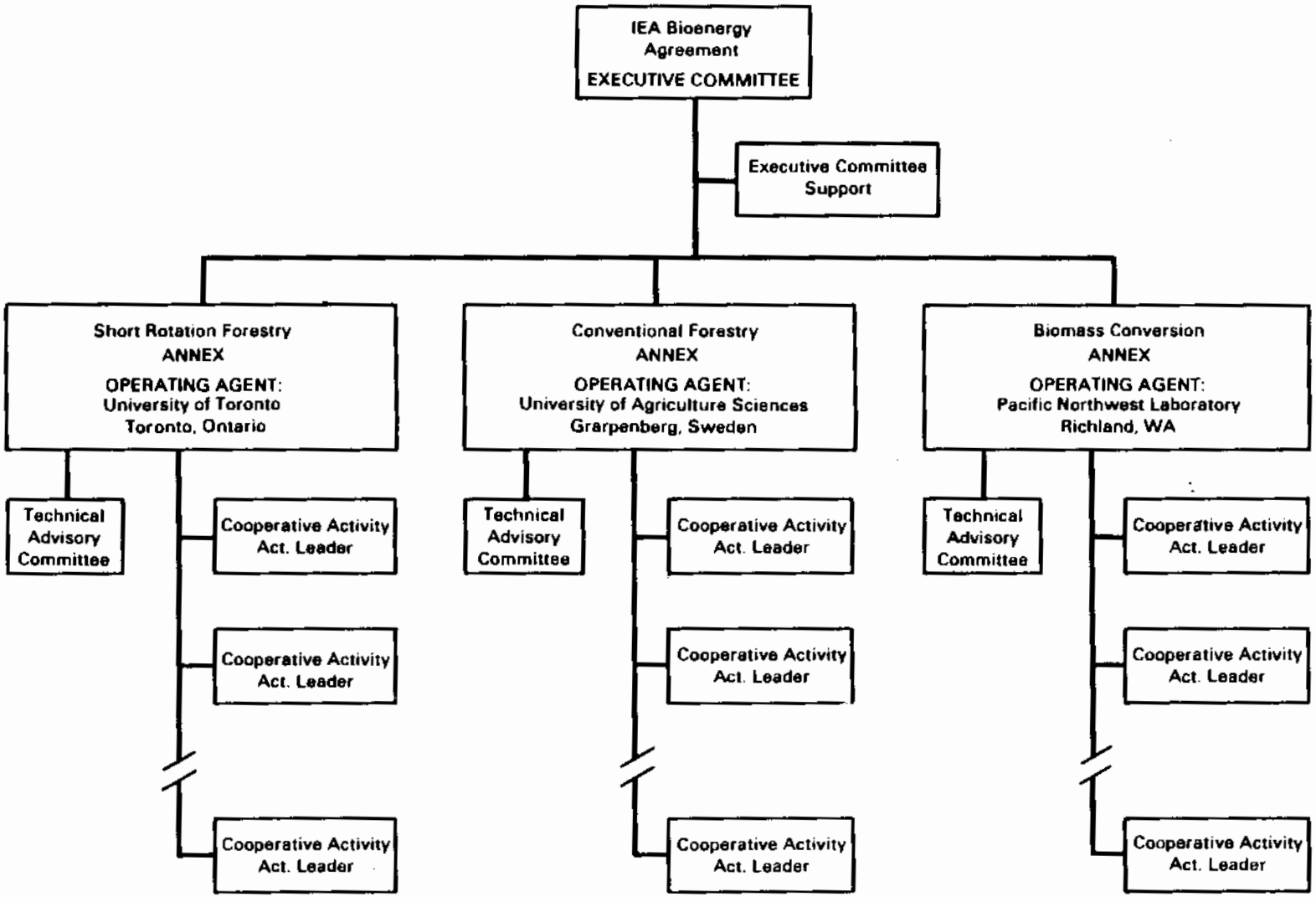
Extensive interest has been expressed in developing voluntary standards which would improve the transfer of information between participating countries. The area of standards is very broad and includes such items as developing standard reporting formats and units, developing standard analytical procedures, making standardized research samples available for comparison, and others. Activities are planned to determine areas where voluntary standards would improve information transfer and would result in establishment of voluntary procedures, formats, etc. where possible. Such standards would not be mandatory on individual researchers or countries but hopefully would be accepted by the research community for improving data quality. The activities in this area will begin in 1986 with evaluation of which issues should be addressed.

Activity	Reference
Voluntary Standards	p. 66

ORGANIZATION AND FUNDING OF COOPERATIVE ACTIVITIES

The organization of the IEA/BE cooperative activities is shown in Figure 1. Overall direction for the activities is provided by an Executive Committee which is composed of a representative of each participating country. Operating Agents are appointed to lead and administer each of the Task Annexes. The Operating Agent for the Conversion Annex is currently Pacific Northwest Laboratory. A Technical Advisory Committee composed of representatives of countries participating in the particular Annex provides advice and direction to the Operating Agent. The actual cooperative activities are headed by Activity Leaders who are appointed by the Lead Country for a particular activity. The organization is described in more detail in the text of the

Structure of IEA Agreement



Conversion Annex, which is attached as Appendix II. A summary of Activity Leaders and Lead Countries is provided in Table 1.

Funding to administer the Conversion Annex and the individual activities is provided by the participating countries. Budgets including both a funding key for contributions by country and a distribution key for funding by Activity is approved on an annual basis by the Executive Committee. A summary of funding by activity for the years 1986-1988 is provided in Table 2. Detailed budget keys for each year, as approved by the Executive Committee in April 1986 are shown in Tables 3-5.

TABLE 1. BIOMASS CONVERSION ANNEX PROJECT ACTIVITY LEADERS

ACTIVITY	1986 BUDGET (US$)	LEAD COUNTRY	LEAD INSTITUTION	PROJECT LEADER
Thermal Conversion				
- Direct liquefaction	25.2	SWE	Energetics AB	Bjorn Kjellstrom
- Combustion safety	12.4	NOR	SINTEF	Erling Oesterboe
- Thermal conv. conf.	12.4	FIN	To be determined	
- World-wide data base	12.6	USA	University of Aston	A. V. Bridgwater
Biochemical Conversion				
- Pretreatment of lignocellulosics	16	NZ	Forest Research Institute	Keith Mackie
- Conv. of C-5 sugars	16	NZ	Massey University	Graham Manderson
- Alcohol fuels	12.6	CAN	Forintek Canada Corp.	John Saddler
- Anaerobic digestion	12.6	CAN	Canviro Consultants, Inc.	A. R. Stickney
General Conversion				
- Municipal solid waste conversion	37.5	UK	AERE Harwell	Chris Dent
Environmental Issues				
- Combustor emissions	19	NOR	Center for Industrial Res.	Christel Benestad
Voluntary Standards	9.9	CAN	Solar Energy Research Institute	Thomas Milne
Operating Agent	25	CAN (Temp)	Battelle Pacific Northwest Lab.	Don J. Stevens
	211.2			

TABLE 2. Biomass Conversion Annex
Activity Funding Summary*

Activity	IEA FUNDS (1000 U.S. Dollars) 1986	1987	1988
Thermal Conversion			
- Direct Liquefaction	25.2	25.2	19.2
- Combustion Safety	9.3	15.0	18.9
- Thermal Conversion Conf.	12.4	25.2	0.0
- World-Wide Data Base	12.4	16.0	0.0
Biochemical Conversion			
- Pretreatment of Lignocellulosics	16.0	19.0	22.0
- Conversion of C-5 Sugars	16.0	19.0	19.0
- Alcohol Fuels	12.6	12.6	12.6
- Anaerobic Digestion	12.6	18.9	18.9
General Conversion			
- Municipal Solid Waste Conversion	37.5	75.0	75.0
Environmental Issues			
- Combustor Emissions	19.2	31.8	19.2
Voluntary Standards	9.9	21.9	24.9
Operating Agent	25.5	28.5	27.4
Totals	208.6	308.1	257.1

*Assumes USA participation at tentative level indicated at EC-17.

TABLE 3. ANNEX IV

ACTIVITIES AND BUDGET FOR 1986*

Each budget figure for a Participant and an activity in the matrix corresponds to a declared interest from the Participant to the activity.

Activity	In-cash Contributions from Participants (1000 US$)										
	AUS	CAN	DEN	FIN	IRE	NZ	NOR	SWE	UK	USA	TOTAL
Thermal Conversion											
- Direct liquefaction		6.3		6.3				6.3		6.3	25.2
- Combustion safety		3.1					3.1	3.1			9.3
- Thermal conv. conference		3.1		3.1			3.1			3.1	12.4
- World-wide data base			3.1			3.1			3.1	3.1	12.4
Biochemical Conversion											
- Pretreatment of ligno-cellulosics	3.2	3.2				3.2		3.2		3.2	16.0
- Conversion of C-5 sugars	3.2	3.2				3.2		3.2		3.2	16.0
- Alcohol fuels	4.2	4.2								4.2	12.6
- Anaerobic digestion		4.2			4.2	4.2					12.6
General Conversion											
- Municipal solid waste conversion		12.5						12.5	12.5		37.5
Environmental Issues											
- Combustor emissions	3.2		3.2	3.2			3.2	3.2		3.2	19.2
Voluntary Standards		3.3		3.3		3.3					9.9
Subtotal	13.8	43.1	6.3	15.9	4.2	17.0	9.4	31.5	15.6	26.3	183.1
(rounded off percentages)	(8)	(25)	(3)	(9)	(2)	(9)	(5)	(17)	(9)	(14)	(100)
Costs of the Operating Agent	2.0	6.3	0.7	2.3	0.5	2.3	1.3	4.3	2.3	3.5	25.5
Total (1000 US$)	15.8	49.4	7.0	18.2	4.7	19.3	10.7	35.8	17.9	29.8	208.6

*Assumes USA Participation

TABLE 4. ANNEX IV

ACTIVITIES AND BUDGET FOR 1987*

Each budget figure for a Participant and an activity in the matrix corresponds to a declared interest from the Participant to the activity.

Activity	In-cash Contributions from Participants (1000 US$)										
	AUS	CAN	DEN	FIN	IRE	NZ	NOR	SWE	UK	USA	TOTAL
Thermal Conversion											
- Direct liquefaction		6.3		6.3				6.3		6.3	25.2
- Combustion safety		5.0					5.0	5.0			15.0
- Thermal conv. conference		6.3		6.3			6.3			6.3	25.2
- World-wide data base			4.0			4.0			4.0	4.0	16.0
Biochemical Conversion											
- Pretreatment of ligno-cellulosics	3.8	3.8				3.8		3.8		3.8	19.0
- Conversion of C-5 sugars	3.8	3.8				3.8		3.8		3.8	19.0
- Alcohol fuels	4.2	4.2								4.2	12.6
- Anaerobic digestion		6.3			6.3	6.3					18.9
General Conversion											
- Municipal solid waste conversion		25.0						25.0	25.0		75.0
Environmental Issues											
- Combustor emissions	5.3		5.3	5.3			5.3	5.3		5.3	31.8
Voluntary Standards		7.3		7.3		7.3					21.9
Subtotal	17.1	68.0	9.3	25.2	6.3	25.2	16.6	49.2	29.0	33.7	279.6
(rounded off percentages)	(6)	(24)	(3)	(9)	(2)	(9)	(6)	(18)	(11)	(12)	(100)
Costs of the Operating Agent	1.7	6.8	0.9	2.6	0.6	2.6	1.7	5.1	3.1	3.4	28.5
Total (1000 US$)	18.8	74.8	10.2	27.8	6.9	27.8	18.3	54.3	32.1	37.1	308.1

*Assumes USA participation

TABLE 5. ANNEX IV

ACTIVITIES AND BUDGET FOR 1988*

Each budget figure for a Participant and an activity in the matrix corresponds to a declared interest from the Participant to the activity.

Activity	In-cash Contributions from Participants (1000 US$)										
	AUS	CAN	DEN	FIN	IRE	NZ	NOR	SWE	UK	USA	TOTAL
Thermal Conversion											
- Direct liquefaction		4.8		4.8				4.8		4.8	19.2
- Combustion safety		6.3					6.3	6.3			18.9
- Thermal conv. conference											
- World-wide data base											
Biochemical Conversion											
- Pretreatment of ligno-cellulosics	4.4	4.4				4.4		4.4		4.4	22.0
- Conversion of C-5 sugars	3.8	3.8				3.8		3.8		3.8	19.0
- Alcohol fuels	4.2	4.2								4.2	12.6
- Anaerobic digestion		6.3			6.3	6.3					18.9
General Conversion											
- Municipal solid waste conversion		25.0						25.0	25.0		75.0
Environmental Issues											
- Combustor emissions	3.2		3.2	3.2			3.2	3.2		3.2	19.2
Voluntary Standards		8.3		8.3		8.3					24.9
Subtotal	15.6	63.1	3.2	16.3	6.3	22.8	9.5	47.5	25.0	20.4	229.7
(rounded off percentages)	(7)	(27)	(1)	(7)	(3)	(10)	(4)	(21)	(11)	(9)	(100)
Costs of the Operating Agent	1.9	7.4	0.3	1.9	0.8	2.8	1.1	5.8	3.0	2.5	27.5
Total (1000 US$)	17.5	70.5	3.5	18.2	7.1	25.6	10.6	53.3	28.0	22.9	257.2

*Assumes USA participation

APPENDIX I

ACTIVITY PLANS

APPENDIX I

ACTIVITY PLANS

The detailed Activity Plans for individual cooperative activities are an integral part of this Program of Work. The Activity Plans have been formulated by the Activity Leaders with input from the participating countries. The Activity Plans follow:

Activity: BIOMASS DIRECT LIQUEFACTION

Lead Country: Sweden

Activity Leader:
Bjorn Kjellstrom
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150 13 TROSA
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Tlx: 12442 FOTEX S
Attn: EXERGETICS

Participants:
Canada
Finland
Sweden
United States (tentative)

Budget (U.S. Dollars):
1986: 25,200
1987: 25,200
1988: 19,200

Program of Work: Attached.

EXERGETICS
ENERGISYSTEMTEKNIK AB
Energi för framtiden - Energy for the future

1986-06-13

I E A Biomass Conversion Project

DIRECT BIOMASS LIQUEFACTION

Project plan 1986 - 1987

1 INTRODUCTION AND BACKGROUND

Direct liquefaction of biomass is one of the possible routes for production of liquid fuels which can substitute gasoline, gasoil or fuel oil. As a first stage in a possible cooperative project for design, construction and operation of a biomass liquefaction test facility, Canada, Finland, Sweden and the USA have carried out a joint study of biomass liquefaction technologies within IEA Co-operative Project D1.

In this study, process concepts studied in the four countries were reviewed an evaluated. Comparative tests were carried out where the same feedstock was used in the experimental liquefaction facilities operated in these countries. Liquid products from liquefaction experiments were analyzed and characterized. Tests on upgrading of the raw biomass oil to gasoline-like products were done. A detailed techno-economic evaluation was carried out for six processes. These were selected to represent different types of processes operated with wood or peat as feedstock.

The results of the study indicate that direct liquefaction of biomass can be used to produce liquid boiler fuels with an energy efficiency of 50 - 60%. Flash pyrolysis at about atmospheric pressure appears as the most economic process for production of boiler fuels. The product may be competitive with petroleum fuel oil at a price level of 200 USD/ton if the cost of the feedstock does not exceed 1.5 USD/GJ. In Sweden and Finland, where the present wood price is about 3.5 USD/GJ, the petroleum fuel oil price must be at least 300 USD/ton if boiler fuel from wood liquefaction shall be competitive.

It was concluded that up-grading of the raw biomass oil to gasoline-like products would probably be possible, although much less experimental work had been done in this field. Whether flash pyrolysis at atmospheric pressure or high pressure liquefaction in a liquid phase is the most economic route to this type of product could not be determined. Estimated production costs for a feedstock cost of 3.5 USD/GJ were twice as high as the import price for gasoline valid in 1983 (380 USD/ton).

Further research related to liquefaction process optimization, equipment design and product up-grading was recommended prior to design and construction of a pilot scale test facility. After the completion of the joint study, such research has continued in all four countries. A continuation also of the co-operative activity was recommended by the working group and has now been agreed to by the IEA Executive Committee. The project plan for this cooperation is presented in the following.

2. OBJECTIVES

The objective of the project is to coordinate ongoing biomass direct liquefaction research to generate an improved data base which can be used for a design study for a biomass liquefaction test facility.

3. SCOPE OF WORK

The cooperative activity will be a continuation of previous interaction and will consist of the following work elements:

Coordinated research

The participating countries will undertake research within their national programs. Topics identified as critical problem areas include

High pressure processes:

- Pressure loss and heat transfer data for flow of high concentration slurries (oil and water carrier);
- Effects on yield and product properties of reduced input of reducing gas and catalyst;
- Catalyst recovery;
- Possibilities to reduce cost for feed preparation and preparation of pumpable feed slurries from raw wood (up to 50% moisture content).

Low pressure processes;

- Identification of a suitable technology for upgrading of low pressure process product to mobility fuel;
- Heat transfer from heated surfaces to feedstock under vacuum pyrolysis conditions (important for sizing and costing of vacuum pyrolysis reactor);
- Design of wide and shallow fluidized bed reactors with short residence time (important for sizing and costing of the reactors in the flash pyrolysis process).

A coordinated program of research on these and other topics of mutual interest will be defined and followed.

Information exchange

Results from task studies in the national programs will be made available to all participating countries on the conditions valid for IEA information exchange.

A newsletter "Direct Biomass Liquefaction News" providing information on the latest results from the national programs will be prepared and distributed every six months.

Continuous evaluation of progress and execution of special studies of limited scope

The progress of the work within the national programs will be evaluated on a six months basis. If necessary, special studies of limited scope will be carried out to provide supplementary information required to assess the applicability, accuracy or significance of results obtained within the national programs.

Updating of the techno-economic assessment

The techno-economic comparison between different process concepts carried out previously by Program Group D will be updated on basis of data generated through this cooperative activity.

4 SCHEDULE

1986

Jan - May	Organization of the project.
Aug 26-28	First Working Group meeting * Presentation of new research results; * Presentation of national research programmes; * Formulation of a co-ordinated research programme; * Need for special studies; * Drafting of Newsletter 1.
29	First PAG meeting (Members of the PAG may take part also in the Working Group meeting if they so wish)
Sept 20	Newsletter No. 1
Dec 16-17	Second Working Group meeting * Review of research results; * Need for special studies; * Drafting of Newsletter 2; * Project plan revision.

1987

Jan 20	Newsletter No. 2
	Annual account audit report 1986
Jan 27	Project Advisory Group meeting
	* Project plan revision for 1987
June 10-12	Third Working Group meeting
	* Review of research results; * Preparation of work plan for up-dating of techno-economic assessment; * Need for special studies; * Drafting of Newsletter No. 3.
Aug 1	Newsletter No. 3
Aug - Oct	Up-dating of state-of-the-art and techno-economic assessment.
Nov 1	Draft reports,"State-of-the-art" and "Up-dated techno-economic assessment".
Nov 23-27	Fourth Working Group meeting
	* Finalizing of reports; * Proposals for stage 3.
Dec 20	Final reports including
	* Revised State-of-the-art report; * Revised techno-economic assessment; * Executive Summary Report with proposals for Stage 3.

1988

Jan 30	Annual account audit report for 1987

5. DELIVERABLES

* The Biomass Liquefaction Newsletter, issues 1 - 3. (Each Newsletter will include a semi-annual progress up-date report also distributed separately to the Project Advisory Group and the Operating Agent.
* Annual account audit report for 1986;
* Project plan revision for 1987;
* Biomass Liquefaction - State-of-the-art 1987
* Techno-economic comparison between selected biomass liquefaction processes.
* Annual account audit report 1987.

6. MANAGEMENT

The activities within the project will be co-ordinated by the Project Manager. The Project Manager is responsible to the Operating Agent for spending of funds within the approved budget.

A Working Group will be set up with technical experts from the participating countries. The Working Group will carry out the reviews of research results, drafting of the Newsletter identification of needs for special studies, preparation of the revised State-of-the-art report and the up-dated techno-economic assessment.

A Project Advisory Group will be set up with representatives of the sponsoring organizations. The main task of this group is to review the progress of the project and to advise and decide on work program modifications.Names and addresses of persons involved in the project are given in Appendix 1.

7. COST ESTIMATE FOR 1986

The budget for 1986 is based on the following in-cash contributions:

	USD
Canada	6 300
Finland	6 300
Sweden	6 300
USA	6 300
	25 200

The cash spending for 1986 will be allocated as follows:

	USD
Management, co-ordination	7 000
Secretarial assistance	2 000
Accounting, auditing	1 000
Communications	1 000
Special studies	3 000
Travel costs	10 000
Newsletter reproduction and miscellaneous	1 200
	25 200

Similar in-cash contributions for 1987 are anticipated.

In addition to the in-cash contributions, each nation will pay for two Working Group members each working one month the first year and two months the second year, in total six months for the two years period, with special tasks assigned to them by the project. These persons will also act as a liaison between the national programmes and the IEA project.

APPENDIX 1

NAMES AND ADDRESSES OF PERSONS INVOLVED IN THE IEA BIOMASS DIRECT LIQUEFACTION PROJECT

PROJECT MANAGEMENT

Project Manager

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Bränslelaboratoriet
SF-02150 ESPOO

Tel: 0-4561
Tlx: 122972

Minna Nissilä
(same address as Yrjö Solantausta)

Activity: COMBUSTION SAFETY ISSUES

Lead Country: Norway

Activity Leader: Mr. Erling Oesterboe
SINTEF/IOF Division 15
N-7034 Trondheim - NTH
NORWAY
Tel: 47-7-593721
Tlx: 55630 SINTF N

Participants: Canada
Norway
Sweden

Budget (U.S. Dollars): 1986: 9,300
1987: 15,000
1988: 18,900

Objective: Examine safety issues including fire and explosive risks in small wood-fired central heating plants.

Outline: Activities initiated by Program Group D in 1984 established methods to collect and evaluate data regarding safety aspect of wood-fired boiler systems. In 1986, further inspection and examination of biomass-fired boilers in Norway will be made. Data will be collected to more closely document fire and explosion problems. Recommendations for safe installation will be presented to member countries in an English-language report.

In the period 1987-1988, the regulations covering biomass combustion safety in the member countries will be compared. Common rules, proposals, and test procedures will be identified. A comparison of differences and experiences will be made for further discussions and work.

1986 Activities: August 1986 - meeting of member countries
December 1986 - report completed

Deliverables: Semi-annual progress report
Yearly audited account
Final report

Activity: INTERNATIONAL BIOMASS THERMAL CONVERSION CONFERENCE

Lead Country: Finland

Activity Leader: To be determined
Contact: Dr. A. V. Bridgwater
Dept. of Chemical Engineering
The University of Aston in Birmingham
Gosta Green
Birmingham B4 7ET
ENGLAND
Tel: 021 359 3611
Tlx: 336997 UNIAST G

Participants: Canada
New Zealand
Norway
United States (tentative)

Budget* (U.S. Dollars): 1986: 12,400
1987: 25,200

*Co-sponsorship will be necessary since all costs could not be covered by this amount. Participation indicates a willingness to send a reasonable number of representatives.

Objective: To help organize on international biomass thermal conversion conference similar to the one held in 1982 in Estes Park, Colorado.

Outline: The activity will take the lead in organizing a second international conversion conference to be held five years after the initial one in Estes Park, Colorado in 1982. The IEA will take the lead in finding additional sponsors, organizing the meeting, and publishing the Proceedings. This second meeting would provide continuity for a series of periodic conferences.

During 1986, an ad hoc committee has been formed to guide this activity. Tentative plans have been formulated regarding meeting location and time, and a format for content is being finalized. Decisions regarding the meeting will be made in 1986, and the meeting will be likely be held in late 1987.

Results: A published Proceedings will be made available on a timely basis.

Activity: WORLD-WIDE DATABASE ON THERMOCHEMICAL BIOMASS PROCESSING ACTIVITIES

Lead Country: UNITED KINGDOM

Activity Leader:
Dr. A. V. Bridgwater
Dept. of Chemical Engineering
The University of Aston in Birmingham
Gosta Green
Birmingham B4 7ET
ENGLAND
Tel: 021 359 3611
Tlx: 336997 UNIAST G

Participants:
Denmark
New Zealand
United Kingdom
United States (tentative)

Budget (U.S. Dollars):
1986: 12,400
1987: 16,000

Activities: See attachment.

INTERNATIONAL ENERGY AGENCY

BIOMASS ENERGY CONVERSION ANNEX

WORLDWIDE DATABASE ON THERMOCHEMICAL BIOMASS PROCESSING ACTIVITIES

Project leader:

Dr Tony Bridgwater
Chemical Engineering Dept.
Aston University
Aston Triangle
Birmingham B4 7ET
UK

August 1986

WORLDWIDE DATABASE ON THERMOCHEMICAL BIOMASS PROCESSING ACTIVITIES

Introduction

Biomass continues to attract considerable attention throughout the world as a renewable energy resource. The energy values of biomass may be realised through technologies involving physical processing, chemical processing, biological processing or thermal and thermochemical processing. Of these technologies, thermochemical processing offers the broadest variety of products ranging from low grade products such as LHV fuel gas, to high grade and high value products such as methanol and gasoline. The economic potential of this technology is evidenced by nearly 100 claimed commercial systems having been identified over the last few years, and many hundreds of installations around the world in both developed and less developed countries.

In addition to this commercial activity, there is extensive supportative R and D aimed at understanding the chemical processes, optimising systems, and developing new processes and new products. There are many exciting research, development and demonstration activities in all continents in the area of thermochemical conversion of biomass. The many potential benefits in collating data on all these activities include improvement of interaction and collaboration, integration of related work programmes, innovation from cross-fertilisation of ideas, and implementation of technologies in viable applications including licensing possibilities.

Objectives

The overall objective of this project is to collate, correlate, analyse and evaluate all activities around the world that are involved in thermochemical conversion of biomass. Activities will be grouped, cross indexed, and critically evaluated. Three main results will be available from the project:

a) Establishment of database:
A comprehensive set of scientific, technical and commercial statistics will be established for as many activities as possible. This will be made available in hard copy form, and will be available in software form for analysis and updating.

b) Evaluation of activities:
Activities will be classified and cross referenced, and critically evaluated in terms of status, relevance and potential. Those activities that appear to merit greater attention will be identified, as well as any potentially interesting areas where work is not currently being

identified, as well as any potentially interesting areas where work is not currently being carried out. Critical aspects of any activity that hinder development or exploitation of the activity will also be identified in order to aid collaboration as described below. Forecasts will be made of the potential scientific and commercial benefits and eventual conclusions from all the activities.

c) Identification of opportunities:

In order to promote interaction at both research and commercial levels, opportunities will be identified for integration, interaction, and/or exploitation of activities. These will include:

* scientific analysis of samples of feedstocks, intermediates and products,
* experimentation on special equipment such as high pressure processing,
* testing of different feedstocks on laboratory and pilot plants,
* cooperation on a technical and/or commercial level to divulge more extensive information than is in the public domain, such as results and costs, and possiblities for licensing,
* consultation on scale-up, design, operation, costing, applications, marketing, and commercialisation.

Scope of work

The work programme will contain the following activities in the order indicated:

1) Discussion with participating countries on the scope of the database - a specimen is appended for comment.

2) Establishment of the database on a computer at Aston University. This will either be a desk top micro-computer or a new main frame computer that is currently being installed. The choice will depend on the sophistication of available databases, and the requirements of the participating countries.

3) Outline entries will be made on the database (2) for as many activities as possible on a worldwide basis by reference to current published literature and particularly the IEA Biomass Abstracts. Key data will be input first to provide a basic checklist.

4) A questionnaire (based on that appended) will then be sent out for each activity identified in (3) with a request for co-operation to produce as detailed an entry as possible. Returned information will be input to the database. [A key feature in obtaining information like this is "information trading" - particpants are much more likely to co-operate if they will have

access to the resultant report, and this aspect will need to be discussed at a future IEA meeting].

5) In parallel with this direct contact with groups, use will be made of the extensive literature that has been accumulated relating to activities in North America and Europe, notably from the US Department of Energy Contractors and the EEC Biomass Energy programme. Information from this source will be input to the database, (2) and (3).

6) In addition to the questionnaires (4) and literature (5) and (8), personal contact with those active in biomass conversion will be made via conferences, seminars and similar situations when active organisations are present.

7) Use will also be made of the extensive network of contacts that have been developed in the area of thermochemical processing of biomass around the world to obtain data, and some reliance will also be placed on representatives of the participating countries.

8) Finally, the IEA Biomass Abstracts will be used as a basic reference source to provide a common literature referencing base. This will also be used to "top up" entries where information cannot be obtained more directly.

9) The database will be updated from all sources in (4) to (9) and checked for consistency.

10) The activities will be classified and cross referenced in a matrix methodology, for example by scale of operation, and/or by technology, and/or by product. This will be explored at an early stage of the project in order to obtain feedback on the relationships examined from the participating countries. The matrix structure will permit identification of a range of opportunities such as overlapping research areas where collaboration might be valuable, and identification of areas where there is apparently no work ongoing.

11) The final part of the exercise will be a critical evaluation of each major activity in the above matrix to identify opportunities, such as anticipated benefits and/or improvements; more potentially attractive areas of work either in terms of improved processes or products; or in terms of interaction and collaboration in related projects. This will be achieved by objective and critical analysis of related activities, and by an examination of the stage of development and likely ultimate or optimum achievement of each activity. This will include theoretical assessment of the technologies concerned where appropriate.

12) The end result of the project will be a substantial hard copy print out of the database, together with a report on the evaluation, and recommendations. Interim reports and

consultative documents will be issued as described below.

Schedule

The programme will commence in August 1986.

		Work programme reference number
1986/7;	liaison over content of database/questionnaire;	1
	establishment of database on computer;	2
	identification and inputting of as complete as possible range of activities;	3
	establishment of contact with some key groups and organisations to collaborate with collection of data.	4,6,7
1987/8;	continuation of data collection and collation;	4,5,6,7
	input of major activities in North America and Europe;	4,5
	correlation with Biomass Abstracts;	8
	establishment of matrix evaluation	10
1988/9;	completion and checking of database;	9
	completion of matrix;	10
	critical evaluation;	11
	report;	12

Milestones

a)	Agreement of scope of database	1
b)	Completion of input of all known activities by name	2,3
c)	Mailing and distributing questionnaires	4
d)	Completion of input from questionnaires and literature	(4,5,6,7,8) 9
e)	Completion of matrix	10
6)	Completion of evaluation	11
7)	Completion of report	12

Deliverables

In addition to the minimum requirements of : annual report, semi-annual progress update, annual project plan revision, and annual account audit; reports and results will be distributed on an as-completed basis according to the scope of work, requirement for feedback, and the schedule of

activities as described above.

Management

The project leader is Dr Tony Bridgwater, Aston University, who will organise establishment of the database and inputting of data at the University using part time staff. Reliance will be placed on a variety of individuals and organisations for collecting, collating and remitting information on each activity, in particular the co-operation of each participating country is actively sought in encouraging all organisations in those countries to co-operate fully in completing and confirming the database entry for their activity. It is also hoped that they will aid identification of all other activities that need to be input to the database, and participate in evolving a useful output from the project.

Use will also be made of the extensive network of contacts that have been developed over the last eight years during work on thermochemical processing of biomass at Aston University. There are a number of active organisations who have agreed to co-operate including Tom Miles, Oregon, USA, and Prof Ton Beenackers in Holland.

Tony Bridgwater has been actively involved in research and consultancy in thermochemical processing of biomass for the last eight years. He has published extensively in this area, organised conferences and workshops in several countries, and carried consultancy for the public and private sector in many parts of the world. He is chairman of the Energy Research Group at Aston University, and has recently been awarded a substantial contract by the EEC for a strategic study of biomass conversion technologies. A CV is attached.

1986 Cost estimate

The budget for 1986/87 is $12 400 with the participating countries being Denmark, New Zealand, UK and USA. Contributions will be devoted to computation, part time labour and travel.

DATABASE ON THERMOCHEMICAL BIOMASS PROCESSING ACTIVITIES

Preferred units

Number .....

Group name .....

Leader and members .....

Address .....

.....

.....

country .....

telephone and telex .....

Year of project commencement .....

Year of project termination .....

Collaborating organisations .....

Source of funds and currency .....

Expenditure to date .....

Related activities .....

Visitors welcome .....

Date of last known report .....

Literature references (IEA) .....

Collaboration

Analytical facilities available .....

Equipment available .....

Testing facilities available .....

Technical cooperation sought or possible .....

Commercial cooperation sought or possible .....

Technical consultation available .....

Commercial consultation available .....

Scale and Size

Commercial	size range	.....	kg/h daf
Demonstration	size	.....	kg/h daf
Pilot	size	.....	kg/h daf
Bench/laboratory	size	.....	kg/h daf
Fundamental	size	.....	g or g/h
Batch or continuous		.....	
Research unit size		.....	*(specify)*

Status

Project name .....

Process (gasificn,pyrolysis,liquefactn,etc) .....

Objectives .....

Number.....*Group name*.....

		Preferred units
Maximum size built	.....	*(specify)*
Maximum throughput achieved	.....	kg/h daf
Capacity, output chemical energy	.....	GJ/h
Capacity, output sensible energy	.....	GJ/h
Efficiency (HV products/HV feed)	.....	%
Scale-up problems	.....	
Other known problems	.....	

Feed

Feedstocks	.....	
Feed pretreatment methods	.....	
Feed limitations (eg size or moisture)	.....	*(specify)*

Reactor

Primary	type	.....	
	pressure	.....	bar
	temperature	.....	deg C
	reagent or gasifying agent	.....	
	catalyst	.....	
	other additives	.....	
Secondary	type	.....	
	pressure	.....	bar
	temperature	.....	deg C
	reagent or gasifying agent	.....	
	catalyst	.....	
	other additives	.....	

Product	Gas Liquid Solid	
proportions by weight	.....	%
analysis available / appended	.....	
particulates	.....	*(specify)*
density / gravity	.....	
HHV (dry basis)	.....	GJ/*(specify)*
applications	.....	
outlet temperature from system	.....	deg C
gas treatment / clean-up methods	.....	
upgrading technology, achievements	.....	
upgrading technology, planned	.....	
upgrading problems	.....	

Number.....Group name.....

Experimentation Preferred Units

- Objectives .....
- Variables currently being studied .....
- Variables already studied .....
- Source of heat / energy .....
- Method of heat transfer .....
- Analysis on-line / off-line .....
- Methods of analysis .....
- Improvements anticipated .....

Function and make of equipment A ..... *(specify)*
Function and make of equipment B ..... *(specify)*
Function and make of equipment C ..... *(specify)*
Function and make of equipment D ..... *(specify)*
(continue on separate sheet if necessary)

Commercial

Capital cost

- cost (money, date, scope - define) ..... *(specify)*
- size of plant ..... t/h daf

Production cost (money/unit) ..... *(specify)*

- major components and % ..... *(specify)*
- size of plant ..... t/h daf

Product values ..... *(specify)*
Financial evaluation performed / available .....
Sales

- completed .....
- in hand .....
- enquiries .....

Licensing

- to .....
- from .....
- arranged .....
- possible / negotiable .....

Future plans .....

Number.....*Group name*.....

Modelling

Process studied .....

Type of model

- Kinetic model and type .....
- Thermodynamic model and type .....
- Empirical model and type .....
- Other (specify) model and type .....
- Reaction stages considered .....
- Special features .....

Tested .....

Validated .....

Accuracy .....

Type of computer .....

Language .....

Programme available .....

Application

- prediction application .....
- design application .....
- range of application .....
- uses .....

Future plans .....

Publications

Appended, please list .....

.....

.....

Notes

FROM:

Tony Bridgwater
Chemical Engineering Dept.
Aston University
Aston Triangle
Birmingham B4 7ET
UK

Telephone: 021 359 3611 ext 4647 TELEX 336997

Activity: PRETREATMENT OF LIGNOCELLULOSICS

Lead Country: New Zealand

Activity Leader:
Dr. Keith Mackie
Forest Research Institute
Private Bag
Rotorua
NEW ZEALAND
Tel: 64 73 475899
Tlx: FRESTRA NZ 21080

Participants:
Austria
Canada
New Zealand
Sweden
United States (tentative)

Budget (U.S. Dollars):
1986: 16,000
1987: 19,000
1988: 22,200

Program of Work: Attached.

IEA/BEA CONVERSION ANNEX

Project plan for activity "Pretreatment of Lignocellulosics"

July 1986

I Introduction and background

In March 1983 the project "Pretreatment of Lignocellulosic Materials" was approved by the International Energy Agency as part of the Forest Energy Agreement. Sweden, Austria, Canada, USA, and New Zealand agreed to participate in the project (termed CPD-2) and by early 1984 a coordinated programme of work was formulated and adopted by the individual laboratories involved.

CPD-2 was proposed for a 3-year term and hence was scheduled for completion by the end of 1986. As such, this programme has meant that CPD-2 has extended into the "new" IEA/BEA Conversion Annex. It is therefore an ongoing programme that will terminate 30 April 1987. Only those activities relating to the current year are detailed below.

II Objectives

The primary objective has been

- to coordinate the research efforts in participating countries aimed at (i) a better understanding of existing pretreatment techniques and (ii) developing improved pretreatment techniques, for rendering woody and agricultural residues amenable to biological conversion for fuels and chemicals production.

III Scope of work

The scope of the work planned over the next 12 months has been defined by the revised programme of work agreed to by all participants as at 29 June 1986.

This project focuses upon pretreatment of lignocellulosics, but in so doing other peripheral topics have been included in the programme of work, e.g. cellulase adsorption and recycling, because the consequences of pretreatment strongly influences downstream processing options.

Major activities for the participants are listed under Section IV, Schedule of work.

IV Schedule

During the period June 1986 - May 1987 the following "activities" are planned.

(i) Conference to be held in Graz, Austria, 24-29 June, focussing on pretreatment. [This conference has in fact been held

already at time of writing!] Programme of work to be reviewed at this meeting.

(ii) Analytical substrate exchange will be continued over next 12 months. This topic, involving the exchange of woody substrates and collation of analytical results, is largely completed but some further testing using pure substrates is planned.

(iii) Standard enzymic assay for testing pretreatment effectiveness will be more widely adopted and comparative results compiled. The "test" procedure has been finalised and agreed upon by all participants. Testing of standard pretreated substrates is currently underway.

(iv) Discussion on other topics within the revised programme of work will continue via the COSY computer network. These topics include:

- Process development (including economics of pretreatment)
- Enzyme adsorption and recycling
- Lignocellulose bioconversion and related projects.

No final meeting for the group is planned within the next 12-month period. The project will terminate 30 April 1987.

V Deliverables

September 1986	*	Proceedings of the Graz symposium, held 24-29 June in Austria. This will be an IEA document encompassing the revised programme of work.
October 1986	*	Published proceedings of the Graz symposium. Authors will have the opportunity to amend or withdraw papers from the IEA proceedings for reasons of confidentiality.
November 1986	*	Semi-annual progress update.
March 1987	*	Report on the substrate exchange activity. (May also be formally published.)
	*	Report on the development of an enzymic method for testing pretreatment effectiveness. (May also be formally published.)
April 1987	*	Final report for project (prepared by Project Leader).
	*	Final audit of accounts.

VI Management

Management will continue as in the past. Assignments (briefly) are as below. A full list of project participants and coordinators is attached.

	Assignment	Location
Dr Keith Mackie	Project Leader and coordinator for substrate exchange activity.	Rotorua, New Zealand
Prof Herman Esterbauer Dr Walter Steiner	Coordinators for pretreatment assay.	Graz, Austria
Dr Lars Vallander	Coordinator for enzymic adsorption and recycling subtopic.	Stockholm, Sweden

VII 1986-87 Cost estimate

Funding for project administration of $12,800 (US) is required.

Activity: CONVERSION OF C-5 SUGARS

Lead Country: New Zealand

Activity Leader: Dr. Graham J. Manderson
Department of Biotechnology
Massey University
Private Bag
Palmerston North
NEW ZEALAND
Tel: 64 63 69089
Tlx: PM PUBTX NZ 3960

Participants: Austria
Canada
New Zealand
Sweden
United States (tentative)

Budget (U.S. Dollars): 1986: 16,000
1987: 19,000
1988: 19,000

Objectives: (1) To coordinate research on appropriate yeast strains for enhancing their pentose to ethanol conversion activities.

(2) To evaluate to the pilot-plant stage fermentation characteristics of pentose fermenting yeasts resulting from the genetic studies and/or from other sources such as national collections of yeasts or natural habitats.

(3) To evaluate the possibility that fermentation products other than ethanol may prove more feasible than ethanol as the fermentation product sought.

While the original objectives were restricted essentially to study of the ethanolic fermentation by the years Pachsolen tannophilus, the objectives will be broadened to allow greater flexibility of approach.

Outline: The cooperative activities on conversion of C-5 sugars were initiated by Program Group O. The activities for 1986-1988 will be in three primary areas.

Cooperative research will continue on the yeast Pachysolen tannophiles to develop a highly flocculent strain. Techniques of mutation, selection, and hybridization will be used and the results will be evaluated. Cooperative research will also be conducted to transfer genetic information which codes for flocculation from brewing strains of Saccaromyces to P. tannophiles using recombinant

DNA techniques. Standard methodologies will be defined, as yeasts developed by such techniques will be evaluated.

Cooperative research will also examine and evaluate yeast strains other than P. tannophiles for converting C-5 sugars. Standardized assays will be developed for evaluation purposes.

Evaluation of process economics will also be performed both for ethanol and for other pentose-derived fermentation energy end-products. Evaluation will be made for P. tannophiles and other yeast strains shown to have promise.

Results: The results of this cooperative activity will be improved strains of yeasts for converting C-5 sugars and standardized analysis techniques. An economic analysis of promising strains will also be performed. The results will be made available in the form of Final and Annual Reports, Proceedings of Meetings, and specialized reports where appropriate.

Proposed Activity Schedule

	1986	1987	1988
	RESEARCH ACTIVITY		
PARTICIPANTS			
Vienna (a)	← Design of ABE Pilot Plant →← - -	To be announced - - - -	
(b)	← Computer Control Systems →←——	To be announced - - - -	
Graz	← Polymer Production from Pentose Sugars ——→		
Innsbruck	←—— To be announced ——→		
Forintek	←—— Butanol & Butanediol Production →← Process Development →		
NRCC	← Basic Physiology, oxygen's role ——→		
Waterloo	←— To be announced ——→		
Lund	←—— Two-stage systems studies ——→		
	←——— Basic studies of enzymes & intermediates ——→		
Massey	← Flocculent Strain Development →← To be announced		
Wisconsin	←— Strain Selection - C. shehatae —→		
	←— Continuous Culture Studies ——→		
Administrative			
1/2 yearly report	*	*	* * *
Final report			
Meetings		?	*

Key: Vienna (a), Prof. A. Schmidt; Vienna (b), Prof. M. Rohr; Graz, Prof. H. Esterbauer and Dr. W. Steiner; Innsbruck, Prof. O. Bobletter; Forinek, Dr. J. Saddler; NRCC, Dr. H. Schneider; Waterloo, Prof. C. W. Robinson; Lund, Dr. B. Hahn-Hagerdal; Massey, Dr. G. Manderson; Wisconsin, Dr. T. Jeffries.

? = Possible meeting in collaboration with first alcohol fuels meeting; (Doug Hayes).

Activity: ALCOHOL FUELS

Lead Country: Canada

Activity Leader:
Dr. John Saddler
Biotechnology Group
Eastern Forest Products Lab.
Forintek Canada Corp.
800 Montreal Road
Ottawa, Ontario
CANADA K1G 3Z5
Tel: (613) 744-9063
Tlx: 053-3606

Participants:
Austria
Canada
United States (tentative)

Budget (U.S. Dollars):
1986: 12,600
1987: 12,600
1988: 12,600

Objective: To examine and evaluate fermentation step in an integrated manner to improve processes for producing alcohol fuels.

Outline: The cooperative activity will build upon the pretreatment work in Activity 4.10 above to examine various steps in alcohol fuel production in an integrated manner. The activities will consider a wide range of biomass feedstocks including:

- wood, agricultural biomass
- paper and waste paper products
- food processing wastes
- municipal solid wastes.

Stage 1: The participants will exchange information and decide on a coordinated research program. A computer conference is proposed initially with a subsequent meeting if necessary.

Stage 2: The coordinated research program will be initiated. Standard analysis and evaluation techniques will be defined. Methods for providing standard feedstock samples will be developed.

Stage 3: Based on the results of the coordinated, economic analysis and evaluation will be performed on integrated alcohol fuels production systems. The results will be compiled in a final report.

Timetable:
1986: Hold computer conference, develop coordinated research program, begin work on standard analysis techniques.

1987: Initiate coordinated research, develop and provide standard samples, begin evaluation.
1988: Complete evaluation and economic analysis, issue final report.

Results: The results of this activity will be analyses and evaluations of alcohol fermentation systems as well as standardized analysis procedures and standard reference samples. The activity will make these results available in Annual, Final, and specialized reports as appropriate.

Activity: ANAEROBIC DIGESTION

Lead Country: Canada

Activity Leader:
Mr. A. R. Stickney
Canviro Consultants, Ltd.
178 Louisa Street
Kitchener, Ontario N2H 5M5
CANADA
Tel: (519) 579-3500
Tlx:

Participants:
Canada
Ireland
New Zealand

Budget (U.S. Dollars):

1986:	12,600
1987:	18,900
1988:	18,900

Program of Work: Attached.

IEA - BIOMASS CONVERSION ANNEX

ANAEROBIC DIGESTION

I INTRODUCTION

Anaerobic digestion technology has been applied to the treatment of municipal wastes for many years. Because of the interest in renewable energy production, energy conservation and environmental concerns, this technology is being applied to a number of agricultural and industrial wastes.

World-wide, there are several hundred full-scale anaerobic digestion systems treating a variety of agricultural and industrial wastes. The engineering design sizing and the actual operational conditions are not readily available or are published in a number of different formats making comparisons between plants difficult.

Energy, Mines and Resources Canada (EMR) developed and presented a proposal at the Sixteenth Meeting of the Executive Committee of the International Energy Agency in Copenhagen, Denmark in October, 1986. It was agreed, after the proposal presentation, that Canada should act as the lead agency and operating agent for the project. The following countries expressed interest and have signed up to participate in the project; Ireland, New Zealand and Canada.

II OBJECTIVES

The proposal submitted by EMR at the Sixteenth Meeting of the Executive Committee was divided into three phases:

Phase I: Canada-wide computer conference featuring monthly performance reports from all agricultural and industrial anaerobic digestion systems according to

a standard data sheet including any observations pertinent to the performance and operation of the digesters.

Phase II: International Computer Conference featuring country by country monthly summary of digester performance as well as any new developments in Anaerobic Digestion Technology.

Phase III: International collaborative effort to assemble a variety of integrated systems to handle different wastes and process requirements.

The specific objectives of the first year for the proposed project is to initiate the Phase I and Phase II activities from the EMR-Canada proposal by developing a computer database containing as much historical design data and current operational data from representative international anaerobic digestion sites and to develop a conferencing system for the data base users to exchange information.

It is anticipated that in subsequent years, additional IEA countries will participate and that the Phase III activities as outlined in the EMR-Canada proposal will be achieved.

III SCOPE OF WORK

1) Contact With Representatives from the International Energy Agency Member Countries and Individuals or Organizations Involved Internationally With Applied Anaerobic Digestion Technology

This phase of the proposed project involves contacting representatives from the participating International Energy Agency (IEA) member countries (Ireland, New Zealand and Canada) and establishing a contact person involved with anaerobic digestion technology in each country. A list of representative anaerobic digestion systems in each

participant country will be developed. A digester from each major design type (i.e. completely mixed, fixed film, upflow anaerobic sludge blanket, etc.) and waste type will be selected from each country for inclusion in the database. We anticipate 6-8 digesters will be selected from each country.

The standard format used with the Canadian database will be used to collect and computerize the relevant digester design and operation conditions for each of the systems identified. The questionnaire used for the Canadian database outlines the required design and operational information required, and will be sent to the various contact people for completion. All the data collected during this phase will be placed in a standardized format ready for entry on the database.

2) Development of the International Anaerobic Digestion System Database and Conferencing System

A database, similar to the Canadian Applied Anaerobic Digestion Technology Database developed by CANVIRO Consultants Ltd., will be set up to contain the international information collected through the questionnaires. The database will be accessible world-wide through DATAPAC, TYMNET, TELENET or the equivalent telephone communication service in each country.

3) Information Transfer, Liaison with Interested Organizations

To promote an interest in and use of the database and conferencing system, an information package will be assembled and distributed to organizations and individuals within the IEA participating countries. The information package will contain a description of the database contents, the procedure to follow to access the database and a guide to using the conferencing system.

4) Second and Subsequent Years Activities

During the second and subsequents years, the information contained on the database will be maintained and updated as required. Additional

relevant information will be added to the database as it becomes available and/or as new technology is developed and applied.

A participants meeting may be organized (depending on interest) to review Anaerobic Technology developments and future prospects.

Activities related to attracting other IEA countries to participate in the Anaerobic Technology conference and database will continue in subsequent years as required.

A more detailed work plan for subsequent years will be developed as the first years activities are carried out and participant responses and suggestions are received.

5) Preparation of Interim and Annual Reports

An interim progress report will be prepared for the fall EC meeting and an annual report is proposed to summarize all the design and operational data contained in the database in a hard copy form. The annual report will be organized into two sections as indicated in Attachment 1.

V SCHEDULE

1) Project Team - for the proposed study key personnel from Canviro Consultants will comprise the project team.

Project Manager - A.R. Stickney. The primary responsibilities of the project manager will include the overall coordination of the project and liaison with the scientific authority.

Project Moderator - J.A. Barclay. The primary responsibility of the moderator will be to contact IEA representatives, establish a contact person in each country to aid in the development of an inventory of representative international anaerobic digestion systems.

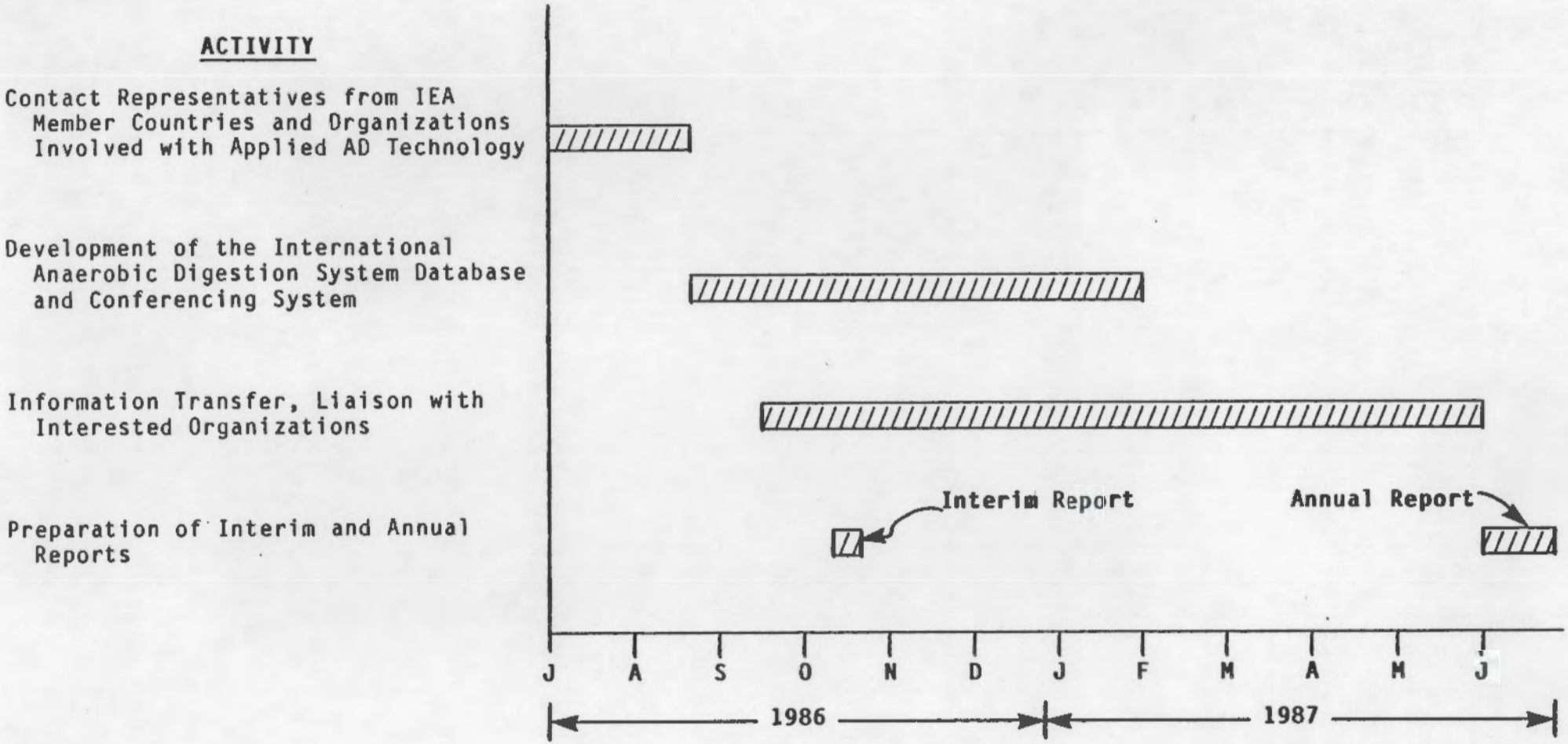


FIGURE 1 - PROPOSED PROJECT SCHEDULE

Project Engineer - D.M. Prairie. The primary responsibilities of the project engineer will be to participate in the collection of the design and historical data, organize the data into a standard format and assist in the development of the database.

VI COST PROPOSAL

TABLE 1. ESTIMATED PROJECT COSTS

PERSONNEL		
		$16,085.00
EXPENSES		
Communications, Copying, etc.		$ 1,100.00
	TOTAL ESTIMATED COST	$17,185.00 Cdn
	TOTAL ESTIMATED COST	$12,600.00 U.S.

CANVIRO is prepared to provide the in-house computer facilities to develop the database and conferencing system and to act as a terminal to the database and conferencing system at no cost to the project. The connect time, long distance telephone or data transfer charges have been estimated and included under communication charges in the cost proposal. No cost for the database user charge and data storage charge have been included.

The estimated project expenditures for fiscal year 1986/87 are $12,600 U.S. ($17,185 Cdn) assuming a project starting date of July 1, 1986.

ANAEROBIC DIGESTION ACTIVITY

ATTACHMENT 1

Section I: Introdution, Summary and Other Relevant Information

The first section of the proposed annual report will introduce the database concept and indicate where additional information on the system may be obtained. This information will introduce the database to potential users of the system that may have found an annual report but were unware of the on-line capabilities.

The objectives of the database and methods of accessing the system will also be presented in the first section of the annual report. A summary table of the representative full-scale and large-scale pilot plant systems operating in the participating IEA member countries will be presented here for quick reference.

An explanation of the data collection, database and data presentation methods will be included in the introductory section of the proposed annual report.

Section II: Design and Operational Information

This section will contain a brief summary of the agricultural or industrial process to which the anaerobic digestion system has been applied. This section will also contain a verbal description of the anaerobic digestion technology applied to the waste stream and a simplified schematic and/or plant layout of the installed facility, if possible.

This section of the proposed annual report will present an excellent summary of the relevant design and operational data of the full-scale and large pilot-scale anaerobic digestion systems in the participating IEA member countries.

Activity: CONVERSION OF MUNICIPAL SOLID WASTE

Lead Country: United Kingdom

Activity Leader:
Mr. Christopher G. Dent
Head, Waste Research Unit
Environmental Safety Group
B146.3 Harwell Lab.
Oxfordshire, OX11 ORA
UNITEO KINGDOM
Tel: 0235-24141 Ext. 2095
Tlx: 83135

Participants: Canada
Sweden
United Kingdom

Budget (U.S. Dollars):
1986: 37,500
1987: 75,000
1988: 75,000

Program of Work: Attached.

Introduction

The International Energy Agency (IEA) is co-ordinating a programme of research based on The IEA Biomass Energy Agreement, covering the entire field of biomass energy, including the use of wastes as fuel. Within this programme, seven research Tasks are identified covering a number of sources of biomass material and the technology for subsequent conversion to energy. Task IV is based on biomass feedstocks research and includes an important area involving the investigation of municipal and industrial solid waste with respect to refuse derived fuel combustion and, more specifically, the production and exploitation of landfill gas. Techniques for the conversion of waste to energy are required to be environmentally acceptable.

It is envisaged, at present, that the UK, Canada and Sweden will co-operate in the study of municipal solid waste conversion, with the UK taking the lead role. The Environmental Safety Group of the Harwell Laboratory has been involved in municipal and industrial waste research and consultancy activities for over fifteen years and is well placed to provide the project leader for this area.

This proposal outlines a programme of work for the period April 1986 - December 1988 in which information and data on the national programmes in progress in the above three countries will be collected and reviewed, research and development needs will be identified, and co-operative projects of defined scope will be commenced after consultation with participating organisations and agencies from these countries and the IEA.

Objectives

To establish and organise co-operative research and development between the participating countries in the area of municipal solid waste conversion with emphasis on the recovery of energy and materials from municipal and industrial wastes and with due cognizance of the need to minimise environmental impacts.

Programme of Work

The following areas will be examined with a view to delineating and implementing defined co-operative research activities.

(a) Thermochemical and biochemical processes

Although energy from waste technologies are emerging commercial systems, research and development is needed to improve their performance and economic return. Studies of fundamental chemical and engineering aspects of combustion and other energy conversion processes will be implemented to improve the understanding of the basic mechanisms involved with the aim of increasing the efficiency of energy conversion.

(b) Pre-treatment of wastes and materials recovery

Methods for pretreatment of solid wastes and recovery of marketable commodities will be examined systematically in comparative trials to yield information for developing optimised techniques.

(c) Standard definitions and nomenclature

At present there is no uniform system of definitions and nomenclature. This problem will be addressed in order to facilitate direct comparison of system design criteria.

(d) Evaluation protocol

Methods and procedures for the evaluation of conversion systems will be standardised to facilitate the comparison of performance and improve technology transfer.

(e) Technology assessment

A comparative assessment of various generic technologies for the conversion of wastes into energy will be made in order to identify areas where further improvements can be made.

(f) Environmental problems

Emissions will be analysed from different types of waste incinerators under varying operating conditions, to establish the conditions associated with minimum potentailly hazardous emissions. Improved incinerator design criteria will also be proposed.

Schedule

The sequence of activities, their durations and reporting milestones are summarised in Figure 1. The proposed annual work schedule is as follows.

April - December 1986:-

- collection and collation of data under headings (a)-(f) above,
- visits to laboratories and centres of expertise in the participating countries to discuss research priorities and needs,
- assessment of current relevant national programmes
- comparison of existing programmes with criteria in IEA documentation, and
- identification of research and development needs.

January - December 1987:-

- design and drafting of a work programme which will meet the requirements of participating countries by:

  (i) complementing national programmes where possible, and
  (ii) commencing activity where practicable to fill existing gaps in technology,

- organisation of a symposium to be held in the UK to discuss the draft programme of work, and
- planning practical research and development programmes with an allocation of specific topics to participating countries and, after consultation, laboratories.

January - December 1988:-

- implementation of initial programmes as agreed during the previous year, and
- production of final project reports for the three year programme

Budgetary Cost Estimate

Harwells' estimated charges for the activities scheduled above are:

	U. S. Dollars
1986	$35,000
1987	75,000
1988	75,000
Total	$185,000

These charges are initial budgetary estimates for further discussion, and include staff effort, travel and subsistence and an allowance for subcontracted research activity in the final year. The following visits have been planned for the purposes of calculation of this estimate.

April - December 1986:

- various UK visits to Warren Spring Laboratory, the Department of Energy (London), other centres of expertise and sites where municipal solid waste conversion is practised,
- two visits to Sweden (participating organisation and other sites as appropriate),
- two visits to Canada (participating organisation and other sites as appropriate), and
- one visit to Battelle Pacific Northwest Laboratories for discussion and progress reporting.

January - December 1987:

- various UK visits as appropriate,
- one visit to Sweden for discussion of the municipal solid waste symposium,
- one visit to Canada for discussion of the municipal solid waste symposium, and
- one visit to Battelle Pacific Northwest Laboratories for discussion and progress reporting.

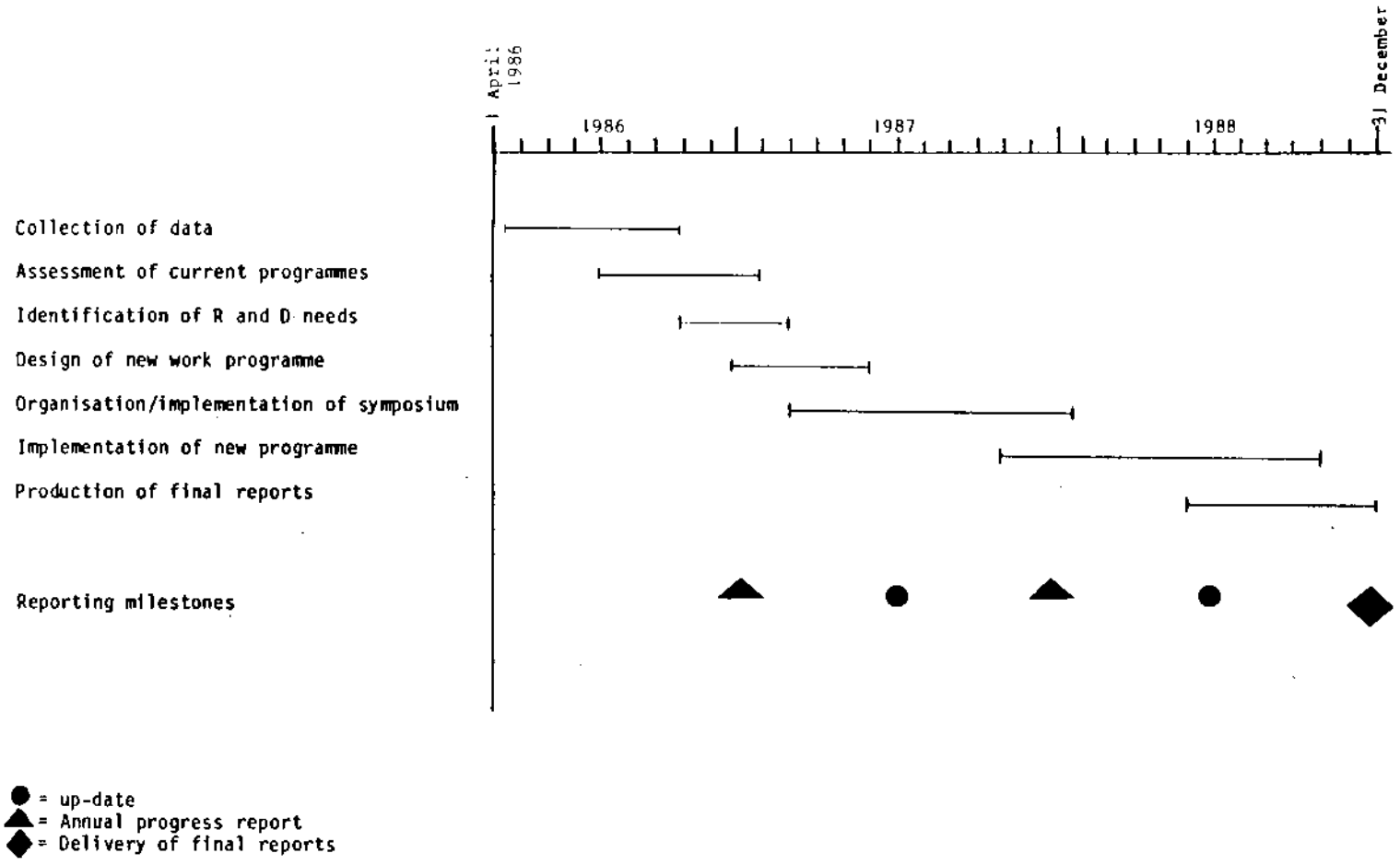
January - December 1988:

- various UK visits as appropriate,
- one visit to Sweden for implementation of the work programme,
- one visit to Canada for implementation of the work programme. and
- one visit to Batelle Pacific Northwest Laboratories for presentation of the final report.

Staff

The work will be conducted by Mr C G Dent, a Senior Scientific Officer in the Waste Research Unit of the Environmental Safety Group (ESG), with support and assistance from other members of the ESG as appropriate to the tasks to be addressed in the developing programme.

Figure 1 Sequence of activities for municipal solid waste programme



Activity: COMBUSTION OF BIOMASS - THE ENVIRONMENTAL ISSUES

Lead Country: Norway

Activity Leader:
Dr. Christel Benestad
Center for Industrial Research
BOKS 350
0314 OSLO 3
NORWAY
Tel: 47-2-452986
Tlx: 71536 SI N

Participants:
Austria
Denmark
Finland
Norway
Sweden
United States (tentative)

Budget (U.S. Dollars):
1986: 19,200
1987: 31,800
1988: 19,200

Program of Work: Attached.

COMBUSTION OF BIOMASS - THE ENVIRONMENTAL CONSEQUENCES

I INTRODUCTION AND BACKGROUND

Increased utilization of biomass combustion for energy recovery in many countries in the western world in addition to more attention of airpollution in general, has led to concern about emissions from biomass combustion. Investigations (1,2) show that emission of polycyclic aromatic hydrocarbons (PAH) and other mutagenic compounds from wood combustion for residential heating gives a considerable contribution to the total air pollution. There is a need for improving the combustion units and decreasing the pollution emitted.

Prospects for further investigation of the IEA project CPD4 is made in the report "Combustion of biomass in Austria, Canada, Finland, Norway, Sweden and USA" (SI-report 840324-1, 1986). These proposals have been discussed with some of the project members. Based on that the progress of the project CPD4 will be as follows.

II OBJECTIVES

The objectives with this project is to measure and characterize biomass combustion emissions. The intention is to contribute to the development of appliances with decreased pollution emission and increased efficiency.

III SCOPE OF WORK

This project will start with studying the characterization methods of organic micropollutants from biomass combustion in small and middlesize plants (<1MW), which are standardized or in common use in the CPD-4 participating countries and in other leading countries. It will be made a comparition of the different methods used for sampling of particles and organic compounds, and the different ways of characterizing the organic compounds emitted in the stack gas. The aim is to find convertions factors between these different characterization methods to make the interpretation of the results from different laboratories easier.

The methods used for stark gas sampling in each country will be studied, and the differences that may be important for the results will be evaluated. It will be decided if there is a need for doing comparative sampling investigations with these different methods from the very same stack gas in the same combustion unit.

1) Ramdahl T; Schjoldager J; Currie L.A; Hanssen J.E; Møller M; Klouda G.A; Alfheim I: Ambient impact of residential wood combustion in Elverum, Norway. The Sceince of Tot. Environ. 36, 81-90 (1984)

2) Alfheim I, Ramdahl T: Mutagenic and carcinogenic compounds from energy generation. Mil-2 Final report. Nordic Councils of Ministers (1986)

Also the different ways of characterizing the emission of organic micropollutants from wood combustion will be evaluated. The amount of PAH, tar, total hydrocarbons and other parameters in use will be compared from data found in the literature and in documentations for standard methods, or/and by chemical analysis of stack gas samples collected in connection with evaluation of the sampling methods, or in ongoing national projects.

IV SCHEDULE

1 year (July -86 to July -87): Collect information about sampling methods and chemical characterization of particles and organic micropollutants in emission from wood combustion. Evaluation of the methods starts.

2 year (July -87 to July -88): Evaluation of the methods continues. Stark gas sampling of particles and organic compounds according to the different methods, or/and collecting starkgas samples is done. Chemical analysis starts.

3 year (July -88 to July -89): The chemical analysis are finished. A final report is written.

V DELIVERABLES

The emphasis of the project will be a final report, with address to laboratories and certification authorities. At the end of each project-year (in July) a short progress report including project plan revision and annual account audit will be written. A semi annual progress update will be send at the end of December each year.

VI MANAGEMENT

The project leader will be Christel Benestad at the Center for Industrial Research in Oslo, Norway. Representatives for the participating countries will work as an advisory board. They will have contact with groups working in this field in their countries, and with the health and environmental authorities. Depending on their interest they will contribute more or less to the project. The sampling and the chemical analysis are done at the Center for Industrial Research or elsewhere. The representatives of each CPD-4 country are listed in Appendix I. The vita of project manager is enclosed in Appendix II.

VII Costs estimated for 1986-87 is US$ 19,2.

APPENDIX I:

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Birgitta Timm
National Swedish Environmental Protection Board
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Dr. Don J. Stevens
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Civ.ing. Kurt Delvig
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Christel Benestad
Center for Industrial Research
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0314 Oslo 3
Norway
(Telex: 71536 SI N) Tel. 47-2-452986

Activity: STANDARDS METHODS OF ANALYSIS OF BIOMASS FOR FUELS AND CHEMICALS

Lead Country: Canada

Activity Leader:
Dr. Thomas A. Milne
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401
USA
Tel: (303) 231-1440
Tlx:

Participants:
Canada
Finland
New Zealand

Budget (U.S. Dollars):
1986: 9,900
1987: 21,900
1988: 24,900

Program of Work: Attached.

I. INTRODUCTION

There is a growing concensus regarding the need for a whole range of standards activities in support of research, development and commercialization of biomass for energy and petrochemical substitutes. This was detailed in the recommendations of a major workshop held at NBS in 1984 (NBS, 1984); in a workshop on low BTU gasification (PNL, 1984); and in the proposed activities of Annex IV of the IEA, "Improvements of Methods for Converting Biomass Feedstocks into Useable Energy Forms". Specifically the NBS Workshop panel on Characterization (members are listed in Appendix A) concluded that:

> "Proper characterization of biomass requires use of analytical methods appropriate for the material under study. The noncritical spplication, for example, of a wood analysis technique for study of a nonlignified substrate could lead to erroneous data and misleading conclusions. A series of analytical tests for whole biomass and its major components were listed with the recommendation that round-robin tests, using reference materials, be conducted. A panel of experts, active in analysis of biomass materials, should be convened to decide on methods to be used for determining components and properties of biomass. The analysts should include considerations of the many new instrumental techniques and methods not contained in the traditional compilations of procedures for wood and paper analysis."

SERI's Technical Information Branch is desirous of producing an information product that will be responsive to the biomass communities' needs for standards analytical methods and psotocols, and has proposed a task to pursue this in FY 1986 and FY 1987. ASTM Committee E-44 has expressed strong interest in ultimately issuing methods developed by the biomass community. Energy, Mines and Reaources has addressed standards through cooperative analyses of pyrolysis oils and through the supply of a reference ("standard") feedstock for certain research programs. IEA Annex IV has approved a task on voluntary standards that is supported by Finland, Canada and New Zealand, with interest shown by several other member and non-member countries.

The following plan is in response to the above identified and expressed needs for voluntary standards for analysis. It draws on the broad and considerable analytical expertise of SERI staff and on the information dissemination capabilities and mission of the SERI Technical Information Branch. The principal investigator will be the manager of the task. His technical background and strong past involvement in the area of biomass standards, includes a one-year research associateship at the National Bureau of Standards, which culminated with the organization of a major workshop on standards held at the NBS in Gaithersburg, Maryland in 1984.

II. GOALS AND OBJECTIVES

The overall goal of a general biofuels standards program is to provide quality assurance in research, development and commercialization through provision of standard methods and protocols and standard materials. Such standards will provide comparability in R&D programs, and a data-base of methods, both of which will promote efficiency in government-funded programs.

The specific objectives of this project are to:

- Define the status of relevant analytical methods for the analysis of raw materials, process intermediates and end products.
- Select analysis topics for further investigation and methods development.
- Recommend useable methods (i.e., using criteria such as simplicity, accuracy, repeatability, instrument availability, and cost).
- Validate key methods through round-robin tests involving ad hoc standard materials (Research Materials according to NBS definitions).
- Collaborate with NBS in the establishment of at least one Standard Reference or Research Material (e.g., cellulose, lignin).
- Design and disseminate an information product containing suggested methods of analysis.

- Work toward eventual adoption and issuance of methods by ASTM and other relevant standards setting bodies.

- Involve major North American organizations and IEA members with biofuels interests.

- Establish an on-going Working Group or Groups, on Analytical Methods.

III. SCOPE AND DURATION OF WORK

The range of analytical methods and protocols of interest is very broad, so that priorities must be set early on. Based on input from the NBS activity and workshop, from Energy, Mines and Resources, from SERI researchers and from Finland and other IEA Annex IV member countries, several analysis topics are chosen for first consideration.

A. Thermochemical Conversion

- Efficiency and emissions test for furnaces, boilers and fuel-gas producers.

- Moisture content of feedstocks and pyrolysis oils.

- Higher Heating Value of feedstocks and fuels.

- Molecular Weights by gel permeation chromatography.

- Solvent fractionation of oils.

- GC/MS of oils.

- Input on methods for these areas by Working Group and suggestions of other possible areas.

B. Biochemical Conversion

- Cellulase enzyme assay.
- Cellulose determination.
- Total potential fermentable sugars in hydrolysates.
- Fermentabilty of sugars from various hydrolyses of lignocellulosic substrates.
- Standard digestibility test.
- Lignin content of pretreated lignocellulosic substrates.
- Input on methods for these areas by Working Group and suggestions of possible additional areas.

The relative emphasis will be approximately 60-80% on biochemical and 20-40% on thermochemical methods. A two-year program is envisioned, with activities of the working group continuing indefinitely, perhaps under the aegis of ASTM or the Canadian Standards Association.

IV. TASK STRUCTURE AND SCHEDULE

Achievement of the objectives outlined above will be accomplished through a phased series of taska and activities involving the principal investigator, hia collesgues at SERI, the sponsoring program managers, the Technical Research Center of Finland, the Working Group and the biomass technology community. The following workplan and schedule is offered, subject to revisions following early input from the sponsors and the working group. The task descriptions are followed by a schedule and a list of deliverables.

YEAR ONE

Task 1. Periodic review of workplan. Consultation with working groups, NBS, and IEA member and non-member countries may indicate broadening of, or changes in, the standards agenda. With the approval of sponsors, the workplan may be revised accordingly.

Task 2. Obtain guidance from Working Group.

2.a. Convene a group of SERI analytical experts to identify priority needs and methods used and expertise needed in Working Group.

2.b. Select Working Group Invitees.

2.c. Establish Working Group.

2.d. Plan Working Group Meeting, tentatively at SERI or in conjunction with Canadian Bioenergy meeting in Vancouver. (Nov. 1986).

2.e. Hold Working Group Meeting.

2.f. Seek affiliation of Working Group with standards setting body like ASTM.

Task 3. Status of Relevant Analytical Methods.

3.a. Collect established methods.

3.b. Collect current methods through correspondence, literature review, computer conferences, meeting questionnaires (e.g., the IEA Annex IV meeting in Graz, Austria - June 1986).

3.c. Visit selected laboratories and attend meetings to obtain additional input.

3.d. Select and recommend analytical topics for further investigation.

Task 4. Arrange round-robin tests of selected methods using standard materials.

Identify tests and participating laboratories. Certain methods of high utility but uncertain reliability, will be chosen for round-robin tests using standard materials. Similarly, a variety of methods ostensibly measuring the same property, could be compared on the same material. Laboratories with both interest and capability will be asked to carry out the tests at their own expense.

Task 5. Standard Materials.

5.a. Obtain ad hoc "standard materials" for use in round-robin tests (such as Avicel, a wood sample, oils or hydrolyzate solutions).

5.b. Consult with NBS on the possibility of establishing a pure cellulose and a lignin standard reference material.

Task 6. Information Product on Methods.

6.a. Plan scope and format of information product.

6.b. Prepare initial draft of information product.

6.c. Issue draft for sponsor approval.

6.d. Issue first edition to public.

Task 7. Methods for Testing Efficiency and Emissions of Biomass Combustion Systems, for Use by Suppliers, Contractors and End-Users. (Tentative subject submitted to R. D. Hayes by Finland who will carry out this task.)

7.a. Collect available methods for efficiency and emission testing of small and large scale combustors and boilers, and equipment for producing fuel gas.

7.b. Estimate useability of testing methods.

7.c. Establish requirements for dissemination of information on methoda to target group.

7.d. Plan future activities.

Task 8. Deliverables.

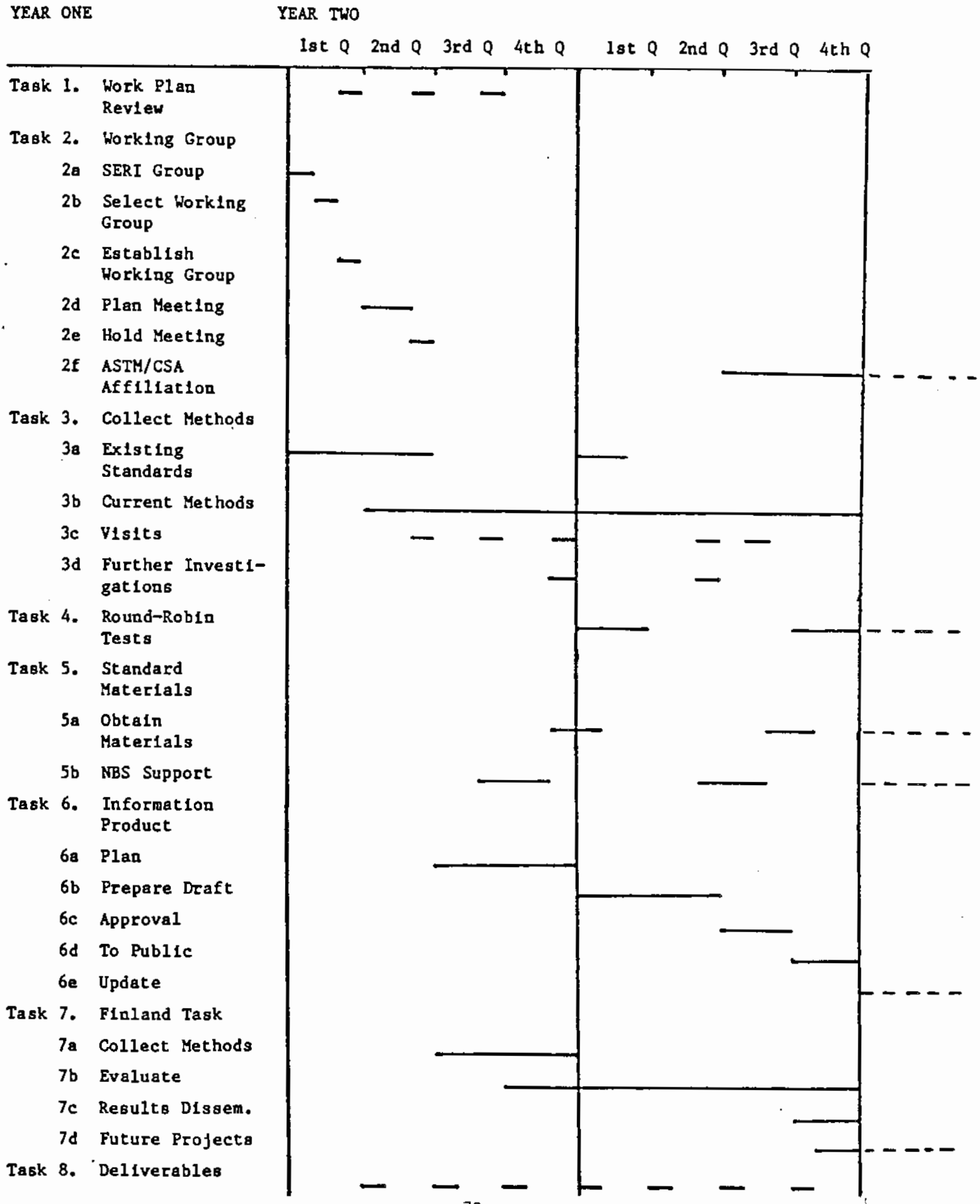
The sponsors will be provided with quarterly, annual and final reports. The principal technical deliverable will be a Technical Information Product containing information about standard test methods and protocols, their applicability and problems, and results of any round-robin tests carried out on selected methods. This will be jointly published on behalf of all sponsors of thia project.

Projected Schedules for these tasks are shown below.

V. MANAGEMENT

It is planned that the entire project be managed by the SERI Solar Fuels Research Division, with Thomas A. Milne as principal investigator and manager of the task, and Helena Chum as scientific resource. Additional SERI staff will be drawn into the project as needed. The work in Finland (task 7) will be managed directly from SERI, with funds coming from the operating agent for administration. Finland will contribute as yet undetermined in-kind support for the task 7 work to be carried out by Finland.

TIME PHASING OF TASKS



REFERENCES

NBS (1984). T. A. Milne, editor. "Proceedings - Workshop on Standards in Biomass for Energy and Chemicals." National Bureau of Standards, Gaithersburg, MD, 1-3 August, 1984. SERI/CC-234-2506.

PNL (1984). Easterling, J. C., D. J. Keenan, A. L. Brenchley, J. A. Russell. "Identifying the Barriers to Commercialization of Low-BTU Gasifiers: Proceedings of a Workshop". Conf-8411156, PNL-SA-13123.

APPENDIX II

IEA BIOENERGY AGREEMENT

TASK IV: BIOMASS CONVERSION

IMPROVEMENTS OF METHODS FOR CONVERTING BIOMASS FEED STOCKS INTO USEABLE ENERGY FORMS

1. Definitions

Conversion of biomass means both biological and thermal methods for producing useable energy and includes feedstock pretreatment prior to conversion as such. Useable energy forms include heat and electricity as well as intermediate gaseous, liquid and solid fuels.

2. Objectives

The objective of this Task is to obtain a review of selected biomass conversion issues, containing systematic economical and environmental assessments of how to improve biomass conversion, all based upon empirical and analytical data.

The selected issues of this Task belong to five areas and are listed below:

(a) Thermal conversion

- Production of improved liquid fuels
- Combustor safety and reliability
- Thermochemical Conversion Conference
- Establishment of worldwide data base of thermal conversion

(b) Biochemical conversion

- Pretreatment of lignocellulosics
- Conversion of C-5 sugars
- Integrated alcohol fuels production systems
- Anaerobic systems

(c) General Conversion

- Cost-effective methods for converting municipal wastes

(d) Environmental Issues

- Characterization and reduction of combustion emissions

(e) Voluntary Standards

- Standardized analytical procedures and reporting formats and units.

3. Means

(a) Background

Within the countries of the Participants of this Task there are substantial ongoing and decided National Research and Development Programmes on Biomass Conversion in the areas to which the issues belong.

(b) Activities

In addition to and heavily supported by the National Research and Development Programmes concerning the areas mentioned the participants will conduct co-operative information exchange, complementary research and analysis activities to accomplish the objectives of this Task.

(c) Responsibilities of the Participants

(1) Each Participant will provide its contribution to the Common Fund as provided in paragraph 7 below.

(2) In order to support the work under this Task each Participant will provide the Operating Agent with Task-relevant information from its National Research and Development Programme on converting biomass feedstocks into useable energy forms, subject to the provisions of paragraph 9 below.

(d) Activity Leaders

An Activity Leader for each Activity shall co-ordinate the work performed under that Activity. The Activity Leader shall be a Participant which provides to the Activity highlevel expertise and undertakes substantial research and development in the field of the Activity. The Activity Leader shall be designated by the Operating Agent in agreement with the Participant and after consultation with the Technical Advisory Committee.

(e) Technical Advisory Committee

The Participants shall establish a Technical Advisory Committee consisting of one expert designated by each Participant. The Technical Advisory Committee shall assist the Operating Agent through the provision of Task-relevant information on national energy programmes as described in sub-paragraph (b)(2) above and shall advise the Operating Agent on other questions related to the performance of the Task.

4. Specific Responsibilities of the Operating Agent

(a) The Operating Agent shall be responsible for the overall management of the work under this Annex and for implementing the decisions of the Executive Committee. To that end, the Operating Agent shall:

(1) Prepare and submit for approval to the Executive Committee not later than three months after the adoption of this Annex and thereafter not later than three months before the following calendar year a detailed Programme of Work and Budget, structured by Activity.

(2) Report to the Executive Committee on the results and progress of the work under the Annex, at least semi-annually.

(3) Upon completion of the Task, compile and disseminate to all Participants a final report and other documentation as set forth in paragraph 5(b) below.

5. Results

The results of this Task will form a scientific base limited to a selection of issues for judgements of how to improve biomass conversion.

The Operating Agent will provide each Participant with one integrated final report and final reports on individual conversion technologies outlining methods for improving efficiency and effectiveness.

6. Time Schedule

This Annex will enter into force on 1st May, 1986, and remain in force for a period of three years. It may be extended by decision of the Executive Committee, acting by unanimity and taking into account any recommendation of the Agency's Committee on Energy Reserach and Development concerning the term of this Annex.

7. Funding

(a) The Participants agree to establish a common fund to finance the work to be performed under this Task including the work of the Operating Agent and the research work of the Participants performed by request of the Operating Agent under this Task.

(b) The expenditures covered by the common fund shall be borne by the Participants in shares as set out in sub-paragraph (d) below and shall not exceed 684 000 USA dollars at running prices. The Executive Committee, acting by unanimity, may agree to increase the level of expenditure.

(c) If significant changes occur, the Executive Committee, acting by unanimity, shall decide whether to adjust the Programme of Work or the Budget.

(d) Participants' Anticipated Contributions to the Common Fund

Participant	Anticipated financial contributions in USD
Austria	52 100
Canada	194 700
Denmark	20 700
Finland	64 200
Ireland	18 600
New Zealand	72 700
Norway	39 600
Sweden	143 400
United Kingdom	78 000
Total	684 000

(e) Each Participant shall bear directly all the costs not covered by the common fund pursuant to sub-paragraph (a) above, including the costs of reimbursing its employees and the expert it designates for the Technical Advisory Committee for travel and other per diem expenses incurred in connection with the work.

8. Operating Agent

Canadian Forestry Service (and an acting basis pending resolution of United States' position).

9. Information and Intellectual Property

(a) Executive Committee's Powers. The publication, distribution, handling, protection and ownership of information and intellectual property provided to or arising from activities conducted under this Annex shall be determined by the Executive Committee, acting by unanimity, in conformity with this Annex.

(b) Right to Publish. Subject only to the patents and copyright restrictions of this Annex, the Participants in this Annex (referred to in this Annex as the "Participants") shall have the right to publish all information provided to or arising from this Annex except proprietary information, but they shall not publish it with a view to profit, except as agreed by the Executive Committee, acting by unanimity. Neither the Participants nor personnel designated by them shall introduce into the Facility proprietary information unless such information is specifically identified and the terms and conditions for its introduction are agreed upon in writing by the Operating Agent and the concerned Participant.

(c) Proprietary Information. The Participants shall take all necessary measures in accordance with this Annex, the laws of their respective countries, and international law to protect proprietary information. For the purposes of this sub-paragraph, proprietary information shall mean information of a confidential nature acquired prior to or outside the scope of this Annex, such as trade secrets and know-how (for example, computer programmes, design procedures and techniques, chemical composition of materials, or manufacturing methods, processes or treatments), which is appropriately marked, provided such information:

(1) Is not generally known or publicly available from other sources;

(2) Has not previously been made available by the owner to others without obligation concerning its confidentiality; and

(3) Is not already in the possession of the recipient Participants without obligation concerning its confidentiality.

It shall be the responsibility of each Participant supplying proprietary information to identify the information as such and to ensure that it is appropriately marked.

(d) Production of Relevant Information. The Operating Agent should encourage the governments of all Agency Participating Countries to make available or to identify to the Operating Agent all published or otherwise freely available information known to them that is relevant to the Task. The Participants should notify the Operating Agent of all pre-existing information and information developed independently of the Task known to them which is relevant to the Task and which can be made available to the Task without contractual or legal limitations.

(e) Reports on Programme Work. Reports containing arising information and pre-existing information necessary for and used in the Task, including proprietary information, shall be provided to the Operating Agent by each Participant performing the work. Each Participant agrees to provide to the Operating Agent all information which is utilized in the activities under this Annex or which is necessary for practising the results of the undertakings in this Annex. The Operating Agent shall provide all such information to all Participants. The Operating Agent shall provide summary reports of work performed under this Annex and results thereof (arising information), excluding proprietary information, to the Executive Committee.

(f) Arising Information. All information developed in connection with and during activities carried out under this Annex (arising information) shall be provided to each Participant by the Operating Agent, subject only to the need to retain information concerning patentable inventions in confidence until appropriate action can be taken to protect such inventions in accordance with sub-paragraph (h) below.

(g) Licensing of Pre-existing Inventions. Each Participant agrees to license all pre-existing inventions covered by patents owned or controlled by it which are necessary for and used in the Task to the other Participants, their governments and the nationals of their respective countries designated by them on reasonable terms, for use in all countries and to the government of any Agency Participating Country for use it its own country of any such invention on reasonable terms and conditions in order to meet its energy needs.

(h) Arising Inventions. Inventions made or conceived in the course of or under the Task (arising inventions) shall be owned in all countries by the inventing Participant, subject to a license on reasonable terms to each of the other Participants, their governments, and the nationals of their respective countries designated by them. Information regarding inventions on which patent protection is to be obtained by the Participants shall not be published or publicly disclosed by the other Participants until a patent application has been filed, provided, however, that this restriction on publication or disclosure shall not extend beyond six months from the date of receipt of such information. It shall be the responsibility of the inventing Participant to appropriately mark reports which disclose inventions that have not been appropriately protected by the filing of a patent application.

In order that public disclosure of inventions shall not adversely affect the patent interest of the Participants, patent approval for release or publication of information generated by or made a part of the activities under this Annex shall be obtained from the Operating Agent prior to any release or publication. Each Participant agrees to license such arising inventions to the Government of any Agency Participating Country for use in its own country on reasonable terms and conditions in order to meet its energy needs.

(i) Copyright. The Operating Agent or each Participant for its own work may take appropriate measures necessary to protect copyrightable material generated under the Task. Copyrights obtained shall be the property of that Participant or the Operating Agent for the benefit of the Participants, provided, however, that Participants may reproduce and distribute such material, but shall not publish it with a view to profit.

(j) Inventors and Authors. Each Participant shall, without prejudice to any rights of inventors or authors under is national laws, take all necessary steps to provide the co-operation from its inventors and authors required to carry out the provisions of this paragraph. Each Participant will assume the responsibility to pay awards or compensation required to be paid to its employees according to the laws of its country.

(k) Determination of "National". The Participants may establish guidelines to determine what constitutes a "national" of a Participant.

10. Participants

The Contracting Parties which are Participants in this Task are the following:

The Republic of Austria

The Canadian Forestry Service

The Ministry of Trade and Industry (Denmark)

Finnish Research Institute

The Government of Ireland

The Forest Research Institute (New Zealand)

The Royal Norwegian Ministry of Petroleum and Energy

The National Energy Administration (Sweden)

The United Kingdom Atomic Energy Authority

APPENDIX III

1984-1986 PUBLICATIONS

IEA FORESTRY ENERGY AGREEMENT

PROGRAM GROUP D: BIOMASS CONVERSION

IEA/FEA PROGRAM GROUP D
LIST OF PUBLICATIONS

COOPERATIVE PROJECT D-1

IEA Cooperative Project D-1. Biomass Liquefaction Test Facility Project. Final Report. National Energy Administration, Sweden.

Vol. 1; B. Kjellstrom. Dec. 1983. "Summary, Conclusions, and Recommendations."

Vol. 2; D. Beckman, A. Bergh, D. C. Elliott, and A. Kannel. June 1983. "State-of-the-Art Review."

Vol. 3; D. Beckman. Nov. 1983. "Results of the Comparative Test Program."

Vol. 4; D. C. Elliott. Dec. 1983. "Analysis and Upgrading of Biomass Liquefaction Products."

Vol. 5; P. McKeough, M. Nissila, Y. Solantausta, and A. Oestman. "Techno-economic Assessment of Selected Biomass Liquefaction."

Vol. 5a; A. Bergholm, A. Kannel, P. McKeough, and A. Oestman. Dec. 1983. "Appendices."

Kjellstrom, B., ed. 1985. A Study of a Biomass Liquefaction Test Facility. National Energy Administration, Sweden.

McKeough, P., M. Nissila, Y. Solantausta, D. Beckman, and A. Oestman. Jan. 1985. Techno-economic Assessment of Direct Liquefaction Processes. Technical Research Center of Finland, Research Report No. 337. NTIS: PB-85-200251/XAB.

Beckman, D. and D. C. Elliott. Feb. 1985. "Comparisons of the Yields and Properties of the Oil Products from Direct Thermochemical Biomass Liquefaction Process." Canadian Journal of Chemical Engineering, Vol. 63. Pp. 99-104.

Oestman, A., and D. Beckman. June 1985. "Upgrading of Biomass-Derived Oils." Canadian Chemical News.

COOPERATIVE PROJECT D-2

K. L. Mackie. June 1984. Pretreatment of Lignocellulosics Materials. Current Research in Participating Laboratories and Coordinated Programme of Work. Forest Research Institute, Rotorua, New Zealand.

Symposium on the Pretreatment of Lignocellulosic Materials: Symposium Preprints. Forest Research Institute, Rotorua, New Zealand, March 25-29, 1985.

Retrospective Search on Production of Ethanol from Cellulose. March 1985. Cooperative Project CPD-2 Report No. 3. Information Technology Group, Institute for Industrial Research and Standards, Ireland.

Symposium Proceedings: IEA/FE Project CPD-2 Programme Review. June 1985. Forest Research Institute, Rotorua, New Zealand. Report No. 4.

COOPERATIVE PROJECT D-3

Oesterboe, E. In press. Problems Concerning Use of Woodfired Boiler Systems. Norwegian Institute of Technology, University of Trondheim, Trondheim, Norway.

COOPERATIVE PROJECT D-4

Benestad, C. March 1986. Combustion of Biomass-Environmental Consequences. Center for Industrial Research, Oslo, Norway. Report Number 84-03-24-1.

COOPERATIVE PROJECT D-5

Manderson, G. J., ed. Sept. 1985. The Conversion of C-5 Sugars to Ethanol. IEA/FE CPD-5 Report No. 1. Massey University, Palmerston North, New Zealand.

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