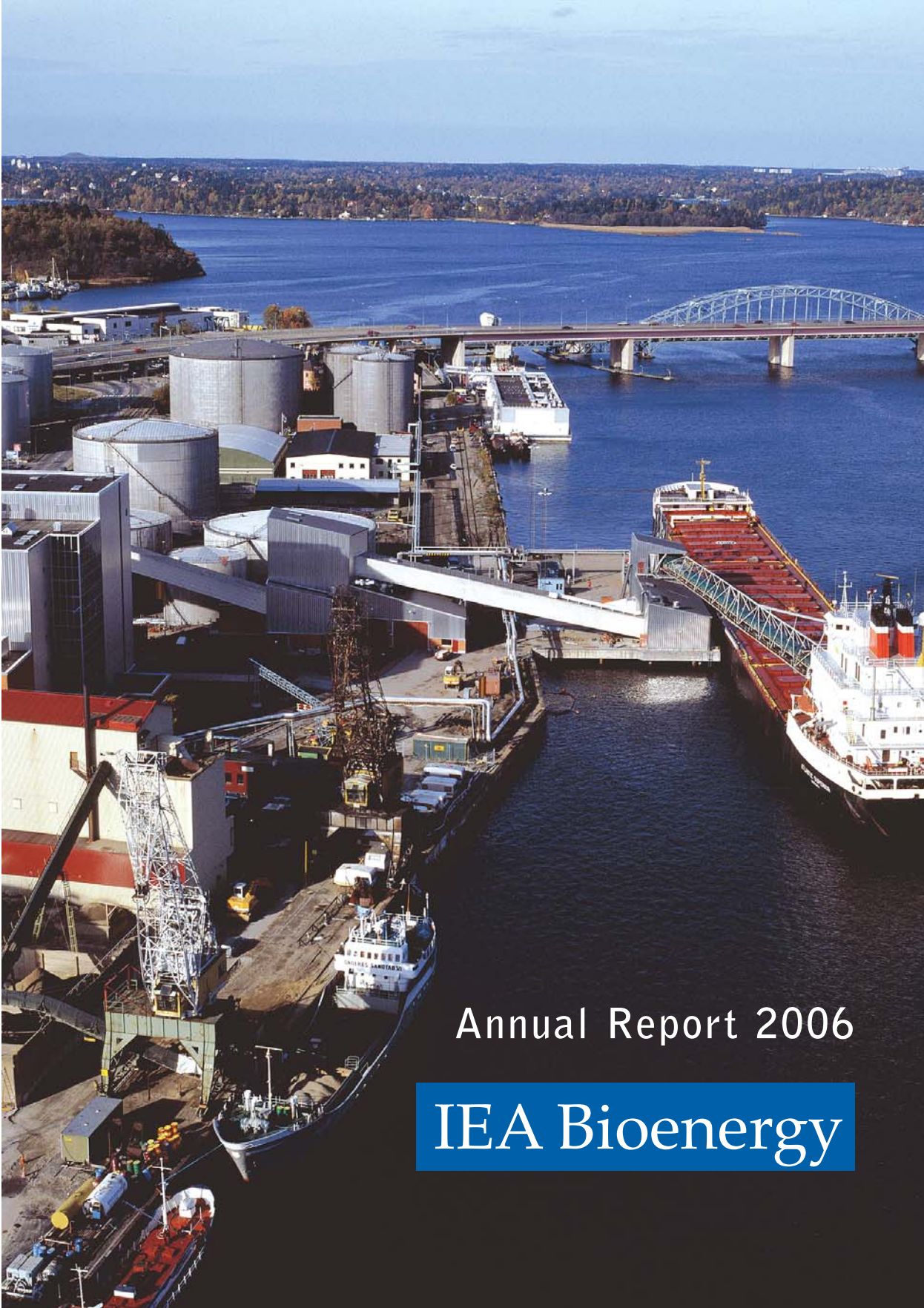

Annual Report 2006

IEA Bioenergy

IEA BIOENERGY: EXCO: 2007:01

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

Cover: Värtaverket CHP plant in Stockholm, Sweden. (Courtesy Fortum, Sweden. Photo: Kurt Pettersson)

Ena Kraft AB in Enköping, Sweden. (Courtesy E. Johansson)

To: IEA Headquarters, Paris

IEA BIOENERGY ANNUAL REPORT 2006

Under the IEA Framework for International Energy Technology Cooperation the Executive Committee of each Implementing Agreement must produce an Annual report for IEA Headquarters.

This document contains the report of the IEA Bioenergy Executive Committee for 2006.

This year, we have presented a special feature on the work within Task 34: Pyrolysis of Biomass.

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

Kyriakos Maniatis
Chairman

John Tustin
Secretary

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

A list of country representatives in the Executive Committee is given in Appendix 7.

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

Biomass Pyrolysis

This feature article provides an overview based on the work of Task 34: Pyrolysis of Biomass. It was prepared by the Task Leader, Professor Tony Bridgwater, Bioenergy Research Group, Aston University, UK.

Introduction

Renewable energy is of growing importance in responding to concerns over the environment and security of energy supply. Biomass is unique in providing the only renewable source of fixed carbon, which is an essential ingredient in meeting many of our fuel and consumer goods requirements. It is also considered the renewable energy source with the highest potential to contribute to the energy needs of modern society for both the developed and developing economies worldwide.[1,2] Wood, energy crops and agricultural and forestry residues are some of the main renewable energy resources available. The biodegradable components of municipal solid waste (MSW) and commercial and industrial wastes are also significant bioenergy resources, although, particularly in the case of MSW, they may require extensive processing before conversion.

Bioenergy could provide the major part of the projected renewable energy provisions of the future as biofuels in the form of gas, liquid or solid fuels, or electricity and heat. There are many ways of providing these biofuels, including thermal and biological conversion, of which pyrolysis, and particularly fast pyrolysis, forms the focus of this review.

Of the available biomass conversion technologies for production of more usable energy forms, fast pyrolysis is the least developed, but offers the benefits of a liquid fuel with concomitant advantages of easy storage and transport as well as higher power generation efficiencies than fossil fuelled systems at the smaller scales of operation that are likely to be realised from bioenergy systems. All the other thermal and biological biomass conversion processes are commercially available, usually with performance guarantees, and are steadily being implemented around the world.

Pyrolysis

Pyrolysis is thermal decomposition occurring in the absence of oxygen. It is also always the first step in combustion and gasification, but in these processes it is followed by total or partial oxidation of the primary products. Lower process temperatures and longer vapour residence times favour the production of charcoal. High temperatures and longer residence times increase biomass conversion to gas, and moderate temperatures and short vapour residence times are optimum for producing liquids. Table 1 indicates the product distribution obtained from different modes of pyrolysis. Fast pyrolysis for liquids production is currently of particular interest because liquids can be stored and transported more easily and at lower cost than solid biomass.[3,4,5,6]

Table 1: Typical product yields (dry wood basis) obtained by different modes of pyrolysis of wood

Mode	Conditions	Liquid	Char	Gas
Fast	moderate temperature, around 500°C, short hot vapour residence time ~ 1 second	75%	12%	13%
Intermediate	moderate temperature, around 500°C, moderate hot vapour residence time ~ 10-20 seconds	50%	20%	30%
Slow (carbonisation)	low temperature, around 400°C, very long solids residence time	30%	35%	35%
Gasification	high temperature, around 800°C, long vapour residence time	5%	10%	85%

Fast pyrolysis occurs in a few seconds or less. Therefore heat and mass transfer processes and phase transition phenomena, as well as chemical reaction kinetics, play important roles. The critical issue is to bring the reacting biomass particles to the optimum process temperature and minimise their exposure to the intermediate (lower) temperatures that favour formation of charcoal. One way this objective can be achieved is by using small particles, for example in the fluidised bed processes that are described later. Another possibility is to transfer heat very rapidly only to the particle surface that contacts the heat source, as applied in ablative pyrolysis. A critical technical challenge in every case is heat transfer to the reactor in commercial systems.

Principles of fast pyrolysis

In fast pyrolysis, biomass rapidly decomposes to generate vapours, aerosols, gases and some charcoal. After cooling and collection, a dark brown mobile liquid is formed that has a heating value of about half that of conventional fuel oil. While it is related to the traditional pyrolysis processes for making charcoal (see Table 1), fast pyrolysis is an

advanced process that is completed in seconds, with carefully controlled parameters, to give high yields of liquid. The essential features of a fast pyrolysis process for producing liquids are:

- Very high heating and heat transfer rates at the reaction interface, which usually requires a finely ground biomass feed.
- Carefully controlled pyrolysis reaction temperature of around 500°C and vapour phase temperature of 400-450°C. The effect of temperature on yields and product spectrum is discussed in the section on pyrolysis liquid below.
- Short hot vapour residence times of typically less than two seconds.
- Rapid cooling of the pyrolysis vapours to give the bio-oil product.

The main product, bio-oil, is obtained in yields of up to 75% by weight (wt) on a dry-feed basis, together with by-product char and gas, which are used within the process to provide the process heat requirements, so there are no waste streams other than flue gas and ash.

A fast pyrolysis process includes drying the feed to typically less than 10% water in order to minimise the water in the product liquid oil, grinding the feed (to around 2 mm particle size in the case of fluid bed reactors) to give sufficiently small particles to ensure rapid reaction, fast pyrolysis, separation of solids (char), and quenching and collection of the liquid product (bio-oil).

Virtually any form of biomass can be considered for fast pyrolysis. While most work has been carried out on wood because of its consistency and comparability between tests, nearly 100 different biomass types have been tested by many laboratories, ranging from agricultural wastes such as straw, olive pits and nut shells to energy crops such as *Miscanthus* and *Sorghum*, forestry wastes such as bark, and solid wastes such as sewage sludge and leather wastes.

A typical fast pyrolysis process is depicted in Figure 1 showing the necessary preparation steps, alternative reactors, and product collection.

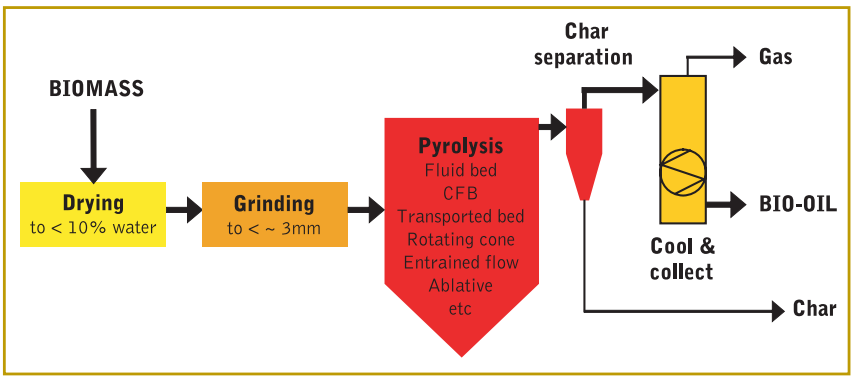

Figure 1: *Conceptual fast pyrolysis process*

Reactors

At the heart of a fast pyrolysis process is the reactor. Although it probably represents at most only about 10-15% of the total capital cost of an integrated system, most research and development projects have focused on the reactor. Increasing attention is now being paid to control and improvement of liquid quality and improvement of collection systems. The rest of the process consists of biomass reception, storage and handling, biomass drying and grinding, product collection, storage and, when relevant, liquid upgrading. The key aspects of these peripheral steps are described later. A comprehensive survey of fast pyrolysis processes for liquids production that have been built and tested in the last 10-15 years has already been published.[4]

Bubbling fluid beds

Bubbling fluid beds - usually referred to as just 'fluid beds' as opposed to 'circulating fluid beds' - have the advantages of a well-understood technology that is simple in construction and operation, good temperature control and very efficient heat transfer to biomass particles arising from the high solids density. Fluid bed pyrolysers give good and consistent performance with high liquid yields of typically 70-75% wt from wood on a dry-feed basis. Small biomass particle sizes of less than 2-3 mm are needed to achieve high biomass heating rates, and the rate of particle heating is usually the rate-limiting step.

Residence times of solids and vapours are controlled by the fluidising gas flow rate and are higher for char than for vapours. As char acts as an effective vapour cracking catalyst at fast pyrolysis reaction temperatures, rapid and effective char separation is important. This is usually achieved by ejection and entrainment followed by separation in one or more cyclones, so careful design of sand and biomass/char hydrodynamics is important.

Figure 2: *Dynamotive 100 t/d fluid bed fast pyrolysis plant in West Lorne, Ontario, Canada*

The earliest pioneering work on fast pyrolysis was carried out at the University of Waterloo by Scott who published extensively.[7,8,9] The largest plant currently operating is that of Dynamotive in West Lorne, Ontario, Canada, which has a 100 tonnes per day (t/d) dry biomass feed demonstration plant, with plans for further plants up to 400 t/d [10] (Figure 2). A 2.5 MWe gas turbine is also provided on site for generation of power for local use and for export to the grid. There are research units at universities and research institutions around the world including State University of Iowa, USA, RTI Canada, IWC Germany, Aston University UK, VTT Finland, and the National Renewable Energy Laboratory (NREL), USA. A typical 1 kg/h laboratory unit is shown in Figure 3.

Figure 3: *Laboratory fluid bed fast pyrolysis units: Aston University 1 kg/h (left) and Iowa State University 5 kg/h (right)*

Circulating fluid beds and transported bed

Circulating fluid beds (CFB) have many of the features of bubbling beds described above, except that the residence time of the char is almost the same as for vapours and gas, and the char is more attrited due to the higher gas velocities, which can lead to higher char contents in the collected bio-oil. An added advantage is that CFBs are potentially suitable for very large throughputs even though the hydrodynamics are more complex - this technology is widely used at very high throughputs in the petroleum and petrochemical industry. However, heat transfer at higher throughputs has not been demonstrated and offers some challenges.[11] Heat supply is usually from recirculation of heated sand from a secondary char combustor, which can be either a bubbling or circulating fluid bed. In this respect, the process is similar to a twin fluid bed gasifier, except that the reactor (pyrolyser) temperature is much lower and the closely integrated char combustion in a second reactor requires careful control to ensure that the temperature and heat flux match the process and feed requirements. VTT has a 20 kg/h process development unit shown in Figure 4.

Figure 4: *20 kg/h fast pyrolysis process development unit at VTT*

A variation on the transported bed is the rotating cone reactor, invented at the University of Twente [12] and implemented by BTG in the Netherlands. In this configuration, the transport is effected by centrifugal forces rather than gas. A 50 t/d plant has been built in Malaysia and was commissioned in summer 2005 (Figure 5).

Ablative pyrolysis

Ablative pyrolysis is substantially different in concept from other methods of fast pyrolysis.[13] In all the other methods, the rate of reaction is limited by the rate of heat transfer through the biomass particles, which is why small particles are required. The mode of reaction in ablative pyrolysis is like melting butter in a frying pan - the rate of melting can be significantly enhanced by pressing the butter down and moving it over the heated pan surface. In ablative pyrolysis, heat is transferred from the hot reactor wall to 'melt' wood that is in contact with it under pressure. The pyrolysis front thus moves uni-directionally through the biomass particle. As the wood is mechanically moved away, the residual oil film both provides lubrication for successive biomass particles and also rapidly evaporates to give pyrolysis vapours for collection in the same way as other processes. The rate of reaction is strongly influenced by pressure, the relative velocity of the wood and the heat exchange surface and the reactor surface temperature. The key features of ablative pyrolysis are therefore:

Figure 5: BTG 50 t/d rotating cone fast pyrolysis plant in Malaysia

- High pressure of particle on hot reactor wall, achieved due to mechanical force (Aston University) or centrifugal force (NREL).
- High relative velocity between particle and reactor wall.
- Reactor wall temperature less than 600°C.

As reaction rates are not limited by heat transfer through the biomass particles, large particles can be used and in principle there is no upper limit to the size that can be processed. The process in fact is limited by the rate of heat supply to the reactor rather than the rate of heat absorption by the pyrolysing biomass, as in other reactors. There is no requirement for inert gas, so the processing equipment is smaller and of potentially lower cost. However, the process is surface-area-controlled so scaling is a linear function of the heat transfer area and thus does not benefit from the economies of scale of other systems such as fluid beds. In addition, the reactor is mechanically driven and is thus more complex. PyTec has recently started operating a 50 t/d demonstration plant in north Germany [14], (Figure 6); and a small research unit operates at Aston University [13], (Figure 7).

Figure 6: PyTec 50 t/d ablative pyrolysis demonstration plant

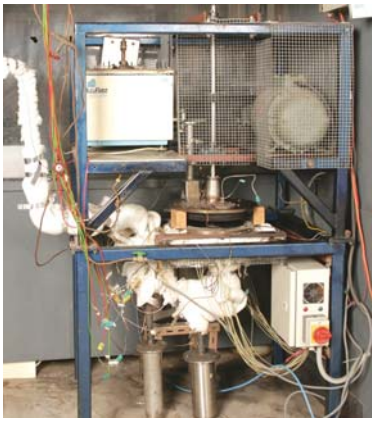

Figure 7: Aston University ablative plate fast pyrolysis reactor (above) and unit (right)

Entrained flow

Entrained flow fast pyrolysis is in principle a simple technology, but most developments have not been as successful as had been hoped, mostly because of the poor heat transfer between a hot gas and a solid particle. High relative gas velocities and high turbulence are required to effect sufficient heat transfer. This requires large plant sizes and high gas flow rates, which results in more difficult liquid collection from the low vapour partial pressure. Liquid yields have usually been lower than fluid bed and CFB systems.

By-products

Charcoal and gas are by-products, typically containing about 25% and 5% of the energy in the feed material respectively. The pyrolysis process itself requires about 15% of the energy in the feed; and of the by-products, only the char has sufficient

energy to provide this heat. The process heat requirement can be derived by burning the gas and/or the charcoal by-product. More advanced configurations could gasify the char to a lower heating value (LHV) gas and then burn the resultant gas more effectively to provide process heat, with the advantage that the alkali metals in the char can be much better controlled and avoid potential slagging problems from direct char combustion. There are many other ways of providing the heat.[11]

Pyrolysis liquid bio-oil

Crude pyrolysis liquid or bio-oil is dark brown and approximates to biomass in elemental composition. It is composed of a very complex mixture of oxygenated hydrocarbons with an appreciable proportion of water from both the original moisture and reaction product. Solid char may also be present. The product spectrum from fast pyrolysis of aspen poplar wood, and the high dependence on temperature, are shown in Figure 8.

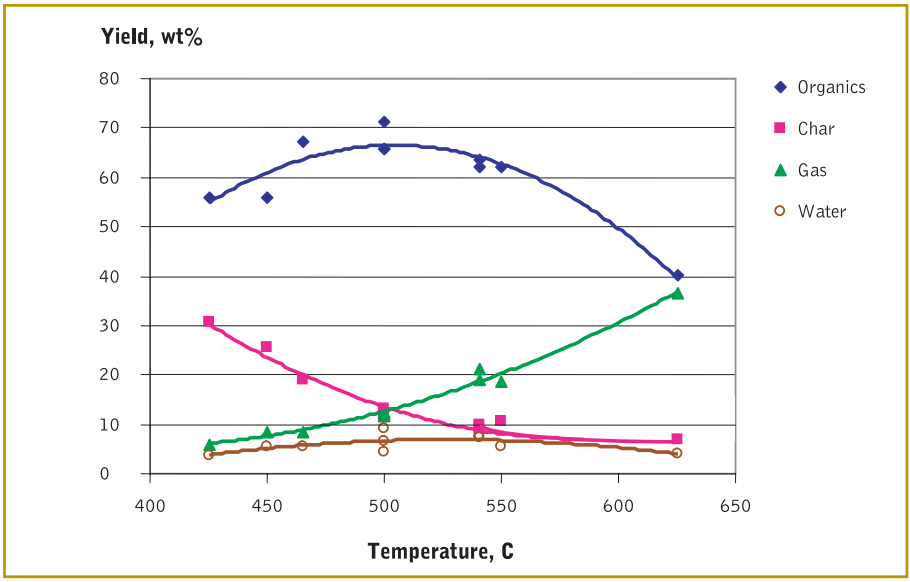

Figure 8: Variation of products from aspen poplar with temperature [15]

The liquid is formed by rapidly quenching and thus 'freezing' the intermediate products of flash degradation of hemicellulose, cellulose and lignin. The liquid thus contains many reactive chemicals, which contribute to its unusual attributes. Bio-oil can be considered a micro-emulsion in which the continuous phase is an aqueous solution of holocellulose decomposition products, which stabilises the discontinuous phase of pyrolytic lignin macro-molecules through mechanisms such as hydrogen bonding.

Bio-oil has a higher heating value (HHV)of about 16-17 MJ/kg as produced with about 25% wt water that cannot readily be separated. It is composed of a complex mixture of oxygenated compounds that provide both the potential and challenge for utilisation. There are some important characteristics of this liquid that are summarised in Table 2 and discussed briefly below, of which the most significant is that it will not mix with any

conventional hydrocarbon-based fuels. Typically it is a dark brown, free-flowing liquid. Depending on the initial feedstock and the mode of fast pyrolysis, the colour can be almost black through dark red-brown to dark green, being influenced by the presence of micro-carbon in the liquid and chemical composition. Hot vapour filtration gives a more translucent red-brown appearance owing to the absence of char. High nitrogen content can impart a dark green tinge to the liquid.

The liquid has a distinctive odour - an acrid smoky smell due to the low molecular weight aldehydes and acids - which can irritate the eyes on prolonged exposure. The liquid contains several hundred different chemicals in widely varying proportions, ranging from formaldehyde and acetic acid to complex high molecular weight phenols, anhydrosugars and other oligosaccharides.

Table 2: Typical properties of wood-derived crude bio-oil

Physical property		Typical value
Moisture content		25%
pH		2.5
Specific gravity		1.20
Elemental analysis	C	56%
	H	6.5%
	O	37.5%
	N	0.1%
	Ash	0%
HHV* as produced		17 MJ/kg
Viscosity (40°C and 25% water)		50cp
Solids (char)		0.1%
Vacuum distillation residue		up to 50%

**HHV: Higher Heating Value*

Characteristics

- Liquid fuel
- Ready substitution for conventional fuels in many stationary applications such as boilers, furnaces, engines, turbines
- Heating value of 17 MJ/kg at 25% wt water, is about 40% that of fuel oil/diesel
- Does not mix with hydrocarbon fuels
- Quality needs definition for each application

The liquid usually forms a stable single-phase mixture when the feedstock is clean wood. It contains varying quantities of water ranging from about 15% by weight (wt%) to an upper limit of about 30-50 wt% water, depending on the feed material, how it was produced and subsequently collected. A typical feed material specification is a maximum of 10% moisture in the dried feed material, as both this

feed moisture and the water of reaction from pyrolysis, typically about 12% based on dry feed, both end up in the liquid product. This results in a liquid with around 25% water. Water levels above 35-40% from high feed moisture or vapour cracking can result in instability and phase separation. Water addition reduces viscosity, which is useful; reduces heating value, which means that more liquid is required to meet a given duty; and can improve stability. The effect of water is therefore complex and important. It is miscible with polar solvents such as methanol, acetone, etc., but substantially immiscible with petroleum-derived fuels.

The density of the liquid is very high at around 1.2 kg/litre, compared with light fuel oil at around 0.85 kg/litre. This means that the liquid has about 42% of the energy content of fuel oil on a weight basis, but 61% on a volumetric basis. This has implications for the design and specification of equipment such as pumps and atomisers in boilers and engines.

Pyrolysis liquids cannot be completely vaporised once they have been recovered from the vapour phase. If the liquid is heated to 100°C or more to try to remove water or distil off lighter fractions, it reacts firstly by polymerisation followed by thermal cracking and eventually produces a solid residue of around 50 wt% of the original liquid and some distillate containing volatile organic compounds and water. Bio-oil has been successfully stored for several years in normal storage conditions in steel and plastic drums without any deterioration that would prevent its use in any of the applications tested to date. However, there is a gradual increase in viscosity over time and in extreme cases of wide temperature fluctuation, phase separation can occur.

Applications of bio-oil

Bio-oil can substitute for fuel oil or diesel in many static applications including boilers, furnaces, engines and turbines for electricity generation.[16] Figure 9 summarises the possibilities. A range of chemicals including food flavourings, specialities such as

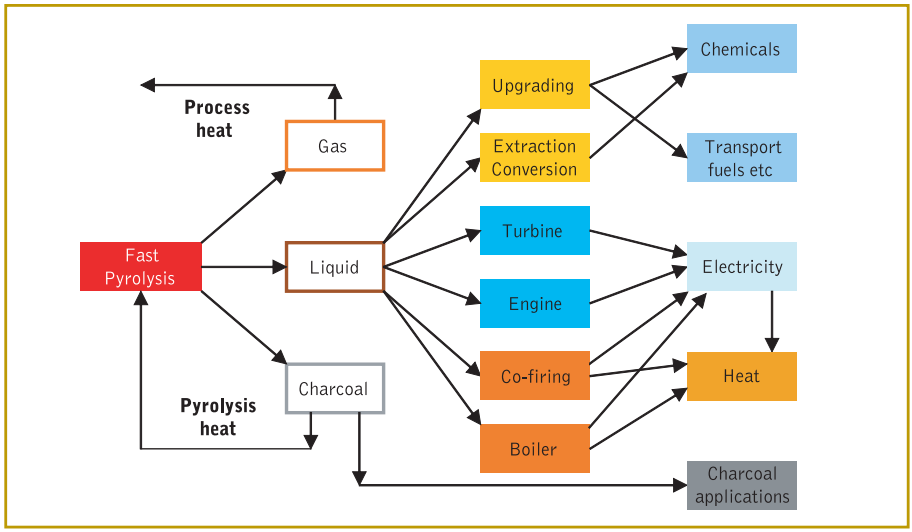

Figure 9: Applications for products of fast pyrolysis

hydroxyacetaldehyde [17], resins [18], agri-chemicals, fertilisers, and emissions control agents can also be extracted or derived from bio-oil. For power generation, at least 400 hours operation has been achieved on a 250 kW_e specially modified dual fuel engine [19] and substantial experience has been gained on a modified 2.5 MW_e industrial gas turbine.

Transport fuels

As biomass is the only renewable source of fixed carbon, there is considerable interest in the production of transport fuels and other commodity chemicals via synthesis gas or syngas as it is usually known. Syngas provides the raw material for production of virtually every fuel and chemical in use today, including conventional and unconventional transport fuels, commodity chemicals and speciality chemicals. Some of the possibilities of considerable topical significance for production of hydrocarbon transport fuels are shown in Figure 10.

There are two main routes to transport fuels that are currently being considered: gasification of bio-oil followed by synthesis; and hydro-processing of bio-oil or separated bio-oil. These are shown in Figure 10.

Gasification and fuel synthesis

Syngas is a mixture of carbon monoxide (CO) and hydrogen (H_2). There are usually other components arising from gasification such as carbon dioxide (CO_2), methane (CH_4), higher hydrocarbons such as ethylene and ethane, propane and propylene, and nitrogen from air gasification. Generally these act as diluents, but different generic and specific processes have different levels of tolerance for each component. There will also be trace contaminants containing sulphur (e.g. H_2S), chlorine (e.g. HCl, COCl) and nitrogen (e.g. ammonia NH_3) in a range of compounds. The concentrations of these trace components will usually require reduction to a few parts per million for most catalyst systems used in synthesising alcohols and hydrocarbons, and each catalyst has its own limitations and tolerances.

Figure 10 includes gasification of solid biomass as well as bio-oil from fast pyrolysis. The dispersed nature of biomass in Europe and the environmental cost of collection and transport are often considered to limit the size of solid feed processes to around 100,000 t/y or 20 MW_e, except in Scandinavia. However, in North and South America this upper limit is usually considered to be much higher. Transport fuel synthesis becomes uneconomic at such small scales of operation, but a decentralised fast pyrolysis network feeding bio-oil as an energy carrier is not limited, and commercially viable scales of operation can then become feasible, even with the small loss of efficiency in the pyrolysis step. In addition, a liquid feed to a pressurised oxygen blown gasifier is less complex and thus lower cost than solid biomass. Partial upgrading of bio-oil into a conventional refinery feedstock is another option that is being widely considered.

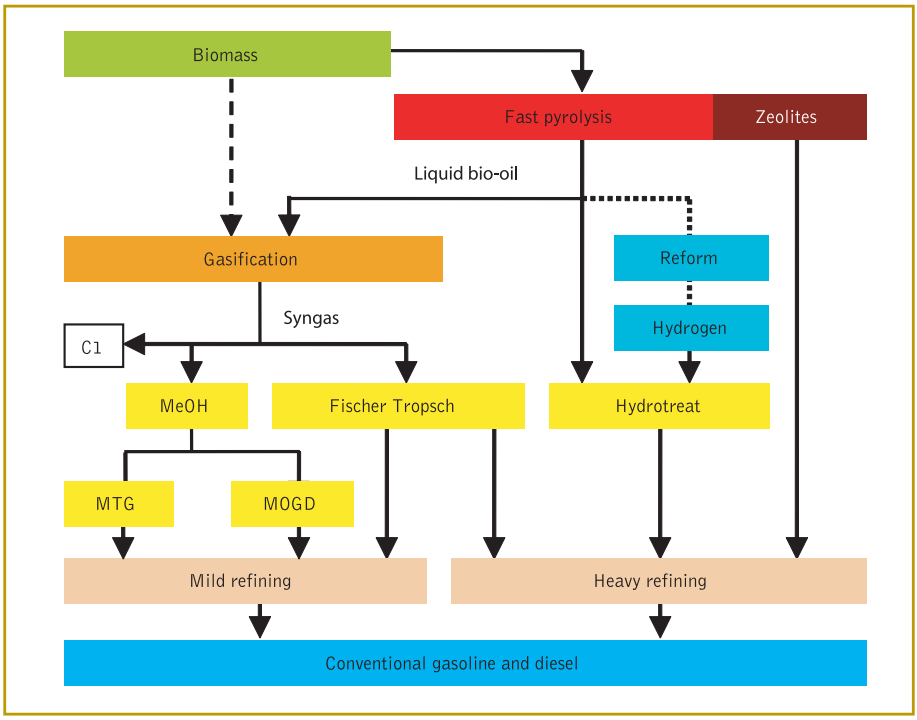

Figure 10: Transport fuels via bio-oil and biomass gasification (MTG: Methanol To Gasoline; MOGD: Methanol to Olefins, Gasoline and Diesel)

Hydro processing of bio-oil and other upgrading methods

Conversion of bio-oil into hydrocarbons requires removal of oxygen. Oxygen rejection from bio-oil can be as water by reaction with hydrogen or as carbon dioxide. Hydroprocessing or hydrotreatment was extensively studied at Pacific Northwest National Laboratory (PNNL) in the USA and the University of Louvain in Belgium in the 1990s, and a comprehensive review of this work has been published.[20] This early work focused on conventional hydro-treating catalysts as used for hydrodesulphurization based typically on Co/Mo or Ni/Mo. While some success was obtained in producing a naphtha-type product in a two-stage high pressure process, catalyst instability problems in the high water content bio-oil and poor economics with low crude oil prices caused interest to wane.[21]

More recently, high oil prices and other pressures have led to a resurgence in interest and hydroprocessing optimization is being carried out at the PNNL on a bench-scale fixed-bed continuous-flow reactor to produce partially upgraded petroleum refinery feedstock with the intent to displace imported petroleum. This is funded by the US Department of Energy as part of a cooperative project with UOP LLC and the NREL.

The alternative of rejection of oxygen as carbon dioxide is based on atmospheric cracking of pyrolysis vapours over zeolite catalysts, which was pioneered at NREL.[22] The inherent attraction is that it is a low pressure process that is integrated into the fast pyrolysis process, and thus offers potential cost savings. However the lower yields and complexity from the requirement to constantly regenerate the coked zeolite catalysts has inhibited

interest in this route. The two routes summarized here have been compared technically and economically.[23,24] Other possibilities for upgrading bio-oil have been reviewed.[16]

Co-firing and co-processing

Co-processing of biomass with conventional fuels is potentially a very attractive option that enables full economies of scale to be realised as well as reducing the requirements for product quality and clean up. The opportunities are summarised in Figure 11. At present, co-firing offers the best opportunities for market penetration of biomass as the overall costs are relatively low because the power cycle in the coal-fired power plant is already there. Bio-oil is particularly attractive for co-firing because it can be more readily handled and burned than solid fuel, and is cheaper to transport and store. Limited trials of co-firing bio-oil in gas fired power stations [25] and a coal-fired power station [26] have also taken place.

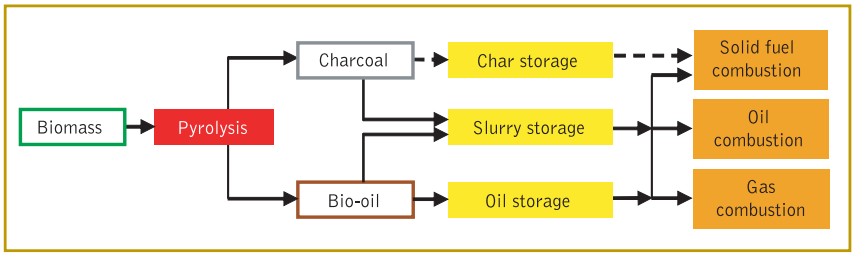

Figure 11: Opportunities for co-processing biomass and biofuels in conventional heat and power applications.

Biorefinery

After many years of production of chemicals from bio-oil, the concept of the biorefinery has suddenly become recognised and accepted. A biorefinery is where fuels and chemicals are produced optimally according to technical, economic, environmental and social criteria.[27] Other similar definitions and explanations have been reported, and Task 34 of IEA Bioenergy has recently produced the definition in Table 3.

Table 3: Definition of a biorefinery [28]

A biorefinery processes and upgrades a renewable raw material (i.e. biomass [a]) into several marketable products [b], emphasising fuels and chemicals.

a. It is important to consider complete use of raw material, optimisation, efficiency, effectiveness, economics and environment.

b. The term 'marketable' includes value, standards, usefulness, environmental acceptability, economics, sustainability and legislation.

Examples of a biorefinery with fast pyrolysis include utilisation of heavy residues from liquid smoke production for co-firing in a power station and production of hydrogen by steam reforming of the aqueous residues from recovery of phenolics for resin production.[29] The key feature and objective is optimum utilisation of products, by-products and wastes as shown in Figure 12. Some of the alternatives for achieving this optimum for production of transport fuels and chemicals are shown in Figure 13.

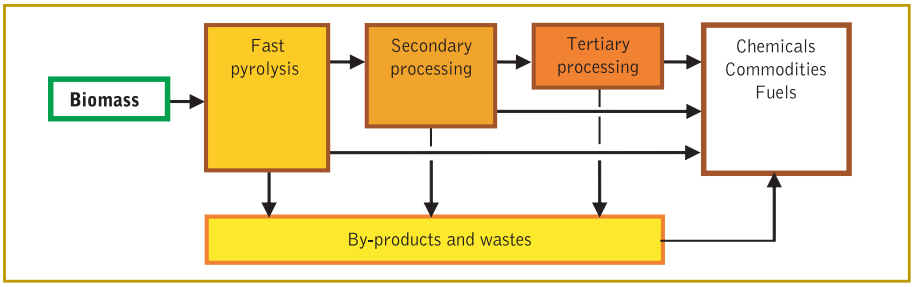

Figure 12: Biorefinery concept

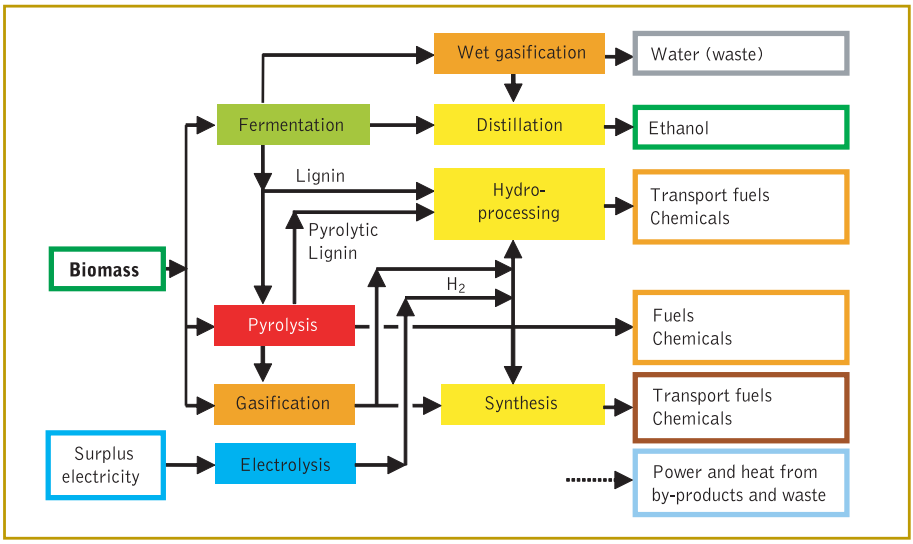

Figure 13: One biorefinery system with processing options for fuels and chemicals

Conclusions

There is substantial and growing interest in thermal processing of biomass for biofuels, to make both energy and chemicals. Fast pyrolysis is a relatively new thermal conversion technology for biomass that has benefited from extensive development in the last 30 years. It offers the key advantage of directly producing a liquid fuel in high yield that can be stored and/or transported to the point of use. This provides considerably more flexibility and allows greater use to be made of economies of scale for power generation, and transport fuel synthesis.

There are technical and economic challenges. Technical challenges lie in scaling up the endothermic pyrolysis reactor, particularly concerning heat transfer, and in improving the quality and consistency of the bio-oil. Economic challenges lie in reducing the capital cost, partly from scaling up and partly by developing and improving the technology. Scaling must consider that, with a few exceptions, bioenergy systems will always be small relative to fossil fuel options and must therefore be technically and economically competitive at much smaller scales of operation than the process and power generation industries are used to handling. It is this ability to improve economies of scale in applications for bio-oil that provides one of the best justifications of fast pyrolysis, whereby bio-oil from decentralised fast pyrolysis plants can be readily transported to central process plants.

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International Energy Agency

The International Energy Agency (IEA) acts as energy policy advisor to 26 Member Countries in their effort to ensure reliable, affordable and clean energy for their citizens. Founded during the oil crisis of 1973-74, the IEA's initial role was to co-ordinate measures in times of oil supply emergencies. As energy markets have changed, so has the IEA. Its mandate has broadened to incorporate the 'Three E's' of balanced energy policy making: energy security, economic development and environmental sustainability. Current work focuses on climate change policies, market reform, energy technology collaboration and outreach to the rest of the world, especially major producers and consumers of energy like China, India, Russia and the OPEC countries. With a staff of around 150, mainly energy experts and statisticians from its member countries, the IEA conducts a broad programme of energy research, data compilation, publications and public dissemination of the latest energy policy analysis and recommendations on good practices.

Objectives

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

Organisation

The IEA is an autonomous agency linked with the Organisation for Economic Co-operation and Development (OECD) and based in Paris. The IEA's main decision-making body is the Governing Board, composed of senior energy officials from each Member country and meeting, from time to time, at Ministerial level. A Secretariat, with a staff of energy experts drawn from Member countries, supports the work of the Governing Board and subordinate bodies. The IEA Secretariat is headed by an Executive Director appointed by the Governing Board. The IEA Secretariat collects and analyses energy data, assesses Member countries' domestic energy policies and programmes, makes projections based on differing scenarios and prepares studies and recommendations on specialised energy topics.

Members

Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and USA. The Commission of the European Communities also participates in the work of the IEA.

Introducing IEA Bioenergy

Welcome to this Annual Report for 2006 from IEA Bioenergy!

IEA Bioenergy is the short name for the international bioenergy collaboration within the International Energy Agency - IEA. A brief description of the 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 'cross-cutting studies' on techno-economic aspects, environmental and economic sustainability, systems analysis, bioenergy trade, fuel standards, greenhouse gas balances, barriers to deployment, and management decision support systems.

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 2006, 22 parties participated in IEA Bioenergy: Australia, Austria, Belgium, Brazil, Canada, Croatia, Denmark, Finland, France, Germany, Ireland, Italy, Japan, The Netherlands, New Zealand, Norway, South Africa, Sweden, Switzerland, United Kingdom, United States of America and the European Commission.

IEA Bioenergy is now 29 years old and is 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, i.e., 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. Two non-Member countries currently participate in IEA Bioenergy, Croatia and Brazil.

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 were 12 ongoing Tasks during 2006:

- Task 29: Socio-economic Drivers in Implementing Bioenergy Projects
- Task 30: Short Rotation Crops for Bioenergy Systems
- Task 31: Biomass Production for Energy from Sustainable Forestry
- Task 32: Biomass Combustion and Co-firing
- Task 33: Thermal Gasification of Biomass
- Task 34: Pyrolysis of Biomass
- Task 36: Energy Recovery from Municipal Solid Waste
- Task 37: Energy from Biogas and Landfill Gas
- Task 38: Greenhouse Gas Balances of Biomass and Bioenergy Systems
- Task 39: Liquid Biofuels from Biomass
- Task 40: Sustainable International Bioenergy Trade: Securing Supply and Demand
- Task 41: Bioenergy Systems Analysis

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 2006 is shown in Appendix 1.

A progress report for IEA Bioenergy for the year 2006 is given in Sections 1 and 2 of this Annual Report.

Magnus Jansson, Lantmännen Agroenergi (left), and Björn Telenius discussing SRC willow production during the ExCo58 study tour. (Courtesy S. Schuck, Australia)

Progress Reports

1. THE EXECUTIVE COMMITTEE

Introduction and Meetings

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 programmes of work, progress reports, and accounts from the various Tasks within IEA Bioenergy. Other functions of the ExCo include publication of an Annual Report, production of newsletters and maintenance of the IEA Bioenergy website. In addition the ExCo produces technical and policy-support documents, workshops, and study tours for the Member Country participants.

The 57th ExCo meeting took place in Paris, France on 18-19 May 2006. There were 43 participants at this meeting. The 58th ExCo meeting was held in Stockholm, Sweden on 4-5 October 2006, with 43 participants including observers. Representatives from IEA Headquarters attended ExCo57.

During 2006, Kyriakos Maniatis from the European Commission was Chairman and J. Peter Hall from Canada was Vice Chairman. At the ExCo58 meeting, Kyriakos Maniatis was re-elected Chairman and J. Peter Hall was re-elected Vice Chairman for 2007.

The ExCo Secretariat is based in Rotorua, New Zealand under the Secretary, John Tustin. The fund administration for the ExCo Secretariat Fund and Task funds is consolidated with the Secretariat, along with production of ExCo publications, the newsletter, and maintenance of the website. By decision at ExCo57, John Tustin will provide the Secretariat and Fund Administration service for the period to 31 December 2009. The contact details for the ExCo can be found in Appendix 7 and for the Secretariat on the back cover of this report.

The work in the ExCo, with some of the achievements and issues during 2006, is described below.

Implementing Agreement

The current term of the Agreement is to 31 December 2009. This was approved by the IEA Committee on Energy, Research and Technology (CERT) at its meeting in November 2004. The text of the IA now includes the IEA Framework for International Energy Technology Co-operation.

New Participants/Contracting Parties

Interest from potential Member Countries continued to be strong in 2006. There was active correspondence with Turkey, in particular with the Turkish Petroleum Corporation (TPAO); the Ministry of Energy and Natural Resources; and TUBITAK Marmara Research Centre, Energy Institute which is the possible Contracting Party. There was also interest from Korea through the Korean Energy Management Corporation (KEMCO).

Some ExCo Members see the possibility that new Member Countries, especially those that do not have strong national programmes in bioenergy RD&D, may dilute the collaboration of the established participants. The ExCo has decided that it should work with the REWP and Secretariat at IEA Headquarters to find a satisfactory way of handling such applications.

The participation of Italy in the Implementing Agreement was terminated around 14 December 2006. Protracted correspondence was unable to achieve payment of a long standing invoice which dated back to 2000. The rules of the Implementing Agreement covering this situation were clear and the ExCo unanimously agreed it should take a firm position and apply Article 10(h) of the Implementing Agreement. Accordingly, a formal 60 day notice letter was issued to ENEA on 11 October 2006, requesting payment of the outstanding funds within 60 days of receipt of the letter. This correspondence emphasised that if payment was not received Italy would be deemed to have withdrawn from the Implementing Agreement. Disappointingly, no payment was received.

For a complete list of the Contracting Parties to IEA Bioenergy please see Appendix 3.

Supervision of Ongoing Tasks, Review and Evaluation

The progress of the work in the Tasks is reported by the Operating Agents to the Executive Committee twice per year at the ExCo meetings. The ExCo has also continued its policy to invite some of the Task Leaders to each ExCo meeting so that they can make the presentation on the progress in their Task and programme of work personally. This has improved the communication between the Tasks and the Executive Committee and has also involved the ExCo more with the Task programmes.

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.

Approval of Task and Secretariat Budgets

The budgets for 2006 approved by the Executive Committee for the ExCo Secretariat Fund and for the Tasks are shown in Appendix 2. Total funds invoiced in 2006 were US$1,720,300; comprising US$223,000 of ExCo funds and US$1,497,300 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 recognise in financial terms.

Fund Administration

The International Energy Agency, Bioenergy Trust Account, at the National Bank of New Zealand is functioning smoothly. In 2006 this account was accessed electronically by Ms Jeanette Allen at the New Zealand School of Forestry, University of Canterbury on behalf of the Secretariat. The account is an interest bearing account denominated in US dollars. Details for making payments are:

Arrange an International Telegraphic Transfer/Swift Money Transfer (MT103) to The ANZ National Bank Ltd, Head Office, 1 Victoria Street, Wellington, New Zealand. Swift/BIC Address: ANZBNZ22 for the credit of 'Bioenergy Research Services Ltd for and on behalf of IEA Bioenergy'. Foreign Currency Account Number IEABRS-USD00. Quoting the Invoice Number.

The ANZ National Bank Ltd's US Dollar Correspondent Bank is JPMorgan Chase Bank, New York, NY, USA (Chips UID 174291 or Federal Wire Number/ABA Number 021000021), SWIFT Code CHASUS33; Account Number 400-929007 (ANZ National Bank Ltd).

The currency for the whole of IEA Bioenergy is US dollars. The main issues faced in fund administration are slow payments from some Member Countries and fluctuations in exchange rates. As at 31 December 2006, there was US$215,538 of financial contributions outstanding.

KPMG is retained as an independent auditor for the ExCo Secretariat Fund. The audited accounts for the ExCo Secretariat Fund for 2005 were approved at ExCo57. The Tasks also produce audited accounts. These are prepared according to guidelines specified by the ExCo. The accounts for the Tasks for 2005 were also approved at ExCo57.

The audited accounts for the ExCo Secretariat Fund for the period ended 31 December 2006 have been prepared and these will be presented for approval at ExCo59.

Task Administration and Development

Tasks in the New Triennium

A substantial part of the ExCo58 meeting was dedicated to discussing and finalising the programmes of work and budgets for the Tasks in the new triennium 2007-2009. Apart from Tasks 29, 34 and 41 which were already approved, Tasks 30, 31, 32, 33, 36, 37, 38, 39 and 40 were all prolonged with new programmes of work and renewed participation by Member Countries. There was one new Task approved which is detailed below. There will be 13 Tasks in the upcoming period.

New Task on Biorefineries

At ExCo58 a new Task 'Biorefineries: Co-production of Fuels, Chemicals, Power and Materials from Biomass' was approved with seven Member Countries participating initially and three more observing in 2007. The Task will be led by Dr Ir Ed de Jong, assisted by Dr Ing René van Ree. The Operating Agent is the Netherlands. The major objective of the Task initially, is to assess the worldwide position and potential of the biorefinery field and to gather insights that will indicate new breakthrough, competitive, sustainable, safe and eco-efficient processing routes for the simultaneous manufacture of transportation fuels, added-value chemicals, (CH)power, and materials – the so-called biorefineries.

Special Project

A new project 'Analysis and identification of gaps in fundamental research for the production of second generation liquid transportation biofuels' was started under the umbrella of Task 41: Bioenergy Systems Analysis. This project is led by Professor Michael Ladisch of the Agricultural and Biological Engineering Department, Purdue University, USA. There are six participants: Finland, the Netherlands, Sweden, UK, USA, and the EC.

Participation in the Tasks has continued to increase. In 2006 there were 111 participations in 12 Tasks. Please see Appendix 1 on pages 81 and 82 for a summary of Task participation in 2006 and 2007.

Strategic Planning and Strategic Initiatives

Strategic Plan

The third Strategic Plan for IEA Bioenergy for the period 2003-2006 was approved at ExCo50 and extended at ExCo52 to 31 December 2009. It underpins a stronger emphasis on market deployment of technologies and systems for sustainable energy production from biomass.

Technical Coordinator

At ExCo58 a new position, Technical Coordinator was approved. The need for this position had arisen from the rapidly increasing requests from the Renewable Energy Working Party Secretariat at IEA Headquarters and also to provide a coordinating mechanism between the Tasks and the Executive Committee and a link between Tasks for projects where more than one Task was contributing. Dr Adam Brown has been appointed to the position. He will report to the Chairman and provide technical support on a project-by-project basis. Many will know Adam as he was Vice Chairman of IEA Bioenergy from 1987 to 1990 and Chairman from 1990 to 1993. An important outcome expected from this appointment is a significant improvement in the development and momentum of policy-relevant outputs from the Tasks.

Strategic Outputs

At ExCo53 in Lucerne it was agreed that from 2005, 10% of Task budgets would be reserved for ExCo specified work. The idea is that these funds will be used to increase the policy relevant outputs of IEA Bioenergy. The ExCo has since moved to commit these funds to specific strategic outputs. It decided that the first priority for use of these '10% held back funds' would be to produce information from the Tasks in support of a strategic position paper on 'The potential contribution of bioenergy to meeting the future global energy demand'. Andre Faaij from the Netherlands has been appointed to lead this project which should be completed in 2007.

The ExCo also decided that a second strategic position paper 'Lifecycle analysis of biomass fuels, power, heat, and products as compared to their petroleum counterparts and other renewables' should be produced by Task 38. A detailed proposal is being produced and this project is expected to proceed in 2007.

Some of the Tasks have also made suggestions on how these 10% held back funds can be used for further strategic outputs. These proposals, and others, will be considered by the ExCo and with assistance from the Technical Coordinator, some of them are expected to proceed.

Workshops

Following the decision at ExCo53 to create time for strategic topics at ExCo meetings it was decided to use the first day of each ExCo meeting for a technical workshop on a topic of high priority to the work of the ExCo. Very successful workshops were held at ExCo57 on 'Planning for the New Triennium' and at ExCo58 on 'Availability of biomass resources, certification/sustainability criteria and land-use and bioenergy in the Kyoto and post-Kyoto framework'. External contributions from technology developers, industrial practitioners, policy advisors and others provided a strong platform for discussion. The presentations, summaries by the rapporteurs, and papers based on the presentations are available on the IEA Bioenergy website. A 'summary and conclusions' publication on each workshop is also being produced by the ExCo.

Collaboration with FAO

The collaboration with FAO under the MoU signed in 2000 has continued. Overall the level of collaboration is significant. Both the Executive Committee and FAO are committed to capitalising on the opportunities provided through this MoU. Current initiatives between the Tasks and FAO include:

- A study of certification of forest fuel production systems as a solution for sustainable use of forest residues for energy - Task 31.
- Communication of Task results on liquid biofuels to developing countries - Task 39.
- Collaboration in the area of certification, standardisation, and terminology for sustainable bioenergy trade - Task 40.
- Collaboration on case studies of forest biomass for energy and wood fuel and charcoal production systems in developing countries - Task 40.

Seminars, Workshops and Sponsorships

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 Tasks later in this Annual Report. The papers presented at some of these meetings are listed in Appendix 4. Seminars and workshops are also arranged by the Executive Committee.

Promotion and Communication

The ExCo has continued to show lively interest in communication of IEA Bioenergy activities and information. The brochure on IEA Bioenergy with information targeted at audiences who are unfamiliar with this collaboration has been widely distributed both within the Member Countries and at major conferences. There is a wide range of other promotional material available through the Secretariat. This includes Annual Reports, technical brochures, copies of IEA Bioenergy News, the Strategic Plan and position papers. The IEA Bioenergy website underpins this publishing activity.

The 2005 Annual Report with the special colour section on 'Options for Trading Bioenergy Products and Services' was very well received. This coloured section was also produced as an independent brochure by Tasks 38 and 40. Only a few copies of the Annual Report from the original print run of 700 remain with substantially increased distribution in electronic format. This is available from the IEA Bioenergy website.

The newsletter IEA Bioenergy News remains popular. Two issues were published in 2006. The first issue featured bioenergy in France and the second issue featured bioenergy in Sweden as special themes. A free subscription is offered to all interested and there is a

wide distribution outside of the normal IEA Bioenergy network. The newsletter is distributed in June and December each year which follows the pattern of ExCo meetings. The contacts for the Newsletter Editor are provided on the back cover of this Annual Report. The newsletter is produced in electronic format so potential subscribers should ensure that the Editor has their email address. IEA Bioenergy News is also available from the IEA Bioenergy website.

Five contributions under the banner of 'IEA Bioenergy Update' were provided to the journal Biomass and Bioenergy in 2006. These covered news from the Executive Committee, events, and Tasks Technology Reports. They also included a summary of the address 'Bioenergy: a complex matrix, full of opportunities and dependent on policy instruments' by the Chairman of IEA Bioenergy, Dr Kyriakos Maniatis, at the opening plenary session of the 14th European Biomass Conference held in October in Paris. This initiative provides excellent access to bioenergy researchers as the journal finds a place in major libraries worldwide.

Interaction with IEA Headquarters

There is regular contact between the IEA Bioenergy Secretariat, and IEA Headquarters in Paris and active participation by ExCo representatives in relevant meetings. During 2006 the Chairman, Secretary, and key Members of the Executive Committee have worked closely with IEA Headquarters in Paris at both administrative and technical levels. Peter Tulej attended ExCo57 in Paris. This participation by IEA Headquarters is greatly appreciated by the Members of the ExCo and helps to strengthen linkages between the Implementing Agreement and relevant Headquarters initiatives.

In conjunction with ExCo57, 36 attendees (including 9 IEA Headquarters staff) participated in a joint meeting on 17 May. There were some excellent presentations from the Headquarters staff. Peter Tulej also made a presentation titled 'Bioenergy IA/IEA Collaboration Opportunities'. He outlined some of the things that could be improved; e.g., visibility at HQ level, better marketing of IA products, participation in REU projects and new joint projects, and the ability to respond quickly to emerging issues. He also detailed a number of current collaboration opportunities including the World Energy Outlook, policy analysis, statistics, biofuels, and the NEET (G8) initiative. The meeting ended with a wide ranging discussion, including opportunities for information sharing and collaboration on projects of mutual interest.

Status Reports according to the template supplied by IEA Headquarters were prepared by the Secretary and forwarded to the IEA Administrator for REWP Implementing Agreements following ExCo57 and ExCo58. A questionnaire from Peter Finckh, Vice Chairman of the End Use Working Party (EUWP) for the Transport sector was completed to assist the report he prepares for the autumn meeting of the EUWP. This report forms part of the exchange of information between Implementing Agreements and the Working Party.

IEA Bioenergy Website

Upgrading of the IEA Bioenergy website is now completed and the new version of the website was launched in early 2006. The look and feel of the old site had been maintained as much as possible so as to cause minimal disruption to users whilst providing improved functionality and flexibility and some useful new features such as improved maintainability, adaptability for the future, and statistical reporting functionality.

ExCo Members Kees Kwant, the Netherlands (left) and Gerhard Justinger, Germany (right) with Eddie Johansson at Ena Kraft AB in Enköping, Sweden.

2. PROGRESS IN 2006 IN THE TASKS

Task 29: Socio-economic Drivers in Implementing Bioenergy Projects

Overview of the Task

The objectives of Task 29 are to:

- achieve a better understanding of the social and economic drivers and impacts of establishing bioenergy fuel supply chains and markets at the local, regional, national and international level;
- synthesise and transfer to stakeholders critical knowledge and new information;
- improve the assessment of the above mentioned impacts of biomass production and utilisation in order to increase the uptake of bioenergy; and
- provide guidance to policy makers.

These objectives will be met through encompassing the results and findings obtained previously in the Task and also through the international state-of-the-art socio-economic evaluation of bioenergy programmes and projects. Activities will be expanded to include developing countries through the FAO and similar organisations. This will include the sharing of research results, stimulation of new research directions in national, regional and local programmes, and technology transfer from researchers to resource managers, planners and industry.

Participating countries: Austria, Canada, Croatia, Ireland, Japan, Norway and the United Kingdom.
Task Leader: Dr Keith Richards, TV Energy Ltd, United Kingdom.
Associate Task Leader: Dr Julije Domac, Energy Institute Hrvoje Pozar, Croatia.
Operating Agent: Mr Gary Shanahan, Department of Trade and Industry, United Kingdom.

The Task Leaders direct and manage the work programme. A National Team Leader from each country is responsible for coordinating the national participation in the Task.

For further details on Task 29, please refer to Appendices 2-6 inclusive; the Task website: *www.iea-bioenergy-Task29.hr*, the biomass and bioenergy educational website: *www.aboutbioenergy.info* and the IEA Bioenergy website *www.ieabioenergy.com* under 'Our Work: Tasks'.

Task Meetings and Workshops

Task 29, together with Tasks 31 and 39 organised an international conference 'Biofuels and Bioenergy: Challenges and Opportunities' held on 28 August - 1 September at the University of British Columbia, Vancouver, Canada. This workshop furthered the Task's work of collecting, synthesising, and sharing leading-edge science and technology that is driving the emerging biofuel and bioenergy sectors. It provided an opportunity for resource managers, power industry representatives, bioenergy systems equipment manufacturers, energy production professionals, energy users, programme managers, educators, scientists and researchers to exchange information and discuss technical and policy aspects around biofuels and bioenergy, as well as issues around sustainable management, production and use of forest biomass for energy, with strong consideration given to the role of society in guiding these developments. The workshop focused particularly on practical solutions to lower barriers to implementation of bioenergy systems. Within that broad general framework, more specific consideration was given in presented papers and posters and field study visits to issues of:

- bioenergy and biofuels as a response to changing natural resource management;
- technical issues around biofuels and bioenergy production;
- reducing environmental impacts from forest energy production systems;
- establishing and managing forest energy systems for specific environmental goals;
- efficiency and economics of forest energy and biofuels operations;
- certification of sustainable forest energy systems;
- social and community development; and
- policies related to both technologies and/or management options.

Another international conference 'Realising the Promise of Bioenergy: Commercial and Practical Issues' was jointly organised with Task 30 and held on 18-21 September in Oxford, UK. Approximately 100 delegates participated each day. Task meetings for both Tasks were also organised. The main conference featured presentations by both Tasks as invited papers and was supplemented by presentations from leading UK bioenergy experts. The conference covered:

- wood fuel supply chains,
- large-scale deployment of energy crops,
- advances in energy crops,
- barriers to bioenergy projects,
- 'Tree Station' developments,
- community benefits of bioenergy projects,
- Energy Service Company (ESCo) best practice,
- the role of local Government in facilitating bioenergy projects,
- the impact of local planning processes, and
- the environmental impacts of bioenergy projects.

The conference was organised locally by TV Energy Ltd with support from Slough Heat and Power, the largest UK green energy producer, SEEDA, GOSE and DEFRA. A keynote address was given by Gary Shanahan of the DTI. Other industry sponsors included RES a company that is increasingly active in bioenergy matters in the UK. Participants were drawn from industry, local, regional, and central government, communities active or contemplating bioenergy schemes, academia and interested parties. There was a poster session that attracted a range of presentations setting out recent project-based activities and results.

Work Programme

The Task work programme in 2006 included completion of a series of case studies from participating countries with particular emphasis on socio-economic components and specifically the drivers leading to a project and its impacts. Five case studies were completed. They are presented in a common format and are available on the Task website. Details of these are:

- Total management approach to forest biomass utilisation by local government in Yamaguchi Prefecture, Japan.
- District heating system in Zakanje Municipality, Croatia.
- Camphill Community Ballytobin, Co. Kilkeny, Ireland.
- Biogreen Energy Products Ltd, Co. Wexford, Ireland.
- The Living Rainforest, Berkshire, England.
- Socio-economics of large urban wood-fuelled cogeneration: sustainable energy supply for Vienna, Austria.

Five further case studies are currently in preparation from the following countries: Norway (2); Austria, and Canada (2).

Another important activity was the preparation of a special issue of the Energy Policy Journal 'Modelling Socio-economic Aspects of Bioenergy Use'. Contributing authors were invited to submit their papers by August and the reviewing process is expected to be finished by December 2006. In total, the special issue will contain 14 papers from experts involved in Task 29 and the wider scientific community.

Canadian and Croatian researchers are collaborating to write a paper that investigates the social and economic drivers that influence bioenergy use. The article will investigate this from an economics point of view while analysing the behaviour of all agents in the economy whose actions can affect the uptake of bioenergy use. These groups include households, firms, and governmental organisations and their actions will be examined with respect to both the supply of, and the demand for, bioenergy.

Other activities consisted of planning and organising the Task workshops and events, the publication of workshop proceedings and preparation of future meetings and activities.

Collaboration with other Tasks/Networking

The Task has actively collaborated with Tasks 30, 31 and 39 (see above). In addition an expert workshop 'Sustainable Biomass' is planned with Tasks 39 and 40 for October 2007 in Croatia.

Website

The Task website (*www.iea-bioenergy-task29.hr*) is periodically reorganised and updated and this will continue. All publications, including workshop proceedings and meeting minutes, Task brochures and posters, Task reports and papers, can be downloaded in PDF format. Several video files, explaining various socio-economic issues related to bioenergy, are available for downloading or online viewing. The visual identity of the website was recently redeveloped and additional material (including presentations from Task workshops, separate articles from all Task proceedings, completed case studies, additional reports and papers) have been made available for downloading.

Deliverables

Deliverables in 2006 included workshop proceedings containing a selection of papers presented at the Task international workshop, invited papers published in recognised international journals, several papers presented at major international events, the two progress reports and an annual audit report to the Executive Committee, and the biomass and bioenergy educational website.

TASK 30: Short Rotation Crops for Bioenergy Systems

Overview of the Task

The objective of Task 30 is to acquire, synthesise, and transfer theoretical and practical knowledge of sustainable short rotation biomass production systems and thereby to enhance market development and large-scale implementation in collaboration with the various sectors involved. The Task also aims to improve the awareness of biomass production potential and to promote the use of biomass for energy in participating countries.

The Task is confined to short rotation crops that entirely or by means of residuals may provide biomass to the energy market, and comprises herbaceous and woody crops in farming systems and plantation forests grown on short rotations. The latter category includes coppice systems and also fast-growing single-stem plantations (rotation period 6 to 12 years). These short rotation systems usually employ willow, hybrid poplar, and *Eucalyptus* species and produce large quantities of biomass suitable for energy purposes. In many instances, they form an important component of nutrient cycling and thus may

play an important role in environmental management. Pest and disease problems associated with short rotation crop systems and ways to mitigate them are an integral part of this work.

Participating countries: Australia, Brazil, Canada, New Zealand, Sweden, United Kingdom, and the USA.
Task Leader: Professor Theo Verwijst, Department of Short Rotation Forestry, Swedish University of Agricultural Sciences, Sweden.
Operating Agent: Dr Bjorn Telenius, Swedish National Energy Administration, Sweden.

The Task Leader directs and manages the work programme assisted by an international team; Associate Task Leaders Bryce Stokes, USA and Ian Nicholas, New Zealand. Nils-Erik Nordh, Sweden is the Task Secretary. A National Team Leader from each country is responsible for coordinating the national participation in the Task.

For further details on Task 30, please refer to Appendices 2-6 inclusive; the Task website *www.shortrotationcrops.com* and the IEA Bioenergy website *www.ieabioenergy.com* under 'Our Work: Tasks'.

Progress in R&D

Task Meetings

An internal 'Handbook' workshop was held on 11-15 September in Uppsala, Sweden by George, Nicholas, Verwijst, and Nordh.

The annual Task business meeting was held on 21 September in Oxford, UK in conjunction with an international conference 'Realising the Promise of Bioenergy: Commercial and Practical Issues' organised by TV Energy in association with Tasks 29 and 30.

Task 30 was represented at the 'North Sea Biomass for Energy Conference; Challenges for Agriculture' held on 25-26 September in Bruges, Belgium, with a presentation by the Task Leader. The Task was also represented at the Bioenergy Australia 2006 Conference, held on 5-8 December in Fremantle, WA, with a presentation by the Australian National Team Leader.

Work Programme

The work programme for the current triennium (2004-2006) reflects the priorities of the participants with regard to the development of Short Rotation Crops (SRC) for energy purposes. The 'high priority areas' of the Task work programme during the triennium are:

Improving production systems efficiencies. *(Responsible person: Theo Verwijst).*
This covers planning, layout, site selection, species selection, planting, site prep, cultivation,

harvest, silviculture and farming, comminution, transportation, sorting, utilisation, recovery, economics, nutrient management, and pest control, etc.

Reducing environmental impacts from SRC production systems *(Responsible person: Brendan George).*
This covers erosion and soil stabilisation, cover crops, nutrient loading, water quality, herbicide and pesticide management, offsite chemical movement, biodiversity, aesthetics, and even environmental economics

Establishing and managing SRC systems for specific environmental benefits. *(Responsible person: John Stanturf with assistance from Andrew Gordon).*
This covers nutrient recycling to restore soil, phytoremediation, carbon sequestration, water filtration and storage - or even transpiration for flood control and site rehabilitation, etc. It incorporates the opportunity for using SRC for a wide variety of environmental benefits.

Identifying co-product opportunities that could facilitate SRC uptake *(Responsible person: Ian Nicholas).*
This covers using SRC either as dedicated crops (all products go to fuels) or as one component of multiple products. It can include fibre, solid wood, etc. from woody systems; grazing in grass systems; or forage in corn systems, bagasse from sugar systems etc.

Accelerated deployment of SRC systems and identification of barriers to large-scale implementation. *(Responsible persons: Charlotte Bruton and Keith Richards).*
This covers the study of technical issues, market mechanisms, steering mechanisms and the effect of regulations and legislation on implementation of SRC for bioenergy.

Finally, systematic SRC knowledge transfer is achieved through the website, newsletters, a handbook, international collaboration, and IEA networks to educate and inform the bioenergy sector.

Website

The Task website *(www.shortrotationcrops.com)* designed with the objective of obtaining a wider Task 30 exposure was updated regularly during 2006. The site has a Task overview, links to key-actors in each of the participating countries as well as sections for individual crop types. It contains most of the Task material produced including the latest Task newsletters.

Collaboration with Other Tasks/Networking

A conference was organised jointly with Task 29 in Oxford, UK. During 2006, Task 30 has exchanged information with the International Union of Forest Research Organisations (IUFRO), International Poplar Commission (IPC) and International Solar Energy Society (ISES).

Deliverables

The references to published abstracts and papers are provided in Appendix 4. Most reports and publications are distributed electronically and can be downloaded from the Task website.

TASK 31: Biomass Production for Energy from Sustainable Forestry

Overview of the Task

The objective of the Task is to develop an integrative framework for information related to biomass production for energy from sustainable forestry, based on leading-edge science and technology, and to share and promote the use of such an information framework with advanced information technology and a high level of collaboration.

The Task encompasses natural forestry systems and single-stem plantation systems, which can provide a source of biomass for energy. The scope is worldwide. Efforts are made to expand activities to include countries with economies in transition. The work includes sharing of research results, stimulation of new research directions in national programmes of participating countries, and technology transfer from science to resource managers, planners and industry. The emphasis is on an integrated approach to biological, economic, environmental, and social components of forestry systems. Multi-disciplinary partnerships of key stakeholders in forest biomass production research, planning, and operations are fostered.

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 countries: Australia, Belgium, Canada, Denmark, Germany, Norway, Sweden, the United Kingdom, and USA.
Task Leader: Mr Jim Richardson, J Richardson Consulting, Canada
Operating Agent: Dr J. Peter Hall, Canadian Forest Service, Canada

The Task Leader directs and manages the work programme assisted by an international team from Canada, Sweden, and the USA. A National Team Leader from each country is responsible for coordinating the national participation in the Task. The national teams in participating countries comprise an extensive group of scientific and technical collaborators.

For further details on Task 31, please refer to Appendices 2-6 inclusive, the Task website *www.ieabioenergytask31.org* and the IEA Bioenergy website *www.ieabioenergy.com* under 'Our Work: Tasks'.

Task Meetings and Workshops

One hundred and thirty participants from 16 different countries took part in a major international joint conference of Tasks 29, 31 and 39 on 27-30 August in Vancouver, Canada. The conference was hosted by the Faculty of Forestry, University of British Columbia and had the overall theme of 'Biofuels and Bioenergy: Challenges and Opportunities'. This theme was addressed over two full days of scientific and technical sessions and a half-day of field visits. In total, 74 presentations were given. Immediately prior to the conference, Task 31 organised a three-day study tour in central British Columbia (BC) which provided an appreciation of forest management in BC and the problems and opportunities for using biofuels in the area. About 25 people participated in the tour. A CD has been produced and distributed, containing all the presentations given at the conference. Formal publication of some of the technical papers is also planned in an international peer-reviewed journal. A Task business session held during the workshop provided opportunities for planning and discussion of the future direction of the Task, including plans for the new triennium beginning in 2007.

Work Programme

The Task work programme includes identifying research needs and opportunities, assimilating and synthesising scientific and technical information, identifying breakthrough technologies, organising annual workshops and study tours, transfer of information to key stakeholders, and collaboration with other IEA Bioenergy Tasks as well as other scientific and technical organisations and institutions. The Task has limited funds for development of new knowledge and technology, but is able to influence the direction of policy and research through development of white papers, state-of-the-art assessments, synthesis reports, and policy-related documents.

In policy-related activity the Task continued to focus on certification of sustainable forest fuel production systems as a tool to satisfy concerns about the possible environmental, economic, and social effects of greatly increased use of biomass from conventional forestry systems for energy. The preliminary analyses of criteria to incorporate in a certification procedure for forest energy are being expanded in collaboration with FAO. This work is exploring existing forest management certification programmes and the environmental, economic, social, and cultural impacts, and legal and institutional framework of wood fuel production in developing and developed countries. Case studies analysing specific local situations, particularly in developing countries, provide illustrations of the general principles involved.

A synthesis report was prepared examining currently available estimates of biomass feedstocks in North America and two European countries and assessing ways in which these estimates are affected by regional and national inventory estimate methodologies, as

well as severe episodic events such as hurricanes and insect epidemics. Variability of biomass feedstock estimates can affect investor confidence in bioenergy projects.

One of the primary means of achieving Task goals and outputs is a series of annual workshops. These involve invited and volunteer scientific and technical experts who present papers and posters, contribute to assessments and discussions, and lead study tours. Case studies of successful applications of sustainable forest management for increased ecosystem productivity, forest health, and efficient utilisation of forest resources, including biomass for energy, are examined.

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 on the internet is actively maintained. The Task website *(www.ieabioenergytask31.org)* is the primary vehicle for information about the Task. It has a broad range of information, including events, reports and publications, photographs, and Task newsletter content. Complete coverage of publications of the present Task is provided, including the extensive output of related past Tasks and activities. Basic Task information is also provided on the IEA Bioenergy website, where Task informational materials, such as workshop announcements, are available.

Industry involvement is important to the Task and particular efforts are made to involve industry participants in workshops and conferences. This was evident in the 2006 joint international conference in Vancouver at which half of the plenary session speakers, including the keynote speaker, were from the private sector. Their contributions helped to illustrate the advancing commercialisation of bioenergy technologies and the challenges to providing a sustainable biomass supply.

Collaboration with Other Tasks

Several Tasks have objectives and interests that are complementary to those of Task 31. Strong links are maintained with these Tasks through sharing of information and, where possible, joint workshops.

Close ties are maintained with Task 29, which was one of the three Tasks involved in the international conference in Vancouver in August. Collaboration with the other Task involved in that conference, Task 39, represented a new level of inter-Task cooperation as the Task's first joint activity with a technology-oriented Task. A close level of collaboration also exists with Task 30 and the Task Leader represented both Tasks at a meeting of the US Short Rotation Woody Crops Operations Working Group in Pasco, Washington in September. Contributions were made to a draft position paper, led by Task 40 on global bioenergy potential.

Opportunities for collaboration and cooperation with other international researchers, organisations and activities, particularly those involved in issues of sustainability of forest

ecosystems, are also pursued. A major collaborative effort with the Forest Energy Programme of FAO is underway on a study of certification of forest fuel production systems as a solution for sustainable use of biomass from forest residues for energy. This project will culminate in a joint, multi-author publication and an international workshop.

Deliverables

The proceedings of the third annual workshop, held in Flagstaff, Arizona, USA in October 2003, were published as a special issue of Biomass and Bioenergy with 16 invited and volunteer papers.

The proceedings of the fourth annual workshop, held in Garpenberg, Sweden and Gran, Norway in September 2004, were also published as a special issue of Biomass and Bioenergy. Ten invited and volunteer papers were included in the special issue following peer review.

Manuscripts making up the proceedings of the workshop held jointly with Task 30 in Western Australia in August 2005 have been peer reviewed by workshop participants and other Task collaborators and have been submitted for publication as a special issue of Biomass and Bioenergy. PowerPoint presentations made at the workshop have also been made available to workshop participants on CD.

The proceedings of the workshop held jointly with Tasks 29 and 39 in Vancouver in August have been made available to workshop participants on CD. Manuscripts based on workshop presentations are also under peer review for publication as a special issue of Biomass and Bioenergy.

A number of presentations were given by the Task at other workshops and conferences, as listed in Appendix 4.

TASK 32: Biomass Combustion and Co-firing

Overview of the Task

The objective of the Task is to stimulate expansion of biomass combustion and co-firing for the production of heat and power on a broad scale. The widespread interest in the work of the Task illustrates the relevance of biomass combustion and co-firing in society. The emphasis of the activities in the Task are currently:

- market introduction to expand the use of biomass combustion in the short term; and
- optimisation of biomass combustion technology in the longer term so that it remains competitive.

Technical issues addressed by the Task are:

- increasing fuel flexibility, including contaminated biomass and biomass pellets;
- advanced process control and sensor development;
- corrosion and deposit formation mechanisms;
- formation and emission of particulates (aerosols) and primary measures for NO_x reduction; and
- the improvement of existing systems and development of new concepts.

This is the last annual report from Task 32 in the 2004-2006 triennium. The work programme of the Task is very similar to that of the previous triennium, with emphasis on topics relating to stand alone industrial combustion and co-firing of biomass in coal-fired power plants. Of all the thermochemical conversion technologies available for biomass, combustion can be regarded as the most widely applied option. It has a global market share exceeding 90%. When compared with gasification, pyrolysis, or liquefaction, combustion technologies are in a more advanced stage of development. Commercial availability is high and there is a multitude of options for integration with existing infrastructure at both large and small-scale. Nevertheless, for further implementation of biomass combustion, the technology needs to be optimised to keep it competitive as gasification and pyrolysis develop. For obvious economic and environmental reasons, co-firing biomass with coal in traditional coal-fired boilers (subsequently referred to as co-firing) is an option that has received growing interest worldwide.

Non-technical issues addressed are policies options which promote or hinder projects, logistics and contracting, environmental constraints and legislation, public acceptance, and financial incentives. An overview of relevant policies will be included in the new version of the 'Handbook of Biomass Combustion and Co-firing'. In addition, the Task will produce a position paper illustrating the potential importance of the technology and barriers that need to be overcome to harness this potential.

Participating countries: Australia, Austria, Belgium, Canada, Denmark, Germany, the Netherlands, Norway, Sweden, Switzerland, United Kingdom, and the European Commission.
Task Leader: Mr Sjaak van Loo, Procede BV, the Netherlands.
Assistant Task Leader: Ir. Jaap Koppejan, Procede BV, the Netherlands.
Operating Agent: Ir. Kees Kwant, SenterNovem, the Netherlands.
Alternate Operating Agent: Mr Erik Wissema, Ministry of Economic Affairs, the Netherlands

The Task Leader directs and manages the work programme. A National Team Leader from each country is responsible for coordinating the national participation in the Task.

For further details on Task 32, please refer to Appendices 2-6 inclusive; the Task website *www.ieabcc.nl* and the IEA Bioenergy website *www.ieabioenergy.com* under 'Our Work: Tasks'.

Task Meetings and Workshops

In 2006 the Task organised two internal meetings as well as two workshops in Jönköping, Sweden and Glasgow, Scotland. The internal Task meetings were used to compare progress in different Task activities with the work programme, reflect on Task initiated workshops, plan future activities and share recent developments on application of biomass combustion in Member Countries. A topic of continuing importance at both Task meetings was the preparation of a second edition of the 'Handbook of Biomass Combustion and Co-firing' – see below.

A Task meeting was organised on 29 May in Jönköping, Sweden, in combination with a workshop on 'Fuel Flexibility in Biomass Combustion: The key to low bioenergy costs?', which was part of the World Bioenergy 2006 Conference. Key parts of the Task meeting were the 'Handbook of Biomass Combustion and Co-firing' and the work programme for the next triennium. In addition, visits were made to Borås, where a BFB combustion installation firing industrial waste and the research facilities of SP. The workshop attracted some 50 participants and was considered very successful. The presentations are available on the Task website.

The second Task meeting was held 19-20 September in Glasgow, Scotland in conjunction with a conference of the European ThermalNet expert network on 'Thermal Conversion of Biomass'. On the first day, the Task meeting was held to discuss progress in Task activities and finalise the work programme for the new triennium. On the second day, a field trip was organised to Longannet power station, a 2500 MWe coal-fired power plant co-firing sewage sludge and wood pellets. The impressive R&D facilities of Mitsui Babcock were also visited. The Task also organised an expert workshop on 'Ash Related Impacts on Boiler Operation, including Corrosion and Deposition'.

The reports of Task meetings and workshops can be downloaded from the Task website. An overview of workshops that were organised in this triennium by the Task is provided below.

Topic	Host	Location and Timing
Co-firing	Netherlands	Rome, Italy, May 14, 2004
Public perception of biomass co-firing	Canada	Victoria, Canada, August 30, 2004
Aerosols from biomass combustion	Austria	Graz, Austria, March 18, 2005
Process control and sensor development	Netherlands	Innsbruck, Austria, September 29, 2005
Recent developments in small-scale systems	Netherlands	Paris, France, October 21, 2005
Fuel flexibility	Sweden	Jönköping, Sweden, May/June 2006 (at the World Bioenergy Conference)
Corrosion and deposit formation	UK	Glasgow, Sweden, September 2006 (together with the EU-ThermalNet project)

Work Programme

The work programme of the Task in the current triennium was based on a prioritisation of topics agreed in 2003. These were:

- Technologies for biomass combustion in small-scale and CHP systems.
- Technologies for co-firing biomass in existing coal-fired boilers.
- Increasing fuel flexibility, including contaminated biomass and biomass pellets.
- Advanced process control and sensor development.
- Corrosion and deposit formation mechanisms.
- Formation and emission of particulates (aerosols) and primary measures for NO_x reduction.
- Improvement of existing systems and development of new concepts.

Progress achieved on these topics in 2006 is described below.

Small and medium scale CHP

Most of the Task activities on CHP are related to the collation and dissemination of research information geared towards lowering investment costs; achieving environmental acceptability; handling alternative and difficult-to-burn feedstock; and demonstrating innovative combustion technology. Attention has been paid to this topic through two Task supported activities:

- preparation of an international overview of initiatives for biomass combustion based CHP plants (Austria, March 2004);
- determination of efficiency for automatic biomass combustion plants and comparison of efficiency and emissions for different operational modes (Switzerland, March 2004); and
- in addition, field trips to three biomass combustion CHP plants in Austria with innovative prime mover concepts were organised

The study 'Energetic Assessment of Energy Systems with Biomass Combustion' by Switzerland was finalised.

Co-firing coal with biomass and related wastes

Though there are many advantages associated with co-firing biomass with coal, improper choices of fuels, boiler design, or operating conditions could minimise or even negate many of the advantages of burning biomass with coal and may, in some cases, lead to significant damage to equipment. The Task focuses on gathering and disseminating information on co-combustion of biomass in existing coal-fired boilers. In cases of co-firing biomass-derived producer gas, pyrolysis oil or charcoal – activities are restricted to co-firing these materials not to the gasification, pyrolysis or carbonisation process. In 2004, two conference workshops were organised on progress in biomass co-firing in general and the public perception of biomass co-firing. The latter meeting was held to discuss with NGO's under what conditions biomass co-firing could be regarded as environmentally sound and acceptable.

In 2005, a study on Biomass Impacts on SCR Catalyst Performance (by former Task participant USA) was finalised. A statement pinpointing the relevance of biomass co-firing was prepared and discussed with the ExCo. It has been published as a Biomass and Bioenergy Update. The Task also provided key input to the ExCo55 workshop. Finally, a searchable internet database on biomass co-firing, which describes around 150 initiatives worldwide on co-firing different types of biomass in different types of coal power plants on co-firing initiatives, was updated. This makes it easy for anyone to trace power plants with experiences on co-firing certain types of biomass/wastes.

In 2006, a workshop was organised on 'Ash Related Issues with Biomass Combustion and Co-firing' in September in Glasgow. Particularly for coal-fired plants co-firing biomass, this is an issue as steam temperatures are typically significantly higher than for dedicated biomass combustion systems. A report on 'Formation of Striated Flows During Biomass-coal Co-firing', by former Task member USA was also finalised in 2006.

Increasing fuel flexibility, including contaminated biomass and biomass pellets
This topic relates to the adaptation of existing combustion installations, in order to enable diversification of fuel sources. This is usually important for larger power plants that obtain their fuel from various sources. On the other hand, more widespread use of standardised fuels such as pellets in standardised equipment may lead to further cost reductions. In 2005 a workshop on 'Recent Innovations in Small-scale Combustion' was organised as part of the European Biomass Conference in Paris. An extensive overview was given particularly on innovative pellet combustion systems. In 2006 a workshop on 'fuel flexibility' was organised as part of the World Bioenergy Conference, held in May/June in Jönköping, Sweden. Attempts to organise this workshop jointly with the IEA Implementing Agreement on Fluidised Bed Conversion did not succeed due to conflicting commitments.

Advanced process control and sensor development
The variability of biomass fuels has led to a request for adequate dynamic control over combustion performance and heat generation. Recently a significant amount of work has been done to develop new devices and concepts for measurement and control systems. In 2005, key inputs were provided to a workshop on 'Modelling and Control of Biomass Grate Furnaces' organised in October in Innsbruck, Austria together with the EU ThermalNet expert network. In 2006, no specific actions were taken on this topic.

Improvement of existing systems and development of new concepts
This topic deals with methods for technical improvement of existing concepts for biomass combustion equipment, as well as the development of totally new concepts for combustion installations. A workshop on the 'Optimisation of Small-scale Combustion Systems' was held in October as part of the 14th European Biomass Conference in Paris. At the workshop a number of recent innovations were presented, such as a very small but cost

effective scale ESP for dust removal from domestic woodstoves. In 2006, no specific actions were taken on this topic.

Collaboration with Other Tasks/Networking

A key factor in the success of the Task is the wide industrial involvement with the work programme, and the interaction with other IEA Implementing Agreements and the European Union. Industrial participation is also enhanced by the active involvement of industry representatives from the participating countries. In the area of biomass co-combustion, interaction between IEA Bioenergy and IEA Coal Research is further intensified by collaboration with the Coal Combustion Science group of IEA Coal Research. A Memorandum of Understanding facilitates information exchange between these bodies.

Task 32 is closely related to other IEA Bioenergy Task activities, especially Task 33: Thermal Gasification of Biomass and Task 36: Energy Recovery from Municipal Solid Waste. Effective coordination is achieved through joint events, and arranging exchange of meeting minutes and reports. All Task 32 reports can be downloaded from the Task website.

Deliverables

Deliverables in 2006 included: organising and minuting of two Task meetings; organisation and reporting a workshop 'Fuel Flexibility in Biomass Combustion' at the World Bioenergy Conference; organisation and reporting a workshop 'Ash Issues in Biomass Combustion'; reporting to the ExCo including a Technology Report on 'Innovative CHP Options from Biomass Combustion'; updating of the international overview of initiatives for biomass co-firing (by Netherlands); finalisation of the study on Striated Flows in Biomass Combustion; maintenance of Task website; and preparation of a second edition of the 'Handbook on Biomass Combustion and Co-firing'.

With respect to the 'handbook', the first edition was published in two prints runs totalling 850 copies and is now out of stock. In 2004 a peer review of the first edition was carried out by Prof Bo Leckner (Chalmers University) and Bo Sander (Elsam Engineering). The results from the peer review have been used to formulate a new Table of Contents and divide the work for the authoring and editing of the second edition. Publisher James and James have agreed to publish this new edition, which is now scheduled for release in May 2007.

In December 2004, the Task signed a License Agreement with the Chinese Academy of Agricultural Engineering (part of the Ministry of Agriculture) for the preparation of a Chinese edition of the Handbook. As of September 2006, a draft version was checked by the Task, and publication is now expected in early 2007

TASK 33: Thermal Gasification of Biomass

Overview of the Task

The objectives of Task 33 are to monitor, review and exchange information on biomass gasification research, development, and demonstration and to promote cooperation among the participating countries and industry to eliminate technological impediments to the advancement of thermal gasification of biomass. The ultimate objective is to promote commercialisation of efficient, economical, and environmentally preferable biomass gasification processes, for the production of electricity, heat, and steam, for the production of synthesis gas for subsequent conversion to chemicals, fertilisers, hydrogen and transportation fuels, and also for co-production of these products.

Participating countries: Austria, Denmark, Finland, Germany, Italy, the Netherlands, New Zealand, Sweden, Switzerland, United Kingdom, USA, and the European Commission.
Task Leader: Dr Suresh P. Babu, Gas Technology Institute, USA
Operating Agent: Mr Larry Russo, US Department of Energy, USA

The Task Leader directs and manages the work programme. A National Team Leader from each country is responsible for coordinating the national participation in the Task.

For further details on Task 33, please refer to Appendices 2-6 inclusive; the Task website *www.gastechnology.org* and the IEA Bioenergy website *www.ieabioenergy.com* under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

The fifth Task meeting was held from 12-14 June in Dresden, Germany. A one day workshop 'WS5 - Biomass Gasification: Gas Cleanup', was held on 13 June, 2006. The third day was allotted for plant visits to Sustec SVZ and Choren in Freiberg, Germany.

The sixth and final Task meeting for the triennium was held on 30-31 October in Chicago, USA. This included a one day workshop, 'WS6 - Biomass Gasification: Success Stories and Lessons Learned'. Visits to the FlexFuel Test Facility at GTI, in Des Plaines, Illinois and the National Bioenergy Centre at the National Renewable Energy Centre in Golden, Colorado, USA were also undertaken.

Work Scope, Approach and Industrial Involvement

The scope of work for the current triennium is built upon the progress made in the previous triennia. In the previous years, information exchange, investigation of selected subtask studies, promotion of coordinated RD&D among participating countries, selected

plant visits, and industrial involvement at Task meetings have been very effective. These remain the basic foundations for developing and implementing a programme of work that addresses the needs of the participating countries.

The Task monitors the current status of the critical unit operations and unit processes that constitute a biomass gasification (BMG) process, and identifies hurdles to advance further development, operational reliability, and reducing the capital cost of BMG systems. The Task meetings provide a forum to discuss the technological advances and issues critical to scale-up, system integration, and commercial implementation of BMG processes. Generally, these discussions lead to selection of subtask studies that focus on advancing the state-of-the-art technology and which address the options to resolve hurdles to technology commercialisation.

The Task has continued the practice of inviting industrial experts to the Task meetings to present their practical experiences and to identify the options for development of process components to advance the state-of-the-art of BMG systems. The interaction with industry provides the opportunity for the National Team Leaders to discuss refinements that should be made to existing product lines and/or processes. Academic experts are also invited as and when the need arises to seek information and cooperation in order to address basic and support research needs.

Work Programme/Subtask Studies

The current work programme includes the following elements:

- Plan and conduct semi-annual Task meetings including workshops on subtask studies selected by the NTLs, and address matters related to the Task mission and objectives. Details are:

Meeting	Associated Workshop	Location and Timing
1st Task meeting	WS1 'Short, Medium, and Long Term Perspectives on BMG'	3-5 May 2004 Vienna, Austria
2nd Task meeting	WS2 'Gas Cleaning and Gas Engines for Small-scale Applications'	25-27 October 2004 Copenhagen, Denmark
3rd Task meeting	WS3 'Hydrogen and Synthesis gas for Fuels and Chemicals' (in co-operation with the Swedish SYNBIOS Conference)	18-20 May 2005 Stockholm, Sweden
4th Task meeting	WS4 'Health, Safety, and Environmental Impact of Small-scale Biomass Gasification Systems' (in co-operation with European GasNet/ThermalNet)	26-28 September 2005 Innsbruck, Austria
5th Task meeting	WS5 'Biomass Gasification Gas Clean-up'	12-14 June 2006 Dresden, Germany
6th Task meeting	WS6 'Biomass Gasification Success Stories and Lessons Learnt'	30-31 October 2006 GTI, Chicago, and NBC/ NREL, Golden, USA

- Survey the current global biomass and waste gasification RD&D programmes, commercial operations and market opportunities for BMG, and identify the technical and non-technical barriers to commercialisation of the technology. Use the survey results to prepare and update Country Reports for information dissemination.

- Conduct joint studies, conferences, and workshops with related Tasks, Annexes, and other international activities to address mutually beneficial issues.

- Identify research and technology development needs based on the results from the work described above as a part of the workshop reports.

- Publish results of the work programme on the Task website *(www.gastechnology.org/iea)* for information dissemination. Maintain the website.

Observations from WS5 'Biomass Gasification: Gas Clean-up'

The objective of the USA gas clean-up R&D programme is comprehensive. It is targeted to remove contaminants (tar, particulates, S, Cl, N, and alkali metals) from raw product gas to meet or exceed strict quality standards for fuels synthesis and also for advanced power generation.

The targets for clean synthesis gas can be summarised as follows: Tars (<0.1 mg/Nm^3 for methanol synthesis); Heteroatoms (<0.1 mg/Nm^3 for methanol synthesis); and Inorganics (< 0.01 mg/Nm^3 for methanol synthesis). Source: 'Unit Operations of Biomass Gasification', Report 2DEN-02.20, NOVEM, 2002. In addition, light hydrocarbons should be reduced to minimise reforming and thus reduce overall process costs.

The NREL/USDOE gas cleanup projects are summarised below:

- *NREL Cleanup and Conditioning Tasks;* PI: D. Dayton: Investigate catalytic steam reforming of tars produced during biorefinery residues gasification at bench- and pilot-scales to advance catalytic gas cleanup technologies.

- *Catalysts for In-Processing Removal of Tars (GTI); PI: L. Felix:* Low-cost catalytic material formed into attrition-resistant refractory substrate using high temperature glass melting technology.

- *Verification of Syngas Quality (PNNL/NREL); PI's: J. White/S. Deutch:* Verify the utilisation of biomass-derived syngas for mixed alcohol production. Improved synthesis catalysts with validated syngas cleanliness requirements.

- *Syngas Cleanup Using a Therminator (RTI, Cratech, Sud Chemie); PI: S. Gangwal:* Develop the therminator module for biomass gas cleanup at 600-700°C. Goal: tar < 0.1 g/m^3; NH^3 > 90% decomposition; H_2S < 20 ppm.

- *Trace Metal Scavenging from Syngas (SRI, UAB, Southern Co., GTI); PI: T. Gale:* High-Temperature sorbents for trace metal capture.

The recent results from in-situ reforming of tar with Olivine in the FICFB technology development at TUV shows promising results with Nickel-Olivine. A comparison of tar content and tar components for Olivine and Nickel Olivine are given below:

	Olivine	Nickel-Olivine
Tar, gms/Nm^3 (dry gas)	12.7	1.2
Indene	52.6%	65.8%
Naphthalene	29.9	23.1
Acenaphthalene	4.8	0.4
Styrene	2.7	6.5
Phenanthrene	2.1	Part of 'Other'
Phenol	1.7	2.8
Fluorene	1.5	0.6
Other	4.7	0.8
Total	100.0	100.0

TUV has also reported the following performance of a monolithic commercial Ni Reforming honeycomb catalyst installed after the gasifier:

	Raw Gas	% Conversion
Tar, gms/ Nm^3 (dry gas)	10.7	99.3
Indene	10.0 %	100 %
Naphthalene	59.0	99.7
Acenaphthalene	10.0	100
Styrene	10.0	95.7
Phenanthrene	4.0	Part of other
2-methyl naphthalene	3.0	Not available
PAH (excl. naphthalene)	-	99.6
Other	4.0	-
Total	100.0	

On conventional solvent scrubbing of raw gases, TUV has tried different solvents and report the extent of tar solubility, expressed as mg/litre, in fuel oil, rapeseed oil, and RME as 117.6, 150.4, and 220.0 respectively.

Another significant gas cleaning effort that is worth tracking is being conducted in support of the Two-Stage Carbo-V®-Gasification Process developed by CHOREN. This process recovers heat from raw gases, removes particulates in membrane filters (100 mg / Nm^3 to 10 mg / Nm^3), and scrubs the product with water etc to produce a clean synthesis gas for subsequent conversion to biofuels. With three stage scrubbing and active carbon adsorption, sulphur in product is reduced to <2 mg/ Nm^3, Cl < 1 mg/ Nm^3, and alkalis reduced to zero.

Advances in High-temperature Gas Cleaning. Porvair has been actively developing a variety of separation processes for coal gasification applications. Many of these separation techniques can be employed with appropriate modifications for biomass gasification. The

products developed so far include:

- Multiple stage separation processes: combination of cyclones/filter elements/catalyst unit.
- Hi-flow multi-cyclone with advanced separation efficiency: advanced cyclone design utilising modified material construction.
- Metallic media for surface filtration: metal fibre using high temperature cermets; and metal powder membranes designed for high efficiency and rapid filter cake discharge following pulse-jet.
- Metal foam for catalytically active filters.

Porvair has an active development effort to demonstrate the benefits of an integrated multiple stage separation process particularly for biomass gasification. The challenges for raw gas clean-up are identified as:

Particulate concentration	up to 1% of flow, by mass
Tar concentration	~ 4000 ppm
Particle size distribution	< 100 micron
Solids bulk density	300 - 600 kg/m^3

When fully developed and demonstrated the integrated systems (ex: pre-filtration cyclones followed by membrane filters and/or catalytic membranes) should improve solids removal/recovery; increase efficiency of pulse jet cleaning; reduce pulse jet operation; and reduce the number of contaminants emitted. As a part of this effort, Porvair is evaluating a variety of permeable media. Rigorous methodologies are followed for metallurgy selection based on gas composition, temperature, and strength to tolerate anticipated pressure drop across membranes to identify:

- media in range of metals and cermets to withstand 900^{0}C.
- sintered metal fibre, sintered metal powder and membrane combinations.
- media which exhibits a permeability range of 3.1 x 10-11 m^2 to 1.8 x 10-13 m^2.
- media which exhibits an efficiency of 99.98% removal of > 0.3 micron particles.
- media with 95% of pore size distribution < 0.45 micron.

Back flushing is an integral part of any membrane separation. Porvair's novelty for designing back flushing is based on the use of the kinetic energy in the pulse air/gas and partially converting it to pressure energy at the venturi. In doing so a sonic pulse results which can effectively clean deposits on membranes.

Porvair has extensive experience with metal foam, used as catalytically active filter in diesel particulate filters. Metal foam is a promising substrate for gas clean-up with high catalytic surface area, low-pressure drop, and good depth filtration properties. Porvair is currently exploring opportunities and partnerships to develop metal foam in biomass gasification hot gas clean-up applications.

Another novel, exploratory yet interesting research is the evaluation of 'Pulsed Carona' tar removal at the Technical University of Eindhoven, The Netherlands (Prof. Guus Pemen, *a.j.m.pemen@tue.nl*). A brief comparison of thermal versus non-thermal plasma is given below:

	Thermal plasma (arc, torch)	Non-thermal plasma (corona, DBD)
Electron energy (eV)	1 - 2	5 - 12
Gas temp. (K)	500 - 15000	300
Electron density (cm-3)	1016 - 1019	1010 - 1014

A pulsed corona is generated by electrical discharges, produced by fast, short duration high-voltage pulses. It is an efficient source of electrons, radicals, and excited molecules. When energetic electrons (<12 eV) collide with gas molecules, the result is a production of O* or OH* radicals. These radicals are chemically very active and they easily attach to or modify other molecules (namely, tars and other hydrocarbons) that it comes in contact with. The development of effective plasma involves the investigation of the influence of power modulator on plasma processing by systematic variation of pulse parameters.

At carona densities of 200 to 500 kJ/Nm^3, naphthalene is completely decomposed at 200^{0}C. In general higher carona densities are required under reducing conditions compared to inert gas conditions. Based on initial investigations that led to complete decomposition of naphthalene, it is determined that tar decomposition occurs mainly via oxidation by O-radicals (O + tar - products). However, CO is a major quench for O-radicals (O + CO - CO_2 + M), but such quenching is less at higher temperatures. However, at higher temperatures, H- radicals inhibit the tar decomposition process.

Results from a typical pilot field test are tabulated below:

Field test at corona energy density 148 J/L			
	Inlet (mg/Nm^3)	Outlet (mg/Nm^3)	Conversion (%)
Total tars	771	434	39
Heavey tars	603	232	62
Light tars	114	202	-77

The economics of carona discharge are determined by the ability to selectively removing tar, dust and other contaminants without sacrificing product gas quality. The estimated energy consumption is about 200 kJ/Nm^3. However, the consumption of energy can be reduced with new developments in corona energisation, process optimisation, and combined plasma/catalytic processing. Investment costs per kW corona power range from 4000 to 6000 Euro or about 224,000 to 420,000 Euro per 1000 Nm^3/hr.

The carona discharge work described above is the combined effort of TU/e - pulsed power, plasma physics, plasma chemistry; CWI, Amsterdam - plasma modelling; ECN - field testing, evaluations; RAS Institute High Temperatures (IVTAN) - plasma chemical modelling; and Moscow Institute Physics and Technology (MIPT) - plasma modelling.

In support of commercialising the GSP Bioliq Process for biofuels, Forschungszentrum Karlsruhe GmbH, or Institute for Technical Chemistry (ITC) has been conducting an exhaustive screening of sorbents for removing trace constituents of HCl and H_2S from hot raw gases. Sorbents have been tested individually and in some cases in series of reactor columns. The results from these investigations will be presented in the WS5 report. Other significant gas clean-up research at ITC include basic research on filtration of sticky and fine particles, sorption of HCl, H_2S by alkali/alkali earth based sorbents up to 800°C, low-temperature catalysis of PAH at 450 to 550°C for tar removal/reforming, development and testing of ceramic candle filters, catalytic coatings of filter materials and elements for tar conversion, reforming, and NH_3 conversion, development of nanostructured highly porous filter membranes, high-temperature synthesis gas cleaning at 500 to 800°C (bioliq™ process) and high-temperature pyrolysis gas cleaning and conditioning (HALOCLEAN™ process).

Observations from the Workshop WS6 'Biomass Gasification: Success Stories and Lessons Learned'

The USA experience and lessons learned with BMG process development are numerous. NREL reported the following at WS6:

- Herbaceous or fibrous biomass requires extraordinary care in handling and feeding. Their low bulk density presents serious problems in designing effective feed handling and high-pressure feed systems.
- Biomass with high volatile matter content and those resulting in reactive chars can be gasified in indirectly heated gasifiers to produce a medium calorific value fuel gas without the use of oxygen.
- If not properly controlled, gasifiers can produce tars that will have large water-soluble components.

At the recently completed USDOE sponsored 30x30 workshop in August 2006, on strategies for BMG and biofuels the key technology issues with scale-up and product gas quality, and process integration were identified as feeder systems; gas cleanup: tars, sulphur, particulates, etc.; matching scale to economy; and lack of adequate demonstration of technologies. The non-technical issues were:

- Business links - fuel resources > conversion > product distribution.
- Competition between biomass, coal, natural gas, and tar sands for talent, construction materials, capital.
- Competing markets for resources.
- Permitting issues.

The 30x30 workshop panel recommended the following R&D needs: feeders (solid biomass); high temperature materials, especially for black liquor gasification; synthesis gas conversion to match scale - better processes/catalysts; gas cleanup; gasifier type; blended fuels; and technology demonstrations.

In the general scheme of selecting commercial projects it is desirable to select processes with extensive operating experience in proposed configuration and demonstrated for 1000-2000 hours at steady state conditions. Scale-up by a factor of 10 is too large to incorporate guarantees and warranties for unproven unit operations, in particular for downstream unit operations dependent on unproven upstream operations. Plant design and construction checking and verification of engineering drawings is vital to ensure mechanically and thermally suitable components are manufactured.

Fuel selection and supply is important and the trade-off between cost and quality should be resolved to ensure sustained supply of fuel with in the desirable range of specifications. Next, fuel yard and fuel feed system are cited as areas giving most problems during start-up phase. Potential problems include odours, pile heating, varying moisture content, and feed handling.

Some of the non-technical issues include competent project management, selection of a competent E&C firm, provision of resources for environmental assessment, project financing, institutional issues, permitting and regulatory issues, partnerships with key customers and suppliers, and the need to demonstrate economic and environmental benefits to local area.

Thomas R. Miles, Jr., Consulting Engineer, reiterated the feed handling issues, given that the bulk density of materials vary quite a bit requiring care in designing both feed handling and feeder equipments. On the business end, quality controlled fuel supply and procurement are major issues for reliable plant operations. It should be noted that fuel supply and reliability are difficult with urban fuels. Contracts, tipping fees, tax credits are essential to first-of-a-kind plant. Besides tax credits, it is important to have good power/product contracts.

Process components should be designed to handle highly abrasive moist feedstocks, although it is desirable to handle uniform dry feed for good gas quality. In-bed feeding for fine wood fuels is essential to ensure carbon conversion and utilisation. Processes should be designed to utilise all forms of waste heat in the best way possible. Ash recycle to energy plantations will ensure returning P and K which may be adequate to pay for feedstock handling costs.

Mr Jim Campion of Biomass Engineering, UK reported a very successful marketing effort. For the present, the Company has decided to manufacture, assemble, and ship 250 kWe gasifier and filter module for several European cities. The modular design enables flexible

site layout and ease of installation for multi-unit sites. The modular units are cold tested at the factory prior to shipping.

The operational issues discussed include fuel delivery systems (bridging in lock hopper, chip size/quality dependent on chipper, moisture outside specification), ash handling (candle failure, sealing of ash screw), gas quality (off-specification tars produced, police filter design), condensate cleaning (active carbon filtration), and WID compliance (cost, fuel risk, corrosion/life issues).

Thomas Koch of TKEnergi reported that the non technical challenges include generally inadequate financial support structure and lack of resources to solve unforeseen problems, keeping and motivating key employees, and the frequent change in national energy policy and as a result the change in financial conditions. Cost competitiveness is still a major issue for biomass energy. The technical choices to cut cost include designing gasifiers without any hot and moving parts and a system that is simple in design and proven for reliable operation. The technical challenges include (explosion safety, gasifier bed stability, mechanical stability of system, thermal transients, life time of ceramics and insulation, reliable measurements of temperature and pressure in zones where tars are present, filter operation, and char loss). It is also reported that parts subject wear and tear should have a minimum life of 2500 hours, preferably 6000 hours.

Many of the WS6 speakers pointed out that the commissioning phase of demonstration projects requires resources typically not allocated in original planning because of optimism and impact on internal rate of return. The related challenges are how to provide for contingencies during project development and how to maintain credibility during an extended start-up phase.

Collaboration with Other Tasks/Networking

Task 33 continues to collaborate with some of the IEA Bioenergy Tasks, plus IEA Hydrogen Annex 16, IEA Pulp and Paper Annex XV, and European GasNet. In addition, the two workshops WS3 and WS4 were organised in conjunction with the Swedish SYNBIOS Conference and in cooperation with European GasNet/ThermalNet activity, respectively.

Deliverables

The Task deliverables include planning and conducting six semi-annual Task Meetings focused on the workshops selected by the Task participants, involving academic and industrial experts, the preparation and distribution of workshop reports; updating Country Reports, a report on biomass gasification activities in all the participating countries of the Task; conducting joint studies, conferences, and workshops with related Tasks, Annexes, and other international activities to address mutually beneficial issues; and preparation of periodic progress, financial, and annual reports as required by the ExCo.

TASK 34: Pyrolysis of Biomass

Overview of the Task

Task 34 started in January 2004 and will finish in December 2007. By agreement between the EC and IEA Bioenergy, it is integrated with the EC Pyrolysis Network, which is part of the new ThermalNet project that started in January 2005 and will finish in December 2007. Thus the two activities are properly synchronised.

The technical focus of PyNe is through a set of Tasks that are firmly integrated with the other two complementary networks on biomass gasification (GasNet) and combustion (CombNet). This has been shown in previous reports with the interesting feature close interactions and complementarity between the three technology areas.

The main activities of Task 34 will continue to focus on resolution of technical issues to aid commercial implementation of fast pyrolysis, information exchange and dissemination by:

- dedicated and focused regular meetings centred on technologies and tasks that will advance the state-of-the-art through critical reviews and commissioning of specialist material,
- collation and dissemination of relevant information through the regular PyNe newsletter, the PyNe website, and direct contact between Task participants and invited guests through the planned programme of meetings, workshops, and conferences,
- a focus on biorefineries to reflect the rapidly growing interest in this area in both Europe and the USA, and
- organising a Round Robin on lignin pyrolysis and processing involving 14 laboratories in Europe and the USA.

Participating countries: Germany, Norway, USA and the European Commission
Task Leader: Professor Tony Bridgwater, Aston University, United Kingdom.
Operating Agent: Dr Kyriakos Maniatis, European Commission, Belgium.

The Task Leader directs and manages the work programme. A National Team Leader from each country is responsible for coordinating the national participation in the Task.

For further details on Task 34, please refer to Appendices 2-6 inclusive; the Task website *www.pyne.co.uk* and the IEA Bioenergy website *www.ieabioenergy.com* under 'Our Work: Tasks'.

Task Meetings and Workshops

Two meetings have been held during 2006: at Lille in April and Glasgow in September. The presentations have been published on the PyNe/ThermalNet websites for all participants.

The next meeting will be held in March 2007 at the 'Success and Visions in Bioenergy' workshop in Saltzburg, Austria. The ExCo has approved sponsorship of this workshop at the level of US$3,000. A meeting of the ThermalNet Task Leaders will be held in Paris in June 2007. The final full meeting will be held in Naples, Italy in October 2007.

Work Programme

The work programme for the ThermalNet project has been published and reported previously. The special PyNe activity on biorefineries provides a focus for PyNe activities and members and has a session at each PyNe meeting. This is led by the USA. Definitions, specifications, and RD&D requirements for biorefineries are being published in the next newsletter as a result of the workshop held in Glasgow. Of particular interest is a Round Robin on lignin pyrolysis in which 14 laboratories around the world are participating.

Newsletter

The PyNe newsletter continues to be an important vehicle for dissemination and is circulated to Member Countries for distribution. The last issue was published in July 2006 and the next issue is at the printers and will be published in December. The PyNe newsletters are now integrated into a combined ThermalNet newsletter that includes GasNet and CombNet to minimise duplication of circulation lists and also to reach a wider audience. These have a circulation of around 5000.

Website/Dissemination

The PyNe website is an important mechanism for information and technology transfer. There is an ongoing programme of maintenance and revision.

Deliverables

Progress Reports to the Executive Committee were produced in May 2006 for ExCo57 in Paris, and in October 2006 for ExCo58 in Stockholm. The presentations from the Task meetings held during 2006 – Lille in April and Glasgow in September have been published on the ThermalNet and PyNe website.

The proceedings from the Victoria Conference 'Science and Technology in Thermal and Chemical Conversion of Biomass' have been published in 2006.

A Technology Report on pyrolysis is included in this annual report.

TASK 36: Energy Recovery from Municipal Solid Waste

Overview of the Task

The objective of Task 36 is to maintain a network of participating countries as a forum for information exchange and dissemination. The waste and energy sector worldwide is currently undergoing a period of intense legislative and institutional change. Keeping abreast of both policy and technology developments is a prime aim of the Task. The sharing of good practice and/or new technology and techniques is also a major goal. The Task participants have chosen a number of key Topic Areas for inclusion in the work programme.

Over the last few years some significant European-led changes have occurred in solid waste management. These include the adoption by the EU of the Landfill Directive, the agreement on a common position on harmonising MSW and hazardous waste incineration and the increasing application of best practice or life cycle based analysis to the determination of waste management policy. These changes will have a profound impact on the way in which solid waste is dealt with, and consequently on the role, and potential for, energy recovery within this. Whilst this impact will be most acute in Europe, other countries will have an interest in developments in Europe and may also follow EU practice.

The pressure to divert biodegradable and combustible waste from landfill is driven by a combination of legislative changes and economics – increasingly there is a shortage of suitable landfill void and its cost base is increasing. These drivers provide an opportunity for the development and deployment of cost-effective energy recovery systems. The deployment of these systems depends on improved efficiency (where the systems are already in place) and a legislative framework that encourages their development. In the latter case information on environmental impacts and costs is of prime importance for decision makers. The work programme for this Task aims to provide such information in a form that is readily accessible to decision makers.

Participating countries: Australia, Canada, Finland, France, Germany, Japan, Norway, Sweden, United Kingdom and the European Commission.
Task Leader: Dr Niranjan Patel, Cornwall County Council, United Kingdom.
Operating Agent: Mr Gary Shanahan, Department of Trade and Industry, United Kingdom

The Task Leader directs and manages the work programme. A National Team Leader from each country is responsible for coordinating the national participation in the Task.

For further details on Task 36, please refer to Appendices 2-6 inclusive, the Task website *www.ieabioenergytask36.org* and the IEA Bioenergy website *www.ieabioenergy.com* under 'Our Work: Tasks'.

Task Meetings and Workshops

Task 36 held two meetings in 2006. The first was held on 31 May – 2 June in Amsterdam, the Netherlands. There were site visits to the city of Amsterdam Waste and Energy Company and the OMRIN MBT plant at Ecopark De Wierde. At the meeting there were invited speakers from FZK Karlsruhe, SenterNovem the Netherlands and also from the European Recovered Fuels Organisation. The second meeting was held on 22-24 November in Espoo, Finland. There was a site visit to Lassila & Tikanojas (the largest private waste company in Finland) new SRF processing plant in Turku. Speakers were invited from Kvaerner Power Oy, the Helsinki Metropolitan Area Council YTV, Lassila & Tikanojas and from VTT.

Work Programme

The Task work programme is comprised of five key Topics Areas as follows.

- Product stewardship/producer responsibility.
- Mechanical biological treatment.
- Greenhouse gas balances for MSW systems.
- Micro-particulate emissions – pm10.
- Thermal treatment of sewage sludge.

Progress on each Topic Area is summarised below.

Product stewardship/producer responsibility

The principle of 'Producer Responsibility' means that the manufacturers, importers, distributors and retailers of products that give rise to the generation of wastes, should take collective responsibility for those wastes, rather than expecting the community to bear the burden of arranging and paying for waste collection, treatment and disposal. The meaning of 'producer' in this context is much broader than the normal sense. Considering the lifecycle of a product from its manufacture until the end of its useful life, it is not only the manufacturer who influences the waste generating and management characteristics of a product – others also play a significant role. However, it is the manufacturer who has the dominant role, since it is the manufacturer who takes the key decisions concerning the design and composition of the product that largely determine its waste generating potential and management characteristics.

The Waste Management Association of Australia led this Topic. The EC, the UK and France also contributed. The project was undertaken in two stages and two reports have been published: a Stage 1 Report 'Discussion Paper on the Theoretical Concepts and Potential Surrounding Extended Producer Responsibility and Product Stewardship'; and a Stage 2 Report 'Review and Assessment of the Performance of PS/EPR Schemes'. The contributions from industry and sponsorship for this topic amounted to AUD$132,000.

Mechanical biological treatment

An alternative to the conventional 'mass burning' of residual MSW, which is of current interest, is the so-called mechanical biological treatment (MBT) processes. These typically split the residual waste stream into three fractions: a recyclable stream (glass, metals), a biological stream (for composting and anaerobic digestion), and a fuel stream for energy recovery. There are about 50 such facilities in operation in Europe mainly in Germany and Austria. There is considerable interest in the rest of Europe in these technologies as a means of achieving the requirements of the Landfill Directive.

This Topic is being undertaken by AEA Technology in the UK. It will be carried out in close co-operation with Task 37. An initial database of MBT plants has been created, which is now available on the Task 36 website. A case study titled 'MBT in Ennigerloh' (Germany) is available and a further two case studies of Eastern Creek (Australia) and SBI Freisland, Omrin, (Netherlands) are being drafted and will be finalised in 2007.

Greenhouse gas balances for MSW systems

This Topic is being led by CANMET in Canada. The scope of the project was modified during 2005. Originally it included the development of a comprehensive spreadsheet that would encompass both GHG implications and economics of management strategies for MSW and provide a waste management optimisation tool. However, the funding body – The Canadian Government Panel on Energy R&D (PERD) – has advised CANMET that work has already been done in Canada to produce an environmental analysis model 'ICF'. This model is able to evaluate the lifecycle environmental and energy effects of waste management processes but does not contain the capital, operating and maintenance costs of these technologies. The objectives of the project were:

- to develop an economic model to be used in conjunction with the ICF;
- to provide a waste management optimisation tool; and
- to show a clear picture of how Canada's management of MSW can assist in meeting Kyoto Protocol targets.

In 2005 the Economic Spreadsheet Model was developed. This comprised:

- Data for three Canadian case studies and economic analyses. Specifically, for the BTA demonstration plant in Toronto; the Edmonton composting facility; and the Burnaby waste-to-energy facility in Vancouver.
- Development, testing and debugging of the comprehensive economics spreadsheet model.
- Running the model (performing optimisation exercises) on a number of scenarios, in conjunction with runs on the ICF Model.

The work programme in 2006 was focused on completion/exporting the model to participating countries. Specifically, fine-tuning of the model and updating of data; provision of instruction in model modification/use to those participating countries desiring this assistance; and preparation/delivery of the final report/model.

Micro-particulate emissions - pm10.

Fine particles can be detrimental to health and are very difficult to reduce with the conventional precipitators. Waste incineration produces fine particles, which contain toxic elements, such as heavy metals. Decreasing total particle emissions does not necessarily decrease fine particle emissions. There are no plans at the moment to set emission limits for different particle size classes (PM0.1, PM1, PM2.5, PM10) formed in incineration, but it is possible in the future because small particles penetrate deep in the airways. There is not much reported information about formation of fine particles or emissions from incinerators or combustion of sorted household waste. In addition, no previous studies are found on the effect of waste quality, sorted vs. unsorted waste, on formation of fine particles and especially on the amount and occurrence of heavy metals.

The Topic was undertaken by VTT in Finland and was completed in June 2006. The project had the following objectives:

- to study the formation of fine particle emissions in waste combustion;
- to study the effect of waste quality on fine particle formation;
- to assess the ability of reducing fine particle emissions with different types of flue gas cleaning equipment;
- to optimise the size and order of flue gas cleaning equipment according to the quality of waste; and
- to assess the possibility to reduce harmful fine particle emissions by producing SRF of higher quality.

The work comprised both laboratory analyses and measurements at waste combustion plants. Fine particle measurements complemented by Waste Incineration Directive related emission measurements were conducted at three plants. Two of these were waste incineration plants in Sweden – a grate-fired district heating plant and a large CFB plant. The third was a co-combustion plant producing steam and electricity. All of the plants were equipped with a bag house filter combined with usage of lime and activated carbon. These filters proved to be highly efficient. Collection efficiency of fine particles was over 99.9%. All trace metal and other measured emissions (particle emissions, dioxins) were below the limits set by the EU Waste Incineration Directive.

The laboratory work and final reporting was completed in spring 2006 and the results will be summarised in the Task 36 final report.

Thermal treatment of sewage sludge

This Topic was led by SINTEF. In Norway, the market for small-scale combustion plants is still attractive, but competitors are struggling to come up with a competitive edge. Norske Inova which is currently in the cruise ship market has developed a system to process organic sludge, which would be possible to integrate with WtE plants. The programme of work for this Topic comprises an international overview of sludge handling in, or in conjunction with, EfW plants (combustion plants) focussing on:

- drying/dewatering;

- feeding systems;
- technologies for burning sludge;
- operational experience of plants burning sludge; and
- environmental experience/consequences of burning sludge.

During 2006 SINTEF contacted Task participants to request literature and help in identifying the relevant industry experts within this field in order to get a comprehensive overview not only on possible technologies to be used, but also on the operational experience of plants. A draft of the final report is now available.

Collaboration with Other Tasks

The Topics 'Greenhouse Gas Balances for MSW Systems' and 'Mechanical Biological Treatment' overlap with the interests of Tasks 38 and 37 respectively. Task 36 reviewed a case study 'GHG impacts of using MSW for energy generation' for Task 38.

Deliverables

The deliverables for the Task in 2006 included: two progress reports to the ExCo; audited financial reports as required by the ExCo; minutes of the Task meetings and technical reports as detailed in Appendix 4.

TASK 37: Energy from Biogas and Landfill Gas

Overview of the Task

The overall objectives of Task 37 are to review and exchange information on anaerobic digestion (AD), and to produce, upgrade, and utilise biogas as an energy source, digestate (compost) as an organic fertiliser, and the anaerobic degradation process as a link in the chain of waste (water) treatment.

The scope of the work focuses on adoption of appropriate waste management practices, promotion of the commercialisation of biogas installations, improvement of the quality of the products, and improving environmental standards. Through the work of the Task, communication between RD&D programmes, the industry, and governmental bodies is encouraged and stimulated. Continuous education as well as specific information for decision makers have been recognised as important topics.

To achieve the objectives, the Task maintains strong relationships with the governments of Member Countries, R&D institutions and industry. Partners are plant and equipment providers, actual and future operators and potential clients interested in the products of anaerobic digestion, i.e., fertiliser (digestate) and biogas.

Participating countries: Austria, Denmark, Finland, Germany, the Netherlands, Sweden, Switzerland, United Kingdom, and the European Commission.
Task Leader: Dr Arthur Wellinger, Nova Energie GmbH, Switzerland.
Operating Agent: Bruno Guggisberg, Swiss Federal Office of Energy, Switzerland.

The Task Leader directs and manages the work programme. A National Team Leader from each country is responsible for coordinating the national participation in the Task.

For further details on Task 37, please refer to Appendices 2-6 inclusive; the Task website *www.iea-biogas.net* and the IEA Bioenergy website *www.ieabioenergy.com* under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

Two major Task meetings were held in 2006. The first meeting took place on 20-22 April in Eskilstuna and Stockholm, Sweden. The participants met at the Swedish Energy Agency (STEM), where Björn Telenius gave an introduction to the new, seven year, Swedish R&D programme on renewable energies. Biomass is at the top of the agenda of the €95 million programme. The major focus will be on alcohol production from lignocellulosic material, black liquor, and pressurised gasification. Country reports were presented by the National Team Leaders and also by an exchange student from Chile. The second part of the business meeting in Stockholm was used to plan the programme for the new triennium 2007-2009.

Half a day was dedicated to visit the Växtkraft plant in Växjö. It is a fully integrated system with agricultural ley crop production, storage, collection of source separated waste, digestion, and recycling of the digestate as fertiliser. 14,000 tpy of organic waste from 130,000 households are combined with 4,000 tpy of grease from kitchens and 5,000 tpy of lay crop (corn, clover) from agricultural land. The crop is ensiled and stored next to the plant. The predicted gas production at full load is 550 m^3 per hour. The biogas from the digester is combined with gas from the wastewater treatment plant. The combined biogas is upgraded to natural gas quality with a methane content of 97% and used as car and truck fuel. A production of 2.3 million litres per year of petrol equivalent is expected.

In Eskilstuna the Task participants visited the wastewater treatment plant which serves 90,000 inhabitants. The sludge together with other wastes from industry is digested in four digesters. The total biogas production is 1 million m^3 per year yielding 600,000m^3 of upgraded biogas (CH_4 97%). The upgraded biogas is compressed to 5 bar and transported to the bus depot, a distance of about 1 km to serve 10 buses and 130 light duty vehicles.

The second meeting took place on 14-16 September in Braunschweig, Germany. Dr Petra Schüssler of Fachagentur Nachwachsende Rohstoffe (FNR), the agency in charge of the biomass R&D programme, gave an overview on the focus of the programme and on the current research projects. Then, as has happened previously, the Task and the German Biogas Association organised a meeting with planners and constructors of biogas plants and equipment. A formal introduction was followed by bilateral discussions in a casual but fruitful environment.

Work Programme

In 2006 the work programme consisted of the following Topics:

- Business meetings.
- Website: update; maintenance; proceedings.
- Industry forum: meeting with German industrials.
- Success stories.
- Brochure on biogas upgrading and use in gas vehicles.
- Publication of workshop on 'Integrated Waste Management and Utilisation of the Products'.
- Technology Report for ExCo58.

The progress made on each Topic is summarised below.

Business meetings

The Task met for two business meetings where major information transfer between the participating countries took place.

Website

The website (*www.iea-biogas.net*) was updated with news and meeting dates on a monthly basis. The country reports were made available along with contributions from observers.

Industry forum

To improve the information transfer with industry the Task organised jointly with the German Biogas Association an informal exchange of ideas during the second Task meeting in Braunschweig.

Success stories

A number of new success stories from Sweden and Austria are in preparation. Two will be published on the Task website describing Linköping gas upgrading and the first Austrian gas upgrading plant. Three more will follow.

Gas upgrading and gas vehicles

Biogas as a vehicle fuel is becoming increasingly popular. Germany and Austria have both started to inject upgraded biogas (biomethane) into the grid and are building the first pumping stations. The Task's expertise is being accepted throughout the biogas community.

It expects to contribute to a brochure for the BiogasMax project – a Framework 6 project – with 26 partners lead by six European cities which will convert public buses to biomethane.

A Technology Report for the ExCo has been written which will also be published in Bioeng. & Biotech. A new brochure on 'Biogas Upgrading to Vehicle Fuel Standards and Injection into the Grid' has been edited and is in press.

Workshop on 'Integrated Waste Management and Utilisation of the Products'
The Task contributed to a summary of the workshop held in Dublin in October 2005.

Collaboration with Other Tasks

The ExCo workshop above was organised in collaboration with Task 36 and both Tasks have worked on the proceedings. There has also been collaboration with Task 36 on the potentials and limits of Mechanical Biological Treatment.

Deliverables

The deliverables for the Task in 2006 included: the website, two progress reports, a Technology Report, minutes of the Task meetings, the country reports, a success story, and the biogas upgrading brochure.

TASK 38: Greenhouse Gas Balances of Biomass and Bioenergy Systems

Overview of the Task

The objective of Task 38 is to integrate and analyse information on greenhouse gases, bioenergy, and land use, thereby covering all components that constitute a biomass or bioenergy system. The current Task focuses on the application of methodologies to greenhouse gas mitigation projects and programmes.

Participating countries: Australia, Austria, Canada, Croatia, Denmark, Finland, Germany, Ireland, the Netherlands, New Zealand, Norway, Sweden, and the USA.
Task Leader: Dr Bernhard Schlamadinger, Joanneum Research, Austria.
Co-Task Leader: Ms Kimberly Robertson, Force Consulting, New Zealand.
Operating Agent: Dr Josef Spitzer, Joanneum Research, Austria.

The Task Leader directs and manages the work programme. The Task Leader is assisted by Susanne Woess-Gallasch (Joanneum Research) and Kimberly Robertson (Force Consulting). A National Team Leader from each country is responsible for coordinating the national participation in the Task.

For further details on Task 38, please refer to Appendices 2-6 inclusive, the Task 38 website www.ieabioenergy-task38.org and the IEA Bioenergy website *www.ieabioenergy.com* under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

In collaboration with Task 40 and Enova the Task organised the following meetings in Trondheim, Norway:

- 3-4 April: an internal Task Business Meeting
- 5-6 April: a workshop on 'Greenhouse Gas Credits Trade versus Biomass Trade: Weighing the Benefits'. The programme and presentations can be found at: *www.iea-bioenergy-task38.org/workshops/trondheim06/*. A summary was prepared for the IEA Bioenergy News Volume 18(1).
- 6 April: a study tour to Allskog's wood chipping facilities at Elkem Thamshavn and Fesil Holla.

Work Programme

In 2006 the Task worked on:

- the organisation of one Task meeting in Trondheim, Norway;
- the planning and continuation of special projects such as case studies;
- updating of the website to provide an easy to use guide for GHG analysis of biomass and bioenergy systems;
- development of online calculation tools to calculate the GHG impact of different bioenergy systems compared to fossil fuel systems in CHP processes;
- publication of a paper on 'Soil Carbon';
- preparation of a brochure on 'Options for Trading Bioenergy Products and Services'
- preparation of a special issue of the journal 'Mitigation and Adaptation Strategies for Climate Change';
- planning for the Task prolongation; and
- planning for a strategic ExCo paper on 'Lifecycle Analysis of Biomass Fuels, Power, Heat, and Products as Compared to their Petroleum-Based Counterparts and Other Renewables'.

Case studies

Work on case studies to analyse specific bioenergy and carbon sequestration projects continued. The goal is to assess and compare the GHG balances of such projects in the participating countries, and to make recommendations for optimisations of these systems. All case studies started in the previous Task period (2001-2003) have now been published and are available at *www.joanneum.at/iea-bioenergy-task38/projects/task38casestudies/*

Case studies from Canada (use of pellets from mountain pine beetle infested wood, hybrid poplar and sawmill residues to produce bioenergy) and Ireland (use of MSW for energy production arising from thermal treatment) were completed in 2006. The reports and brochures are available at *www.ieabioenergy-task38.org/projects/*

The following case studies were initiated in this Task period and will be completed in 2007.

- Austria/Croatia: Dedicated energy crops for biogas production in Austria and JI assessment for such a plant in Croatia (only the Croatian part is to be funded by the Task).
- Denmark: Alternative applications for thermal energy arising from biomass fired co-generation plants: The case of a South African CDM project with an additional socio-economic analysis.
- Australia: Impact on GHG balance of utilising char as a soil amendment.
- USA/Netherlands: Greenhouse gas balance of biofuels produced via gasification.

Soil Carbon paper

The Task is publishing a paper on 'Soil Carbon in Bioenergy Systems'. This 12 page coloured brochure was prepared by Annette Cowie from the New South Wales Department of Primary Industries, Australia. It focuses on the relationship between soil carbon sequestration and bioenergy, addressing the implications of the overall GHG balance of bioenergy and land use projects, and for carbon accounting under the Kyoto protocol. It will be available in early 2007.

Brochure on 'Options for Trading Bioenergy Products and Services'.

In cooperation with Task 40, the Task produced a feature article for the IEA Bioenergy 2005 Annual Report. A coloured brochure based on this article has been prepared, including a summary of the joint Task 38 and Task 40 workshop on 'GHG Credits Trade versus Biomass Trade - Weighing the Benefits' in Trondheim. It will be available in early 2007.

Special issue of the journal 'Mitigation and Adaptation Strategies for Climate Change'

This issue has been edited by Task participants Leif Gustavsson, Roger Sathre, Bernhard Schlamadinger, and Kimberly Robertson. It features papers presented at the Östersund (September 2003) and Rotorua (March 2004) Task workshops - see Appendix 4 for details.

Strategic paper for the ExCo

The Task started planning a strategic paper for the ExCo on 'Lifecycle Analysis of Biomass Fuels, Power, Heat, and Products as compared to their Petroleum-Based Counterparts and Other Renewables'. A draft proposal was prepared for ExCo58 and this will be amended according to the comments received.

Collaboration with Other Tasks/Networking

The Task collaborates widely with other IEA Bioenergy Tasks and also external organisations. A joint workshop with Task 40 took place in Trondheim. The Irish case study was extensively reviewed by Task 36. The Danish case study is being carried out in conjunction with Task 29. The Austrian case study involves collaboration with Task 37. The Canadian case study was carried out in conjunction with Task 40.

Technology Transfer/Communication

The Task website and the internal FTP site are continually updated. New publications and announcements are distributed through the 'climate change' mailing list.

The 'methodological toolbox' function on the website has been substantially updated to provide an easy to use guide on how to perform GHG emission reduction assessments for biomass and bioenergy systems. This is aimed at those who have some technical expertise and provides information on Defining the System; Methodologies; Software Tools; Data and Case Study Examples. The website also provides information about international climate change policy.

The Task finished work on a simple online calculator for biomass CHP and heating systems. This tool allows comparison of different bioenergy systems with fossil fuel systems and calculates GHG emission reductions. This is now available on the website.

Deliverables

Apart from the wide range of deliverables mentioned above, the Task also produced progress reports, the proposal for prolongation, and a Technology Report for the ExCo. Other outputs were minutes of the Task meeting and updating of the website. Please see Appendix 4 for more details.

TASK 39: Liquid Biofuels from Biomass

Overview of the Task

The objective of this Task is to provide participants with comprehensive information to assist with the development and deployment of biofuels for motor fuel use. The Task is building upon the successes of previous efforts to deal in a coordinated manner with both the technical and the infrastructure issues related to biofuels. To meet this objective, the Task is:

- providing information and analyses on policy, regulatory and infrastructure issues that will help participants encourage the establishment of the infrastructure for biofuels as a replacement for fossil-based fuels;

- catalysing cooperative research and development projects to help participants develop improved, cost-effective processes for converting lignocellulosic biomass to ethanol;
- providing information and analyses on specialised topics relating to the production and implementation of biodiesel technologies; and
- providing for information dissemination, outreach to stakeholders, and coordination with other related groups.

The Task structure allows participants to deal with biofuels in a comprehensive manner.

Participating countries: Austria, Canada, Denmark, Finland, Germany, Ireland, Italy, the Netherlands, South Africa, Sweden, United Kingdom, USA, and the European Commission.
Task Leader Dr Jack Saddler, University of British Columbia, Canada.
Operating Agent: Dr J. Peter Hall, Natural Resources Canada, Canada.

The Task Leader together with three Subtask Leaders directs and manages the work programme. A National Team Leader from each country is responsible for coordinating the national participation in the Task.

For further details on Task 39, please refer to Appendices 2-6 inclusive; the Task website *www.task39.org* and the IEA Bioenergy website *www.ieabioenergy.com* under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

The Task was active in 2006. On 2 May, a Task business meeting was held at the 28th Symposium on 'Biotechnology for Fuels and Chemicals' in Nashville, USA. On 27-30 August, a conference was hosted jointly with Tasks 29 and 31 and focused on biofuels within larger bioenergy systems. Details on these events are provided below.

Work Programme

The work programme for the Task included the following elements.

Providing information on policy, regulatory, and infrastructure issues
The overall objective is to provide governments and policy makers with improved information that will help them identify and eliminate non-technical barriers to liquid biofuels deployment. Work continued in the following areas:

Country-specific information on biofuels: Task 39 continues to compile country-specific information on biofuels including fuels usage, regulatory changes, major changes in biofuels policies, and similar items. The purpose of this effort is to maintain Task 39's role as a central source of relevant information on biofuels. The Task has participated in the

EC-funded VIEWLS project by assisting with data collection – primarily to provide information from North America. New reports on barriers to biodiesel and ethanol production and use have been commissioned. This work will continue in the new triennium.

Case studies: The Task is focusing data-gathering exercises on demonstration and industrial-scale commercial facilities for biofuel production around the world. This information will provide a ready reference to the current state-of-the-art in producing biofuels. In the new triennium these case studies will focus on implementation issues.

International trade of biofuels: The Task is considering issues related to the international trade of biofuels, including supply and demand for such fuels and regulatory issues involved in promoting and developing trade. In particular, the impact of fuel mandates (already present in the EC and in parts of North America) on international demand for biofuels is being considered. The Task will work closely with Task 40 on these issues in the next triennium.

Financial instruments: The Task continues to consider ways in which capital investment in the biofuels sector might be encouraged, given the unique circumstances of individual jurisdictions. A case study of successful policy instruments for promoting biofuel infrastructure in USA has been completed, as has a market-based analysis of biodiesel implementation.

Technical aspects of lignocellulosic biomass-to-ethanol processes

The Task provides an information exchange network for participants who are conducting research and development activities in the area of lignocellulosic biomass-to-ethanol. The working group in this area is focused on the technical and economic issues related to this technology option. A workshop was held in late 2005 to address these issues in Ystad, Sweden. In early 2006, the final proceedings of the workshop held in Ystad were produced and are available on CD.

In August, the Task, in conjunction with Tasks 29 and Task 31 and the Faculty of Forestry at the University of British Columbia, hosted a workshop 'Biofuels and Bioenergy: Challenges and Opportunities'. Held in Vancouver, this event attracted 150 industrial, academic, and government participants, and provided an overview of cutting-edge issues around commercialising biofuel and bioenergy opportunities. For further information or a summary of the meeting, please contact Warren Mabee.

The conference allowed the Task participants to continue their exploration of the links that exist between technical and policy issues as they impact biofuels implementation, but within the context of larger bioenergy systems and sustainable forest management. Sessions examined country-specific polices and technical programmes covering this range of issues, as well as progress toward commercialisation from an industry point of view. The sessions were punctuated with breaks and field trips to allow opportunities for networking

and dialogue. Summaries of the sessions are provided in Issue 17 of the Task newsletter. In late 2006, the proceedings of the conference were produced and are available on CD.

Specialised topics related to biodiesel

The biodiesel subtask hosted a biodiesel workshop 'Biodiesel in Germany: Learning from a Success Story' on 12-14 June in Potsdam, Germany. Fifty biofuels experts from around the world participated in this event. The first two days included presentations on biofuel policies, biodiesel markets, production technologies, and research projects. The objective was to provide information exchange between stake holders, decision makers, and leading scientists from industry, government and funding organisations as well as lobby groups, standardisation organisations and research institutes. Participants in Task 39 used this event to learn from the German experience and vice versa. The third day saw participants take a study tour of biodiesel and biogas production plants. For a summary of the workshop including copies of presentations, please visit *www.task39.org*

Newsletter

The Task published two newsletters in 2006. They provided information about the Task activities and international events related to biofuels. These newsletters are available from the editor as detailed in Appendix 4.

Collaboration with Other Tasks/Networking

The Task has ongoing interactions with related groups. The Task is working with various EC-funded projects as described earlier to ensure effective information exchange. In 2006, the Task worked with Tasks 29 and 31 to host the joint conference in Vancouver, Canada. The Task also continued discussions with Task 40 on biomass supply and international trade of biofuels. In addition, the Task participated in a meeting with FAO experts which broadened Task communication to experts from developing countries. Finally, the Task continued to participate in the wrap-up of the EC-funded VIEWLS project.

Website

The website has been redesigned and was re-launched in early 2005 to improve access to the information produced by the Task. Please visit *www.task39.org*. This website is now being updated to reflect the next triennium of Task 39.

Deliverables

The formal deliverables for the Task in 2006 included: two progress reports, one Technology Report and audited financial accounts as required by the ExCo. Also minutes of the Task meetings and articles for IEA Bioenergy News and IEA Bioenergy Updates.

The Task produced two newsletters and five technical reports on the issues relating to the implementation of ethanol from lignocellulosics, and on biodiesel implementation in North

America. Reports on biodiesel technologies and implementation strategies are being finalised, while other reports are available through the Task website. These are detailed in Appendix 4. Finally, the Task published the proceedings of a workshop held in Ystad, Sweden, in 2005, as well as the proceedings from the joint Biofuels and Bioenergy conference held in Vancouver.

TASK 40: Sustainable International Bioenergy Trade: Securing Supply and Demand

Overview of the Task

The objective of the Task is to support the development of sustainable, international bioenergy markets and trade, recognising the diversity in resources and applications. Through the international platform provided by IEA Bioenergy, combined with industry partners, government bodies and NGO's, the Task contributes to the development of sustainable bioenergy markets both in the short- and long-term and on different scales (from regional to global).

Key aims are:

- to improve the understanding of biomass and bioenergy markets and trade;
- to analyse the possibilities to develop biomass resources and exploit biomass production potentials in a sustainable way, including supply chains and required logistics;
- to perform coherent analyses of biomass markets and trade by modelling and scenario analysis;
- to evaluate the political, social, economic and ecological impact of biomass production and trade, and develop frameworks to secure the sustainability of biomass resources and utilisation; and
- to provide a significant and ongoing contribution to market parties, policy makers, international bodies as well as NGO's through high quality information on these topics.

The vision of the Task on global bioenergy trade is that it will develop into a real 'commodity market' which will secure supply and demand in a sustainable way. Sustainability provides the key ingredient for long-term security.

Participating countries: Belgium, Brazil, Canada, Finland, Germany, Italy, the Netherlands, Norway, and Sweden and the United Kingdom.
Task Leader (Scientific): Dr André Faaij, Copernicus Institute, Utrecht University, the Netherlands.
Task Leader (Administrative): Mr Peter-Paul Schouwenberg, Essent Energy, the Netherlands.
Operating Agent: Dr Kees Kwant, SenterNovem, the Netherlands.

The Task Leaders direct and manage the work programme. A National Team Leader from each country is responsible for coordinating the national participation in the Task.

For further details on Task 40, please refer to Appendices 2-6 inclusive; the Task website *www.bioenergytrade.org* and the IEA Bioenergy website *www.ieabioenergy.com* under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

During 2006, the Task organised three workshops. The first workshop 'Future Visions of Biomass Trade' was jointly arranged with EUBIONET II for an invited group of experts in January in Utrecht. It was part of a research project carried out by the Lappeenranta University of Technology within the work programme of the Task (Deliverable 3). The workshop, attended by 14 experts, focused on collecting and refining their knowledge, experiences, and tacit information on future scenarios of biomass trade and markets. After the workshop, this research will continue and scenario drafts will be further developed with the participants. The results of the study were presented at the 3rd IEEE International Conference on Management of Innovation and Technology, 21-23 June 2006 in Singapore.

The second major workshop was held jointly with Task 38 in Trondheim, Norway (in cooperation with Enova). The main theme of this workshop was to discuss the advantages of the various trading possibilities, the necessary accounting rules, and criteria to select the most efficient mechanisms under varying circumstances. It provided a forum for government, business, and academic representatives to exchange and gain information on the status of the various biomass carbon trading and certificate trading markets. The presentations included examples of current biomass imports to several EU countries, methodological frameworks to compare the advantages of physical trading and carbon trading, certification of biomass, and an overview of developments within the clean development mechanism (CDM). In total 50 participants attended the workshop. It concluded that the various trading options for biomass and emission credits produced by biomass have various pros and cons for buyers and sellers, depending on the potentials, markets, and timeframes considered. Nevertheless, trading options strongly enhance the use of biomass, because supply and demand for energy, CO_2 emission reduction and other benefits of biomass can be matched where this was previously not the case. Furthermore, developing proper and workable GHG accounting systems and overall sustainability evaluations (e.g., for biofuel production and trade) are needed, but could be developed in conjunction with the lessons learned from CDM bioenergy projects. This is a very important field for market parties, policy makers and the participants of Tasks 38 and 40 and will be addressed in future work.

The third major workshop was held on 24-25 October in Lappeenranta, Finland. Joint organisers with the Task were: Lappeenranta University of Technology, Finnish Funding Agency for Technology and Innovation (Tekes), ClimBus Technology Programme, and EUBIONET II. The workshop was titled 'An International Seminar on Developing Bioenergy Markets Focusing on Forest Sector and Russia'. The target groups attending the workshop were specialists working in bioenergy and forest sectors as well as academics and officials who deal with related issues in their every day work. It was attended by approximately 90 participants, of which 40 were foreign visitors representing 19 different nationalities. After the seminar EUBIONET II project in collaboration with the Task organised a two day bioenergy study tour in the St. Petersburg area.

The presentations given at these workshops and the meeting reports are available from the Task 40 website, *www.bioenergytrade.org*

The Task also held two internal meetings in 2006, preceding the workshops in Norway and Finland. During these meetings the progress with and finalisation of various deliverables was discussed and plans for the continuation of the Task in 2007-2009 were decided.

Work Programme and Outputs

An overview of the work programme is given below.

Market experience. Coordinator: Sweden - supported by all participant
The aim is to obtain an overview of current trading experiences and markets as well as potential markets. A total of eight country reports were either first published or updated in 2006. These reports have been disseminated via the Task website, and are downloaded frequently. The final synthesis report is currently being written and will be included in a special issue of Biomass and Bioenergy. The Netherlands are mainly responsible for the finalisation of this deliverable.

Strategic advice on barriers, opportunities and strategy. Coordinator: Netherlands - supported by all participants
The aim is to compile a strategic document that provides an inventory of barriers (technical, logistic, economic, organisation, regulatory) and opportunities for developing working biomass and bioenergy markets and international trade, and to formulate strategies to cope with the barriers.

The Task has published a key deliverable describing the opportunities and barriers for sustainable international bioenergy trade. The report includes a number of strategies to overcome the main barriers currently hampering international bioenergy trade. These strategies were formulated and unanimously agreed by the Task participants comprised of representatives from industry, governmental and scientific institutions. A shortened version which focuses mainly on barriers to trade has been published as a Technology Report.

Modelling markets. Coordinators: Norway, Netherlands, Finland
This activity will provide insight to the development of biomass resources and supplies in relation to market demand; e.g., by applying various modelling tools. A review was undertaken of current modelling efforts in the area of biomass and trade. This work was funded by the extra budget available in 2006, and is the main responsibility of Norway, supported by the Netherlands. Preliminary results were presented at the Task meeting in Finland and the final report will be available in February 2007.

Supply chain analysis. Coordinators: Finland, Canada, Norway, Sweden, Netherlands
This work covers performance evaluations (techno-economic) and further development/ optimisation of long distance bioenergy supply chains, in particular sea transport. The approach adopted was to undertake case studies of supply chains and transport systems. A number of logistic chain analysis studies have been carried out in Canada, Norway, Finland, and Russia. On the demand-side, a study has been published on the co-firing fuel supply situation in the UK. These efforts are currently being summarised, and will be published in a synthesis paper early in 2007.

Certification systems. Coordinators: Netherlands, FAO, UK
Issues regarding certification, standardisation and terminology for sustainable bioenergy trade were the focus of this programme. After several publications and activities on biomass certification and sustainability criteria, a comprehensive scientific paper for Biomass and Bioenergy has been prepared. The paper covers biomass certification systems, related certification systems in agriculture and forestry, policy developments within the Task participant countries on certification (mainly the Netherlands, UK, Belgium, and Germany), describes boundary conditions and possible drawbacks of certification systems, and formulates several strategies on how to further introduce biomass certification. This work was led by the Netherlands, in collaboration with FAO (Gustavo Best and Ingmar Jürgens), the UK (Jeremy Woods and Frank Rosillo-Calle) and the Oekoinstitut (Uwe Fritsche). The report was published in December 2006 on the Task website, and will be included in the special issue of Biomass and Bioenergy. It will also be published in leaflet form to reach a broader audience.

As an additional output, the Copernicus Institute and the University of Campinas published an extensive report on the sustainability of ethanol from sugar cane in Brazil, its compliance with newly-defined Dutch sustainability criteria from biomass, and potential additional costs to meet the most demanding sustainability criteria. This report will also be available on the Task website.

Pilot projects and case studies - impact analysis. Coordinators: FAO; Netherlands, UK, Canada
The aim was to identify possibilities for pilot and demonstration projects and aim for supporting their development especially in developing countries (e.g., Africa), and to provide insights (e.g., through case studies and best practice examples) to the

socio-economic and ecological impacts of biomass production and trading schemes and demonstrate how bioenergy trade can contribute to sustainable development targets.

Over the course of the triennium, several desk top case studies have been carried out, e.g., dedicated biomass plantations in Mozambique or the sustainability of ethanol production from sugarcane in Brazil. The establishment of actual pilot projects in developing countries has been slow, but in 2006 the FAO was setting up case studies in Chile, Brazil, Tanzania, Madagascar, Senegal, and the Philippines to test principles, criteria and indicators for forest biomass used for energy and wood fuel and charcoal production systems.

Evaluation of markets - ethanol. Coordinators: Brazil, UK, Canada
The focus was on evaluating markets for fuel ethanol trade and, more specifically, on the Brazilian experience of large-scale fuel ethanol production and exports. The ethanol market research was conducted over the course of 2005 and 2006. It will also be submitted to the special issue of Biomass and Bioenergy.

At the Task meeting in Trondheim it was decided to carry out two additional market studies:
- A European market study for pyrolysis bio-oil, carried out by Doug Bradley (Canadian NTL). The report was published in December 2006.
- A study on pellets and sawdust, carried out jointly by ETA Florence, Lappeenranta University, and the University of Campinas. The results will be published in early 2007.

Dissemination. Coordinators: Netherlands - supported by all participants
Dissemination of the work and results of the Task have been actively carried out at a number of conferences and workshops in 2006 (see below). Currently, a brochure is being prepared with Task 38 on trading GHG emission reduction certificates versus trading physical biomass. Also, the Task has issued a leaflet on its general activities. Another key tool for dissemination of information is the Task website.

Collaboration with Other Tasks/Networking

As described above, events were organised jointly with Task 38, EUBIONET II and other institutions. At these events the work of the Task was disseminated in presentations and papers. The work of the Task was also presented to a number of other audiences, including:
- World Bioenergy Conference and Exhibition, Jönköping, Sweden.
- 'European Technology Platform for Biofuels' conference, Brussels, Belgium.
- UN Commission for Sustainable Development (CSD-14): International cooperation on bioenergy, New York, USA.
- 'Biofuels for Transportation - Global Potential and Implications for Sustainable Agriculture, Energy and Security in the 21st Century' conference, Washington DC, USA.
- Intercoop Europe, 17th General Assembly 2006 'Bio-based Economy and the role of

Agriculture' workshop, Oostende, Belgium.

- 'The Way Forward to Sustainable Bioenergy' workshop, organised by WWF International, Brussels, Belgium
- 'Bioenergie - Welche Forschungsfragen stellen sich?' konferenz, organised by der Deutschen Bundesstiftung Umwelt und der Universitat Kassel, Kassel, Germany.
- Bioenergy Transportation. Mareforum, Rotterdam, The Netherlands
- 'Growing Fuel in Developing Countries: Lessons from Brazil and India' conference, organised by the Global Subsidies Initiative International Institute for Sustainable Development, Bern, Switzerland.
- Round-Table conference on 'Biofuels', organised by Houthoff Buruma N.V., Brussels, Belgium.
- Symposium 'Kyoto, bioenergy and forests', organised by Den Kgl. Veterinær- og Landbohøjskole (KVL), Copenhagen, Denmark.
- Expert Meeting organised by UNCTAD 'Participation of Developing Countries in New Dynamic Sectors of World Trade', Geneva, Switzerland.

The Task aims to continue this wide communication/collaboration in 2007. A joint workshop with EUBIONET II on 'Biomass Policy, Certification, and Trade' is scheduled for February 2007. Also other joint workshops are envisaged, e.g., a workshop on 'international pellet trade' with the EU-funded Pellet-@las project. Furthermore, in the upcoming triennium collaboration is envisaged with other IEA Bioenergy Tasks.

Website

The website has been maintained and developed over the triennium. A library function has been added. Visitor numbers increased from an average of 1600 per month in 2005 to over 2000 per month by the end of 2006 and the quantity of monthly downloaded data continues to increase. Task deliverables such as the country reports, logistic chain studies, the report on opportunities and barriers for trade etc., along with presentations given at workshops are available online. Visitor numbers are expected to increase further in 2007.

Deliverables

In the final year of the triennium a number of key deliverables were published as described above. Publications in 2006 included a special issue of the journal Energy for Sustainable Development on 'Bioenergy Trade and Sustainable Development'. Furthermore, Task participants also published in various journals such as Renewable Energy World and the International Sugar Journal. In 2007 a special issue of Biomass and Bioenergy will be published containing a number of the key deliverables mentioned above. Please see Appendix 4 for a full list of publications.

TASK 41: Bioenergy Systems Analysis

Overview of the Task

The objective of the Task is to supply various categories of decision makers with scientifically sound and politically unbiased analyses needed for strategic decisions related to research or policy issues. The target groups are particularly decision makers in Ministries, national or local administrations, deploying agencies, etc. Depending on the character of the Projects some deliverables are also expected to be of direct interest to industry stakeholders. Decision makers, both public and private, have to consider many aspects, so the Task needs to cover technical, economical, and environmental data in its work. The Task's activities build upon existing data, information sources, and conclusions. It does not intend to produce new primary scientific data.

The Task differs from the other Tasks in that it does not have networking as one of its prime objectives. Nor do the Task's activities have continuous and repeating components, e.g., biannual meetings, country updates, etc. The work programme has a pronounced Project emphasis with each Project having very specific and closely defined objectives.

Because of its special character in terms of participation, financing and cross-cutting orientation, the Task aims to become a valuable resource and instrument to the ExCo serving the ExCo with highly qualified resources to carry out projects, involving several parties (e.g., other Tasks and organisations) as requested by the ExCo. Due to the close contact with the other Tasks the new Task is intended to develop into a platform for joint Task work and a catalyst for proposals from the Tasks to the ExCo.

Participating countries: Germany, Sweden, United Kingdom, USA and the European Commission
Task Leader: Mr Sven-Olov Ericson, Ministry for Sustainable Development, Sweden
Operating Agent: Dr Björn Telenius, Swedish National Energy Administration, Sweden

The Task Leader directs and manages the Project work. The ExCo Member from each participating country acts as the National Team Leader and is responsible for coordinating national input to the Projects undertaken.

For further details on Task 41, please refer to Appendices 2-6 inclusive; and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Progress in R&D

Work Programme

A systems analysis is taken as the starting point, aiming at illustrating unique possibilities and options related to bioenergy as well as explanation of limitations and obstacles to

development and deployment of bioenergy. Among these limitations and obstacles are sometimes significantly lower acceptances and less factual understanding among the general population. These have been suggested as causative explanations for less public recognition for bioenergy than for other competing types of renewable energy. The work programme for the Task is being developed with the aim of bringing more clarity and up-to-date multi-disciplinary facts and discussion regarding the potential resource supply, markets, and environmental issues for bioenergy.

The work programme is intended to be comprised of a series of Projects. Each Project has its own budget, work description, timeframe, and deliverables and is approved by the participants. The focus is on the needs of the participants by way of Project deliverables. The first Project commenced in 2005. It has been decided to develop the methodology for formation of Project teams including a tendering procedure. After the partners agree on the general direction of a Project more detailed specifications are developed and experts nominated by the partners in the Task. When quotations from experts on a whole or part of a study are received, the Team Leader is to finalise the Project description and propose to the partners the details of the work including expert(s) to contract for the work.

Project 1 'Bioenergy - Competition and Synergies'

A proposal for Project 1 'Bioenergy – Competition and Synergies', was circulated to the participants and agreed in principle by them to proceed with a core team of two experts. At the time of preparation of this Annual Report a revised Project description has been circulated to the partners asking for their approval and nomination of candidate experts.

The Project will focus on issues regarding competition of bioenergy production with other activities and ambitions which could limit the realisation of bioenergy's potential; and synergies, multiple benefits, and added values that bioenergy could offer relative to current conventional systems. It will aim to illustrate unique possibilities and options related to bioenergy as well as explanations of limitations and obstacles to the development and deployment of bioenergy. In particular, the Project will study relevant aspects of bioenergy constituting synergies and competition with agriculture and safe and secure supply of food and corresponding issues concerning forestry and traditional forest industries.

This initial study will present examples of competition and synergies relevant to successful development of bioenergy systems. The examples will aim to contribute to the understanding of competition situations that limit bioenergy development and offer analysis and discussion on lessons learned and the possibilities for various synergies between bioenergy and other conventional practices.

This initial Project is expected to also contribute to the identification of further Projects for analysis.

Project 2 'Analysis and Identification of Gaps in Fundamental Research for the Production of Second Generation Liquid Transportation Biofuels'

At ExCo56, Larry Russo the Alternate Member for USA proposed a new Project to be undertaken within Task 41. This initiative led to a formal proposal (Project 2) which was approved by written procedure and came into force on 13 January 2006. Dr Michael Ladisch, Professor at the Laboratory of Renewable Resources Engineering, Purdue University, is the Project Leader.

The Project Leader has been working with the participants (Finland, the Netherlands, Sweden, UK, and the EC) to develop a global view of gaps in research that need to be filled to address production of second generation liquid biofuels. A series of conference calls, coupled with a survey of the literature and discussion and review with experts within IEA Bioenergy, have been the mechanisms used. Project 2 is building upon the work of other Tasks within IEA Bioenergy. Initially the Project addressed cellulosic ethanol, and is now examining Fischer Tropsch liquids and green diesel.

Translational efforts that put the bio-molecules or thermally processed renewables into the fuel tank complement the fundamental research on these fuels, and may involve chemical, thermal, biochemical, and/or biological processing applied to a range of feedstocks. The Project is addressing research barriers, trends, and gaps in the production and use of lignocellulosic ethanol, P-series fuel, liquid Fischer Tropsch fuels, or dimethyl ether (DME), from synthesis gas and upgraded pyrolysis bio-oils. P-series fuels are a blend of methyl-tetrahydrofuran, ethanol, and natural gas condensates (C4 to C5). The topics fall into the following areas:

- Effects of different biomass materials;
- Linking biomass composition/cell wall structure to gasification;
- Gas clean-up (H_2S, COS, CS_2, HCl, NH_3, HBr, HF, soot, tars);
- Robust Fischer Tropsch catalysts; and
- Process synthesis and design (economics).

Gaps in fundamental research identified to date include biomass pre-treatment for cellulosic materials, as well as the ability to ferment a range of sugars (both hexoses and pentose) to ethanol or butanol. While significant strides have been made in enzyme (cellulose) hydrolysis, further improvements in activity of the enzymes, enzyme activity with respect to hemicelluloses, and resistance to inhibition are needed. In the case of thermal processing, a research gap appears to be the clean-up of the synthesis or producer gas that results form biomass sources, particularly with respect to particulates and other metallic components (ash) that may poison Fischer Tropsch catalysts.

Project 2 is also addressing barriers related to green diesel – which is defined as a high boiling component other than diesel derived from vegetable oil. Several oil companies are already examining the waste oils from food use for processing through a refinery, and hence biodiesel is not included in the Project. The systems integration approach needed

for conversion of cellulosic and carbohydrate components into ethanol, and the processing of the remaining material into oils or other products to be used as a feed stock for a petroleum refinery, is another potential research gap. Fractionation of components from cellulosic materials, or of co-products of bioprocessing of cellulosic materials, could result in a more effective and complete utilisation of the biomass materials, and would also address how existing processing infrastructure might be used to increase the fraction of renewable fuels introduced into a liquid fuel distribution system. In this context, the stabilisation of pyrolysis oils derived from the co-product of cellulose ethanol production, i.e., lignin, is relevant since this oil could be shipped to a small petroleum refinery for the purpose of cracking and upgrading to gasoline. This is one scenario whereby both ethanol and gasoline, produced locally from renewable sources, would be mixed to produce E85.

This brief summary represents a progress report from the Project and the details may change as the work continues. A report on the Project will be provided at ExCo59 in April 2007, and an abstract has been submitted for an oral presentation at the Annual Symposium on Biotechnology for Fuels and Chemicals in Denver on 29 April – 2 May 2007.

IEA BIOENERGY TASK PARTICIPATION IN 2006

TASK	AUS	AUT	BEL	BRA	CAN	CRO	DEN	FIN	FRA	GER	IRE	ITA	JAP	NEL	NZE	NOR	SA	SWE	SWI	UK	USA	EC	TOTAL
29: Socio-econ		●			●	●					●		●			●				⊗			7
30: SRC	●			●	●										●			⊗		●	●		7
31: Forestry	●		●		⊗		●			●						●		●		●	●		9
32: Combustion	●	●	●		●		●			●				⊗		●		●	●	●		●	12
33: Gasification		●					●	●		●		●		●	●			●	●	●	⊗	●	12
34: * Pyrolysis										●						●					●	⊗	4
36: MSW	●				●			●	●	●			●			●		●		⊗		●	10
37: Biogas		●					●	●		●				●				●	⊗	●		●	9
38: GHG	●	⊗			●	●	●	●		●	●			●	●	●		●			●		13
39: Biofuels		●			⊗		●	●		●	●	●		●			●	●		●	●	●	13
40: Trade			●	●	●			●		●		●		⊗		●		●		●			10
41: Systems								P2		●				P2				⊗ P2		● P2	● P2	● P2	5
Total	5	6	3	2	8	2	6	6	1	10	3	3	2	6	3	7	1	10	3	10	7	7	111

⊗ = Operating Agents

P2 = participate in Task 41, Project 2 (ExCo Project)

● = Participant

* = Actual participation is higher because this is a joint programme with EC participants

TASK PARTICIPATION FOR THE NEW TRIENNIUM (2007-2009) as at 26 February 2007

TASK	AUS	AUT	BEL	BRA	CAN	CRO	DEN	FIN	FRA	GER	IRE	JAP	NEL	NZE	NOR	SA	SWE	SWI	UK	USA	EC	TOTAL
29: Socio-econ		●			●	●					●	●			●				⊗			7
30: SRC	●			?	●								Obs	●			⊗		●	●		6
31: Forestry					⊗		●	●		●			Obs		●		●		●	●		8
32: Combustion		●	●		●		●	●		●			⊗		●		●	●	●		●	12
33: Gasification		●			●		●	●		●			●	●			●	●		⊗	●	11
34: * Pyrolysis										●					●					●	⊗	4
36: MSW					●				●	●			●		●		●		⊗		●	8
37: Biogas		●			●		●	●	●	●			●				●	⊗	?		●	10
38: GHG	●	⊗	●			●		●		●							●			●		8
39: Biofuels	●	●			⊗		●	●		●	●	●	●		●	●	●		●	●	●	15
40: Trade			●	?	●			●		●			⊗		●		●		●			8
41: Systems								P2		●			P2				⊗ P2		● P2	● P2	● P2	5
42: Biorefineries		●			●		●	Obs	●	●	Obs		⊗				Obs				●	7
Total	3	7	3	0	10	2	6	7	3	11	2	2	7	2	7	1	10	3	8	7	8	109

⊗ = Operating Agents
P2 = participate in Task 41, Project 2 (ExCo Project)
? = participation decision awaited
● = Participant
Obs = Observer in 2007
* = Actual participation is higher because this is a joint programme with EC participants

BUDGET IN 2006: SUMMARY TABLES

Budget for 2006 by Member Country (US$)

Contracting Party	ExCo Funds	Task Funds	Total
Australia	10,000	68,220	78,220
Austria	11,000	73,000	84,000
Belgium	8,000	40,900	48,900
Brazil	7,000	28,000	35,000
Canada	13,000	105,720	118,720
Croatia	7,000	26,000	33,000
Denmark	11,000	75,400	86,400
Finland	12,000	89,820	101,820
France	6,000	15,320	21,320
Germany	15,000	126,720	141,720
Ireland	8,000	36,500	44,500
Italy	8,000	36,500	44,500
Japan	7,000	27,320	34,320
Netherlands	12,000	86,000	98,000
New Zealand	8,000	38,000	46,000
Norway	12,000	82,220	94,220
South Africa	6,000	10,500	16,500
Sweden	15,000	149,720	164,720
Switzerland	8,000	36,500	44,500
UK	15,000	147,720	162,720
USA	12,000	103,900	115,900
European Commission	12,000	93,320	105,320
Total	223,000	1,497,300	1,720,300

BUDGET IN 2006 - SUMMARY TABLES

Budget for 2006 by Task (US$)

Task	Number of participants	Annual contribution per participant	Total Task funds
Task 29: Socio-economic Drivers in Implementing Bioenergy Projects	7	12,000	84,000
Task 30: Short Rotation Crops for Bioenergy Systems	7	13,000	91,000
Task 31: Biomass Production for Energy from Sustainable Forestry	9	14,400	129,600
Task 32: Biomass Combustion and Co-firing	12	11,500	138,000
Task 33: Thermal Gasification of Biomass	12	11,000	132,000
Task 34: Pyrolysis of Biomass *	4	10,000	10,000
Task 36: Energy Recovery from Municipal Solid Waste	10	15,320	153,200
Task 37: Energy from Biogas and Landfill Gas	9	14,000	126,000
Task 38: Greenhouse Gas Balances of Biomass and Bioenergy Systems	13	14,000	182,000
Task 39: Liquid Biofuels from Biomass	13	10,500	136,500
Task 40: Sustainable International Bioenergy Trade: Securing Supply and Demand	10	15,000	150,000
Task 41: Bioenergy Systems Analysis, Project 1	5	21,000	105,000
Task 41: Bioenergy Systems Analysis, Project 2	6	10,000	60,000
Total			**1,497,300**

*Norway and the European Commission pay directly. Actual participation is higher than indicated because this is a joint programme with the European Commission.

CONTRACTING PARTIES

Stephen Schuck and Associates Pty Ltd (Australia)

The Republic of Austria

The Government of Belgium

The National Department of Energy Development of the Ministry of Mines and Energy (Brazil)

Natural Resources Canada

The Energy Institute 'Hrvoje Pozar' (Croatia)

The Ministry of Transport and Energy, Danish Energy Authority

The European Commission

The National Technology Agency of Finland (TEKES)

L'Agence de l'Environnement et de la Maîtrise de l'Énergie (ADEME) (France)

Federal Ministry of Consumer Protection, Food and Agriculture (Germany)

The Sustainable Energy Authority of Ireland

Ente per le Nuove Tecnologie, l'energia e l'ambiente (ENEA) (Italy)*

The New Energy and Industrial Technology Development Organization (NEDO) (Japan)

SenterNovem (The Netherlands)

The New Zealand Forest Research Institute Limited

The Research Council of Norway

Department of Minerals and Energy (Republic of South Africa)

Swedish Energy Agency

The Swiss Federal Office of Energy

The Department of Trade and Industry (United Kingdom)

The United States Department of Energy

*The participation of Italy was terminated around 14 December 2006.

LIST OF REPORTS AND PUBLICATIONS

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Babu, S. National Perspectives on Biomass Gasification: from Task 33 Member Countries - Task 33.

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Task 37

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Please also visit the Task website: *www.bioenergytrade.org*

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TASK 33 - Thermal Gasification of Biomass

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TASK 34 - Pyrolysis of Biomass

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TASK 38 - Greenhouse Gas Balances of Biomass and Bioenergy Systems

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TASK 39 - Liquid Biofuels from Biomass

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