Annual Report 1999

IEA Bioenergy: ExCo: 2000:01

IEA Bioenergy

IEA Bioenergy Annual Report 1999

IEA Bioenergy is an international collaborative agreement set up in 1978 by the International Energy Agency (IEA) to improve international cooperation and information exchange between national bioenergy RD&D programmes. IEA Bioenergy aims to realise the use of environmentally-sound and cost-competitive bioenergy on a sustainable basis, to provide a substantial contribution to meeting future energy demands.

To: IEA Headquarters, Paris

IEA BIOENERGY ANNUAL REPORT 1999

The IEA Committee on Energy Research and Technology (CERT) has recommended that an Annual Report shall be submitted for each of the IEA Implementing Agreements.

This document contains the report of the IEA Bioenergy Executive Committee.

This year, we have presented a special feature of the biomass gasification activities within the countries participating in Task 20 'Thermal Gasification of Biomass'.

The contributions from the Task Leaders, research collaborators and Operating Agents to this report are gratefully acknowledged.

Josef Spitzer	John Tustin
Chairman	Secretary

Contents

Editor: John Tustin, IEA Bioenergy Secretary, Rotorua, New Zealand

Preparation, design and layout of cover and colour section: Suresh Babu and members of Task 20; Institute of Gas Technology, USA. Also Carlin Valenti Ltd, Tauranga, New Zealand.

Further information on IEA Bioenergy can be obtained from the Executive Committee Secretary, see Appendix 5 of this Annual Report.

A list of country representatives in the Executive Committee is given in Appendix 6.

The opinions and conclusions expressed in this report are those of the authors.

Thermal Gasification of Biomass

An overview of activities within the countries participating in Task 20 prepared by Task Leader, Suresh P. Babu and the collaborating members.

Introduction

Renewable biomass and biomass derived fuels could readily replace fossil fuels in many of the present energy utilization applications with concomitant environmental benefits. Gasification is a form of biomass energy conversion producing a fuel that could substitute for fossil fuels in high efficiency power generation and CHP applications. While fossil fuel resources are heavily concentrated in coal mines and oil and gas wells, biomass resources are dispersed and hence the fuels they produce are more expensive than fossil fuels. However, biomass is a renewable resource and may become a significant component in the global sustainable energy mix as fossil fuel resources begin to be depleted. For example, short rotation poplar crops as shown below. In addition, biomass utilization can expedite mitigation of greenhouse gas emissions and carbon sequestration cycles and promote 'green' industries with associated growth in rural economies. Biomass gasification fuels may be able to use the existing natural gas distribution network and, with minor equipment modifications, biomass fuel gases could be readily used in most of the present natural gas energy conversion devices.

Courtesy of NREL,USA

Air-blown gasification of biomass produces a clean burning fuel gas that could be used for direct combustion in boilers to produce heat and steam, or in gas and Stirling engines to produce electricity in the 20-30% efficiency range. Pressurized gasification with close-coupled gas turbines offers the capability to produce electricity at 40% or higher efficiency. Enriched-air or oxygen blown gasification produces a synthesis gas, suitable for conversion to hydrogen, chemicals, fertilizers, or substitute liquid fuels. Fuel gas, synthesis gas, and hydrogen could be used in fuel cells which could further raise the efficiency of power production to the 40-50% range. Recognizing these benefits, many countries are actively developing biomass gasification technologies for on-site power generation, for co-generation, and for the production of substitute fuel gases.

The Task activities are focused on information exchange, promoting cooperative RD&D among member countries, and interaction with industry to expedite commercialization of biomass gasification. The following sections highlight selected biomass gasification projects in the member countries of the Task. For more complete information, including principal contacts, please see Appendix 7 and visit Task 20 on the IEA Bioenergy website: www.forestresearch.co.nz/ieabioenergy.

Austria

There are two gasification demonstration projects in Austria: the first is at Zeltweg and the second is two new plants which are being designed around the FICFB Process. A third project, the bark gasification project at Pöls, is also described. Biomass gasification could become the second most important conversion process in Austria, especially for power production.

Zeltweg BioCoComb Project

Courtesy of Zeltweg BioCoComb Project, Austria

In a demonstration project supported by the EC Thermie Programme a biomass gasifier for bark, wood chips, sawdust, etc has been installed at the 137 MW_e pulverised coal fired power station of Verbund-Austrian Hydro Power AG in Zeltweg, Austria. The project title 'BioCoComb' is an abbreviation for 'Preparation of Biofuel for Co-Combustion' where co-combustion means combustion together with coal in existing power plants. The gas produced substitutes approximately 3% (~ 10MW_{th}) of the coal fired in the boiler. The biomass fuel from plants is used in its raw form. Only the coarse fraction of the biomass has to pass a shredder and is then fed together with the fine fraction into the gasifier. Partial gasification of the biomass is carried out at a temperature of 820°C, in a circulating fluidised bed reactor, which maintains uniform temperatures throughout the gasifier. Temperatures are low to prevent slagging. The low calorific value (LCV) gas produced is directly led via hot gas duct into an existing pulverised coal fired boiler for combustion. The carryover char from partial gasification passes through a cyclone separator and is fully combusted in the coal boiler. The plant started its trial runs in November 1997 and has been in successful commercial operation since January 1998.

The main advantages of the BioCoComb concept are:

- drying of feed biomass is not required since the resulting LCV gas is acceptable for co-firing;
- partial gasification of biomass results in a smaller gasifier;
- no gas cleaning or cooling is required thus preventing tar condensation problems;
- the relatively low gasification temperatures prevents slagging;
- there are favourable effects on power plant emissions (CO_2, NOx);
- there were no substantial modifications to the existing coal fired boiler;
- there is high flexibility in arranging and integrating the main components into existing plants.

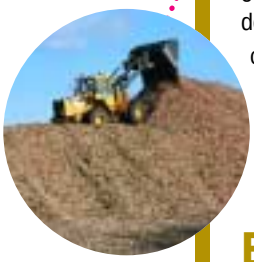
New plants based on the FICFB Process

At present there are two FICFB Process plants in the detailed design stage. An 8 MW_{th} gasification plant will be located in Güssing, Burgenland and a 2 MW_{th} plant will be located in Wiener Neustadt, Niederösterreich. In the bigger plant a gas turbine, and in the smaller plant a gas engine will be used to produce electricity from the gas. The plant in Güssing will begin operation in summer 2000 and the smaller plant will commence operation in winter 2000.

The FICFB Process consists of a fluidised bed reactor divided into two zones, a gasification zone and a combustion zone. The bed material is circulated between these two zones while the gaseous products are kept separated. The circulating bed material promotes heat transfer between the combustion and the gasification zones. The fuel is fed into the gasification zone and gasified with steam. The gas produced in this zone is therefore nearly free of nitrogen. The bed material, together with some carryover char, circulates to the combustion zone. This zone is fluidised with air to burn the char particles. The exothermic reaction in the combustion zone provides the energy for the endothermic steam gasification zone. With this concept it is possible to produce a medium calorific value product gas without the use of pure oxygen.

Pöls Bark Gasification Project

The Pöls bark gasification project employing the Lurgi circulating fluidised bed (CFB) gasifier was built in 1987 in Pöls, Austria by a large paper mill, The plant was designed to handle up to 6.6 TPH of dry bark, which is of approximately 35 MW_{th} capacity. Crushed and air dried bark is gasified in the air-blown CFB gasifier operating at about 1 bar pressure. The resulting LCV fuel gas was to be partially cooled and fired in the paper mill's lime kiln. However, because of the undesirable contamination of the lime with the ash contained in the fuel gas, the gasifier is not operated continuously and it is now used for testing and evaluation purposes only.



Brazil

Brazilian BIG-GT Demonstration Project

The Brazilian Wood Biomass Integrated Gasification-Gas Turbine (BIG-GT) demonstration project, is to be located in the state of Bahia, in northeast Brazil. The TPS low pressure, circulating fluidised bed (CFB) gasifier has been selected for the project which is supported by the Brazilian Government, UNDP, the World Bank, and the UN Global Environmental Facility. At present the project is being supported by MCT and a consortium made up of ELETROBRAS, and Companhia Hidro Eletrica do Sao Francisco. The proposed 32 MW_e project will use a GE LM2500 gas turbine. A description of the TPS process is given under some of the projects described below.

Canada

BIOSYN Gasification and Gas Conditioning Technologies

The BIOSYN gasification process was developed during the 1980s by BIOSYN Inc, a subsidiary of Nouveler Inc, and a division of Hydro-Quebec. The process is based on a bubbling fluidised bed gasifier containing a bed of silica or alumina capable of operating up to 1.6 MPa. Extensive oxygen-blown biomass gasification tests were conducted during 1984-88, in a 10 t/hour demonstration plant located at St-Juste de Bretennieres, Québec, to produce synthesis gas for methanol production. Air blown atmospheric gasification tests were also conducted for evaluating cogeneration. The BIOSYN process proved the technical feasibility of gasifying biomass from forest and agricultural residues. Subsequently, by using a 50 kg/h process development unit, the BIOSYN process has also proven the feasibility of gasifying primary sludges, refuse derived fuel (RDF), rubber residues (containing 5-15% Kevlar), and granulated polyethylene and propylene residues.

Courtesy of BIOSYN Inc, Canada

The process accepts feed particle sizes up to 5 cm, feed bulk densities higher than 0.2 kg/l and feed moisture content up to 20%. The thermal efficiency for biomass gasification varies from 70-80%. The fuel gas composition ranges from 30-55% N_2, 16-30% CO_2, 12-30% CO, and 2-10% H_2. Air blown gasification produces 2 Nm^3 fuel gas/kg of dry biomass. The gas yield reaches 4 Nm^3 of fuel gas/kg of polyethylene. With air as the gasifying agent the higher heating value (HHV) of the fuel gas is about 6 MJ/Nm^3. Enriched air, with 40% oxygen, can produce a fuel gas having a HHV of about 12 MJ/Nm^3 at half the gas yield. The raw gas cyclones remove 85-95% of entrained particulates.

The supporting research and development includes gas scrubbing for efficient tar removal with reduced water requirements, recycling the insoluble tars to the gasifier, wet oxidation and adsorption of dissolved organic compounds in the scrubbing water, and recycling carbon-rich ashes and carry over carbon with adsorbed organic compounds to the gasifier. This effort also includes hot-gas filtration of entrained dust using a static bed of perlite particles and a moving sand bed filter, and catalytic steam cracking of tar. Proprietary catalysts can decompose 99% of tars and 97% of naphthalene compounds. The BIOSYN technology is commercialized by Enerkem Technologies Inc, a subsidiary of the Kemestrie Group, a spin-off company of the University of Sherbrooke. A commercial installation to gasify 2.2 t/hour of granulated polypropylene residues is now under construction in Spain. The electricity output will be sold to the grid. Environmental International Engineering SL, a Spanish-based development and engineering group, in partnership with Enerkem, will erect and commission the plant in late 2000.

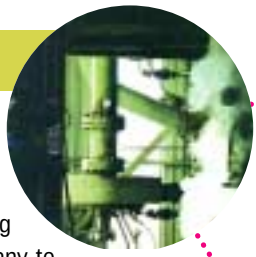
Denmark

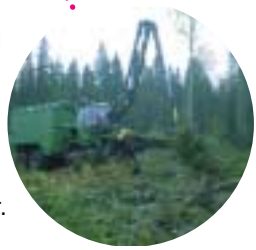
Harboøre Project

Courtesy of Voeland Research Centre, Denmark

Between 1988 and 1992, the Danish boiler manufacturer Ansaldo Vølund Energy chose to build an updraft, counter current, moving bed gasifier for the Harboøre District Heating Project located on the west coast of Jutland. The updraft gasifier was selected to circumvent feed drying, to achieve 99% carbon conversion, and to produce a high heating value fuel gas with low dust content. The Vølund gasifier is based on a German design and it is now operated with woody biomass, at 4 MW_{th} capacity, to provide heat to about 550 homes. The raw gas containing condensible tar and other organic compounds is cooled and scrubbed to separate and recycle these combustible condensates back to the gasifier. Extensive research and technology development was conducted in support of this facility to test novel heat exchangers, tar cracking schemes, minimization and disposal of emissions and effluents, and operation of IC engines. The gasifier could be operated at higher capacity in the future for cogeneration applications. In January 2000, two 1.5 MW_e gas engines were installed to cogenerate electricity and district heat.

Høgild Project





This 0.5 MW_{th} capacity CHP project supplying heat and power for 120 homes and residences in Høgild near Herning, started with the French Martezo co-current downdraft moving bed gasifier. The project owner Herning Municipality, contracted the Hollesen Engineering Company to reconstruct the gasifier. Since December 1998, the gasifier has been operating satisfactorily. The feed stock for gasification is double screened dry wood residues (15% or less moisture content) and waste from woodworking factories. The raw gas from the gasifier is cooled and cleaned using a wet scrubber, a sawdust filter, and a filter type water separator. The fuel gas with a lower heating value of 4-4.8 MJ/Nm^3 is burnt and consumed in a Mercedes gas engine to produce heat and power. The efficiency of electricity production is about 24%.

Blære Project

The Department of Energy Engineering at the Technical University of Denmark (DTU) has developed a two-stage gasification process. Based on this technology a cogeneration plant producing 250 kW_{th} and 100 kW_e was built at Blære, Aars by the Danish REKA Maskinfabrikken company. Wood or straw is pyrolysed in a first stage screw-conveyed reactor by external heating at 600°C. The resulting volatiles react with preheated air/steam mixture to produce a low-tar-containing fuel gas which is used to gasify the

residual char from the pyrolysis step. The resulting fuel gas is cooled and cleaned in a venturi scrubber and is fed to a 12 litre Perkins engine rated at 100-120 kW_e. The waste heat from the engine exhaust is used to heat the first stage pyrolysis reactor. The efficiency of electricity production is estimated to be 25%. Tests in the 50 kW_{th} DTU Pilot Plant showed that if the feed is dried to 30-35% moisture content the process may consume the entire condensate and there may not be any need to provide a waste water treatment facility. The pilot plant tests produced a fuel gas with a heating value of 6 MJ/Nm^3 at a thermal efficiency of about 90%.

Finland

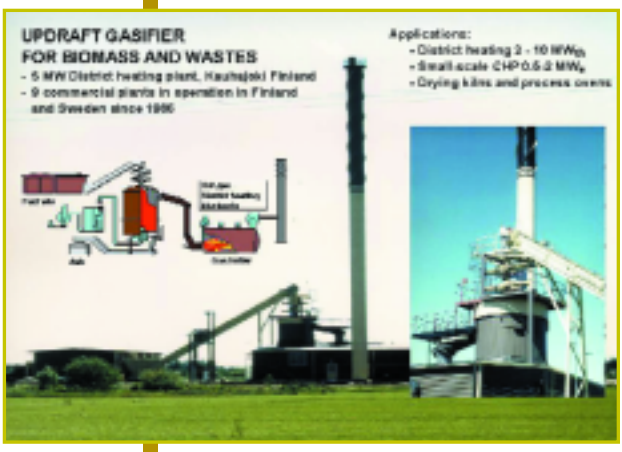
Lahti Kymijärvi Project

In 1997-98, the Lahden LÄMPÖVOIMA Oy, installed a 60 MW_{th} capacity atmospheric pressure Foster Wheeler (formerly Ahlström) CFB biomass gasifier, at a cost of approximately US$15 million at its 200 MW_e fossil fuel fired power station. This power plant was originally built in 1976 to use fuel oil. In 1986 the burners in the boiler were converted to natural gas and a natural gas turbine cycle was added. The biomass gasification plant was installed primarily to use locally available fuels and waste materials including plastics. The gasifier is a single gasifier vessel with a cyclone and an air preheater for heating the gasification air to approximately 400°C. The LCV gas is cooled from approximately 830-850°C to 700°C before it is transported in a pipeline to the boiler. The raw gas has no adverse effect on the performance of the boiler. Emissions are reduced and the heating surfaces in the boiler stay relatively clean. The reported gas composition (in volume %) is: 12.9% CO_2; 4.6% CO; 5.9% H_2; 40.2% N_2; 33.0% H_2O; 3.4% C_xH_y. The heating value of the LCV gas is approximately 2.0-2.5 MJ/Nm^3. The NOx emissions were reduced by 5% (permitted level is 230 mg/MJ for both NOx and SO_2) and the dust emissions were reduced by half because of increased conductivity of dust. However HCl emission increased by a small quantity of 5 mg/Nm^3. The present breakdown of fuels in the boiler is approximately: 11% LCV fuel gas from the gasifier, 69% coal, 15% natural gas to boiler, and 5% natural gas to gas turbine. The annual average total efficiency is approximately 80%, the fuel to power efficiency with gas turbine in operation is 35%. The gas turbine has increased the efficiency by 4% points. The plant supplies 200 MW_e power to the national grid (110 kV line round the town) and 250 MW_{th} heat to the town (100,000 inhabitants) and surrounding houses (main pipe 700 mm). The district heating system was constructed in 1958.

Courtesy of Lahti Kymijärvi Project, Finland

BIONEER Process

The BIONEER gasifier is an updraft moving bed gasifier, producing tarry LCV fuel gas. The gasifier consists of a refractory lined vessel with a rotating cone-shaped grate. Biomass fuel is fed from the top, from where it flows downwards through drying, pyrolysis, gasification and combustion zones. The residual ash is discharged from the bottom by the rotating grate. The temperature of the combustion zone is regulated by humidifying gasification air. Air and steam are fed as the gasification media through the grate. Since updraft gasification produces a raw gas with significant amounts of tar, the gas cannot be either transported long distances or directly used in IC engines. In the existing BIONEER plants the gas is burnt in a close coupled boiler to generate steam and hot water for district heating. During the mid 80s, VTT and BIONEER conducted extensive tests with a variety of feed stocks (eg wood chips, forest wastes, peat, straw, RDF pellets, and coal and RDF mixed with wood chips) in a 1.5 MW_{th} pilot plant located at BIONEER's Hämeenlina works. A typical gas composition with 41% moisture content wood chips consists of 30% CO, 11% H_2, 3% CH_4, 7% CO_2, and 49% N_2, with a HHV of 6.2 MJ/Nm^3. The tar content of dry product gas is estimated to be in the range of 50-100 g/Nm^3. Between 1985 and 1986, when fuel oil prices were high, eight commercial BIONEER plants, with capacities ranging from 4-5 MW_{th}, were commissioned, five in Finland and three in Sweden. Four plants are operated with wood or wood and peat mixtures while the rest are operated with peat only. Most of the gasifiers are in operation at small district heating plants to provide circulating hot water. The BIONEER plants are completely automated and operated with minimal personnel costs.



Courtesy of Bioneer Kauhojoki, Finland

Ahlstrom Corporation bought the BIONEER company originally owned by YIT Corporation. After Foster Wheeler acquired Ahlstrom, a 6.4 MW_{th} plant was installed at Ilomantsi, in eastern Finland in 1996. The estimated investment cost for district heating applications is about 350 $kECU/MW_{th}$ and the operating cost is about 17 ECU/MWh.

Wisa Forest Pyroflow Gasifier

In 1981, Ahlstrom Corporation developed the first 3 MW_{th} capacity pilot CFB gasifier from its successful CFB pyroflow combustion technology at the Hans Ahlstrom Laboratory at Karhula. The first commercial Ahlstrom Pyroflow CFB gasifier was commissioned in 1983 at the Wisa Forest Pulp and Paper Mill in Pietarsaari, Finland. The fuel for the 35 MW_{th} (about 150 t/day of biomass) gasifier is primarily bark and sawdust, sized up to 5cm, and dried at 150°C to about 15% moisture content. The biomass is fed from the side into the circulating sand of an air-blown CFB gasifier maintained at about 900°C. The hot fuel gas at 700°C, is fed directly to a lime kiln. The objective of replacing 85% of the fuel oil for the lime kiln was achieved within a

few months of start up. Between 1985 and 1986, three more gasifiers, two in Sweden (25 MWth at Norrsundet Bruks, AB, Norrsundet and 27 MW_{th} at ASSI, Karlsborg Bruk, Karlsborg) and one in Portugal (15 MW_{th} at Portucel, Rodao Mill), were built and commissioned for firing lime kilns.

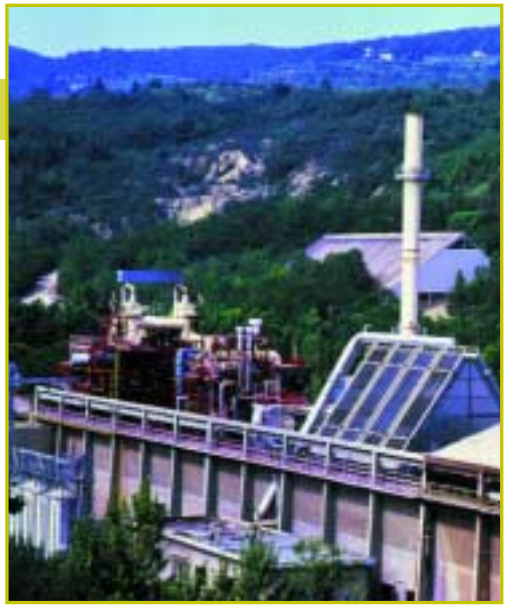
Italy

Thermie Energy Farm Project

Courtesy of Bioelettrica, Italy

The Thermie Energy Farm (TEF) Project by Bioelettrica SpA employing the atmospheric Lurgi CFB-gasifier is now under construction at Cascina, near Pisa. The 43 MW_{th} capacity plant will produce about 14 MW_e. The air-blown gasifier will gasify up to 3.5 cm biomass feedstocks (poplar and Robinia wood chips, olive residues, grape residues, and sawdust) with about 5% moisture (after drying at the plant by the flue gases from the heat-recovery steam generator) at a temperature of about 800°C and 1.5 bar(a) pressure. The raw LCV fuel gas is cleaned of most particulates in cyclones, cooled, scrubbed, and compressed prior to producing electricity in a gas turbine and heat-recovery steam generation and steam turbine plant. The project is owned by Bioelettrica SpA, whose shareholders are USF Italia, Electricidade de Portugal-EDP, Lurgi, Energia Verde, and Fumagalli, and receives financial contribution from the EC under the Thermie 1994 programme. The plant is expected to be operational in the middle of 2002.

SAFI SpA RDF Gasification Project



Courtesy of SAFI SpA Gasification Project, Italy

The first commercial TPS CFB gasification process was built for RDF gasification at Loc Testi, Passo dei Pecorai, Greve in Chianti. RDF pellets, up to 150 mm long, are fed into the lower section of a 15 MW_{th} capacity CFB gasifier, at a rate of about 3 t/hour. The TPS gasifier operates at low (2500 mm water) pressure and a temperature of about 875°C, employing air as the gasification/fluidizing agent. Part of the air is injected at the bottom of the gasifier and the remainder is injected part way up the vessel. This pattern of air distribution creates a high-density bed in the lower part of the vessel, which allows the gasifier to handle relatively large-sized fuel particles. The CFB of sand particles are maintained by a superficial gas velocity of about 3-10 m/s.

The pellets are gasified within the 2-2.2 seconds residence time producing an LCV fuel gas of about 8 MJ/Nm^3. The raw gas passes through two stages of solids separation before being fed to a furnace/boiler to generate steam for producing 6.7 MW_e in a condensing steam turbine. The overall power generation efficiency is about 19-20%. Alternatively, part of the raw gas can be fired in a nearby cement kiln. The flue gas exiting the boiler is cleaned in a three-stage Research Cottrell scrubber before venting through the stack. The plant has been operated intermittently due to difficulty in obtaining a continuous supply of RDF pellets.

The Netherlands

KARA/BTG Co-current Downdraft Gasifier System

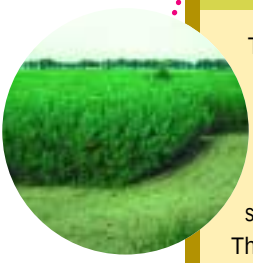
This 150 kW_e system incorporates two special features:

- The use of a low-speed (750 rpm), low-cost, robust engine made in China. This marine diesel engine is re-designed for use in connection with rice husk gasifiers. The engine is less sensitive to impurities and its efficiency is lower than modern, lean-burn engines. Any loss due to the low engine efficiency is compensated by incorporation of a roots blower to compress the fuel gas to enhance its volumetric heating value.
- The fuel gas enters the engine at a temperature higher than the dew-point, thus avoiding any condensation.

The system consists of a fuel feeding conveyor, gasifier, two cyclones, baffle filter, gas cooler, bag-house filter, roots blower, and gas engine.The gasifier feed is either sized or briquetted block-sized wood. The fuel gas has a heating value of about 4.5 MJ/Nm^3, with tar and dust content below 100 mg/Nm^3.

A demonstration plant is scheduled for early 2000 at a briquetting plant near KARA. Power will be delivered to the grid while the heat will be used for the drying system of the briquetting plant. The developers include a consortium of KARA Energy Systems BV, BTG biomass technology group BV and CPS, CompackSys BV, with funding support from Shell International Renewables and Novem.

Stork Thermeq Co-current Downdraft Gasification System



This 400 kW_e system consists of a double valve fuel feeder, a gasifier developed at Energy Research Centre Netherlands (ECN), thermal catalytic tar cracker developed and patented by BTG, and an IC engine for producing electricity. A 400 kW_e demonstration plant will be constructed during 2000 in Goor. The gasifier will be fed partly with composted waste wood. The electricity will be supplied to the grid and sold to Essent as 'green' power and the heat will be used in the greenhouses in Goor. The main objective is to demonstrate and validate the technology for subsequent scale-up to a commercially viable, fully automated, turnkey biomass gasification installation producing 2 MW electrical and 4 MW thermal power. The developers include a consortium of Stork Thermeq, BTG and KARA.

Amergas BV Project

This 30 MW_e project is under construction at the Amer powerstation at Geertruidenberg in southern Holland, to gasify low quality demolition wood (about 150,000 TPY) which cannot be recycled by the chipboard industry. The gasifier is an 83 MW_{th} low-pressure, Lurgi CFB gasifier. The product gas will be cooled for steam recovery, scrubbed to remove particulates and ammonia and burnt in the coal fired Amer 9 cogeneration unit. The unit has a net production capacity of 600 MW_e and 350 MW_{th}. The start up of the plant is planned for early 2000.

Courtesy of NOVEM, The Netherlands

Norway

At present there are no demonstration or commercial biomass gasification projects in Norway. Potential applications for gasification may be to improve pulp and paper mill operations and for cogeneration in remote sites.

Sweden

Gotaverken Project (Varo)

The Gotaverken (Kvaerner) process employs a CFB gasification process developed in a 2 MW_{th} pilot plant at the Royal Institute of Technology. Sized and dried fuel is fed a few meters above the bottom of the gasifier to create two distinct zones. In the upper zone, biomass is flash pyrolyzed by coming in contact with hot circulating dolomite, at a temperature of 645°C, and produces fuel gas rich in C_2+ and some tars. In the lower zone the recycled residual char is combusted with air to produce the hot flue gases that promote flash pyrolysis in the upper zone. The circulating bed of dolomite promotes tar cracking and reduces the amount of heavy hydrocarbons produced in the gasifier.
The LCV fuel gas is partially cooled in a heat exchanger to preheat gasification air and then burnt in a lime kiln. The plant start up was in 1987 and turned over to the customer in 1988. A typical gas composition is 15% CO, 10% H_2, 5% CH_4, 3% C_2+, 16% CO_2, 8% H_2O, and 43% N_2. Gotaverken has not built any more such biomass gasification plants due to low oil prices.

Värnamo Project

This is the first demonstration of the pressurized Foster Wheeler-Ahlstrom CFB biomass gasification process, operating at 20 bar pressure and 950-1000°C. The 18 MW_{th} capacity IGCC demonstration cogeneration plant uses a feed stock consisting of 40% wood chips and 60% bark. The hot-gas filter employs high temperature ceramic Schumacher candle filters. The gas composition (in volume %) is reported as 10-12% H_2; 15.5-17.5% CO; 5-7% CH_4; 14-17% CO_2; 45-50% N_2. The fuel gas heating value is 5-6 MJ/Nm^3 (dry gas); tars <5g/Nm^3; alkalies <0.1 ppm; NH_3 <700 ppmv; dust <2 ppm by wt. The measured plant emissions include NOx 50-125 ppmv; SOx 5-10 ppmv; CO 50-200 ppmv; HC 0-4 ppmv; and dust approximately 5 mg/Nm^3 (dry gas).

Courtesy of Sydkraft, Sweden

The raw gas contains about 10-12% undecomposed steam and the hot gas filter is operated at 350-400°C. The raw gas LHV is about 5 MJ/Nm^3. The demonstration plant employs the EGT Ruston Typhoon gas turbine. To handle the LCV fuel gas, the natural gas turbine burners and their enclosing cans were enlarged in size. The exhaust from the gas turbine at 450°C passes through an Ahlstrom heat recovery steam generator to produce superheated steam. A Nadrowski steam turbine is used to generate electricity. The turbine air compressor produces 10-12 bar air, which is compressed further in a booster compressor to produce gasification air at 20 bar pressure. The demonstration plant was commissioned in March 1993 and over the last two to three years the plant has operated successfully in an integrated fashion for many thousands of hours.

Termiska Processor AB (TPS) Process

Since the mid 1980s TPS has been developing a low pressure, air-blown CFB gasification process. The initial applications were planned for fueling lime kilns. In the late 1980s TPS licensed the process to Ansaldo of Italy and provided the design for two pelletized RDF gasifiers for a commercial plant in Greve-in-Chianti, Italy. The plant was designed by Studio Ingenaria Ambientale and built by Ansaldo Aerimpianti. The plant owner is Servizi Ambientali Area Florentina (SAFI). Further details of the SAFI gasification project is given under the Italian gasification projects. The TPS process was also selected for the ARBRE project in UK and the BIG-GT project in Brazil.

Switzerland

Pyroforce Gasification Plant

A commercial 200 kW_e Pyroforce gasifier with a Jenbacher engine is currently under construction at a military research center near Interlaken. The plant employs a Pyroforce gasifier, based on the KHD (Kloeckner Humbolt Deutz) high temperature gasification process and a dry gas clean up system. The downdraft moving bed gasifier maintains a temperature of 1200-1300°C in the combustion zone. Plant commissioning is scheduled for the middle of 2000. Although pilot tests were conducted with demolition wood, uncontaminated wood chips will be used as the gasification feed material.

Indian Institute of Science-DASAG Gasifier

Courtesy of IISc, Switzerland

The Indian Institute of Science (IISc)-DASAG gasifier is an air-blown, low pressure, open-top, co-current, downdraft, moving bed system with a specially designed lateral air inlet to reduce tar production. The gasification feed material is uncontaminated woody biomass materials. A pilot demonstration plant designed for 330 kW_{th} and 100 kW_e capacity is in operation at Châtel-St-Denis. The plant is equipped with a Swiss gas cleaning system and a 6 cylinder Liebherr gas engine. The present electrical output is 55 kW_e. The electrical efficiency of the plant (from wood to electricity) is 24%. The plant had operated for about 700 hours by November 1999. Continuous tests lasting up to 1500 hours are expected to be complete by February 2000. Air-blown gasification tests with biomass feed up to 8 cm in particle size, produced a gas composition with 18% CO, 13% CO_2, 2% CH_4, 18% H_2, 15% H_2O, 34% N_2, 50 mg/Nm^3 tar, and 700 mg/Nm^3 particulates.

Courtesy of IISc, Switzerland

United Kingdom

ARBRE Project

Courtesy of ARBRE Energy Ltd, UK

The ARBRE project employs the low pressure TPS gasifier. The 8 MW_e capacity plant is currently under construction in Yorkshire. The project integrates the use of Yorkshire's municipal sludge for growing short rotation coppice plants for biomass gasification and includes recycling the gasifier ash back to the coppice plantations as a soil conditioner. The biomass feed stock is derived from 2000 hectares of willow and poplar short rotation

coppice plantation. The air-blown TPS gasifier is close coupled to a CFB catalytic tar cracker to reduce tar in the LCV gas which is cooled and water scrubbed to produce a clean fuel gas. The fuel gas is compressed and combusted in a gas turbine heat recovery steam generation system to produce 8 MW_e employing a Typhoon European Gas Turbine. The projected overall electrical efficiency is 31%. Initial shakedown and startup of the gasifier is scheduled for early 2000. The project team consists of Yorkshire water, TPS, and AEP, part of Compagnie Generale des Eaux of France, who will provide operating and maintenance services.

Boughton Pumping Station CHP Project

This is the second installation by Rural Generation Ltd, the company that developed UK's first on-farm CHP biomass-fuelled plant in Londonderry. The new plant produces 100 kW_e and approximately 180 kW of heat. The plant includes a downdraft, moving bed gasifier based on the concept of Professor J. Martins of the University of Louvain in Belgium. The power is produced by a six cylinder, dual fuel, Iveco engine running on 80% wood and 20% diesel - although eventually it will run on 10% diesel. The ex-works price for such a unit, including the gasifier, gas clean-up system, engine and generator, and heat recovery unit, is about £80,000. However, local factors can influence the cost significantly. The unit produces heat and electricity for a converted water pumping station in Ollerton, Nottinghamshire. The station was originally built in 1905, to house the steam operated pumps that supplied the city of Nottingham. It is now used as a workshop and office complex, with restaurant and conference facilities. The basement houses a popular 'hands on' sustainable energy exhibition. The project does not have a NFFO contract, although the plant puts electricity into the local grid at peak-price times of day, like its forerunner in Londonderry.

Courtesy of Rural Generation Ltd, UK

Blackwater Valley Museum Project

B9 Energy Biomass Ltd, undertook this project in 1995 to develop and operate a wood fuelled, combined heat and power unit to provide heating and clean electricity for 400 homes. The project team consists of B9 Biomass, Armagh City and District Council and the Blackwater Valley Museum, Benburb. The fuel used will be a mixture of wood from existing forests and coppiced willow from local farmers. However, to begin with, until grants are in place to encourage farmers to grow willow, the unit will use sawmill wood chips. The plant uses a downdraft, moving bed gasifier linked to a reciprocating engine to produce around 400 kW of heat and 200 kW of electricity at 415 volts. This is transformed to 11kV and carried away on the NIE grid. The plant is capable of 24 hours per day unmanned operation for a

Courtesy of B9 Energy Biomass Ltd, UK

period of six days after which the ash is removed. Over the 15 years of the electricity contract approximately £1,000,000 will be spent locally on fuel and labour. The installation is the first of its type in the world and was built in Northern Ireland at a cost of £250,000. The commercial demonstration project at Blackwater Valley has the potential to raise further orders for Northern Ireland.

Other UK gasification projects include: Rural Generation Ltd, Brook Hall Estate, Northern Ireland - Downdraft/Louvain gasifier, 100 kW_e - based on forest fuels; Shawton Engineering, Warrington, England - Downdraft/ Shawton gasifier, 100 kW_e - based on wood waste; Compact Power, Bristol - indirectly heated gasifier, 1 MW_{th} - based on industrial and other wastes; and Waste Gas Technology, South Wales - indirect/WGT rotating drum gasifier, 1 MW_{th} - based on sewage sludge.

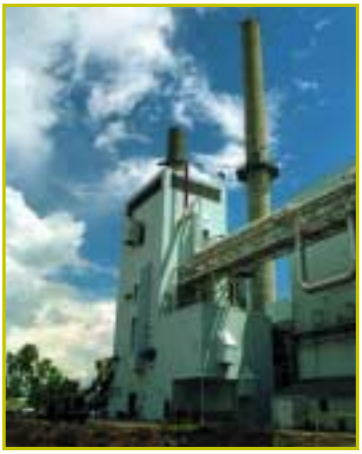
United States of America

Vermont Battelle/FERCO Project

The Battelle/FERCO project employs the low pressure Battelle gasification process which consists of two physically separate reactors:

- a gasification reactor in which the biomass is converted into a MCV gas and residual char at a temperature of 850°C, and
- a combustion reactor that burns the residual char to provide heat for gasification.

Heat transfer between reactors is accomplished by circulating sand between the gasifier and combustor. Since the gasification reactions are supported by indirect heating, the primary fuel gas is a medium calorific value fuel gas. A typical product gas composition obtained in pilot plant tests, at steam to biomass ratio of 0.45, is 21.22% H_2; 43.17% CO; 13.46% CO_2; 15.83% CH_4 and 5.47% C_2+. The estimated HHV of this fuel gas is 17.75 MJ/Nm^3. A 200 t/day capacity Battelle demonstration gasification plant was built at the McNiel Power Plant and plant shakedown and initial testing is now in progress with wood chips. During the first phase the fuel gas will be cofired in the existing McNeil boiler. In subsequent phases, the fuel gas will be cooled for heat recovery, scrubbed, recompressed prior to energy conversion and recovery in a 15 MW_e gas turbine system. The project participants include; US DOE Biomass Power Program, FERCO, Battelle Columbus Laboratory, Burlington Electric Department, Zurn Industries, OEC/Zurn, and NREL.



Courtesy of Future Energy Resources Corp, USA

MTCI Process

The MTCI gasification process also employs indirect heating to promote steam gasification of biomass to produce a MCV fuel gas. The gasifier combusts part of the fuel gas in pulsed combustion burners which promote heat transfer to the gasification section. Extensive pilot plant tests were conducted in a 20 t/day process development unit (PDU) at MTCI laboratories near Baltimore, Maryland. These tests also included an evaluation of black liquor gasification. Based on the PDU tests a 50 t/day capacity black liquor gasification demonstration unit was built at Weyerhaeuser's New Bern facility. The MTCI process group is currently designing and building a modular system and also seeking partnerships and support to demonstrate other gasification applications.

IGT RENUGAS Process

The IGT RENUGAS process employs a 20 bar pressurized bubbling fluidised bed process. The process was extensively tested with a variety of biomass materials, including bark-sludge mixtures, bagasse, and pelletized alfalfa stems in a 12 t/day process development unit (PDU) at IGT test facilities in Chicago. Subsequently USDOE selected the IGT process for scale-up and demonstration, using bagasse, at the HC&S sugar mill at Paia in Hawaii. Since this 100 t/day demonstration plant had limited success in handling the low-density, shredded bagasse, the project was terminated. A typical gas composition obtained in the IGT PDU with bagasse at 2.24 MPa, and 850°C is 19% H_2; 26% CO; 37% CO_2; 17% CH_4 and 1% C_2+. The heating value of this fuel gas is approximately 13 MJ/Nm^3. The project participants included: US DOE Biomass Power Program, IGT, Westinghouse Electric Corporation, State of Hawaii, PICHTR, and HC&S.

Courtesy of Institute of Gas Technology, USA

The pressurized RENUGAS process coupled with hot-gas particulate and alkali cleanup is ideally suited for IGCC applications and to generate electricity at efficiencies in the 40-42% range. IGT is currently seeking partnerships and support for further demonstration of the RENUGAS process.

Small Modular Biopower Projects

The objective of this program, sponsored and managed by DOE, NREL, and SNL, is to develop small modular biopower projects that are fuel flexible, efficient, simple to operate, have minimum negative impacts on the environment, provide power in the 5 kW - 5 MW range, and are useful for domestic and international markets. The ten projects selected for the Phase 1: Feasibility Studies are given below:

Company	Technology	Size, kW_e
Agrilectric	Fluid-bed Combustor/Steam Turbine	500-5000
Bechtel	Gasifier/Engines/Gas Turbine	500-1500
Bioten	Direct-fired Combustion Turbine	5000
Carbona	Gasification/Steam Turbine	1000-3000
CPC	Gasification/IC Engine	10-25
EERC	FBC/Steam Turbine	500-5000
NIMO	Gasification/IC Engine/Gas Turbine	500-5000
Reflective Energies	Gasification/Gas Turbine	100-1000
STM	Gasification/Stirling Engine	25-70
SunPower	Gasification/Stirling Engine	1-10

These projects are under evaluation to provide funds for Phase 2: Prototype Testing and Phase 3: Integrated Systems Demonstration.

Brightstar Synfuels

Brightstar Synfuels, Houston, Texas and Baton Rouge, Louisiana, employs a modular, skid-mounted, tubular entrained-flow steam gasification system. The estimated cold-gas efficiency with 40% moisture feed is about 80%, with no tar formation. Three 1.5 MW units are planned for East Texas, for natural gas replacement, and there is a potential project to couple the gasifier with an IC engine in Australia.

Thermal Technologies

Thermal Technologies, Inc. Camp Lejune, North Carolina employs a downdraft gasifier, operating at a maximum temperature of 982°C. Extensive tests were conducted in a 816 kg/hr pilot unit with 10% moisture feed. The resulting 0.49Nm^3/s fuel gas at 6.35 MJ/Nm^3 is fed to a Waukasha L7042 turbo-charged engine/generator to produce 700 kW_e.

Primenergy

Primenergy, Tulsa, Oklahoma employs an updraft gasifier in a 36 t/day capacity pilot unit. Sixteen different feed stocks have been tested, including switch grass, paper mill sludge, rice straw, bagasse, and poultry litter. So far sixteen commercial units ranging in size from 50-550 t/day of rice husk have been installed to produce heat (for hot air or steam) or electricity (up to 12 MW). A 600 t/day capacity rice husk gasification plant is now under construction at Riceland Foods, Stuttgart, Arkansas for producing 15 MW_e using an extraction steam turbine and a 150 t/day capacity rice husk gasification plant is under construction at Riceland Foods, Jonesboro, Arkansas coupled to a 7 t/hour steam boiler and three parboiled rice dryers.

Cratech

Cratech, Tahoka, Texas employs an air-blown, high pressure gasifier. A 2.2 t/hour capacity unit coupled to a 225 kW Solar Spartan Turbine is now under construction.

International Energy Agency

The International Energy Agency (IEA) is an autonomous body which was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. It carries out a comprehensive programme of energy co-operation among its Member countries.

The basic aims of the IEA are:

- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use;
- To maintain and improve systems for coping with oil supply disruptions;
- To operate a permanent information system on the international oil market;
- To promote rational energy policies in a global context through cooperative relations with non-Member countries, industry and international organisations;
- To assist in the integration of environmental and energy policies.

A. Introducing IEA Bioenergy

Welcome to this Annual Report for 1999 from IEA Bioenergy!

IEA Bioenergy is the short name for the international bioenergy collaboration within the International Energy Agency - IEA. A brief description of IEA is given on the preceding page.

Bioenergy is defined as material which is directly or indirectly produced by photosynthesis and which is utilised as a feedstock in the manufacture of fuels and substitutes for petrochemical and other energy intensive products. Organic waste from forestry and agriculture, and municipal solid waste are also included in the collaborative research, as well as broader "system studies" on techno-economic aspects and greenhouse gas balances.

The IEA Implementing Agreement on Bioenergy, which is the "umbrella agreement" under which the collaboration takes place, was originally signed in 1978 as IEA Forestry Energy. A handful of countries took part in the collaboration from the beginning. In 1986 it broadened its scope to become IEA Bioenergy and to include non-forestry bioenergy in the scope of the work. The number of participating countries has increased during the years as a result of the steadily increasing interest in Bioenergy worldwide. By the end of 1999, nineteen parties participated in IEA Bioenergy: Australia, Austria, Belgium, Brazil, Canada, Croatia, Denmark, Finland, France, Italy, Japan, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom, United States and the Commission of the European Communities. Australia, the most recent member country, signed the Implementing Agreement on 16 March 1999.

IEA Bioenergy is 21 years old and a well-established collaborative agreement. All OECD countries with significant national bioenergy programmes are now participating in IEA Bioenergy, with very few exceptions. The IEA Governing Board has decided that the Implementing Agreements within IEA may be open to non-member countries, ie for countries that are not members of the OECD. For IEA Bioenergy, this has resulted in a large number of inquiries from potential participants, and as a consequence of this, a number of new members are expected.

The work within IEA Bioenergy is structured in a number of Tasks, which have well defined objectives, budgets and time frames. The collaboration which earlier was focused on Research, Development and Demonstration is now increasingly also emphasising Deployment on a large scale and worldwide.

There are thirteen ongoing Tasks during the period 1998-2000:

- Task 17: Short Rotation Crops for Bioenergy
- Task 18: Conventional Forestry Systems for Bioenergy
- Task 19: Biomass Combustion
- Task 20: Thermal Gasification of Biomass
- Task 21: Pyrolysis of Biomass
- Task 22: Techno-Economic Assessments for Bioenergy Applications
- Task 23: Energy from Thermal Conversion of MSW and RDF
- Task 24: Energy from Biological Conversion of Organic Waste
- Task 25: Greenhouse Gas Balances of Bioenergy Systems
- Task 26: Biotechnology for the Conversion of Lignocellulosics to Ethanol
- Task 27: Liquid Biofuels
- Task 28: Solid Biomass Fuels Standardisation and Classification
- Task 29: Socio-economic Aspects of Bioenergy Systems

Task 29 is a new initiative. It will commence on 1 January 2000 and run for three years. In addition, there is a special kind of Task (Task XVI: Technology Assessment Studies for the Conversion of Cellulosic Materials to Ethanol in Sweden) involving two participants; USA and Sweden. This Task which began in the previous programme period, is the first effort within IEA Bioenergy to undertake a more market orientated programme, with strong industrial involvement.

Members of IEA Bioenergy are invited to participate in all of the Tasks, but each member is free to limit its participation to those Tasks which have a programme of special interest. The Task participation during 1999 is shown in Appendix 1.

A progress report for IEA Bioenergy for the year 1999 is given in Section B of this Annual Report.

B. Progress Report

1. THE EXECUTIVE COMMITTEE

The IEA Bioenergy Executive Committee acts as the 'board of directors' of IEA Bioenergy. The Committee plans for the future, appoints persons to do the work, approves the budget and, through its members, raises the money to fund the programmes and administer the Agreement. The Executive Committee (ExCo) also scrutinises and approves the progress reports and accounts from the various Tasks within IEA Bioenergy.

The 43rd ExCo meeting took place in Svolvær, Norway, on 26-28 May 1999. The 44th ExCo meeting was held in Kyoto, Japan, on 11-12 November 1999.

During 1999, Josef Spitzer from Austria was Chairman of the ExCo and Kyriakos Maniatis from the CEC was Vice Chairman. At the ExCo44 meeting, these two gentlemen were re-elected to the same positions for 2000.

On 1 January 1998, the ExCo Secretariat moved from Tellus Energi AB, Sweden to Rotorua, New Zealand under the new Secretary, John Tustin. At the same time, the fund administration for the ExCo and Task funds was also consolidated with the Secretariat, and the newsletter and website transferred from Aberdeen University to New Zealand. This consolidation of the management of IEA Bioenergy was a major step. At ExCo44, it was unanimously agreed that John Tustin would be contracted to provide the Secretariat and Fund Administration services for the period 1 January 2001-31 December 2003. The contact details for the ExCo and Secretariat can be found in Appendices 5 and 6.

The work in the ExCo, with some of the achievements and issues during 1999 is described below.

The new programme for 2001-2003

During 1999, some of the meeting time in the Executive Committee was devoted to the planning of Tasks for the period 2001-2003. Following submission of 'expressions of interest' and discussion at ExCo44, a tendering process was initiated for ten new programmes as follows:

- Short Rotation Crops for Bioenergy Systems
- Conventional Forestry Systems for Sustainable Production of Bioenergy
- Biomass Combustion and Co-firing
- Thermal Gasification of Biomass
- Pyrolysis of Biomass
- Techno-economic Assessments for Bioenergy Applications
- Energy from Integrated Solid Waste Management Systems

- Energy from Biogas and Landfill Gas
- Greenhouse Gas Balance of Biomass and Bioenergy Systems
- Liquid Biofuels

With the cooperation of USA and Canada, it was agreed to combine the work of the current Tasks 26 and 27 into one comprehensive new Task on 'liquid biofuels'. This was an excellent response to the initiative of the EUWP/REWP to coordinate all transportation related efforts in their Implementing Agreements. Decisions on the tenders received will be made at ExCo45 in The Netherlands. In connection with the start of this new programme, the duration of the Implementing Agreement on Bioenergy will be prolonged until 31 December 2004.

Supervision of Ongoing Projects – Review and Evaluation

The progress of the work within IEA Bioenergy is reported by the Operating Agents to the Executive Committee twice per year in connection with the ExCo meetings. As part of this process, at ExCo40 it was decided that some of the Task Leaders should be invited to attend each ExCo meeting to make the Task presentation on their progress and programme of work personally. The idea was to improve the communication between the Tasks and the Executive Committee and also to involve the ExCo more with the Task programmes. This has worked well and both the Task Leaders and the ExCo have been pleased with the outcome of this initiative.

The work within IEA Bioenergy is regularly evaluated by the IEA Committee for Energy Research and Technology (CERT) via its Renewable Energy Working Party (REWP) and reported to the IEA Governing Board. IEA Bioenergy also participated in the major four-year review of Implementing Agreements which was recently completed and reported by the CERT to the IEA Governing Board. IEA Bioenergy was found to be a strong and well-established programme with appropriate objectives and good management. It was also commended on its strategic plan and encouraged to continue to monitor and report successes. The latter was seen as an important means of securing support and resources. However, the review did identify a need to increase the strategic responsiveness of the renewable energy programmes as a whole. The main elements of the CERT's strategy for this are: increased emphasis on climate change, enhanced involvement of industry, dissemination of information on climate-friendly technologies to non-IEA member countries, and increased attention by the CERT to communication with the Working Parties and Implementing Agreements.

There is regular contact between the IEA Bioenergy Secretariat, and IEA Headquarters in Paris and active participation by ExCo representatives in relevant meetings.

Approval of Task and Secretariat Budgets

The budgets for 1999 approved by the Executive Committee for the ExCo Secretariat and for the Tasks are shown in Appendix 2. Total funds invoiced in 1999 were US$1,126,746; comprising US$118,750 of ExCo funds and US$1,007,996 of Task funds. Appendix 2 also shows the financial contributions made by each member country and the contributions to each Task. Very substantial "in-kind" contributions are also a feature of the IEA Bioenergy collaboration but these are not shown because they are more difficult to value in financial terms.

For Task XVI, the budget is US$500,000, part of which is covered by industrial partners. These funds are not shown in Appendix 2 because they are not handled by the IEA Bioenergy Fund Administrator. In addition, there are also considerable "in-kind" contributions to this Task.

Fund Administration

The International Energy Agency, Bioenergy Trust Account, at the National Bank of New Zealand is functioning smoothly. The account is accessed electronically by Forest Research on behalf of the Secretariat. The account is an interest bearing account denominated in US dollars. Details for making payments are:

Remit funds to:	Chase Manhattan Bank, New York, USA
	Swift Code: CHASUS33
For credit of account:	The National Bank of New Zealand Limited
	Wellington, New Zealand
	Account number: 001-1-941473

Quoting: IEABIO-USD00 plus the invoice number.

The currency for the whole of IEA Bioenergy is now US Dollars. The main issue faced in fund administration is slow payments from some member countries. As at January 2000, there were US$118,371 of financial contributions for 1999 still outstanding.

KPMG is retained as an independent auditor. The audited accounts for the ExCo Secretariat Fund and Task Funds for the period 1 January 1998 to 31 December 1998, were approved at ExCo43. The audit provided an unqualified opinion that the financial accounts of the Trust account were a true and fair record.

Task Administration

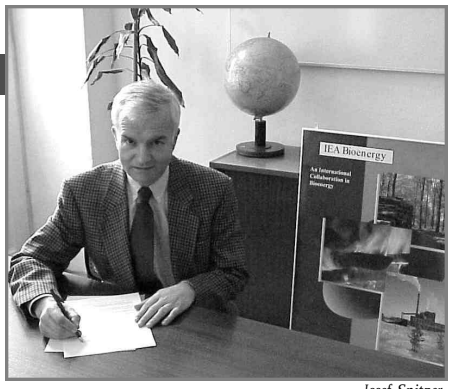
At ExCo43, Task XVI ‘Technology assessment of cellulosic materials to ethanol in Sweden’ and Task 22 ‘Techno-economic assessment of bioenergy applications’ were both prolonged to 31 December 2000. At ExCo44, the revised guidelines on withdrawal from Tasks were approved. These guidelines had been used on previous occasions but needed to be restated to assist the ExCo in handling occasional requests of this nature in a consistent manner.

New Participants

It is pleasing to report that Australia joined IEA Bioenergy during 1999. The Implementing Agreement was signed at the IEA Headquarters on 16 March with Stephen Schuck and Associates Pty Ltd as the Contracting Party. Dr Schuck is the Executive Committee Member. Initial participation was in Task 17 'Short Rotation Crops for Bioenergy' but from 1 January 2000 Australia will also join Tasks 18, 19, 23 and 25.

Interest from potential member countries continued to be strong in 1999. India has indicated a strong wish to join with their Ministry of Non-conventional Energy Sources as the Contracting Party. South Africa has also shown strong interest following a Task 26 workshop in that country. They have been invited to observe appropriate meetings in 2000 to assist their membership decision. Other countries showing active interest have included Ireland, the Slovak Republic and Estonia.

Collaboration with FAO



Josef Spitzer, Chairman of IEA Bioenergy signing the agreement.

At ExCo44 a Memorandum of Understanding between IEA Bioenergy and FAO Rome was approved. Formal signing by Mr M. Hosny El-Lakany, Assistant Director-General of FAO's Forestry Department and Dr Josef Spitzer, Chairman of IEA Bioenergy, took place early in 2000. This agreement will facilitate collaboration on projects of mutual interest in the field of bioenergy and wood energy in particular. The prime contact at FAO will be Mr Miguel Trossero, Senior Forestry Officer (Wood Energy) of FAO's Forest Products Division. The expected benefits include: improved information dissemination, cost-effective promotion of bioenergy activities, improved technology transfer and opportunities for demonstration and deployment in developing countries, in-kind contributions in the areas of bioenergy data gathering and database information and collaboration in specific technical areas. Overall, this MoU was a pleasing outcome from discussions which had been ongoing for some time.

Mr Miguel-Angel Trossero (left) signing the MoU with Mr Hosny El-Lakany, Assistant Director-General of FAO's Forestry Department (right).

Strategic Plan 1998-2002

The second Strategic Plan for IEA Bioenergy was distributed early in 1999. The need for a new Strategic Plan arose from recognition of the impact of increased bioenergy use on predicted global climate change, increased interest shown by non-member and developing

countries to participate in IEA Bioenergy, the changing information needs of the developing bioenergy industry, revision of the REWP strategy, reorganisation of the Task and operational structure of IEA Bioenergy, and increased access to the Internet. The plan has been well received. During 1999 implementation of the Strategic Plan has been a priority item for the ExCo, Operating Agents and Task Leaders. Good progress has been achieved.

Conferences and Industry Exhibitions

NOVEM kindly hosted an IEA Bioenergy presence on their stand at the World Sustainable Energy Fair in Amsterdam in May. The Secretary supplied a range of literature for distribution to interested parties.

There was a strong presence of IEA Bioenergy at the 4th Biomass Conference of the Americas which was held in Oakland, California, in September. The Chairman gave a keynote address at the opening session and there were presentations by various Tasks as well as poster presentations. A conference stand for IEA Bioenergy distributed promotional material in the exhibition area of the conference and also provided website demonstrations. There was a very strong response to the oral and poster presentations and it was agreed that these seem to be the most successful mechanism for publicising the achievements of IEA Bioenergy.

There was also a strong presence of IEA Bioenergy at the 3rd European Motor Biofuels Forum in Brussels in October. The Chairman gave a keynote speech titled 'The role of bioenergy in greenhouse gas mitigation', and three Task Leaders also presented papers. Two other members chaired workshop sessions. A conference stand displayed the IEA Bioenergy posters and provided brochure and newsletter material to interested parties.

At the invitation of the Slovak Biomass Association, the Chairman attended the 'Renewable Energy Conference' in Bratislava in September. At the same time, he took the opportunity to discuss the possibility of the Slovak Republic joining IEA Bioenergy with senior government officials.

In addition to the above, substantial time has been devoted to assisting with the planning and running of the 1st World Conference and Exhibition on Biomass for Energy and Industry which will be held in Seville, Spain in June 2000. IEA Bioenergy is a co-sponsor of this event and the Tasks are planning both participation in the main conference and associated Task meetings in Seville around that time.

Seminars and Workshops

A large number of seminars and workshops are arranged every year by individual Tasks within IEA Bioenergy. This is a very effective way to exchange information between the participants. These meetings are described in the progress reports from the different Tasks later in this Annual Report and the papers presented at some of these meetings are listed in Appendix 3.

Occasionally, seminars and workshops are also arranged by the Executive Committee. In May, at ExCo43, the committee supported a workshop titled 'From bioenergy R&D to deployment'. Speakers from the European Commission, Canada, Norway, Denmark and New Zealand provided interesting case study presentations.

Information Material and Promotion

There is a wide range of promotional material available through the Secretariat. This includes a general brochure on IEA Bioenergy, the Strategic Plan 1998-2002, Annual Reports, the position paper 'The role of bioenergy in greenhouse gas mitigation', a brochure titled 'Short rotation forests for bioenergy', copies of the newsletters and a set of four conference posters on CD-Rom.

The 1998 Annual Report with the special colour section on 'Greenhouse gas balances of bioenergy systems' was very well received. Only a few copies remain from the original print run of 1800. However, this report is also available through the IEA Bioenergy website.

The 'new look' newsletter IEA Bioenergy News remains popular. Two issues were published in 1999. A free subscription is offered to all interested and there is a wide distribution outside of the normal IEA Bioenergy network. Future editions will be distributed in June and December each year which follows the pattern of ExCo meetings. Because postage is a major cost item it is proposed that distribution via the website will continue to be a major initiative. The contacts for the Newsletter Editor are provided in Appendix 5.

The IEA Bioenergy website was established in 1996 and moved to New Zealand in early 1998. The current address is www.forestresearch.co.nz/ieabioenergy. In June 1998, a total revamp of the site was released with a "frames" format for clarity and simple navigation between sections. Links were provided to the homepages of each of the current Tasks as well as to the IEA Headquarters homepage, other IEA Implementing Agreement sites and other Bioenergy sites. The site is proving an increasingly popular source of information about IEA Bioenergy. For example, in February 2000 the number of successful hits for the site was 16,398, with 1542 unique users. The average user session was 7.38 minutes. This is very encouraging and in response the Secretariat is planning further improvements including a personalised URL. The new address is ieabioenergy.com

Greenhouse Gas Mitigation

Since IEA Bioenergy, and particularly Task 25 prepared the position paper on "The Role of Bioenergy in Greenhouse Gas Mitigation" for the Fourth Conference of the Parties to the United Nations Framework Convention on Climate Change in Buenos Aires, the activity in this area has been sustained. More recently, Task 25 has been collaborating intensively with the Intergovernmental Panel on Climate Change (IPCC). For more details, please see the Task 25 progress report.

2. PROGRESS IN 1999 IN THE TASKS

TASK XVI: Technology Assessment of Cellulosic Materials to Ethanol in Sweden

Overview of the Task

The objective of Task XVI is to develop technologies for the conversion of straw and wood to ethanol for transportation fuels. The aim is also to advance the design and assessment of the biomass to ethanol processes for production in Sweden, based on straw and wood residues. Included in the objectives is establishment of combustion characteristics of the lignin remaining after the ethanol production and development of a technical database that can be used for the design of a commercial scale plant. This is the first effort within IEA Bioenergy involving a more market-oriented Task and strong industrial participation.

The participating countries are Sweden and the USA.

As in other Tasks, a Task Leader appointed by the Operating Agent (the USA) directs and manages the work programme. A National Team Leader from each country is responsible for co-ordinating the national participation in the Task.

For further details on Task XVI, please refer to Appendices 2-5 inclusive and www.forestresearch.co.nz/ieabioenergy under 'Current Tasks' on the IEA Bioenergy website.

Progress in R&D

Work Programme

The Task was initiated in October 1997 and was planned as a comparatively short (1-year) common effort between Sweden and the USA. The governments planned to work closely with industries in each country to gather data that would be used for designing a commercial biomass-to-ethanol facility.

The Task has experienced numerous delays. Initially, the Task encountered difficulties in coming to closure on this agreement. Although the contractual mechanisms were in place, Task funding could not be approved until a reorganization within the Swedish government was completed. The new Swedish National Energy Administration completed its reorganization, and by late 1998 had reaffirmed its commitment to the project.

Further delays have been encountered due to Intellectual Property (IP) issues. Competing private companies have questioned the ownership of certain IP elements of the work, and these issues are being resolved in the court system. Neither IEA Bioenergy nor Task XVI are involved, but the legal proceedings have delayed the experimental work indefinitely. The issues were unforeseen when the project started but are representative of the types of problems that can occur when large industries are involved in international, government co-sponsored projects.The progress on the Task will be re-evaluated in 2000, and a decision will then be made on whether to continue the effort.

TASK 17: Short Rotation Crops for Bioenergy

Overview of the Task

The objective of Task 17 is to meet the need of bioenergy industries through technical improvement of biomass crop production technologies, through documenting and disseminating information on the potential environmental benefits of biomass crop production systems and through developing information to enhance market development in collaboration with the private sector. The overall aim is to further develop the existing short rotation biomass production systems, to improve awareness of the bioenergy production potential of the concept, and to promote use of biomass for energy in participating countries. The intention is to strengthen the contact and co-operation between scientists, machine developers, entrepreneurs in the production chains, and end users, with the aim to improve understanding of the problems and to find means of solving them.

'Short rotation crops for bioenergy' means woody crops such as willows, poplars, *Robinia* and *Eucalyptus* with coppicing abilities as well as lignocellulose crops such as reed canary grass, switchgrass, *Miscanthus* and others.

The country participation includes Australia, Canada, Croatia, Denmark, France, Italy, The Netherlands, Sweden, UK, USA, and the Commission of the European Communities (CEC). From 1 January 2000, France will withdraw.

For further details on Task 17, please refer to Appendices 2-5 inclusive.

Progress in R&D

Task Meetings and Workshops

The Task was very active in 1999. A joint meeting between Task 17 and the IUFRO group 1.09 'short rotation forestry' was held in Las Banos, The Philippines on 3-7 March, with participants from the following countries; USA, Malaysia, South Korea, The Philippines, Sweden, Indonesia, Laos, Bhutan, Japan and Vietnam. The following topics were addressed:

- choice of plant species for short rotation forestry for energy, food, feed and wood,
- plantation management and harvesting of short rotation forestry crops,
- intensive culture of short rotation forests,
- vegetation filters, and
- the economics of short rotation forestry.

A proceedings from the meeting is in press and will be available in January 2000.

A second meeting of the Task was held in Auburn, USA on 6-9 September. This meeting was focused on herbaceous crops such as switch grass (*Panicum virgatum*), reed canary

grass (*Phalaris arundinaceae*) and others. Attendees from member countries gave 'country reports' and specialists in water use efficiency, carbon sequestration, biodiversity and carbon dioxide taxation also gave papers. These will all be published in the proceedings together with a contribution from Professors Garcia Pinatti and Laercio Couto from Brazil who spoke about a new approach to electricity production from woody biomass.

Professors Pinatti and Couto from Brazil presented a new method based on prehydrolysis of biomass producing two products: catalytic cellulignin fuel for electric energy generation through combined cycle gas-type turbine/steam turbine and prehydrolysate for biomass chemicals such as furfurol, alcohol, xylitol. Attendees were told that the new technology can process any kind of biomass (wood, sugarcane, agricultural residues and organic solid waste), is fully ecological, has no market limitations and competes economically with hydroelectric and fossil fuel energy and hydrocarbon products. The new technology is based on the application of advanced materials in the biomass processing reactor and in the gas-type turbine. A full report will be given in the proceedings from the Auburn meeting.

From the presentations given at the workshop and as a result of field tours in Auburn and Birmingham, it was obvious to all the participants that the USA has exciting prospects for large scale substitution of fossil fuels with biomass for energy production. The excursions demonstrated the great potential of switch grass, which can produce up to twenty tons of dry matter or more, per hectare per year. Other very interesting crops for bioenergy production were mimosa (*Albizia julibrissin*) and the giant reed (*Arundo donax*). Mr Robert Harris informed the group about the 'Executive Order 13134' signed by President Clinton on 2 August 1999 titled 'Developing and Promoting Biobased Products and Bioenergy.' The Order will guide co-ordination of federal efforts to accelerate the development of 21st century biobased industries that use trees, crops, agricultural, forest, and aquatic resources to make an array of commercial products including fuels, electricity, chemicals, adhesives, lubricants, and building materials. In an accompanying executive memorandum, the President set a goal of tripling US use of biobased products and bioenergy by 2010. Reaching this goal ... 'would generate billions of dollars of new income for farmers, create employment opportunities in rural communities, and reduce greenhouse gas emissions by as much as 100 million tons per year - the equivalent of taking more than 70 million cars off the road'. The President's executive order establishes a permanent Interagency Council on 'biobased products and bioenergy'. It was especially relevant to Task members that this announcement immediately preceded the meeting in Auburn where the potential of large scale biomass crop production was so clearly demonstrated.

'Full scale implementation' was one of the 'high priority areas' identified for investigation by the Task. A special group, chaired by Stig Ledin, Sweden, was asked to study and report on the development of EKOKRAFT at Hedemora in Sweden and to compare that project with the developments at Newbridge and Carlisle in the United Kingdom. The idea with EKOKRAFT is to produce biomass for energy, using waste water as fertiliser for short rotation willow coppice plantations, to use the woody biomass for generation of hot water and electricity, to recycle ash and nutrients between rural and urban areas and in the process clean the water. EKOKRAFT is conceived as a demonstration programme of how, even under the severe sub-Arctic climate conditions, environmental problems can be transformed into assets. In the UK there are at least two projects of interest with respect to 'full-scale implementation'. These are the Newbridge project with a planned 22 Mw

plant and satellite plants of 10-16 Mw, and the Carlisle project with a planned 20 Mw plant and satellites of 16-25 Mw. These electricity-producing plants will work with pyrolysis of organic material and gas turbines. Eventually, short rotation crops will be used as providers of organic material. The group have written a report which will be published in the proceedings from the Auburn meeting.

Deliverables

The deliverables from the Task in 1999 included: minutes of business meetings; two progress reports to the ExCo; and the proceedings of three 'short rotation forestry' workshops held in Uppsala, Sweden, Las Banos, the Philippines, and Auburn, USA. In addition to these outputs, reports are in preparation on priority topics including: 'sustainability'; 'large scale implementation'; and 'water and nutrient use efficiency'.

TASK 18: Conventional Forestry Systems for Bioenergy

Overview of the Task

The objectives of Task 18 are to develop systems and guidelines for environmentally sustainable and economic production of biomass for energy from conventional forestry systems, and to promote their acceptance and use in relation to silviculture, forest management, harvesting and transportation.

The Task is developing and synthesizing information needed to design or implement sustainable forest management and harvesting systems for production of biomass for energy in conjunction with other forest products. Within the overarching theme of sustainability, Task collaborators evaluate productivity, environment, social, economic, and legal and institutional criteria, within the context of plantation and naturally regenerated forests in key forest regions of member countries. These criteria are common to the international processes defining sustainable forest management such as the Montreal Process.

Task collaborators envisage that, through their efforts, integrated assessments of forest management practices, environmental conditions and socio-economic factors will improve productivity, forest health and efficient utilization of forest resources, including biomass for energy from plantations and naturally regenerated forests in the major forest biomes. The primary end users for Task outputs are forest managers, researchers and bioenergy planners, but Task outputs will also be useful for policy makers, NGOs and the interested public.

Participating in the Task in 1999 were Belgium, Canada, Denmark, Finland, The Netherlands, New Zealand, Norway, Sweden, the United Kingdom, the United States and the European Commission. An application by Australia to join the Task in 2000 was approved by the Executive Committee in November 1999. The Task is led by an

international team from Canada, Finland and the United States. The national teams in participating countries comprise an extensive group of scientific and technical collaborators.

For further details, please refer to Appendices 2-5 inclusive and also the main IEA Bioenergy website at www.forestresearch.co.nz/ieabioenergy.

Progress in R&D

Task Meetings and Workshops

The second annual Task workshop was held in Charleston, South Carolina, USA 19-25 September. The theme was 'Integrating production of energy in sustainable forestry: guiding principles and best management practices'. With the objective of identifying guiding principles for sustainable bioenergy production from conventional forestry systems, state-of-the-art knowledge was presented and discussed in three main topic areas:

- silvicultural systems, including treatments and practices for combined bioenergy and wood products outputs, and economic and social analyses,
- harvesting and procurement, including quantity and quality of wood fuel, and cost reduction, and
- environmental impacts of bioenergy production and harvesting systems, with a focus on material balances (including soil carbon), soil/site productivity, and biodiversity.

Almost 50 participants from 11 countries took part in a day of field visits and three days of technical presentations. The field day featured visits to Westvaco Company's forest operations to see an overview of sustainable ecosystem management, including an experimental site under the 'Long term site productivity program', and new harvesting systems with potential for use of forest residues for fuel. During the technical program, a total of 24 papers and 10 posters were presented. Most of the papers will be published in a peer-reviewed proceedings as a special issue of the New Zealand Journal of Forestry Science.

Following the decision of Australia to join the Task and invitations from that country and New Zealand, a decision was made that the final Task workshop in 2000 will be held near Brisbane, Australia, with an associated field tour in New Zealand.

Work Programme: Synthesis Publication

A primary Task output is a publication that synthesizes available ecological, physical, operational, social and economic information, and identifies gaps in knowledge related to sustainable biomass production and harvesting systems. The book is organized around the criteria for sustainable forest management: productivity, environment, social, economic and legal and institutional framework. It will emphasize guiding principles and state of the art knowledge in a concise and distilled form, rather than trying to provide a detailed 'how-to' handbook covering every possible situation. The scale of resolution for the information will be primarily at the 'forest region' level. An attempt will also be made to

provide information or interpretations on generalizable principles that span forest regions, such as effects of management on soil carbon. This Task output will be useful for regional or global modelling applications. The primary audience for the publication is forest resource managers and planners to enable them to evaluate the ability of specific forest regions to sustainably meet bioenergy production demands.

The outline of the contents of the publication was finalized and chapter objectives were prepared. Authors and contributors for most of the individual sections of the book have been identified by members of the Task leadership team who are responsible for co-ordinating book chapters, and writing is underway.

A contract for publication of the book has been signed with Kluwer Academic Publishers of the Netherlands. The possibility of future electronic publication in CD-ROM format is being considered.

Papers presented at the annual Task workshop in September included several which are intended to become sections of the publication. The workshop incorporated a thorough discussion of the publication project, including its objectives, intended audience, probable distribution, authorship and content. A schedule was agreed for the further preparation of the book, which will ensure its publication by the end of the Task.

Deliverables and Promotion

Communication of the goals, activities and outputs of the Task is a vital element of the promotional aspect of the Task. A strong presence for the Task has been established on the Internet, through the main IEA Bioenergy website, and is being actively maintained. Most Task informational materials are available through this site, including workshop announcements and a list of collaborators.

The proceedings of the first annual Task workshop, which took place in Nokia, Finland in September 1998, were published in the Forest Research Bulletin series of the New Zealand Forest Research Institute. The publication includes a total of 27 invited and volunteer papers, of which six are in the form of extended abstracts and four are poster abstracts. Seven of the papers came from a joint workshop session which was held with Task 25 Greenhouse Gas Balances of Bioenergy Systems. Papers from the joint session were also published in a proceedings document by Task 25.

A poster describing and illustrating Task goals and the approach taken to achieving them has been displayed at workshops and conferences as well as at the locations of National Team Leaders and others. During 1999 it has been on display at the Washington, D.C. headquarters of the US Forest Service, the Vantaa Research Centre of the Finnish Forest Research Institute and at a major bioenergy event in Norway.

The Task published the first of a series of Technical Notes, intended primarily to communicate to forest managers and practitioners valuable practical information emerging from Task activities. This first double issue, distributed through National Team Leaders in early 1999, included a review of the technical lessons to be learned from field visits associated with the workshop in Finland, as well as an analysis of current systems for energy wood production in Denmark, and economic perspectives on energy wood as a welcome new market for low-value wood in a densely populated small country (The Netherlands). The second issue will appear early in 2000.

Collaboration with Other Tasks

Several other current IEA Bioenergy Tasks have objectives and interests that are complementary to those of Task 18. Strong links are maintained with these Tasks through sharing of information and, where possible, joint workshops. Discussions have taken place with Task 17 'Short rotation crops for bioenergy' regarding a possible joint meeting, recognizing that there is no clear boundary between the biomass sources of interest to the two Tasks. There has also been on-going discussion and collaboration with Task 25 'Greenhouse gas balances of bioenergy systems' in relation to common interests and complementary expertise, particularly in carbon sequestration. Opportunities for collaboration and co-operation with other international researchers, organizations and activities are also being pursued, particularly where there is involvement in issues of sustainability of forest ecosystems.

TASK 19: Biomass Combustion

Overview of the Task

Task 19 builds on the work programme of the previous Biomass Combustion Activity within the 'old' Task XIII, which ceased in December 1997. Since combustion is well-established commercially and accounts for over 90% of the bioenergy conversion technologies in use, the scope of the work emphasises the expanded use of biomass combustion for heat and power generation, in close co-operation with industry. The main benefits of combustion compared with other technologies (i.e. gasification, pyrolysis, liquefaction) is that combustion technology is commercially available and can be integrated with existing infrastructure. For further implementation, combustion technology should nevertheless be continuously optimised to maintain competitiveness with improving gasification and pyrolysis technologies.

The objective of Task 19 is to stimulate the use of biomass combustion for the production of heat and power on a wider scale. This objective will be achieved by generating and disseminating information on technical and non-technical barriers and solutions. Significant factors in Task 19 are industrial participation, interaction with other IEA Bioenergy Tasks and interaction with the relevant CEC programmes. Enhancement of the industrial participation can be realised by formulating joint projects between participating members and industry.

The emphasis of the activities in the Task is therefore on:

- market introduction for expanding the use of biomass combustion in the short term;
- optimisation of biomass combustion technology to remain competitive in the longer term.

The country participation includes Austria; Belgium; Brazil; Canada; Denmark; Finland; France; Netherlands; Norway; New Zealand; Sweden; Switzerland; United Kingdom; USA and the Commission of the European Communities (CEC). From 1 January 2000, Australia will join the Task and France will withdraw.

For further details on Task 19, please refer to Appendices 2-5 inclusive.

Task Meetings

Two Task meetings were held in 1999. The first was held on 25-27 May in Amsterdam, The Netherlands. The second was on 31 August, in Livermore, USA. The minutes of these meetings were distributed to all interested parties.

Work Programme

Based on the priorities identified by the participating countries and discussions at the first Task meeting, seven projects have been formulated. Progress with these is summarised below.

Ash related problems during combustion - Co-ordinator: USA. An overview of the research experiences of the USA related to ash deposition and co-firing has been provided. The prediction of ash deposition in biomass boilers is regarded as very important because of its drastic impact on heat transfer in the boiler. Ash deposition rates and mechanisms are highly selective for the type of chemical compounds present in the biomass fuel and the boiler design. This makes successful prediction of deposition rates very difficult.

Characterisation and utilisation of biomass ashes - Co-ordinator: Austria. The Task initiated a 'round robin' test focusing on biomass fuel and ash analysis. A workplan document has been prepared which describes the project. These activities in the field of precision data for characterisation of biomass and biomass ashes have been harmonised with the initiatives in this field taken by Task 28 and the CEC projects and CEN.

Information gathered by Task 19 has been used in formulating a joint IEA/CEC project for the characterisation of biomass and biomass ashes. The activities should assess analysis problems and eventually lead to an IEA-standard. Austria has developed a comprehensive database for biomass and biomass ashes and Task members have been encouraged to extend this database.

Classification of biofuels - Co-ordinator: The Netherlands. Information exchange has taken place on the classification systems used in member countries. This activity is co-ordinated with the project 'Characterisation and utilisation of biomass ashes' above.

Modelling - Co-ordinator: The Netherlands. A questionnaire has been prepared with the aim to assess and collate the modelling activities that have been performed in various projects. It has been widely distributed. Organizations approached include the members of Task 19, all Task Leaders of other IEA Bioenergy Tasks and the 30 EC-JOULE projects that include modelling activities. Task members have also been requested to distribute the questionnaire to relevant organisations in their respective countries. About 40 questionnaires have been returned. An evaluation of the results has been presented and reported. As a follow-up activity a 'modelling workshop' will be organised at the 1st World Biomass Conference in Seville, Spain for organisations involved in biomass modelling.

CHP - Co-ordinator: Switzerland. An overview of theoretical and practical experience with biomass based CHP has been presented. It was decided to further extend the information with additional country data and to prepare a final report.

State-of-the-art combustion - Co-ordinator: The Netherlands. A draft report has been prepared by The Netherlands and distributed amongst the Task members for comments and additions. Only a few additions to the report were provided by the members. In its present form the report requires more input to serve as a final IEA report. The problem is a lack of financial support for the participating members to provide their contribution. This financial back-up should be provided by national programmes, however, part of the Task budget for 1999 and 2000 has been allocated for member contributions to further develop the state-of-the-art report into a 'Handbook of Biomass Combustion'.

Co-firing - Co-ordinators: USA/The Netherlands. The ExCo concluded that it was highly desirable to include co-firing in the activities of Task 19. The Task has recognised several issues that should be investigated. These include, on the combustion-side, NOx emissions, ash deposition, char burnout and the effects of catalysts. Another important issue is the preparation and feeding of biomass in coal fired boilers. One important critical success factor for co-firing is ash utilisation. Some existing standards in place prescribe that cement production can only be done with coal ash. Consequently, there is no proper outlet channel for the biomass/coal ash.

The activities on co-firing will be co-ordinated with the activities in this field by IEA Coal Research. A meeting between Task 19 and the Coal Combustion Science group of IEA Coal Research took place on 11 October at the Coal Science Conference in Pittsburgh, USA. This meeting concluded that:

- a mutual working package will be formulated, ensuring information exchange between the two groups;
- a public conference session on co-combustion of biomass with coal, together with the IEA Coal Combustion Science group will be hosted at the 1st World Biomass Conference in Seville.

To gain information about the national programmes on co-firing in member countries a questionnaire has been sent out to Task members and to the ExCo-members.

Collaboration with Other Tasks

The work of the Task is closely related to other IEA Bioenergy programmes, especially in the areas of biomass gasification, co-firing of biomass and techno-economic analysis. Co-ordination of the activities is stimulated by the exchange of meeting minutes and reports and the arranging of joint meetings.

Deliverables

The deliverables from the Task in 1999 included: facilitation of seven projects; two Task meetings; three study tours (a 24 MW_e wood chip fired power plant in Cuijk, The Netherlands; a coal fired power plant co-firing 60,000 tons of wood in Nijmegen, The Netherlands; and a visit to Sandia National Laboratories in Livermore, USA); a report on modelling activities; a draft report on the state-of-the-art of biomass combustion; and a workplan for a round robin on biomass characterisation; a joint IEA/CEC proposal for characterisation of biomass and biomass ashes; a questionnaire to survey national projects on co-firing; two progress reports to the ExCo; and successful organisation of collaboration between IEA Coal Research and Task 19 on 'co-firing'.

TASK 20: Thermal Gasification of Biomass

Overview of the Task

The objectives of Task 20 are to review and exchange information on biomass gasification research, development, and demonstration (RD&D), seek continuing involvement with bioenergy industries, and promote co-ordinated RD&D among the participants to eliminate technological impediments to commercialization of thermal gasification of biomass. The ultimate objective is to promote the commercialization of biomass gasification for the production and direct utilization of clean-burning fuel gas as a substitute for conventional fuels in boilers, gas engines, and Stirling engines, for district heating, co-generation and power generation applications, and for the production of synthesis gas for subsequent conversion to chemicals, fertilizers, and transportation fuels and also to produce hydrogen for fuel cell power generation.

In this Task, 'gas processing' means gas clean-up and further conversion of gas to hydrogen, chemicals, liquid fuels, and fertilizers. 'Moving bed' gasifiers are synonymous with 'fixed bed' gasifiers.

The participating countries are Austria, Brazil, Canada, Denmark, Finland, Italy, Norway, Sweden, Switzerland, The Netherlands, UK, USA and the Commission of the European Communities.

For further details on Task 20, please refer to Appendices 2-5 inclusive.

Progress in R&D

Work Scope, Approach and Industrial Involvement

The scope of work for the Task for the period 1998-2000 is a continuation of the previous Gasification Activity within the 'old' Task XIII which was completed in December 1997. In this Activity, information exchange, co-ordinated RD&D, and industrial involvement had been very effective, so these remain the basic foundations for the work programme of the new Task.

Biomass gasification can convert a variety of biomass materials to produce a flexible fuel form that could readily replace fossil fuels in many of the present energy conversion applications with significant environmental benefits. Air-blown gasification of biomass in moving bed gasifiers produces a low calorific value (LCV) fuel gas which has been used for district heating and on-site power generation employing gas engines. Examples include the BIONEER process in Finland and the Pyroforce gasification process. LCV fuel gas from circulating fluidized bed (CFB) gasifiers, is now used as a clean burning fuel gas in boilers, lime kilns, and in co-fired pulverized coal boilers with many economic and environmental benefits. The Wisa Forest gasifier and the Lahti projects in Finland are illustrative of these applications. However, the overall efficiencies of such systems remain low. The present generation of moving bed and both low pressure and high pressure CFB and bubbling bed gasification RD&D projects are targeted to fully explore the benefits of

biomass utilization by improving system efficiencies, reliability, economics, and environmental benefits. The pressurized, IGCC CFB Foster Wheeler-Alstrom Gasifier at Varnamo, Sweden demonstrated that it is possible to realize power generation efficiencies of more than 45%. Advanced integrated system designs utilizing treated waste water sludges, short rotation forestry, high efficiency gasification of dedicated and mixed feed stocks and waste materials, high efficiency fuel gas energy conversion, recycling of gasification ash materials as soil conditioners, and effective effluent treatment are the criteria for selection, design, and implementation of the present biomass gasification RD&D projects. The ARBRE project in Yorkshire, UK is one such fully integrated biomass gasification project.

Biomass gasification fuels may be able to use the existing natural gas distribution network and, with minor equipment modifications, biomass fuel gases could be readily used in most of the present natural gas energy conversion devices. It is anticipated that the development, demonstration, and optimization of biomass fuel gas energy conversion devices will become an essential part of global efforts to pursue the exploration of sustainable energy so that mankind has an environmentally preferable option to substitute for depleting fossil fuels.

Recognizing these benefits, many countries are actively developing biomass gasification technologies for on-site power generation, co-generation, and for the production of substitute fuel gases. The introductory section in this Annual Report summarizes the current biomass gasification projects in the member countries of the Task.

With increasing interest and commitment to 'green-energy' in many of the Western countries, emphasis in the work programme has been given to identification of mature and near-mature small, medium, and large-scale gasification technologies that are proven to be ready for commercial applications. In addition, the participating national experts (PNEs) will study and identify critical technological impediments to commercial implementation of advanced biomass gasification processes. This exercise will help the PNEs to prioritize and develop their national RD&D plans. When successfully developed the results from these RD&D programs will collectively contribute to advancing the state-of-the-art of biomass gasification.

The Task as a whole reviewed a variety of subtask studies and the key issues related to each subtask study. In this process they were prioritized, a co-ordinator was assigned by consensus to lead individual subtask studies, and schedules were developed to undertake such studies. The seven subtask studies in the current programme of work were outlined in detail in the 1998 Annual Report and are not repeated here.

The Task has continued the practice of inviting industrial experts to the Task Meetings, to promote interaction between industry and working group members. This interaction is expected to promote the development of technologies where there is clearly an identified need and to incorporate the specific needs in the product development and manufacturing plans and schedules of industry.

The Task is also continuing its interaction with industrial experts to develop reference protocols for evaluation purposes and to evaluate the options to resolve critical technical issues. So far the effective interaction between industry and the PNEs has also led to many co-operative RD&D projects.

Task Meetings

Task Meetings are generally linked to special topic workshops and seminars, and plant visits. The third Task meeting was held from 12-14 May in Helsinki, Finland. A one-day seminar on 'Technology overview, system improvements and research needs' was organized with industrial participation. There was also a plant visit to the Lahti co-firing project.

The fourth Task meeting was held from 18-19 October in Burlington, Vermont, USA and on 21 October in Washington, D.C. USA. A one-day seminar on 'Process waste treatment, minimization, and disposal' was organized with industrial participation.

The Task participants have agreed on the following schedule for future meetings, seminars on special topics, and plant visits. The fifth Task meeting will be held on 5-7 April 2000 in The Netherlands and include a plant visit to the AMER project. The sixth Task meeting will be held on 4-6 October 2000 in the U.K. and include a visit to the ARBRE project. At this meeting there will also be a special workshop session, with industrial participation, on the topic of 'Fuel gas energy conversion devices'. In addition to these Task meetings, a strong presence is planned for the 'gasification sessions' at the 1st World Biomass Conference 5-9 June 2000 in Seville, Spain.

Deliverables

The deliverables from the Task in 1999 included: two Task meetings combined with biomass gasification plant visits; two special topic discussions with industrial participation in association with Task meetings; preparation and distribution of meeting minutes; two Task progress reports; a Task presentation at ExCo44 in Kyoto; and preparation of a special section on biomass gasification for the 1999 IEA Bioenergy Annual Report. All Task reports are distributed to the Task participants, the Secretary of IEA Bioenergy, and the ExCo members.

The Task has proposed to the organizing committee of the 1st World Biomass Conference in Seville, Spain, to organize and present sessions on biomass gasification demonstration, commercial project case studies and case histories, and workshops on 'R&D needs' and 'Biomass derived fuels energy conversion devices'.

The end-of-Task deliverables will include reports from each of the seven subtasks and an overall end-of-Task report.

TASK 21: Pyrolysis of Biomass

Overview of the Task

The overall objective of Task 21 is to develop and extend the Pyrolysis Network (PyNe) that provides a forum for the discussion, evolution and dissemination of all aspects of biomass fast pyrolysis from preparation of feedstock through the fast pyrolysis process to utilisation of the liquid product for energy, electricity and chemicals production.

The specific objectives of PyNe are:

- to establish a forum for promotion and development of biomass fast pyrolysis,
- to establish good interactive and collaborative links between researchers, industry and policy makers,
- to actively contribute to the development of the science and technology and resolve major issues to enable the technology to be implemented more quickly and more effectively,
- to ensure that the benefits and advantages of fast pyrolysis are communicated to as wide an audience as possible.

The activities in the Task are focused on Subject Groups for development and evolution of science and technology which are discussed and reviewed at regular meetings. These meetings are held two or three times a year. Reports from all these activities are reported in the newsletter and are further disseminated via the website.

The Task is a joint programme between IEA Bioenergy and the CEC. The participating countries are: Austria, Belgium, Brazil, Canada, Denmark, the Commission of the European Communities, Finland, France, Germany, Greece, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, UK and USA .

As in other Tasks, a Task Leader, appointed by the Operating Agent (the Commission of the European Communities), directs and manages the work programme. In each country participating in Task 21 a National Team Leader is nominated, responsible for the co-ordination of the national participation in the Task.

For further details on Task 21, please refer to Appendices 2-5 inclusive and also the Task website: www.pyne.co.uk

Progress in R&D

Task Meetings and Workshops

The Task was very active in 1999. The third Task meeting was held in Montpellier, France in April in conjunction with two workshops. A study tour to Dynamotive, Canada was undertaken. A joint meeting was held with Tasks 22 and 27 in Oakland, USA prior to the 4th Biomass Conference of the Americas. At the same location, the Task also held a Steering Committee meeting and a workshop on 'modelling'. The Task was well represented, and had a high profile at this conference with six papers being presented from the work of the Task and a further eight papers by Task National Team Leaders. Minutes for all of these meetings have been published and distributed.

Subject Groups

The technical and scientific focus of the Task is on the Subject Groups, which have been described previously in the 1998 Annual Report and also in the PyNe newsletter. All the groups made formal presentations at the 4th Biomass Conference of the Americas. They are all making good progress with their activities and only significant developments are highlighted below.

Analysis and Characterisation Group - Dietrich Meier, IWC, Germany and Anja Oasmaa, VTT, Finland. A 'round robin' was initiated at the end of 1999 for chemical and physical analysis of bio-oils. In this project, four bio-oils will be evaluated at 17 laboratories.

Health, Safety and Environmental Group - Philippe Girard, CIRAD, France. An application was made to the EC 5th Framework Programme for substantial funding to carry out toxicological tests on bio-oil in order to obtain formal authorisations. Unfortunately this was not successful, but another application will be made in 2001.

Implementation Group - Max Lauer, Joanneum Research, Austria. A questionnaire has been sent to all PyNe members to begin to evaluate the competitiveness of fast pyrolysis across Europe.

Science and Fundamentals Group - Jan Piskorz, RTI, Canada. A second workshop on 'modelling in fast pyrolysis' was held prior to the 4th Biomass Conference of the Americas. There was an excellent attendance. The minutes of this meeting will be published in January 2000 and a report included in the next PyNe newsletter.

Stabilization and Upgrading Group - Stefan Czernik, NREL, USA and Rosanna Maggi, UCL, Belgium. Rosanna Maggi has left Europe and Stefan Czernik has carried this group since early 1999. A substantial report has been commissioned from Jim Diebold which was co-sponsored by NREL. This report provides a thorough review of bio-oil instability and potential methods for improvement. The work of this group is substantially completed and Stefan Czernik will now contribute to a review of the applications of bio-oil.

Overall, the network has continued to be the leading source of up-to-date information on the science and technology of fast pyrolysis of biomass that includes production of bio-oil and applications for the products. All members have maintained a high level of commitment and participation at meetings is still increasing. The integration of the IEA Bioenergy Task 21 with the EC sponsored network is working very well indeed and no problems have been encountered.

Collaboration with Other Tasks/Networking

A joint meeting was held with Task 22 Techno-economic Assessment and with Task 27 Liquid Bio-fuels prior to the 4th Biomass Conference of the Americas. A second meeting with Task 27 Liquid Bio-fuels has been arranged in Austria in January 2000.

The Task provided a complete 'Biomass pyrolysis session' at the 4th Biomass Conference of the Americas which was organised and co-chaired by Stefan Czernik, the USA National Representative and Tony Bridgwater, the Task Leader. The latter also attended ExCo 44 in Japan in November 1999 and presented the work of the Task to the Executive Committee.

Newsletter

The half-yearly newsletter is growing in popularity with continuing demand for copies. Three thousand copies of each issue are printed and distributed all around the world. Much of the information, including back copies in PDF format, is available on the PyNe website. The 8th issue in September 1999 included a questionnaire to find out what readers think of the newsletter and what they would like to see in future issues. The

analysis of this questionnaire will be published. Any request relating to newsletter circulation should be addressed to the Task Leader.

Website

The Task 21 website: www.pyne.co.uk/ has been launched independently on the Internet from Aston University. It is regularly updated and is proving to be very popular. The number of visits per month is averaging 1800 from worldwide origins.

Deliverables

The deliverables from the Task in 1999 included: two Task newsletters; the 'PyNe guide to fast pyrolysis of biomass for fuels and chemicals'; minutes of two Task meetings; minutes of one joint meeting with Tasks 22 and 27; two minutes of steering group meetings; and fourteen papers presented at the 4th Biomass Conference of the Americas.

The deliverables in 2000 will include: the 9th and 10th issues of the newsletter; output from subject group meetings; updating of the database of pyrolysis and related activities; and a major conference on the topic 'Progress in Thermochemical Biomass Conversion' to be held in Austria from 17-22 September.

TASK 22: Techno-Economic Assessments for Bioenergy Applications

Overview of the Task

The objectives of Task 22 are to promote the commercialisation of new bioenergy technologies and products by car rying out site specific pre-feasibility studies and to support the development of new technologies for appropriate bioenergy applications.

Together with industrial partners, the Task participants have studied selected bioenergy applications on a techno-economic basis. Technologies studied included small scale power production, active flue gas condensation in biomass district heating plants, pyrolysis for alternative fuel oil to be used within a city and production of a slow release fertiliser from fast pyrolysis oil. These studies are now completed. The results will be utilised by industry, funding agencies and research organisations.

The Task was originally planned for one and half years with the last Task meeting to be held in connection with the 4th Biomass Conference of the Americas in August 1999. However, at ExCo43, it was agreed that the Task would be prolonged to 31 December 2000, with new studies in the participating countries.

The original participating countries were Austria, Brazil (from August 1998), Canada, Finland, Sweden, and the USA. The companies involved with this phase of the Task programme were Joanneum Research, RTI Ltd, Sermet Oy, and Stockholm Energi AB. Participants in the prolongation are Canada, Finland, Sweden and USA. Decisions by Austria and Brazil on this are still outstanding.

For further details on Task 22, please refer to Appendices 2-5 inclusive and also the Task website: www.vtt.fi/ene/bioenergy

Task Meeting: Collaboration

A Task meeting was arranged in connection with the 4th Biomass Conference of the Americas in Oakland, California, 27-31 August. A joint seminar with Task 21 was also held at this time.

Work Programme

Pre-feasibility studies on bioenergy applications have been produced. The technologies studied included power production in small scale, active flue gas condensation in biomass district heating plants, pyrolysis for alternative fuel oil to be used within a city, and production of a slow release fertilizer from fast pyrolysis oil. These projects, which were undertaken in Austria, Canada, Finland, Sweden, and the USA, have been completed. Descriptions of these studies are detailed below.

Austria: Improved Heat Recovery in Biomass District Heating Plants

Heat recovery from flue gas in biomass furnaces of district heating plants increases efficiency, because of the high water content of wood chip and bark fuels. Due to the water content of the biofuel, the lower heating value is normally about 50% of that of dry wood. However, if the flue gas is cooled down to about 30ºC, large quantities of heat (30 to 50% of the furnace capacity) may be recovered by condensation. When the flue gas temperature is lowered to 70ºC, the heat recovery is only 10%. If a heat pump is used, the low-temperature condensation heat - recovered from the flue gas - may be raised from 30ºC to the temperature of the district heat return level. For this purpose, a resorption heat pump with a mechanical compressor should be used due to the high coefficient of performance (COP). An analysis of different heat pump processes showed that a mechanically run resorption heat pump is the best option.

In the framework of the techno-economic assessments on the active condensation system proposed, data measured for an existing biomass district heating plant were used for the simulation of the technical behaviour of the plant. These data of 6-minute plant operation were extremely important for obtaining realistic results due to the partial load operation, which is the predominant case in practical operation. The results of the technical calculations showed that the COP lies in the range of 7 to 9 in all cases of partial load operation of the heat pump. These COP values are - with reference to other heat pump types - particularly high. Prerequisites for this excellent technical operation are technical maturity of apparatus design, plant control and optimised control algorithms. In partial load operation, the necessary compressor operation has to be controlled exactly by well-designed power electronics.

The economic investigations showed that due to the high COP the amortisation times of such plants could be in the range of 1-2 years depending on investment cost, water content and partial load factor. The investment costs were varied between 1,200,000 (specific cost of 2400 ATS/kWth) and 600,000 ATS, the water content in the range of 30-55% and the partial load factor 0.4-0.6.

The economic evaluation of an active condensation system with a resorption heat pump is based on the capital value and on the amortisation time. Regardless of investment cost and water content, the investment is economic for a partial load factor of 0.4 onwards (see fig. 1 below). For a partial load factor of 0.3, the water content should exceed 40% for an economical investment.

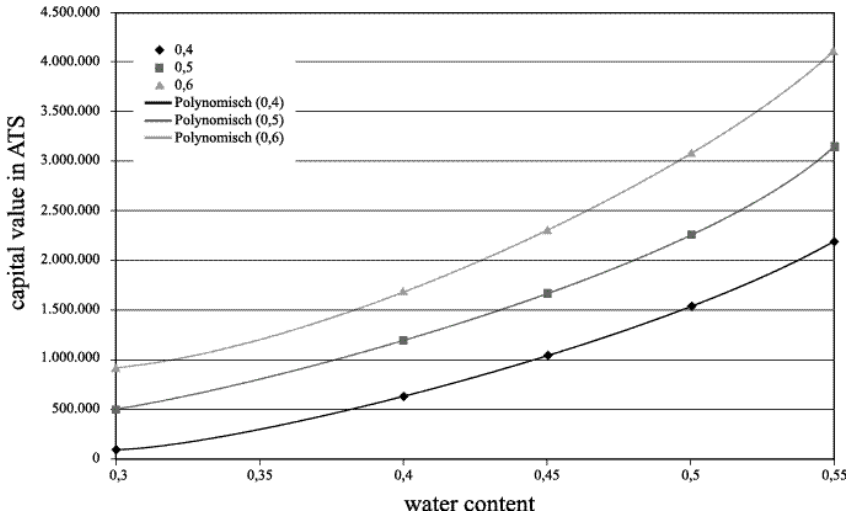


Figure 1. Effect of partial load factor on the capital value, when no subsidies are granted.

Canada: By-products from Fast Pyrolysis Liquid

A techno-economic assessment has been completed for a slow release fertilizer production plant from bio-oil that is produced from the fast pyrolysis of biomass. The production of slow release fertilizers from biomass is based on patented technology developed by Resource Transforms International Ltd, of Waterloo, Canada.

This assessment was based on scaling up the technology to a production plant producing approximately 20,000 t/yr of solid fertilizer from whole bio-oil, containing 10% Nitrogen. This size of plant would process all of the bio-oil from a 200 t/d (wet, 50% moisture basis) bio-oil from wood production plant. The cost to produce slow release fertilizer from bio-oil was compared with the costs of conventional slow release and specialty fertilizers.

Mass and energy balances for the key operations of the plant, reactor and dryer, were determined using a steady-state simulation model developed using ASPEN Plus simulation software. The bio-oil feed costs were determined from previous studies for similar sized plants completed by the IEA Bioenergy 'techno-economic analysis of bioenergy systems' Activity. Plant operating costs were based on operation at a site in Canada. Sensitivity analyses were studied for key process performance and cost parameters such as wood and bio-oil feedstock costs.

Finland: Small Scale Power Production

The study focused on comparing production of electricity at 2 MW_e. The scale was selected to study how well the commercial steam boiler power plant competes with the new power plant concepts being proposed, especially in the small scale; and also to produce estimates of cost and performance for the new concepts.

The systems compared were:

- a Rankine steam boiler power plant,
- a gas engine power plant using gasification fuel gas - the gasifier and the engine are integrated,
- a diesel power plant using fast pyrolysis liquid as a fuel. Liquid production and the power plant are de-coupled.

The overall efficiencies for these systems are: the Rankine cycle 17.5%, gasification - gas engine 23.9%, and pyrolysis - diesel engine 24.7%. The potential improved efficiencies for the three technologies are 23, 28.5, and 31.5%, respectively. Estimated specific investment costs for the power plants are 2300, 4200, and 3600 US$/$kW_e$, respectively.

It was shown that the Rankine cycle is superior compared to the gasification gas engine and pyrolysis diesel engine with current cost data. Increasing fuel cost 50% from the base value 45 FIM/MWh (2.3 US$/GJ) improves the competitiveness of new concepts, but the Rankine is continuously more economic. Increasing the rate of interest used for capital cost estimates (thus taking profit into account for an investor) improves the competitiveness of the Rankine cycle further, compared to the other alternatives. Potential improvements for all technologies were considered. It is estimated that there is potential for further development in all of the concepts studied. If all the improvements are valid simultaneously, the cost of electricity from all systems is practically the same.

Sweden: Pyrolysis Liquids as Boiler Fuel

Stockholm Energi AB, Sweden, is currently using wood pellets and tall oil pitch as renewable fuel for district heating within the Stockholm city area. Pyrolysis liquid is a potential substitute for petroleum fuel oil. A technical, economic, and environmental assessment for the whole utilisation chain was carried out.

Upgraded wood fuels may be developed in several ways. Pellet manufacture and pyrolysis of wood into liquid fuel are two immediate routes where the latter tentatively may substitute fuel oil in existing boilers and heaters. A techno-economic assessment and comparison of these routes was carried out from the raw material to combustion in a boiler or heater. In the upgrading processes the unit operations and the equipment to a large extent can be assumed the same; receiving and storage of raw material, drying and milling. The key processes - pelletising and pyrolysis - are different as well as transportation of the products and the combustion technique.

In the comparison, data from existing pellet factories had to be related to estimated data for an assumed pyrolysis unit. This was handled by using the real data as far as possible even for the pyrolysis process. To achieve a consistency in the manufacturing costs, the pyrolysis unit was assumed to be equipped with a steam dryer to enable a by-product credit as is the case for most pellet units in Sweden. By means of this the total energy

efficiency was raised to about 90 % in contrast to 70 % which is usually assumed for the pyrolysis process. The pellet manufacture has an energy efficiency of almost 100 % when by-product steam is considered.

Despite lower operating costs in the pyrolysis the manufacturing costs were still relatively higher. (The absolute, total manufacturing costs were not calculated). However, due to larger transport volumes (for the same amount of energy) and more complicated systems with the solid pellet fuel the difference was almost eliminated.

Although the combustion of pyrolysis oil has been demonstrated to be difficult due to the properties of the oil, estimates on the required equipment for the firing still show lower investments than are at hand for pellet combustion. In consequence, the assessment of the entire flow from raw material to 'hot water' and flue gases gives a small preference to pyrolysis oil. This, however, requires the mentioned by-product utilisation. Otherwise pellet manufacture seems slightly advantageous since the energy efficiency of pyrolysis is lower. Further, it also has to be demonstrated that the flue gas treatment from combustion of pyrolysis oil is not too difficult. Finally, it was concluded that further development of the quality of pyrolysis oil is necessary. Today's examples on oil are very uneven and cannot easily substitute conventional fuel oil. In that respect pellets are superior.

USA: Small, Modular Biopower Projects

Small, modular biopower systems have the potential to help supply electric power to the more than 2.5 billion people in the world who currently live without it. The potential exists because most of these people live in areas where large amounts of biomass are available for fuel. Small systems, those with rated capacities of 5 megawatts and smaller, could potentially provide power at the village level to serve many of these people.

Small biomass systems also have a great potential market in industrialized regions of the world in distributed applications. These applications consist of power generation attached to the transmission and distribution grid close to where the consumer uses electricity; some might be owned by the consumers themselves and would be connected to the power grid on the customer side of the electric meter. Both of these applications have large potential markets both inside the United States and abroad.

Compared to small, modular power systems powered by fossil fuels that predominate in today's markets, biomass provides an alternative that is more environmentally acceptable. Furthermore, successful commercialization of small biopower systems completes the development of a biopower industry covering all ranges of expected power applications, including small systems for village power or distributed applications; combined heat and power systems for industrial applications; and cofiring, gasification, and advanced combustion for utility-scale power generation. Working with industry, the US Department of Energy's 'small modular systems project' is developing small biopower systems that are efficient and clean. The project consists of feasibility studies, prototype demonstrations, and proceeding to full system integration based on a business strategy for commercialization. For more information please refer to:
http://www.eren.doe.gov/biopower/smallmod.html

Deliverables

The deliverables from the Task include; development and maintenance of the website at www.vtt.fi/ene/bioenergy; preparation of the 'summary report' including the national pre-feasibility studies; and feedback to the IEA Bioenergy ExCo and others on the technical studies undertaken.

TASK 23: Energy from Thermal Conversion of MSW and RDF

Overview of the Task

The objective of Task 23 is to produce a comprehensive status report of the latest developments in, and deployment of, conversion technologies for Municipal Solid Waste (MSW) and Refuse Derived Fuel (RDF).

Energy recovery utilising conventional systems (grate fired mass burn incineration) is an established mature technology and dominates the market. Over the last few years attention has focused on newer technology such as fluidised bed combustion and, even more recently, on gasification and pyrolysis based systems. A number of commercial scale facilities based on these newer technologies are currently under construction, or at an advanced stage of planning. Their performance may well impact on the nature of the energy recovery market.

In addition to technology development, waste management policies and practices have become ever more sophisticated and complex. In order to effectively progress with developing the waste management infrastructure it is vital that policy and decision-makers have access to the latest information on the potential and application of technology and be aware of international trends in this sector. The work programme in this Task aims to provide such information.

The participating countries are: Canada, France, Finland, Japan, Sweden, Norway, The Netherlands and the United Kingdom. Australia will join the Task from 1 January 2000.

As in other Tasks, a Task Leader, appointed by the Operating Agent (the United Kingdom), directs and manages the work programme. In each country participating in Task 23 a National Team Leader is nominated, responsible for the co-ordination of the national participation in the Task.

For further details on Task 23, please refer to Appendices 2-5 inclusive.

Progress in R&D

Task Meetings

Three Task meetings were held in 1999. The first was held during April, in Paris. The meeting included site visits to the Centre de Recherches pour L'Environnement L'Energie et Le Déchet (Environment Energy and Waste Research Centre) at Limay; a tour of the

Mantes La Jolie Thermal Treatment Plant and a tour of AZALYS, a brand new facility with grate furnace and complete gas treatment and NOx for St Germain en Laye.

The second meeting was a joint seminar with the ISWA Working Group on Thermal Treatment of Waste, WGTT on 30 September - 1 October, in Malmö, Sweden. Also co-operating in the seminar were the Swedish Association of Waste Management, RVF and The Solid Waste Company of Southwest Scania, SYSAV, Sweden. The seminar covered the latest technical developments in the field of waste to energy. The meeting was very successful and attracted approximately 200 delegates.

The final Task meeting of 1999 was held in Kyoto, Japan in November and included a study visit to Ibaraki City Environment and Hygiene Centre. In 1980, Ibaraki City adopted a new waste treatment system to respond to ever increasing and diversifying waste. Firstly the recyclable waste is removed, then the remaining waste is melted at high temperatures and converted into re-usable slag and iron. The slag and iron can be used in a broad range of commercial applications, such as construction material for pavements, interlocking blocks for road facing and counterweights for construction machines. The only remaining residue is fly ash from the dust collector, which minimises both the necessity for landfill and the overall cost of waste treatment.

Work Programme

The work programme for Task 23 consists of six topics as follows:

- the management of residues from thermal conversion,
- advanced conversion technologies for MSW treatment,
- fluidised bed combustion of MSW,
- co-firing of MSW,
- a review of MSW management policies and technology deployment trends,
- characterisation of MSW/RDF components and mixtures for combustion systems.

The management of residues from thermal conversion. A draft report is now available and is currently being circulated for review. It is expected the final report will be available early in 2000.

Fluidised bed combustion of MSW. Several reports are being prepared including case studies of the Robbins Resource Recovery Facility in Chicago, USA, the Lidköping plant in Sweden and the DERL Energy from Waste Facility in Dundee, Scotland. Brief details on these case studies are presented below:

Robbins facility. The case study for the Robbins Resource Recovery Facility was completed by David Granatstein of CANMET in co-operation with Wilfrid Hesseling of TNO-MEP, the Netherlands. Conclusions are as follows:

- MSW feed processed at the facility is reduced in mass by approximately 25% before being fed to the circulating fluidised bed incinerators. Recovery of 5% ferrous metals, 1% aluminium and 19% glass and compostables is achieved. While the metals are readily marketed, the glass/organics fraction is utilised as daily landfill cover, owing to no local market for this material.

• The incineration process reduces the refuse derived fuel to about 5% by volume (15% by mass). This residue comprises 80% fly ash (captured by the baghouse filters) and 20% bottom ash (collected as it falls through the distributor plate at the bottom of the furnace). The finer bottom ash is recycled with the bed sand, and some of both the fly and bottom ash is sold as a Portland cement replacement (good pozzolanic properties are imparted by the aluminium content). Because of high hauling and tipping charges for the remaining ash, Foster Wheeler is actively pursuing new markets.

• Overall efficiency of electrical generation from MSW has been calculated as 22.8% (based on LHV), equivalent to 0.633 MWh/t, and typical of a comparable mass burn incinerator. Boiler efficiency was 88.7%.

• Based on a total investment of US$301 million, and a sales price for electricity of $0.025/kWh, the payback time has been calculated as 10.2 years. Foster Wheeler expects the value of electricity to increase to $0.04-0.05/kWh once the industry is deregulated. This would have the effect of reducing the payback time significantly, and might be enough to allow Foster Wheeler to make a profit. This would also increase annual payments to the village of Robbins.

• Analytical data confirms that the facility can easily meet environmental regulations set by USEPA and IEPA for stack emissions and fly and bottom ash. The plant has been cited frequently for exceedances of CO and UHC limits; however, these are associated mainly with start-up (using natural gas).

Lidköping plant. A draft report of the case study of the Lidköping plant has also been completed. It is expected the final report will be available early in 2000.

DERL facility. A draft report of the DERL Energy from Waste Facility in Dundee, Scotland was completed in September 1999. The next meeting of Task 23 will take place in Edinburgh, Scotland and the meeting includes a site visit to this plant.

Collaboration with Industry

The Swedish participant Åsa Hagelin from RVF is also secretary for the ISWA Thermal Treatment Working Group, so a close collaboration between the two groups continues. It is planned to hold another joint seminar with ISWA/WGTT on experiences with co-firing recycled fuels in modern CHP plants in Finland in March 2001. The work programme topics relating to 'The management of residues from thermal conversion' and 'A review of MSW management policies and technology deployment trends' will be carried out in co-operation with the ISWA/WGTT.

Deliverables

Deliverables from 1999 included; the proceedings from the Brescia seminar; the proceedings from the Malmö seminar; the final report on the Robbins Resource Recovery Facility case study; the draft report on the Lidköping case study; the draft report on the DERL Dundee Energy from Waste Facility case study; and the draft report on 'Management of residues from thermal conversion'.

TASK 24: Energy from Biological Conversion of Organic Waste

Overview of the Task

The objective of Task 24 is to provide information exchange and promote the use of anaerobic digestion of municipal and industrial solid wastes to generate energy, reduce pollution and recycle organic matter and nutrients.

Energy recovery from organic wastes using anaerobic digestion to process particular wastes (sewage treatment, industrial wastewaters, landfill gas) is an established mature technology and dominates these specific markets. However, there are sites where appropriate deployment of anaerobic digestion has not been made in these established markets and demonstration of the benefits needs to be made. Also, many other organic wastes that are appropriate for energy recovery through anaerobic digestion are not exploited and thus have the potential of additional unnecessary pollution. Over the last few years attention has focused on the environmental impact of landfill and incineration of organic wastes and newer systems have been developed to recover the energy from 'solid' organic waste and to recycle the organic matter. A number of commercial scale facilities based on these newer technologies have been built and the number of facilities is increasing. However, market penetration is still low.

The participating countries are Denmark, Finland, Sweden, Switzerland and the United Kingdom.

As in other Tasks, a Task Leader, appointed by the Operating Agent (the United Kingdom), directs and manages the work programme. In each country participating in Task 24 a National Team Leader is nominated, responsible for the co-ordination of the national participation in the Task.

For further details on Task 24, please refer to Appendices 2-5 inclusive.

Progress in R&D

Task Meetings

Four meetings were held in 1999. The first took place in Paris in January 1999. At the same time, a meeting was held with the chairman of the ISWA biological treatment group which helped to forge links with this group. The second meeting took place in Stuttgart, Germany in March. The meeting was held alongside a conference titled, 'Hygienic and environmental aspects of anaerobic digestion: legislation and experiences' which was organised by Task Members. The aim of the conference was to develop the experience from operating digesters and research work on the pathogen kill and biological safety of the use of the products from anaerobic digestion. The conference was targeted at official veterinarians and others who have a role in the development of regulations for use of wastes-based products on land. Twelve very informative papers were presented and a high quality discussion ensued. The meeting included a site visit to a commercial digestion plant treating source separated organic waste. The third meeting was held in Barcelona,

Spain in June in conjunction with the International Symposium of Anaerobic Digestion of Solid Waste. The final Task meeting of 1999 was held in Brussels in October in conjunction with the 3rd European Motor Biofuels Forum.

Work Programme

The work programme for Task 24 consists of six topics as follows:

- revision and editing of systems and markets report,
- biogas upgrading technologies,
- source separation technologies of organic wastes,
- quality management of digestate,
- sanitisation workshop,
- plant database.

Revision and editing of systems and markets report. It is planned to edit and re-issue the very successful booklet on anaerobic digestion systems, towards the end of 2000. Initial discussions on the revised content of the booklet were held at Barcelona.

Biogas upgrading technologies. A review of biogas upgrading technologies has been completed. This review forms part of the assessment of advanced biogas utilisation. The report details the current state of biogas upgrading technology for improving biogas quality to be used either in pipeline distribution or as a vehicle fuel. This technology will also be important in the future for advanced gas use applications such as fuel cells where high conversion efficiencies are expected.

Source separation of organic wastes. A review of source separation systems for the collection of organics from households will be progressing during 2000. The programme of work covers:

- the rationale for when source separation would be used, concentrating on the products that could be produced (high quality, agriculture, land restoration/energy crops) compared to those that would be more difficult to produce and the reasons why this would be so.
- the issues that require consideration in the choice of system e.g. sacks or bins, range of materials to collect, frequency, etc.
- the impact of source separation on the anaerobic digestion system.

Progress on this topic has been delayed owing to a change in employment of the Swedish member Simon Lundeberg and the leadership of this project has now passed to Leif Nilsson.

Quality management of digestate. The programme of work includes; feedstock control (screening, heavy metals issues, etc); process control; sampling; digestates; and measurement techniques. The report on this work will be published as a chapter of the Biogas Brochure. The initial drafts are expected in early 2000.

Sanitisation workshop. This conference, already mentioned above, took place on 31 March in Stuttgart. The aim of the conference was to develop the experience from operating digesters and research work on the pathogen kill and biological safety of the use of the products from anaerobic digestion. The conference was targeted at official

veterinarians and others who have a role in the development of regulations for use of wastes-based materials on land. The workshop was well attended with an invited audience of over 50 officials and influential specialists. The proceedings have been distributed by the German Veterinary Association. The arrangement was that Task 24 would take over any unsold copies for distribution. However, the proceedings have been sold out and another print run is being arranged.

At the Task meeting in Barcelona, it was discussed how best to build on the success of the veterinarians' conference. It was agreed that a further conference, which would attract trade associations, veterinarians and the ministry of agriculture, would be a way forward in bringing these people together, with the aim of discussing a pathogen standard. The Task Leader will approach the European Commission to see if that organisation will take the lead in organising such a conference.

Plant database. A database of anaerobic digestion plants and contacts has been maintained and distributed electronically to the participating members. The collection of these data is an ongoing activity in the Task and the database will be updated regularly. This database will also be used to update the information in the highly successful brochure from the anaerobic digestion Activity within the old Task XIV.

Deliverables

Deliverables in 1999 included: the proceedings of the 'Sanitisation workshop'; the biogas upgrading report; the 'Source separation issues report' (first draft); and updating and distribution of the plant database.

TASK 25: Greenhouse Gas Balances of Bioenergy Systems

Overview of the Task

The objective of Task 25 is to analyze, on a full fuel cycle basis, all processes involved in the use of bioenergy systems, with the aim of establishing overall greenhouse gas balances.

The participating countries are Austria, Canada, Croatia, Finland, New Zealand, Sweden, the United Kingdom, and the United States. Australia will join the Task from 1 January 2000.

As in other Tasks, a Task Leader, appointed by the Operating Agent (the Republic of Austria), directs and manages the work programme. In each country participating in Task 25 a National Team Leader is nominated, responsible for the co-ordination of the national participation in the Task.

For further details on Task 25, please refer to Appendices 2-5 inclusive and also the Task 25 website at www.joanneum.ac.at/iea-bioenergy-task25.

Task Workshop

The 1999 meeting of Task 25 took place in Gatlinburg, Tennessee, USA, 27-30 September, 1999. It was jointly organized by ORNL, Oak Ridge, USA and Joanneum Research, Graz, Austria. The workshop topic was 'Bioenergy for mitigation of CO2 emissions: the power, transportation, and industrial sectors'. It included a half-day business session where the future of Task 25 beyond the year 2000 was discussed, two days of workshop sessions, a one-day excursion, and a session where the joint paper on 'baseline scenarios' was further developed. The workshop proceedings will be published in January 2000 in the same style as previous proceedings and installed on the Task 25 website.

A special issue of Environmental Science & Policy (Vol.2 No.2, 1999) based on the Rotorua workshop proceedings was published in May 1999 and has been distributed widely. For example to the authors of the IPCC 'Special Report on land-use, land-use change, and forestry'.

More detailed information on these events can be found on the Task 25 website as well as in the proceedings of the workshop held at Gattlinburg.

Bibliography

The new, electronic edition of the bibliography 'Greenhouse gas balances of bioenergy, forestry, wood products, land use, and land use change' containing existing publications, unpublished reports and databases has been completed. This bibliography includes not only literature with reference to 'bioenergy' and 'greenhouse gases', but also work that deals with greenhouse gases as they relate to land use (e.g. agriculture, forestry) and land use change, as well as information on the greenhouse gas implications of some selected fossil-fuel based energy systems in order to enable a comparison with biomass energy systems. Biomass for energy is often produced as a co-product or by-product of conventional wood products, which are also covered by this bibliography. It consists of information on author(s), title, journal, issue, page numbers, date of publication, keywords and abstract. The updated version of the bibliography is downloadable as a pdf file from the Task 25 homepage. A CD containing the bibliography has been distributed to the participants at the workshop in Gatlinburg, and is available on request.

Website

The Task 25 homepage is continuously updated and extended. It now includes information on selected projects, models and other activities in the participating countries.

Contributions to the IPCC and Others

The Task has been collaborating intensively with the Intergovernmental Panel on Climate Change (IPCC). A number of individuals from Task 25 contributed to the IPCC 'Special report on land use, land use change and forestry'. These included: M. Apps, J. Ford-Robertson, H. Haroon, T. Karjalainen, B. Schlamadinger, and G. Marland.

Task 25 also contributed to a report, commissioned by the IEA Greenhouse Gas R&D Programme, and carried out by the New Zealand Forest Research Institute titled 'Use of forestry by products for power generation' and reviewed reports by the IEA Greenhouse Gas R&D Programme including a report titled 'Interaction between forestry sequestration of CO2 and the market of timber'.

TASK 26: Biotechnology for the Conversion of Lignocellulosics to Ethanol

Overview of the Task

The main objective of Task 26 is to promote the establishment of biomass-to-ethanol demonstration plants which are championed and funded by industry. Specific goals within the three-year time scale of the Task have been formulated and these are detailed below.

The participating countries are Canada, Denmark, Finland, The Netherlands and Sweden.

As in other Tasks, a Task Leader, appointed by the Operating Agent (Canada) directs and manages the work programme. For each participating country, a National Team Leader is nominated who is responsible for co-ordinating the national participation in the Task.

For further details on Task 26, please refer to Appendices 2-5 inclusive and www.forestresearch.co.nz/ieabioenergy/home.htm under 'Current Tasks' on the IEA Bioenergy Homepage.

The participants have R&D programs within their countries in order to meet the above objectives and carry out co-operative research based on their national programs. The work of the Task is structured around the following goals.

- To provide a forum for participating countries interested in developing biomass-to-ethanol processes.
- To communicate progress in the commercialization of biomass-to-ethanol processes.
- To continue the exchange of the technical and economic assumptions and the models used in various techno-economic modelling efforts of participating groups.
- To catalyze or initiate 'special projects' funded by additional funding outside of the IEA.

Progress towards these four goals is reported below.

Progress in R&D

To provide a forum for participating countries interested in developing biomass-to-ethanol processes.

Exchange of personnel. The exchange of personnel has continued with students, post-doctoral scholars and research staff participating in international conferences to both

familiarize themselves with other work and to encourage discussion on collaboration or exchange. As a result of the meeting in Norway in 1998 there was an exchange of five students between Canada, Scandanavia and The Netherlands.

Organization of workshops/symposia. Detailed below are workshops/symposia that have been held recently by Task 26 and plans for future meetings.

Anaheim meeting. The Task 26 network co-sponsored a session 'Hydrolytic Enzymes' which was held within the 217th American Chemical Society (ACS) National Meeting in Anaheim on 21-25 March 1999. The workshop had 44 participants from 11 countries and represented academia, the public sector, consultants and the industrial sector (10 participants). An ACS volume titled 'Glycosyl Hydrolases in Biomass Conversion' containing peer-reviewed papers from this session will be published next year.

South African meeting. The recent Task 26 workshop held at the Itala Game Reserve was a milestone in a number of instances. Firstly, the workshop was being held for the first time in South Africa (SA) and probably the first time on the African continent. Secondly, the workshop was international, in the true sense of the word, with delegates from all continents except Asia. The final delegate count was 62 from 16 countries. In a 4-day format, 31 participants presented oral presentations and these were bolstered by 38 poster presentations. The highlights of the presentations and details of the plenary speakers can be found in the Task 26, Newsletter No. 6 at the IEA Bioenergy website.

Other meetings. Two further meetings at Gatlinburg and Hawaii are at an advanced stage of organisation. In addition, the Task is exploring the opportunity for a Spring 2001 meeting in the Baltic countries, in conjunction with the Nordic Bioenergy Programme. Strong participation by Task 26 members in the 1st World Conference on Biomass in Seville is expected.

External collaboration and technology transfer. The newsletters, although representing a substantial time commitment and expense to create and distribute, have been very successful at transmitting information to both participating and non-participating countries. The workshops have facilitated participation by European, North American, South American, Asian and African countries. The Task has continued to receive enquiries for information on IEA Bioenergy and especially 'lignocellulosics-to-ethanol processes' from researchers and consultants in countries such as Argentina, Australia, South Africa, China, Cuba, Mexico, UK, Croatia, Hungary, Indonesia, Pakistan and India. These enquiries often lead to invited observers/presenters at the Task 26 workshops. They also result in discussions about other IEA Bioenergy activities.

Interaction with other Tasks. Copies of the newsletter are sent to a number of the other Tasks in IEA Bioenergy. Donald O'Connor from Task 26 presented biomass-to-ethanol information at the Gatlinburg meeting of Task 25. He discussed some of the modelling efforts in his presentation titled 'Full fuel cycle analysis of greenhouse gas emissions from biomass derived ethanol fuel in Canada'. There has also been an exchange of newsletters and meeting arrangements between Task 26 and Task 27 to assist the newsletter editors in transmitting information to the general membership of each Task.

Potential members. The Task Leader has had discussions with past participating countries (USA, Austria and Italy) and with potential new member countries (Australia, Brazil, Croatia, Ireland, Russia and South Africa) about joining Task 26. Brazil has since joined IEA Bioenergy. South Africa has requested Observer status of both Task 26 and the Executive Committee for 2000 with a view to subsequent membership.

To communicate progress in the commercialization of biomass-to-ethanol processes.

Progress in commercialization of biomass-to-ethanol processes has been communicated through both the newsletter and the symposia. The three issues (Nos. 4, 5 and 6) of the newsletter that were published in 1999 have been sent out to all of the past participants in the biomass-to-ethanol network, and participants in the new Task. The newsletters have provided a forum to accomplish a number of the Task's goals. The Task has also continued to update and expand the mailing list - now over 450 individuals or organizations. Feedback on the newsletters has continued to exceed expectations. They are providing appropriate information on upcoming events and international perspectives on the global status of technology associated with the lignocellulosics-to-ethanol process. Each newsletter issue has been added to the IEA Bioenergy website by sending a copy to the IEA Bioenergy webmaster.

To continue the exchange of the technical and economic assumptions and the models used in various techno-economic modelling efforts of participating groups.

The Task has developed a survey that will be sent around to the various techno-economic modelling groups to determine the economic, financial and political differences found in the various countries. Over the remaining time in this Task period it is hoped to incorporate these differences into the UBC model to provide more widespread applicability of the comparison. The Task is also continuing to document the UBC model to provide a comprehensive package for distribution to other participating IEA Bioenergy 'techno-economic' modelling groups.

To catalyze or initiate 'special projects' funded by additional funding outside of the IEA.

The Vancouver meeting, which has been described previously, was an example of a special project with funding coming from outside of the IEA. The current interest in GHG reduction opportunities associated with the lignocellulosic-to-ethanol process has drawn in many different interest groups from various countries and includes industrial and investment partners. This bodes well for the potential to follow-through on projects that include joint country and industrial partnerships with the parties wanting to combine and develop technologies associated with lignocellulosic-to-ethanol processes.

TASK 27: Liquid Biofuels

Overview of the Task

The objective of Task 27 is to identify and eliminate non-technical barriers that impede the deployment of liquid fuels. To meet this objective, participants are conducting information exchange and analysis activities to provide governments, policy makers, and stakeholders with improved information on non-technical issues related to biofuels.

Current participants in Task 27 are Austria, Canada, the European Commission, Sweden and the United States; with USA serving as Operating Agent. Canada joined the Task in 1999.

For further details on Task 27, please refer to Appendices 2-5 inclusive and also the Task 27 website at www.joanneum.ac.at/iea-bioenergy-task27/task27.htm.

Progress in R&D

Task Meetings

The Task held its first working group meeting in Washington D.C., USA, in January 1999. Working meetings were also held in Stockholm, Sweden on May 31 - June 1, 1999, and in Brussels, Belgium on 7-8 October, 1999. Future meetings are scheduled for Austria on 31 January - 2 February 2000 and for Europe in May 2000.

The Task had a joint workshop with the 'Pyrolysis' and 'Techno-economic Analysis' Tasks in Oakland, USA, in June 1999. Another joint workshop with the 'Pyrolysis' Task is scheduled for Austria in January 2000 and will feature an industry-driven seminar on biofuels.

Work Programme

The work programme for the Task was developed in the January 1999 meeting in Washington D.C. The work of the Task includes the following elements:

Providing information for governments and policy makers. The overall objective of this component is to provide governments and policy makers with improved information that will help them identify and eliminate non-technical barriers to liquid fuels deployment. Issues identified as being highest priority for the participants in 1999 included:

- Fuel properties and standards. The Task is compiling existing standards for biofuels such as B5, B20, B100, E10, E20, E85. The objective of this effort is to determine if current specifications are adequate, or if additional standards are needed to help the biofuels market. The development of such standards, if needed, would be up to industry.

- Tax issues. The Task is identifying and comparing taxation and incentives policies of participating countries to determine their influence in driving the biofuels industries. Examples of taxes and incentives include CO^2 emissions regulations, alternate motor fuel taxes, barrier taxes, and others.

- Business-related issues. The Task is identifying and comparing industry financing, including mechanisms and sources and examining ways industry has been able to quantify value-added benefits such as calculating the cost/kg of carbon dioxide savings.

- Life cycle analyses (LCAs). The Task is compiling biofuels LCAs produced in the participating countries in an effort to make these studies more readily available. Further comparison of the results of the existing studies will be conducted if needed.

- Regulatory and policy issues. Other non-technical barriers including feedstock incentives, set asides, clean air incentives, financial incentives, and others are being identified and evaluated for their impact on biofuels.

Involving stakeholders in the Task. The objective of this effort is to identify and involve potential liquid biofuels stakeholders in the Task. The industrial and trade associate stakeholders are very important to the development of biofuels. Providing better access to those people and organizations will help the participants by making each of them aware of stakeholders outside of their own particular region. In 1999, the Task met with various stakeholder interests such as the Swedish Bioethanol Foundation to obtain insight into the broad base of issues related to biofuels.

Interacting with related IEA Tasks and others. The Task is co-ordinating its work with other related activities including IEA Bioenergy Tasks XVI, 22, and 26; the IEA Greenhouse Gas R&D Programme; the IEA Alternate Motor Fuels Agreement, and others. In 1999, Task 27 had discussions, joint meetings, and other interactions with a variety of related groups.

Website

The work programme has included the construction and maintenance of a website to improve access to the information developed by the Task. The address is www.joanneum.ac.at/iea-bioenergy-task27.

TASK 28: Solid Biomass Fuels Standardisation and Classification

Overview of the Task

The objectives of Task 28 are to:

- develop a set of standards for solid biomass fuels to be used by efficient and economical energy conversion systems.
- promote the standardisation of the specifications and classification for solid biomass fuels by international standards bodies such as ISO.
- help create an international solid biomass fuels market in which solid biomass fuels can be traded amongst producers (farmers, foresters, fuel companies) and users (utilities, district heating companies, industries, etc.) with quality assurance and guarantees. The solid biomass fuels market will help to promote bioenergy in general, assist in the penetration of biomass conversion technologies into the energy market and provide a stable framework for all stakeholders; fuel producers, equipment manufacturers, and end users. This will assist IEA Bioenergy member countries in attaining the Kyoto Protocol objectives.

The participating countries are the Commission of the European Communities (CEC), Denmark, Norway and the United States. In addition, The Netherlands will join the Task from 1 January 2000.

This Task is a joint programme between IEA Bioenergy and the CEC. As in other Tasks, a Task Leader, appointed by the Operating Agent (the Commission of the European Communities), directs and manages the work programme.
For further details on Task 28, please refer to Appendices 2-5 inclusive.

Standardisation Activities in the Context of CEN

The work to develop a set of standards for solid biomass fuels (or solid biofuels) began in a workshop established by CEN (the organisation responsible for the production of European Standards) in November, 1998. The Workshop receives technical support through a combined project supported by the European Commission's (EC) THERMIE and FAIR Programmes, and co-ordinated by Green Land Reclamation Ltd and the University of Stuttgart.

The first plenary meeting of representatives from CEN, the THERMIE and FAIR Programmes, and participants in IEA Bioenergy Task 28 was held in Stuttgart, Germany, on 9 and 10 March 1999. That meeting considered:

- a preliminary review of the status of existing national and international standards for solid biofuels;
- proposed definitions, classification and scope of fuels to be included in the standardisation work, including a definition of the borderline between solid biofuels and wastes; and
- a preliminary critical assessment of available standards and the need for work to refine them for use on a European/international scale.

Representatives of 13 countries presented brief overviews of the state-of-the-art of standards for solid biofuels in their respective countries and it was agreed that partners in the FAIR project and IEA Task 28 participants would prepare Country Reports to provide a record of the present national status of standards and an indication of particular needs for the future. There was lively discussion about the borderline between biofuels and wastes. Some countries wanted only 'clean' biomass fuels to be included while others argued strongly for the scope to include waste-derived fuels and demolition wood. When a preliminary critical assessment of available standards was presented and discussed, it was agreed that priority should be given to the development of standards for sampling and testing solid biofuels because they form the basis of specifications for products traded in the market and are not dependent on the origin of the fuel.

It was announced in June 1999, that the CEN Technical Board had decided to upgrade the workshop activity and re-name it CEN/Technical Board/Working Group Solid Biofuels (henceforth referred to as CEN/BT/WG108 Solid Biofuels). The aim of CEN/BT/WG108 is to draft and agree a work programme for submission to the CEN Technical Board that lists the standards needed to facilitate and support the expansion of the solid biofuel market. The work programme will include the titles, scope and target dates of the standards as well as an indication of which standards must be developed first. It is intended to finalise the work programme by the end of February 2000, at the latest.

The second plenary meeting of representatives from CEN, the THERMIE and FAIR Programmes and participants in IEA Bioenergy Task 28 was held in Stockholm, Sweden, on 14 and 15 September 1999. That meeting considered:

- conclusions drawn from the review of the status of existing national and international standards for solid biofuels;

• the first draft of a work programme for the development of standards for solid biofuels that could be adopted by a CEN Technical Committee;

• the borderline between biofuels and wastes, and its impact on the standardisation work.

Representatives of 15 countries summarised the conclusions of their investigations into the state-of-the-art of standards for solid biofuels in their respective countries. The first draft of the work programme was presented, but it was emphasized that it had been prepared in advance of the Country Reports, and therefore could not contain all of the recommendations made in those documents within its scope. However, a satisfactory structure for the document had been developed that would serve as a basis for future drafts.

The delegates then discussed the scope of the fuels to be included in the work programme. The three main elements were identified as solid biofuels, peat and solid recovered (waste-derived) fuels. A proposal to encompass an undivided spectrum of solid fuels within the activities of CEN/BT/WG108, received a mixed response from the leaders of the national delegations. Some considered that the scope should be confined to uncontaminated biofuels, to preserve the perceived 'clean green' image of those materials in the public eye and to avoid paying waste-taxes on the fuel. Others thought that the growth of the market for renewable energy would benefit much more from the development of standards for a broad range of fuels.

Since the meeting in Stockholm, the scope of fuels has been discussed by various EC Directorates and their associated committees, and it seems most likely that, at least for the present, peat and solid recovered fuels will be excluded from the Standardisation Mandate given to CEN. In view of that, a revised draft work programme was produced in December, which proposed 24 standards documents under the following main headings:

- terminology, definitions and description,
- fuel specifications, classes and quality assurance,
- sampling and sample reduction,
- physical/mechanical tests,
- chemical tests.

A final draft work programme will be presented at the next meeting of CEN/BT/WG108 in Brussels, Belgium, on 8 February 2000. Once it has been formally adopted and the EC has issued a Standardisation Mandate to CEN, a new CEN Technical Committee will be established and drafting work for the standards documents can begin.

Quality Assurance

The scope of CEN/BT/WG108 does not include the development of quality assurance schemes, but it is clear that such schemes will be needed to provide the framework within which standards can be applied to the production of solid biofuels. Green Land Reclamation Ltd, acting as co-ordinator for a consortium of 10 partners, prepared and submitted a proposal entitled 'Quality-systems for solid biofuels' to the EC's Fifth Framework Programme for Research and Development in September. The consortium includes the United States representative in Task 28. The proposed project includes the development of a model quality system within the framework of ISO 9000 'Quality

Systems' and a review of the application of ISO 14001 'Environmental Management Systems' to the production and use of solid biofuels.

Collaboration with Other Tasks

As a result of a meeting between the leaders of Tasks 19 and 28 in August, Green Land Reclamation Ltd, acting as co-ordinator for a consortium of 15 partners, prepared and submitted a proposal entitled 'Identification and reduction of sampling and testing errors in the field of solid biofuels' to the EC's Fifth Framework Programme for Research and Development in September. The consortium includes the Task Leader and the Austrian representative of Task 19, and the United States representative in Task 28. The proposal incorporates the following key items:

- inter-laboratory comparisons of chemical tests on biofuels and ashes,
- preparation of reference materials for chemical analyses of biofuels and ashes,
- certification of reference materials for chemical analyses of biofuels and ashes,
- inter-laboratory comparisons of physical tests on biofuels,
- investigation of methods for sampling of biofuels,
- investigation of methods for sample reduction of biofuels.

Table 1 - IEA BIOENERGY TASK PARTICIPATION IN 1999

Task	AUS	AUT	BEL	BRA	CAN	CRO	DEN	FIN	FRA	ITA	JAP	NEL	NOR	NZE	SWE	SWI	UK	USA	CEC	Total Participants in Task
XVI. Tech assessment of cellulosic materials to ethanol in Sweden															•			•		2
17. Short rotation crops for bioenergy	•				•	•	•		•	•		•			•		•	•	•	11
18. Conventional forestry systems for bioenergy			•		•		•	•				•	•	•	•		•	•	•	11
19. Biomass combustion		•	•	•	•		•	•	•			•	•	•	•	•	•	•	•	15
20. Thermal gasification of biomass		•		•	•		•	•		•		•	•		•	•	•	•	•	13
21. Pyrolysis of biomass				•	•													•	•	4*
22. Techno-economic assessments for bioenergy applications		•#		•#	•			•							•			•		6
23. Energy from thermal conversion of MSW and RDF					•			•	•		•	•	•		•		•			8
24. Energy from biological conversion of organic waste							•	•							•	•	•			5
25. Greenhouse gas balances of bioenergy systems		•			•	•		•						•	•		•	•		8
26. Biotechnology for conversion to ethanol					•		•	•				•			•					5
27. Liquid biofuels		•			•										•			•	•	5
28. Solid biomass fuels standardisation and classification							•						•					•	•	4*
Total Task Participation	1	5	2	4	10	2	7	8	3	2	1	6	5	3	11	3	7	10	7	97

* Actual participation is higher because these are joint programmes with CEC participants.

\# Still to advise on participation in the prolongation of Task 22.

BUDGET IN 1999: SUMMARY TABLES

Table 2: Budget for 1999 by Member Country ($US)

Member country	Total ExCo funds	Total Task funds	Total funds
Australia	4,450	7,778	12,228
Austria	6,250	52,784#	59,034
Belgium	4,900	20,283	25,183
Brazil	5,800	28,501#	34,301
Canada	8,500	113,282	121,782
Croatia	4,900	21,661	26,561
Denmark	7,150	69,319	76,469
European Commission	7,150	54,879	62,029
Finland	7,600	90,744	98,344
France	5,350	30,181	35,531
Italy	4,900	14,596	19,496
Japan	4,450	15,320	19,770
Netherlands	6,700	59,799	66,499
Norway	6,250	52,421	58,671
New Zealand	5,350	34,166	39,516
Sweden	8,500	118,522	127,022
Switzerland	5,350	28,741	34,091
UK	7,150	78,922	86,072
USA	8,050	116,097	124,147
Total	118,750	1,007,996	1,126,746

Cost of participation in prolongation of Task 22 is excluded.

BUDGET IN 1999: SUMMARY TABLES

Table 3: Budget for 1999 by Task ($US)

Task	Number of participants	Annual contribution per participant	Total Task funds
Task XVI: Tech. assessment of cellulosic ... etc.	2	in kind	0
Task 17: Short rotation crops for bioenergy	11	7,778	85,558
Task 18: Conventional forestry systems ... etc.	11	13,200	145,200
Task 19: Biomass combustion	15	7,083	106,245
Task 20: Thermal gasification of biomass	13	6,818	88,634
Task 21: Pyrolysis of biomass	4*	9,600	28,800*
Task 22: Techno-economic assessments ... etc.	6	10,000ø	50,000
Task 23: Energy from thermal conv. of MSW ... etc.	8	15,320	122,560
Task 24: Energy from biological conversion ... etc.	5	14,840	74,200
Task 25: Greenhouse gas balances ... etc.	8	13,883	111,064
Task 26: Biotechnology for the conversion ... etc.	5	9,600	48,000
Task 27: Liquid biofuels	5	20,000	100,000
Task 28: Solid biomass fuels standardisation ... etc.	4*	#	47,735*
Total	97		1,007,996

*Actual participation is higher than indicated because these are joint programmes with the CEC. The 'Total' column only shows funds handled by the IEA Bioenergy Secretary.

#There is a differential IEA Bioenergy contribution for CEC and non-CEC participants in this programme. In 1999, CEC countries paid $10,000 and non-CEC countries $27,735.

øThe programme was prolonged from 1 October 1999 to 31 December 2000. Participants in the prolongation paid $10,000 in 1999; others paid $5,000.

LIST OF REPORTS

Except where noted, the reports are available through the Task Leader of the relevant Task. For the addresses, please see Appendix 5.

Reports Issued by the Executive Committee

IEA Bioenergy Annual Report 1998. ExCo:1999:01

IEA Bioenergy News Volume 11, No. 1. August 1999.

IEA Bioenergy News Volume 11, No. 2. December 1999.

The newsletters are available through the Newsletter Editor - address in Appendix 5.

Reports From Task XVI

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Christersson, L. and Ledin, S. 1999. IEA Bioenergy Task 17; Short rotation crops for energy purposes. Proceedings of the first meeting of IEA Bioenergy, Task 17 in Uppsala, Sweden, 4-6 June 1998. Dept. Short Rot. For. SLU. Uppsala, Sweden. Report 64.

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De Franceschi, J. and McIlwrick, M. Assessing remote First Nation communities for their potential to utilise biomass-fuelled heating systems.

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McCallum, B. Woodchip supply system options for remote communities.

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Korpilahti, M. Moilanen and Finér, L. Wood ash recycling and environmental impacts, state-of-the-art in Finland.

Claesson, S., Lundmark, T. and Sahlén, K. Treatment of young Scots-pine-dominated stands for simultaneous production of wood fuel and quality timber.

Lundkvist, H., Eriksson, H.M., Nilsson, T. and Arvidsson, H. Ecological effects of recycling of hardened wood ash.

Hörnlund, T., Lundmark, T. and Egnell, G. A comparison between different methods for extracting wood fuel after clear-felling.

Buford, M., Stokes, B.J., Sanchez, F.G. and Carter, E.A. Using biomass to improve site quality and carbon sequestration.

Smith, C.T., Ford-Robertson, J., Tate, K.R. and Scott, N.A. Framework for assessing the contribution of soil carbon to New Zealand CO2 emissions.

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Williams, T.A. Nitrate leaching from intensive fiber production on abandoned agricultural land.

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Jones, H.E., Madeira, M., Herraez, L., Dighton, J., Fabi,o, A., Gonz·lez-Rio, F., Fernandez Marcos, M., Gomez, C., TomÈ, M., Feith, H., Magalh,es, M.C. and Howson, G. The effect of organic-matter management on the productivity of Eucalyptus globulus stands in Spain and Portugal: tree growth and harvest residue decomposition in relation to site and treatment.

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Koppejan, J. and Sulilatu, F. Biomass combustion - state of the art review (second draft). TNO Institute of Environmental Sciences. July 1999.

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Morris, K.W., Piskorz, J. and Majerski, P. BioTherm™. A system for continuous quality, fast pyrolysis bio-oil, DynaMotive Technologies Corp. Vancouver, British Columbia, Canada; RTI, Vancouver, British Columbia, Canada.

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Bridgwater, T. and Piskorz, J. What is bio-oil?

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Di Blasi, C. Numerical simulation of biomass fast pyrolysis - influences of external heat transfer resistances and reaction constants.

Prins, W. Modelling the rotating cone pyrolyser.

Naber, J. Priorities in modelling the HTU process.

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Suuberg, E. Char porosity.

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Bellan, J. Validated biomass particle kinetics and its application to vortex reactor

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Roy, C. Scaling-up vacuum pyrolysis reactors.

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Minutes from the third meeting of Task 24, Barcelona, Spain. Available from Pat Wheeler, AEA Technology Environment, E6 Culham, Abingdon, Oxfordshire, OX14 3ED, UK, email patrick.wheeler@aeat.co.uk.

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Sakon, J. Catalytically enhanced endocellulase E1 from *A. cellulolyticus*.

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Freer, S. Gene structure of a bifunctional cellulase gene (Cel A) isolated from *Teredinobacter turnerae*.

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Tenkanen, M. Cellulase core proteins from Trichoderma reesei: binding properties and efficiency in cellulose hydrolysis.

Chanzy, H. Hydrolysis of model cellulose systems by cellulosomes and fungal cellulases.

Baker, J. Cellulase action as viewed using an analytical membrane-reactor assay.

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Saddler, J. Influence of fiber characteristics on the cellulase accessibility to softwoods.

Everleigh, D. A heat stable hemicellulase system from Thermotoga neapolitana.

Sada, B. Alpha-L-arabinofuranosidase in biotechnology.

Szakacs, G. Production of cellulase and xylanase by solid substrate fermentation.

Sreenath, H. Cellulase production by fungi associated with fermented sausages.

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Saddler, J.N. Biotechnology for the conversion of lignocellulosics to ethanol: from research to deployment

Session I: Process development and experience

Lukas, J.H. Co-fermentation of hexoses and pentoses from hydrolysed lignocellulosic material by a genetically engineered thermophilic Bacillus.

Wyman, C.E. Commercial ethanol production from agricultural residues.

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Girio, F.M. Lignocellulosic wastes fractionation using hydrothermal-based treatments for xylo-oligosaccharide production.

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Session IV: Microbial conversions: fermentation

Jönsson, L.J. Identification and removal of phenolic fermentation inhibitors in lignocellulose hydrolysates.

Bothast, R. Conversion of corn fiber to fuel ethanol: applications of metabolic engineering technologies.

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Kersten, P. Redox regulation and metabolic interactions between carbohydrate and lignin decay; possible roles for glyoxal oxidase.

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A website is available; http://sunce.eihp.hr/english/bioen/Task29/task29-e.htm

KEY PARTICIPANTS IN EACH TASK

TASK XVI - Technology Assessment of Cellulosic Materials to Ethanol in Sweden

Operating Agent: Ray Costello, Department of Energy, USA

For contacts see Appendix 6.

Task Leader: Ray Costello, Department of Energy, USA

For contacts see Appendix 6.

The Task is a joint initiative between Sweden and USA. Strong industrial participation is planned. The contact person in each country is listed below:

Country	National Team Leader	Institution
Sweden	Lars Tegnér	Swedish National Energy Administration
USA	Raymond Costello	US Department of Energy

TASK 17 - Short Rotation Crops for Bioenergy

Operating Agent: Lars Tegnér, Swedish Nat. Energy Administration, Sweden

For contacts see Appendix 6.

Task Leader: Lars Christersson, Swedish University of Agricultural Sciences, Sweden

For contacts see Appendix 5.

The Task is organized with 'National Teams' in the participating countries. The contact person (National Team Leader) in each country is listed below:

Country	National Team Leader	Institution
Australia	Tom Baker	Dept. of Natural Resources, Victoria
Canada	Andy Kenny	University of Toronto
CEC	Ann Segerborg-Fick	CEC - DG Research
Croatia	Davorin Kajba	University of Zagreb
Denmark	Jens Bonderup Kjeldsen	Danish Institute of Agricultural Sciences Research Centre
France	Hilaire Bewa	ADEME

Continued from Task 17

Italy	Georgio Schenone	ENEL S.p.A. - Polo Energie Alternative
Sweden	Lars Christersson	Swedish Univ. of Agricultural Sciences
the Netherlands	Leen Kuiper	SBH Stichting Bos en hout
UK	John Seed	Border Biofuels Ltd
USA	Lynn Wright	Oak Ridge National Laboratory

TASK 18 - Conventional Forestry Systems for Bioenergy

Operating Agent: Peter Hall, Dept. of Natural Resources, CFS, Canada

For contacts see Appendix 6.

Task Leader: Jim Richardson, Ottawa, Canada*

For contacts see Appendix 5.

Associate Task Leader: Pentti Hakkila, VTT Energy

Associate Task Leader: Tat Smith, Texas A&M University

Task Secretary: Alison Lowe, NZ Forest Research Institute Ltd

The Task is organized with 'National Teams' in the participating countries. The contact person (National Team Leader) in each country is listed below:

Country	National Team Leader	Institution
Belgium	Jean-Françoise Van Belle	CRA
Canada	Jim Richardson	J. Richardson Consulting
Denmark	Niels Heding	Forest & Landscape Research Inst.
CEC	Johannes Klumpers	CEC - DG Research
Finland	Pentti Hakkila	Finnish Forest Research Inst.
the Netherlands	Niek Borsboom	State Forest Service
New Zealand	Peter Clinton	NZ Forest Research Inst.
Norway	Simen Gjølsjø	Norwegian Forest Research Inst.
Sweden	Heléne Lundkvist	Swedish Univ. of Agric. Sciences
UK	Barrie Hudson	Forestry Contracting Association
United States	Carl Trettin	USDA Forest Service

TASK 19 - Biomass Combustion

Operating Agent: Gerard Smakman, NOVEM, the Netherlands

For contacts see Appendix 6.

Task Leader: Sjaak van Loo, TNO, the Netherlands

For contacts see Appendix 5.

The Task is organized with 'National Teams' in the participating countries. The contact person (National Team Leader) in each country is listed below:

Country	National Team Leader	Institution
Australia	Peter Coombes	Delta Electricity
Austria	Ingwald Obernberger	Technical University of Graz
Belgium	Yves Schenkel	Département de Génie Rural, Centre de Reserche Agronomiques
Brazil	Francisco Domingues Alves de Souza	Institute for Technological Research - IPT Cidade Universitária - CEP
Canada	Richard Logie	Energy Technology Branch, Department of Natural Resources CFS
CEC	Garbine Guiu	European Commission - DG Research
Denmark	Henrik Houmann Jakobsen	dk-TEKNIK
Finland	Heikki Oravainen	VTT-Energy
France	Severinne Bouvot-Maudit	ADEME
the Netherlands	Sjaak van Loo	TNO-MEP
Norway	Øyvind Skreiberg	The Norwegian University of Science and Technology
New Zealand	John Gifford	NZ Forest Research Institute Ltd
Sweden	Claes Tullin	Swedish National Testing and Research Inst.
Switzerland	Thomas Nussbaumer	Verenum
United Kingdom	William Livingston	Mitsui Babcock Energy Limited
USA	Donald Hardesty	Sandia National Laboratories

TASK 20 - Thermal Gasification of Biomass

Operating Agent: Ray Costello, Department of Energy, USA

For contacts see Appendix 6.

Task Leader: Suresh P. Babu,
Institute of Gas Technology, USA

For contacts see Appendix 5.

The Task is organized with 'National Teams' in the participating countries. The contact person (National Team Leader) in each country is listed below. Also shown, where appropriate, are other participants within some of the member countries.

Country	National Team Leader	Institution
Austria	Hermann Hofbauer	Institut fur Verfahrenstechnik
Brazil	Nelson Seiji Yokaichiya	Institute for Technological Research - IPT Cidade Universitária - CEP
Canada	Nicolas Abatzoglou	University of Sherbrooke and KEMESTRIE, Inc.
	Ed Hogan	Canmet Energy Technology Center
	Georges B.B. Lê	Ministére Resources Naturelles
CEC	Kyriakos Maniatis	European Commission - DG Energy
Denmark	Henrik Christiansen	Danish Energy Agency
	Erik Winther	Elkraft Power Co.,Ltd
	Ulrik Henriksen	Technical University of Denmark
Finland	Esa Kurkela	VTT Energy
Italy	Emanuele Scoditti	ENEA
	Henk J. de Lange	Bioelettrica
the Netherlands	Hube Stassen	University of Twente
	Kees Kwant	NOVEM
	Gert H. Huisman	Schelde Engineers & Contractors
Norway	Morten Fossum	SINTEF Energy Research
Sweden	Erik Rensfelt	TPS Termiska Processer AB
	Jan Oskarsson	TPS Termiska Processer AB
Switzerland	Ruedi Bühler	Ingenieurburo Umwelt & Energie
	Philipp Hasler	Verenum Research

UK	Nick Barker	AEA Technology plc.
USA	Richard Bain	NREL

TASK 21 - Pyrolysis of Biomass

Operating Agent: Kyriakos Maniatis,
European Commission, Brussels

For contacts see Appendix 6.

Task Leader: Tony Bridgwater,
Aston University, United Kingdom

For contacts see Appendix 5.

This Task is a joint programme between IEA Bioenergy and the EC, coordinated by Tony Bridgwater. The contact person (National Team Leader) in each country is listed below:

Country	National Team Leader	Institution
Austria	Maximilian Lauer	Joanneum Research
Belgium	Yves Schenkel	CRA, Gembloux
Brazil*	Ademar Hakuo Ushima	Institute for Technological Research - IPT Cidade Universitária - CEP
Canada*	Jan Piskorz	RTI - Resource Transforms International Ltd
Country	**National Team Leader**	**Institution**
Denmark	Karsten Pedersen	Danish Technological Institute
EC*	Tony Bridgwater	Aston University
Finland	Anja Oasmaa	VTT Energy
France	Philippe Girard	Cirad Forêt Maison de la Technologie
Germany	Dietrich Meier	BFH-Institute for Wood Chemistry
Greece	Yannis Boukis	C.R.E.S. - Biomass Department
Ireland	Pearse Buckley	University of Dublin
Italy	Columba Di Blasi	Universita di Napoli Federico II
the Netherlands	Wolter Prins	Twente University of Technology BTG
Norway	Morten Gronli	SINTEF Energy
Portugal	Filomena Pinto	INETI-ITE-DTC
Spain	Jesus Arauzo	Universidad de Zaragoza

Continued from Task 21

Sweden	Erik Rensfelt	TPS Termiska Processer AB
UK	Tony Bridgwater	Aston University
USA*	Stefan Czernik	NREL

* Formal participation is through IEA Bioenergy.

TASK 22 - Techno-Economic Assessments for Bioenergy Applications

Operating Agent: Kai Sipilä, VTT Energy, Finland

For contacts see Appendix 6.

Task Leader: Yrjö Solantausta, VTT Energy, Finland

For contacts see Appendix 5.

The Task is organized with 'National Teams' in the participating countries. The contact person (National Team Leader) in each country is listed below:

Country	National Team Leader	Institution
Austria	Eric Podesser	Joanneum Research
Brazil	Marcos Vinicius Gusmao Nascimento	CEPEL - Centro de Pesquisas de Energia, Electrica
Canada	David Beckman	Zeton Inc
Finland	Yrjö Solantausta	VTT Energy
Sweden	Anders Östman	Kemiinformation AB
USA	Ralph Overend	NREL

TASK 23 - Energy from Thermal Conversion of MSW and RDF

Operating Agent: Richard Kettle, Dept. of Trade and Industry, United Kingdom

For contacts see Appendix 6.

Task Leader: Niranjan Patel, AEA Technology plc, United Kingdom

For contacts see Appendix 5.

Asst. to Task Leader: Grace Gordon, AEA Technology plc, United Kingdom

For contacts see Appendix 5.

The Task is organized with 'National Teams' in the participating countries. The contact person (National Team Leader) in each country is listed below:

Country	National Team Leader	Institution
Canada	Ben Anthony	Canmet Energy Technology Centre
Finland	Raili Vesterinen	VTT Energy
France	Elizabeth Poncelet	ADEME
Japan	Hiroshi Sano	NEDO
the Netherlands	Vera Ortmanns	VVAV
Norway	Lars Sorum	SINTEF
Sweden	Asa Hagelin	RVF - The Swedish Assoc. of Waste Management
UK	Gerry Atkins	Energy from Waste Association

TASK 24 - Energy from Biological Conversion of Organic Waste

Operating Agent: Richard Kettle, Dept. of Trade and Industry, United Kingdom

For contacts see Appendix 6.

Task Leader: Patrick Wheeler, AEA Technology plc, United Kingdom

For contacts see Appendix 5.

Asst. to Task Leader: Grace Gordon, AEA Technology plc, United Kingdom

For contacts see Appendix 5.

The Task is organized with 'National Teams' in the participating countries. The contact person (National Team Leader) in each country is listed below:

Country	National Team Leader	Institution
Denmark	Jens Bo Holm Nielsen	The Biomass Institute, SUC
Finland	Björn Wecksten	Eco-Technology JVV OY
Sweden	Anna Lindberg	Sweco/VBB Viak
	Leif Nilsson	RVF/Swedish Association of Waste Management
Switzerland	Arthur Wellinger	Nova Energie
UK	Chris Maltin	Maltin Pollution Control Systems Ltd

TASK 25 - Greenhouse Gas Balances of Bioenergy Systems

Operating Agent: Josef Spitzer, Joanneum Research, Austria

For contacts see Appendix 6.

Task Leader: Bernhard Schlamadinger, Joanneum Research, Austria

For contacts see Appendix 5.

The Task is organized with 'National Teams' in the participating countries. The contact person (National Team Leader) in each country is listed below:

Country	National Team Leader	Institution
Austria	Bernhard Schlamadinger	Joanneum Research
Canada	Mike Apps	Natural Resources Canada
Croatia	Vladimir Jelavic	Ekonerg Holding
Finland	Ilkka Savolainen	VTT Energy
New Zealand	Justin Ford-Robertson	New Zealand Forest Research Institute Ltd.
Sweden	Leif Gustavsson	Lund University
U.K.	Robert Matthews	Forestry Commission Research Agency
U.S.A.	Gregg Marland	ORNL

TASK 26 - Biotechnology for the Conversion of Lignocellulosics to Ethanol

Operating Agent: Peter Hall, Dept. of National Resources, Canada

For contacts see Appendix 6.

Task Leader: Jack Saddler, University of British Columbia, Canada

For contacts see Appendix 5.

The Task is organized with 'National Teams' in the participating countries. The contact person (National Team Leader) in each country is listed below:

Country	National Team Leader	Institution
Canada	Jack Saddler	University of British Columbia
Denmark	Birgitte Ahring	Technical University of Denmark

Finland	Liisa Viikari	VTT Biotechnology and Food Research
the Netherlands	J.J.J. den Ridder	NEDALCO B.V.
Sweden	Bärbel Hahn-Hägerdal	Lund University

TASK 27 - Liquid Biofuels

Operating Agent: Ray Costello,
US Department of Energy, USA

For contacts see Appendix 6.

Task Leader: Don Stevens,
Battelle Northwest Laboratory, USA

For contacts see Appendix 5.

The Task is organized with 'National Teams' in the participating countries. The contact person (National Team Leader) in each country is listed below:

Country	National Team Leader	Institution
Austria	Manfred Wörgetter	Federal Institute for Agricultural Engineering
Canada	Ed Hogan	Natural Resources Canada
CEC	Ann Sergerborg-Fick	CEC - DG Research
Sweden	Anders Östman	Kemiinformation AB
USA	Raymond Costello	US Department of Energy

TASK 28 - Solid Biomass Fuels Standardisation and Classification

Operating Agent: Kyriakos Maniatis,
European Commission, Brussels

For contacts see Appendix 6.

Task Leader: Andy Limbrick,
Green Land Reclamation Ltd,
United Kingdom

For contacts see Appendix 5.

This Task is a joint programme between IEA Bioenergy, the CEC and the European Committee for Standardization (CEN), coordinated by Andy Limbrick. The contact person for each participating organisation in each country is listed below:

Continued from Task 28

Country	National Team Leader	Institution
Austria#	Ingwald Obernberger	Technical University of Graz
	Manfred Wörgetter	Federal Institute for Agricultural Engineering
Belgium#	Yves Schenkel	CRA, Gembloux
CEN	Christian Lenander	Sydkraft (Sweden),Chairman CEN/BT/WG108
	Lars Sjöberg	STG (Sweden), Secretary CEN/BT/WG108
	Guido De Jongh	CEN Headquarters, Brussels
Denmark#*	Finn Bertelsen	Danish Energy Agency
	Erik Ravn Schmidt	Elsamprojekt
	Pieter Kofman	Danish Forest and Landscape Research Institute
EC#	Kyriakos Maniatis	EC DG Energy
	Ann Segerborg-Fick	EC DG Research
	Luca Marmo	EC DG Environment
Finland#	Raili Vesterinen	VTT Energy
	Jukka Konttinen	Carbona
France#	Christophe Barel	ADEME
Germany	Martin Kaltschmitt	University of Stuttgart IER
	Hans Hartmann	Technical University of Munich
	Johannes Albrecht	Lurgi Umwelt
Greece	Emmanuel Koukios	National Technical University of Athens
Ireland	Paul Johnston	University of Dublin
Italy#	Raffaele Spinelli	Consiglio Nazionale delle Ricerche, IRL
The Netherlands#	Ludger Dinkelbach	ECN
	Gert Huisman	Schelde Engineers & Contractors
Norway#*	Simen Gjølsjø	Norwegian Forest Research Institute
Portugal	Dulce Boavida	INETI-ITE-DTC
Spain	Francisco Marcos Martin	Cátedra de Termodinámica
Sweden#	Anders Hallgren	TPS Termiska Processer
	Sören Hansson	Sycon Energikonsult
	Jan Erik Mattsson	Swedish University of Agricultural Sciences

Switzerland#	Jean-Louis Hersener	Swiss Federal Research Station for Agricultural Economics and Engineering
UK#	Andy Limbrick	Green Land Reclamation
	Jim Birse	British Biogen
	Fred Dumbleton	AEA Technology
USA#*	Larry Baxter	Sandia National Laboratories

Member country of IEA Bioenergy. * Provides funding through IEA Bioenergy.

TASK 29 - Socio-economic Aspects of Bioenergy Systems

Operating Agent: Branka Jelavic

For contacts see Appendix 6.

Task Leader: Julije Domac

For contacts see Appendix 5.

This Task is organised with National Teams in participating countries. The contact person (National Team Leader) in each country is listed below:

Country	National Team Leader	Institution
Austria	Reinhard Madlener	Inst. For Advanced Studies Carinthia
Canada	Joe De Franceschi	Natural Resources Canada, CFS
Croatia	Julije Domac	Energy Institute 'Hrvoje Pozar'
Japan	To be announced	
Sweden	To be announced	
United Kingdom	Keith Richards	AEA Technology plc

SOME USEFUL ADDRESSES

ExCo Chairman 2000

Josef Spitzer
Joanneum Research
Elisabethstrasse 5
A-8010 GRAZ
AUSTRIA

Phone: +43-316-876-1332
Fax: +43-316-876-1320
Email: josef.spitzer@joanneum.ac.at

ExCo Vice Chairman 2000

Kyriakos Maniatis
DG ENERGY
European Commission
Rue de la Loi/Wetstraat 200
B-1049 BRUSSELS
BELGIUM

Phone: +32-2-296-2505
Fax: +32-2-296-6261
Email: km_bio@yahoo.com

ExCo Secretary 1998 - 2000

John Tustin
NZ Forest Research Institute Ltd
Private Bag 3020
ROTORUA
NEW ZEALAND

Phone: +64-7-343-5819
+64-7-348-2563 (home)
Fax: +64-7-343-5330
Email: iea.bioenergy@forestresearch.co.nz
jrtustin@xtra.co.nz (home)

Editor of 'IEA Bioenergy Newsletter'

Justin Ford-Robertson
NZ Forest Research Institute Ltd
Private Bag 3020
ROTORUA
NEW ZEALAND

Phone: +64-7-343-5899
Fax: +64-7-343-5332
Email: jfr@forestresearch.co.nz

WebMaster of 'IEA Bioenergy website'

Rina Siegenthaler
NZ Forest Research Institute Ltd
Private Bag 3020
ROTORUA
NEW ZEALAND

Phone: +64-7-343-5899
Fax: +64-7-348-0952
Email: webmaster@forestresearch.co.nz

IEA Bioenergy homepage address:

ieabioenergy.com (new)
www.forestresearch.co.nz/ieabioenergy/home.htm (old)

IEA Liaison

Mr Laurent Dittrick
IEA, Office of Energy Technology,
Efficiency and R&D
9 Rue de la Fédération
F-75739 Paris CEDEX 15
FRANCE

Phone: +33-1-4057-6757
Fax: +33-1-4057-6759
Email: laurent.dittrick@iea.org

OA = Operating Agent

TL = Task Leader

Operating Agent Task XVI: USA (duration until 31 December 2000)

OA:Ray Costello (address etc., see below)

TL: Ray Costello
US Department of Energy
Office of Solar Thermal, Biomass
Power and Hydrogen
EE-13, Room 6H-058
1000 Independence Avenue S.W.
WASHINGTON, DC 20585
USA

Phone: +1-202-586-4898
Fax: +1-202-586-8185

Email:raymond.costello@hq.doe.gov

Operating Agent Task 17: Sweden (duration 1998-2000)

OA:Lars Tegnér (address etc., see Appendix 6)

TL: Lars Christersson
Department of Short Rotation
ForestrySwedish University of
Agricultural Sciences
SLU, PO Box 7016
S-750 07 UPPSALA
SWEDEN

Phone: +46-1867-2550
Fax: +46-1867-3440
Email:lars.christersson@lto.slu.se

Operating Agent Task 18: Canada (duration 1998-2000)

OA:Peter Hall (address etc., see Appendix 6)

TL:Jim Richardson
1876 Saunderson Drive
Ottawa, Ontario
CANADA K1G 2C5

Phone: +1-613-521-1995
Fax: +1-613-521-1997
Email: Jrichardson@on.aibn.com

Operating Agent Task 19: The Netherlands (duration 1998-2000)

OA:Gerard Smakman (address etc., see Appendix 6)

TL:Sjaak van Loo
TNO - MEP, PO Box 342
NL-7300 AH APELDOORN
THE NETHERLANDS

Phone: +31-55-549-3745
Fax: +31-55-549-3740
Email: s.vanloo@mep.tno.nl

Operating Agent Task 20: USA (duration 1998-2000)

OA:Ray Costello (address etc., see Appendix 6)

TL:Suresh P. Babu
Institute of Gas Technology
1700 South Mount Prospect Road
DES PLAINES, Illinois 60018-1804
USA

Phone: +1-847-768-0509
Fax: +1-847-768-0516
Email: sbabu@igt.org

Operating Agent Task 21: The European Commission

(duration 1998-31 March 2001)

OA:Kyriakos Maniatis (address etc., see Appendix 6)

TL: Tony Bridgwater
Chem. Eng. And Appl. Chem.
Aston University
Aston Triangle
BIRMINGHAM B4 7ET
UNITED KINGDOM

Phone: +44-121-359-3611
Fax: +44-121-359-6814
Email: a.v.bridgwater@aston.ac.uk

Operating Agent Task 22: Finland

(duration: prolonged to 31 December 2000)

OA:Kai Sipilä (address etc., see Appendix 6)

TL:Yrjö Solantausta
VTT Energy
PO Box 1610
FIN-02044 VTT, ESPOO
FINLAND

Phone: +358-9-456-5517
Fax: +358-9-460-493
Email: yrjo.solantausta@vtt.fi

Operating Agent Task 23: United Kingdom (duration 1998-2000)

OA:Richard Kettle (address etc., see Appendix 6)

TL:Niranjan Patel
AEA Technology plc,
E6/58 Culham, Abingdon
OXON, OX14 3ED
UNITED KINGDOM

Phone: +44-1235-464-158
Fax: +44-1235-463-001
Email: niranjan.patel@aeat.co.uk

Grace Gordon
(assistant to Niranjan Patel)
AEA Technology plc,
B154, Harwell, Didcot
OXON. OX 11 0RA
UNITED KINGDOM

Phone: +44-1235-433-609
Fax: +44-1235-433-964
Email: grace.gordon@aeat.co.uk

Operating Agent Task 24: United Kingdom (duration 1998-2000)

OA:Richard Kettle (address etc., see Appendix 6)

TL: Patrick Wheeler
AEA Technology plc,
F6/1.04 Culham, Abingdon
OXON OX14 3ED
UNITED KINGDOM

Phone: +44-1235-463-135
Fax: +44-1235-463-004
Email: patrick.wheeler@aeat.co.uk

Grace Gordon
(assistant to Patrick Wheeler)
AEA Technology plc,
B154, Harwell, Didcot
OXON. OX 11 0RA
UNITED KINGDOM

Phone: +44-1235-433-609
Fax: +44-1235-433-964
Email: grace.gordon@aeat.co.uk

Operating Agent Task 25: Austria (duration 1998-2000)

OA:Josef Spitzer (address etc., see Appendix 6)

TL:Bernhard Schlamadinger
Joanneum Research
Elisabethstrasse 5
A-8010 GRAZ
AUSTRIA

Phone: +43-316-876-1340
Fax: +43 316-876-1320
Email: bernhard.schlamadinger@joanneum.ac.at

Operating Agent Task 26: Canada (duration 1998-2000)

OA:Peter Hall (address etc., see Appendix 6)

TL:Jack Saddler
Department of Wood Science
University of British Columbia
Faculty of Forestry
4th Floor, Forest Sciences Centre
4041-2424 Main Mall
VANCOUVER, BC
CANADA V6T 1Z4

Phone: +1-604-822-9741
Fax: +1-604-822-9104
Email: saddler@interchange.ubc.ca

Operating Agent Task 27: USA (duration 1 April 1998-2000)

OA:Ray Costello (address etc., see below)

TL:Don Stevens
MS K8-17, Battelle Northwest
Laboratory, PO Box 999
Richland WA 99352
USA

Phone: +1-509-372-4603
Fax: +1-509-372-4370
Email: don.stevens@pnl.gov

Operating Agent Task 28: The European Commission

(duration 1 October 1998-31 March 2001)

OA:Kyriakos Maniatis (address etc., see Appendix 6)

TL:Andy Limbrick
Green Land Reclamation Ltd
1, Furze Platt Road
Maidenhead
Berkshire SL6 7ND
UNITED KINGDOM

Phone: +44-1628-778-077
Fax: +44-1628-634-340
Email: greenland2.glr@dial.pipex.com

Operating Agent Task 29: Croatia

(duration 1 January 2000-31 December 2002)

OA:Branka Jelavic (address etc., see Appendix 6)

TL:Mr Julije Domac
BIOEN Program Coordinator
Energy Institute 'Hrvoje Pozar'
Ulica grada Vukovara 37
10000 ZAGREB

Phone: +385-1-632-2848
Fax: +385-1-611-8401
Email: jdomac@eihp.hr

Keith Richards (Associate TL)
AEA Technology plc,
Harwell, Didcot
OXON, OX11 ORA
UNITED KINGDOM

Phone: +44-1235-433-586
Fax: +44-1235-433-990
Email: keith.richards@aeat.co.uk

ExCO MEMBERS AND ALTERNATES

	Member	Alternate Member
AUSTRALIA	Dr Stephen Schuck Australian Biomass Taskforce Steve Schuck And Associates Pty Ltd 7 Grassmere Road Killara, Sydney New South Wales 2071 Phone: +61-2-9416-9246 and 9416-7575 Fax: +61-2-9416-9246 Email: Steve.Schuck@bigpond.com	To be announced
AUSTRIA	Dr Josef Spitzer Joanneum Research Elisabethstrasse 5 A-8010 GRAZ Phone +43-316-876-1332 Fax: +43-316-876-1320 Email: josef.spitzer@joanneum.ac.at	Professor Dr Hermann Hofbauer Institut für Verfahrenstechnik, Brennstofftechnik und Umwelttechnik Technical University Getreidemarkt 9 A-1060 WIEN Phone: +43-1-58801-15970 Fax: +43-1-58801-15999 Email: hhofba@mail.zserv.tuwien.ac.at
BELGIUM	Mr Jean Renault Adm. for Research & Development Ministry of SME and Agriculture Boulevard Simon Bolivar, 30-20è étage B-1000 BRUSSELS Phone: +32-2-208-4738 Fax +32-2-208-4743 Email: jean.renault@cmlag.fgov.be	Mr Roger Piscaglia Adm. for Research & Development Ministry of SME and Agriculture Boulevard Simon Bolivar, 30-20è étage B-1000 BRUSSELS Phone: +32-2-208-4744 Fax: +32-2-208-4743 Email: roger.piscaglia@cmlag.fgov.be
BRAZIL	Mr Eugenio Miguel Mancini Scheleder Director National Dept of Energy Development Ministério De Minas E Energia - MME Esplanada dos Ministérios, Bloco U, 7° Andar - S/724 Brasilia DF 70065-900 Phone: +55-61-321-2032 Fax +55-61-224-1973 Email: mancini@mme.gov.br	Mr Rubem Brito General Coordinator of Energy Systems National Dept of Energy Development Ministério De Minas E Energia - MME Esplanada dos Ministérios, Bloco U 5th Floor Brasilia DF 70065-900 Phone: +55-61-319-5299/321-7072 Fax +55-61-224-1973 Email: rubembrito@mmm.gov.br
CANADA	Dr Peter Hall Department of Natural Resources Canadian Forest Service 580 Booth Street, 7th floor OTTAWA, Ontario K1A 0E4 Phone: +1-613-947-8987 Fax: +1-613-947-9090 Email: phall@nrcan.gc.ca	Mr Joe Robert Department of Natural Resources CANMET Energy Technology Centre 580 Booth Street, 13th floor OTTAWA, Ontario K1A 0E4 Phone +1-613-996-6195 Fax: +1-613-996-9416 Email: jrobert@nrcan.gc.ca
CROATIA	Dr Branka Jelavic Head Dept for Renewable Resources Energy Institute 'Hrvoje Pozar' Ulica grada Vukovara 37 10000 ZAGREB Phone: +385-1-612-5455 Fax: +385-1-611-8401 Email: bjelavic@eihp.hr	Mr Julije Domac BIOEN Program Coordinator Energy Institute 'Hrvoje Pozar' Ulica grada Vukovara 37 10000 ZAGREB Phone: +385-1-632-2848 Fax: +385-1-611-8401 Email: jdomac@eihp.hr
DENMARK	Mr Klaus Mandrup Danish Energy Agency 44 Amaliegade DK-1256 COPENHAGEN K Phone: +45-33-927-551 Fax: +45-33-926-867 Email: km@ens.dk	Mr Ulf Meyer Henius Advisory Committee Biomass Research Arnevangen 29 DK-2840 HOLTE Phone: +45-45-803-890 Fax: +45-45-505-095 Email: ulf.meyhen@mail.tele.dk

	Member	Alternate Member
FINLAND	Professor Kai Sipilä VTT Energy PO Box 1601 - Espoo FIN-02044 VTT Phone: +358-9-456-5440 Fax: +358-9-460-493 Email: kai.sipila@vtt.fi	Dr Heikki Kotila National Technology Agency (TEKES) PO Box 69 FIN-00101 HELSINKI Phone: +358-10-521-5873 Fax: +358-10-521-5905 Email: Heikki.Kotila@tekes.fi
FRANCE	Dr Elizabeth Poncelet ADEME, Centre D'Angers 2 Square Lafayette - BP 406 F-49004 ANGERS Cedex 01 Phone: +33-2-4120-4128 Fax: +33-2-4187-2350 Email: poncelet@ademe.fr	To be announced
ITALY	Dr Vito Pignatelli ENEA Via Anguillarese 301 00060-S. Maria di Galeria ROME Phone: +39-06-3048-4506 Fax +39-06-3048-6514 Email: vito.pignatelli@casaccia.enea.it	Dr Roberto Avella ENEA Via Anguillarese 301 00060-S. Maria di Galeria ROME Phone: +39-06-3048-3945 Fax: +39-06-3048-6452 Email: avella@casaccia.enea.it
JAPAN	Mr Yoshitaka Tokushita NEDO Sunshine 60 Bldg No 1-1, Higashi-Ikebukuro, 3-chome TOSHIMA-KU, TOKYO 170 Phone: +81-339-879-484 Fax: +81-359-921-349 Email: tokushitayst@nedo.go.jp	Mr Hideo Yoshikawa NEDO Sunshine 60 Bldg No 1-1, Higashi-Ikebukuro, 3 chome TOSHIMA-KU, TOKYO 170 Phone: +81-339-879-481 Fax: +81-359-921-349 Email: yoshikawahdo@nedo.go.jp
THE NETHERLANDS	Dr Gerard Smakman NOVEM PO Box 8242 NL-3503 RE UTRECHT Phone +31-30-239-3454 Fax +31-30-231-6491 Email: G.Smakman@novem.nl	Dr Kees Kwant NOVEM PO Box 8242 NL-3503 RE UTRECHT Phone: +31-30-239-3458 Fax: +31-30-231-6491 Email: K.Kwant@novem.nl
NEW ZEALAND	Mr Justin Ford-Robertson NZ Forest Research Institute Ltd Private Bag 3020 ROTORUA Phone: +64-7-343-5899 Fax: +64-7-343-5332 Email: jfr@forestresearch.co.nz	Mr John Gifford NZ Forest Research Institute Ltd Private Bag 3020 ROTORUA Phone: +64-7-343-5899 Fax: +64-7-343-5507 Email: john.gifford@forestresearch.co.nz
NORWAY	Dr Olav Gislerud The Research Council of Norway PO Box 2700, St Hanshaugen N-0131 OSLO Phone: +47-22-037-108 Fax: +47-22-037-104 Email: olav.gislerud@forskningsradet.no or og@forskningsradet.no Home Email: ogisleru@c2i.net	Mr Trygve Riis The Research Council of Norway PO Box 2700, St Hanshaugen N-0131 OSLO Phone: +47-22-037-347 Fax: +47-22-037-307 Email: trygve.riis@forskningsradet.no
SWEDEN	Dr Lars Tegnér Swedish Nat. Energy Administration Box 310 SE-631 04 Eskilstuna SWEDEN Phone: +46-16-544-2101 Fax +46-16-544-2261 Email: lars.tegner@stem.se	Dr Björn Telenius Swedish Nat. Energy Administration Box 310 SE-631 04 Eskilstuna SWEDEN Phone: +46-16-544-2109 Fax +46-16-544-2261 Email: björn.telenius@stem.se

	Member	Alternate Member
SWITZERLAND	Mr Martin Rüegsegger Head Biomass RD&D Bundesamt für Energie (BFE) CH-3003 BERN Phone: +41-31-322-56-40 Fax: +41-31-323-25-00 Email: martin.ruegsegger@bfe.admin.ch	Dr Gerhard Schriber Swiss Federal Office of Energy Research Coord. & Special Fields Section CH-3003 BERN Phone: +41-31-322-5658 Fax +41-31-323-2500 Email: gerhard.schriber@bew.admin.ch
UNITED KINGDOM	Mr Richard Kettle Department of Trade and Industry 1 Victoria Street LONDON SW1 0ET Phone: +44-171-215-2648 Fax: +44-171-215-2674 Email: richard.kettle@hend.dti.gov.uk	Mr Gary Shanahan Department of Trade and Industry 1 Victoria Street LONDON SW1 0ET Phone: +44-171-215-6483 Fax: +44-171-215-2674 Email: gary.shanahan@dti.gov.uk
UNITED STATES	Dr Raymond Costello US Department of Energy Office of Solar Thermal, Biomass Power and Hydrogen EE-13, Room 6H-058 1000 Independence Avenue S.W. WASHINGTON, DC 20585 Phone: +1-202-586-4898 Fax: +1-202-586-8185 Email: raymond.costello@hq.doe.gov	Mr Richard Moorer US Department of Energy Office of Transportation Technologies EE-30 1000 Independence Avenue S.W. WASHINGTON. DC 20585 Phone +1-202-586-5350 Fax: +1-202-586-9815 Email: richard.moorer@hq.doe.gov
EUROPEAN COMMISSION	Dr Kyriakos Maniatis DG ENERGY European Commission Rue de la Loi/Wetstraat 200 B-1049 BRUSSELS Phone: +32-2-296-2505 Fax: +32-2-296-6261 Email: km_bio@yahoo.com	Mrs Garbine Guiu DG RESEARCH European Commission Rue de la Loi/Wetstraat 200 B-1049 BRUSSELS Phone: +32-2-299-0538 Fax: +32-2-299-3694 Email: Garbine.Guiu@cec.eu.int

THERMAL GASIFICATION CONTACTS

AUSTRIA

Zeltweg BioCoComb Project New plants based on the FICFB Process Pöls Bark Gasification Project	Mr Reinhard Rauch Email: rrauch@mail.zserv.tuwien.ac.at

BRAZIL

Brazilian BIG-GT Demonstration Project	Dr Eduardo Carpentieri 333-Bonji, Anexo 1-Bloco B-Sala 3-CEP-50.761-901, RECIFE PE Phone: +955 81 229 2405 Fax: +955 81 229 2991 Email: carpenti@chesf.gov.br Dr Elphego Jorge de Souza

CANADA

BIOSYN Gasification and Gas Conditioning Technologies	Prof Esteban Chornet, President Enerkem Technologies Inc 4220, Garlock, Sherbrooke, Quebec Phone: +1 819 569 4888 (ext. 224); and +1 819 821 7904 Fax: +1 819 569 8411; and +1 819 821 7955 Email: kem@interlinx.qc.ca

DENMARK

Harboøre Project	Mr Ole Kristensen Voelund Research Centre, Centervej 2, DK 6000 Kolding Phone: +45 7556 8874 Fax: +45 7556 8689 Email: vordosk@post4.tele.dk
Høgild Project	Mr Arne Hollesen Hollesen Engineering and Boilers Co, Drejervej 2, DK-7451 Sunds Phone: +45 9714 2022 Fax: +45 9714 2686

Blære Project	Prof Ulrik Henriksen DTU Institute of Energetics, Building 402, DK-2800 Phone: +45 4525 4172 Fax: +45 4593 5761 Email: gaspro@inet.uni-c.dk

FINLAND

Lahti Kymijärvi Project	Mr Olavi Lindholm, Plant Manager Lahden Lämpövoima Oy, PO Box 24 FIN-15111 Lahti Phone: +358 38233240 Fax: +358 38233504
BIONEER Process Wisa Forest Pyroflow Gasifier	No name provided Foster Wheeler Energia Oy, Helsinki Office, PO Box 45, FIN-00441 Helsinki, Sentnerikuja 2 Phone: +358 10 393 11 Fax: +358 10 393 6199 Email: fwenergy@fwc.com

ITALY

Thermie Energy Farm Project	Mr H. J. de Lange Bioelettrica, Via Cesare Battisti 47, 56125 Pisa Phone: +39 050 53 5479 Fax: +39 050 53 5477 Email: delange@bioelettrica.it
SAFI SpA RDF Gasification Project	Ing. Gianluca Barducci Phone: +39 055 28 3533 Fax: +39 055 28 9186 Email: tavolini@tin.it

THE NETHERLANDS

KARA/BTG Co-current Downdraft Gasifier System	Mr H. Knoef BTG Phone: +31 53 489 2897 Email: btg@ct.utwente.nl Mr K. Reinders KARA Phone: +31 54 687 6580 Email: kara@introweb.nl

Stork Thermeq Co-current Downdraft Gasification System	Mr A. Grooters Stork Thermeq BV Phone: +31 74 240 1060 Email: office@thermeq.storkgroup.com
Amergas BV Project	Mr W. Willeboer EPZ Phone: +31 162 584 624 Email: w.willeboer@epz.nl

SWEDEN

Gotaverken Project	Mr Per Lindgren Götaverken Miljö AB, Post Box PB 8876, SE-402 72 Göteborg Phone: +46 31 501995 Fax: +46 31 229867 Email: per.lindgren@gmab.se
Värnamo Project	Mr Krister Ståhl Sydkraft AB, S-20509 Malmö Phone: +46 40 255000 Fax: +46 40 6115184
Termiska Processor AB (TPS) Process	Mr Erik Rensfelt, Managing Director TPS Termiska Processer AB, Studsvik, S-61182 Nykoping Phone: +46 155 22 1385 Fax: +46 155 26 3052 Email: erik.rensfelt@tps.se

SWITZERLAND

Pyroforce Gasification Plant	Mr W. Gemperle Pyroforce Energy Tech., Reusseggstrasse 17, CH-6020 Emmenbruecke Phone: +41 41 420 4433 Fax: +41 41 420 4476 Email: welcome@pyroforce.ch
Indian Institute of Science-DASAG Gasifier	Mr P. Giordano CCC, c/o Monnard SA, Rte de Vevey, CH-1618 Châtel-St-Denis Phone: +41 21 948 8661 Fax: +41 21 948 7973 Email: info@xylowatt.ch Home Page: www.xylowatt.ch

UNITED KINGDOM

ARBRE Project	Mr Keith Pitcher, Development Manager ARBRE Energy Limited, 2 The Embankment, Sovereign Street, Leeds, LS1 4BG Phone: +44 113 231 2767 Fax: +44 113 234 2322 Email: Keith_Pitcher@yorkshirewater.plc.uk
Boughton Pumping Station CHP Project	Mr John Gilliland Rural Generation Ltd, Brook Hall Estate, 66 Culmore Road, Londonderry Phone: +44 1504 354 635 Fax: +44 1504 350 970
Blackwater Valley Museum Project	Ms Debra Jenkins B9 Energy Biomass Ltd, 9 Shipquay Street, Derry City Co. Londonderry BT48 6BJ Phone: +44 1504 27 1520 Fax: +44 1504 30 8090 Email: d.jenkins@b9energy.co.uk

UNITED STATES OF AMERICA

Vermont Battele/FERCO Project	Mr Mark A. Paisley Director of Technology Development Future Energy Resources Corp, 3500 Parkway Lane, Ste 440, Norcross, GA Phone: +1 770 662 7800 Fax: +1 770 662 7807
MTCI Process	Mr Bill Austin Thermochem (MTCI), 6004 Chemical Rd, Baltimore, MD 21226 Phone: +1 410 354 9890 Email: waustin@tchem.net
IGT RENUGAS Process	Dr Suresh Babu Director of Technology Planning Institute of Gas Technology, 1700 So. Mount Prospect Road, Des Plaines, IL 60018-1804 Phone: +1 847 768 0509 Fax: +1 847 768 0516 Email: sbabu@igt.org

Small Modular Biopower Projects -

Carbona Corporation	Mr J.G. Patel, President Carbona Corporation, Suite E5300, 4501 Circle 75 Parkway, Atlanta, GA30339 Phone: +1 770 956 0601 Fax: +1 770 956 0063 Email: carbona_atl@ibm.net
Brightstar Synfuels	Mr Ron Menville, Vice President P.O. Box 539, St. Gabriel, LA 70776 Phone: +1 504 642 2500 Fax: +1 504 642 2503
Thermal Technologies	Ms Carol Purvis EPA, Camp Lejune, NC Phone: +1 919 541 7519
Primenergy	Mr Kevin McQuigg, Vice President PO Box 581742, Tulsa, OK 74185 Phone: +1 918 835 1011 Fax: +1 918 835 1058 Email: www.primenergy.com
Cratech	Mr Joe D Craig PO Box 70, Tahoka, TX 79373 Phone: +1 806 327 5220 Fax: +1 806 998 5467
BG Technologies LLC	Dr Pascal (Pat) DeLaquil III 1155 15th Street, NW, Suite 810, Washington, DC 20005 Phone: +1 202 452 1911 Fax: +1 202 452 8323 Email: bgsystems@BGTLLC.com
Bioenergy Development	Mr Earl A. Rogers, President Bioenergy Development Corporation, 45 Rockefeller Plaza, 20th Floor, New York, NY 10111 Phone: +1 212 865 2513 Fax: +1 212 865 8713
Energy Products of Idaho	No name provided 8014 Germantown Road, Philadelphia, PA 19118 Phone: +1 713 248 5244 Fax: +1 713 248 2381

Wright Malta	Mr J.A. Coffman, Manager Wright Malta Corporation, Malta Test Station, Plains Road, Ballston Spa, NY 12020 Phone: +1 518 899 2227
Producer Rice Mill (PRM) Energy	Mr Ron Bailey Jr, President PRM Energy Systems, 504 Windamere Terrace, Hot Springs, Arkansas 71913 Phone: +1 501 767 2100 Fax: +1 501 767 9698
Community Power Corporation	Mr Robb Walt, President 15796 East Chenango Avenue, Aurora, CO 80015 Phone: +1 303 690 7869 Fax: +1 303 617 1280 Email: robbcpc@aol.com
Hamilton Mauer International	Mr Rolf Mauer, President PO Box 42333, Houston, TX 772422333 Phone: +1 713 468 6805 Fax: +1 713 468 0761
Thermogenics	Mr Steven Brand 3620 Wyoming Boulevard, NE, Ste 210, Albuquerque, NM 87111 Phone: +1 505 298 4381 Fax: +1 505 296 4860
Foster Wheeler	Mr Neil R. Raskin, Director Global New Products, Foster Wheeler Development Corporation, Perryville Corporate Park, Clinton, NJ 088094000 Phone: +1 908 713 3190 Fax: +1 908 713 3195 Email: neil_raskin@fwc.com