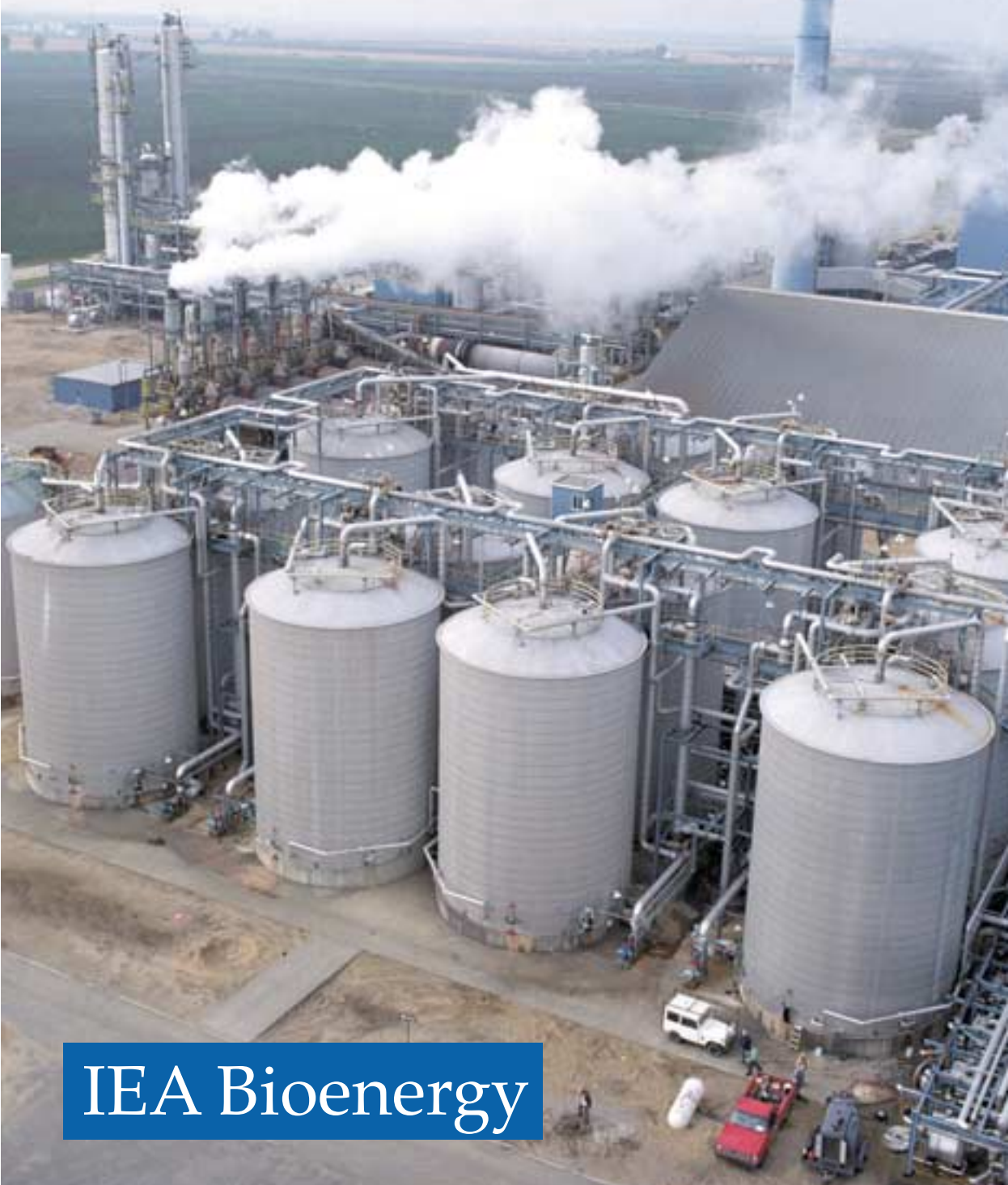


# Annual Report 2005



**IEA Bioenergy**

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: Ethanol pilot plant based on corn fibre and other cellulosic material, New Energy Company of Indiana, USA.  
(Courtesy DOE/NREL and W. Gretz)*



*The Barra Grande alcohol and sugar production plant in Brazil produces ethanol from sugar cane on a commercial scale for the transportation sector.*

To: IEA Headquarters, Paris

IEA BIOENERGY ANNUAL REPORT 2005

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 2005.

This year, we have presented a special feature on the work within Task 38: Greenhouse Gas Balances of Biomass and Bioenergy Systems and Task 40: Sustainable International Bioenergy Trade: Securing Supply and Demand.

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.

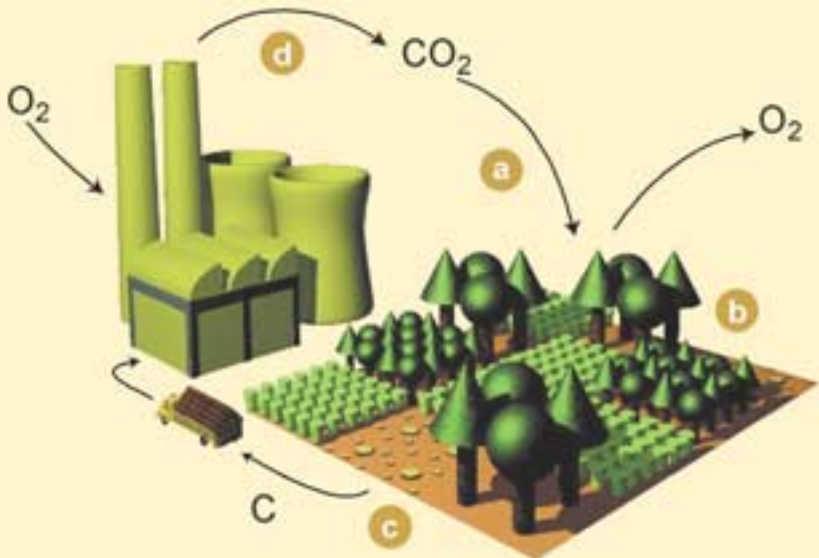
# Options for Trading Bioenergy Products and Services

This feature article provides an overview based on the work of Tasks 38 and 40. The opinions expressed are those of the authors.

## Introduction

Bioenergy is increasingly utilised to reduce emissions of greenhouse gases (GHG). Various options exist for trading bioenergy and bioenergy services between countries. In this paper, trade in biomass fuels, electricity, renewable certificates, and CO<sub>2</sub> credits are presented as options for business and policy makers as they try to meet increasing energy demands, while at the same time addressing national and international commitments to reduce GHG (CO<sub>2</sub>) emissions and increase renewable energy sources.

Bioenergy has the advantage that it is CO<sub>2</sub> neutral, if the biomass is sustainably produced; and biomass fuels can be stored until the energy is demanded by the user, therefore meeting both peak and baseline energy demands. Biomass can take various forms, such as residues from forestry, agriculture, and industry. It can be grown in dedicated woody or herbaceous energy crops, and can be transformed into various solid, liquid, and gaseous biofuels.



*Carbon recycling. a: CO<sub>2</sub> is captured by the growing crops and forests; b: oxygen (O<sub>2</sub>) is released and carbon (C) is stored in the biomass of the plants; c: carbon in harvested biomass is transported to the power station; d: the power station burns the biomass, releasing the CO<sub>2</sub> captured by the plants back to the atmosphere. Considering the process cycle as a whole, there are no net CO<sub>2</sub> emissions from burning the biomass. (Source: Matthews, R. and Robertson, K. 2002. [www.joanneum.at/iea-bioenergy-Task38/publications](http://www.joanneum.at/iea-bioenergy-Task38/publications))*

Biomass energy systems include the following services:

- Energy in the form of useful electricity, heat, or liquid/gaseous fuel.
- Reductions of net GHG emissions, thus addressing global climate concerns.
- Other benefits of renewable energy sources, such as job creation, reduction of local air pollution, reduced reliance on a limited resource, etc.

Estimates of the potential contribution of bioenergy range from 100 to over 500 EJ during this century. In developed countries domestic biomass potentials are often used to a high degree, though in some countries untapped potentials remain. Also, there is often a high production cost for biomass in developed countries. In the long term, the pressure on available biomass resources will increase. Without the development of biomass resources (e.g., through energy crops and better use of residues) and a well-functioning biomass market, the often ambitious targets for bioenergy use may not be met.

The development of truly international markets for biomass may become an essential driver for biomass production, as the potential is currently unrecognised in many regions of the world. Many developing countries have a large technical potential for agricultural and forest residues and dedicated biomass production, e.g., sugar cane, wood, or other crops. Given the lower costs for land and labour in many of these countries, production costs are much lower, and thus offer an opportunity to export biomass.

Since biomass is an energy source that is present over large land areas, the need for collection and transport systems arises. Conventional thinking is that biomass should be used locally, perhaps transported up to a distance of 50-100 km, to strike the optimum between economies of scale of the conversion plant, and the variable costs of biomass transport.



*Pellets and briquettes made from sawdust are more suitable for transport than biomass raw materials which are often bulky and of low calorific value (Courtesy BrikettEnergi, Sweden)*

However, although many trade flows do take place between neighbouring regions or countries, increasingly trade is occurring over long distances. Examples are the export of ethanol from Brazil to Japan, EU, and the USA; palm kernel shells from Malaysia to the Netherlands; wood pellets from Canada to Sweden, etc. Also the European Commission is planning a communication on future prospects for biofuels reflecting on 'the question of measures to promote the production of biofuels, including such production in less-developed countries'. This is happening despite the bulky and lower calorific value of most biomass raw material. These examples and various analyses show that biomass can be economically transported over longer distances, provided that transport occurs in bulk (such as by train or ship), and that biomass can be increased in density to reduce its volume and make transport more cost-effective. Furthermore, analyses of bioenergy trade chains still show significant advantages in GHG reduction potential in comparison to fossil fuel chains.

One of the main drivers for increasing the use of bioenergy is to reduce CO<sub>2</sub> emissions. Biomass is a CO<sub>2</sub>-neutral energy source to the extent that CO<sub>2</sub> uptake by plants for growth equals the release of CO<sub>2</sub> from the energy conversion. In national GHG inventories the use of biomass will result in less emission reported from using fossil fuels; CO<sub>2</sub> emissions from bioenergy are reported, but not counted in national totals. Thus the relative benefit of biomass leads to an improvement in the national GHG inventory. When biomass is traded between countries, the exporter will experience a CO<sub>2</sub> flux from the atmosphere to his land, whereas the importer will experience a CO<sub>2</sub> flux from his energy system to the atmosphere, both roughly cancelling each other out. In cap-and-trade programmes of GHGs, gross CO<sub>2</sub> fluxes from biomass oxidation should not be counted in the GHG inventory of the consumer if a GHG incentive to use bioenergy is to be maintained. Technically, if biomass is produced sustainably (no net addition of CO<sub>2</sub> to the atmosphere), both producer and consumer experience a zero carbon stock change, and the consumer will experience a reduction in CO<sub>2</sub> emissions from fossil fuels in their inventory.

Demand for bioenergy is increasing as concerns about climate change lead to implementation of policy measures that favour renewable energy sources over their fossil-fuel-based competitors. Examples of such policy measures and mechanisms are renewable energy mandates, feed-in tariffs for electricity from renewables, trading of green certificates and cap-and-trade systems for GHG. Demand is also driven by price mechanisms such as subsidies and taxes. All of these mechanisms seek to internalise the externalities of fossil fuel use in terms of climate change and other impacts, and provide a more balanced energy choice.



*Loading logs for transportation by truck (Courtesy UK Forest Research Photo Library)*

There is not only a demand for useful energy, but also for 'climate friendly' energy systems and energy systems that bring with them all the other advantages of renewable energy. Biomass energy can help meet all three demands. It is noteworthy that the first benefit, useful energy, must usually be provided at the location of demand, whereas the other two types of services are less dependent on location. It does not matter where reduction of GHG occurs, because the atmosphere is well mixed globally and an emission (or reduction therein) will have an equal effect wherever it occurs. Similarly, many of the benefits of renewable energy (such as decreased use of limited fossil fuel resources) will not depend on where the biomass is used, although these benefits do occur locally.

This suggests that biomass may not have to be transported in all circumstances, especially where the demand is largely for climate friendly and renewable energy sources. Instead, it may be possible to convert biomass into useful energy at the place where it occurs, and 'transport' the produced electricity, to the location where these services are in demand, or possibly trade the nonmaterial services such as 'CO<sub>2</sub> neutrality' or 'renewable features' under mechanisms such as those identified above.

## Matching Supply and Demand for Bioenergy Services

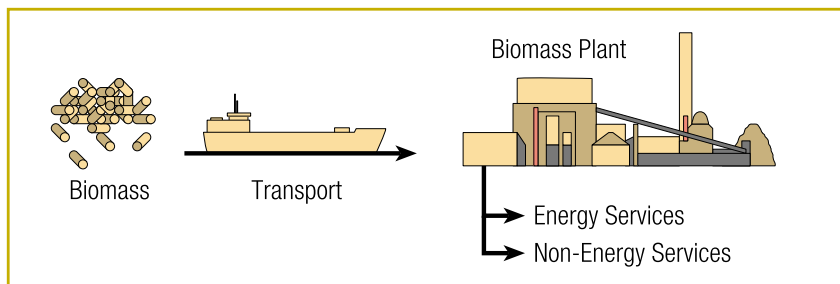
Energy supply and demand can be considered at different levels e.g., country, region, company, or individual projects. This discussion will refer for convenience to the location with energy demand as 'Country D' and to the location with surplus biomass supply as 'Country S'.

### Trading Energy Carriers

#### Biomass Fuels

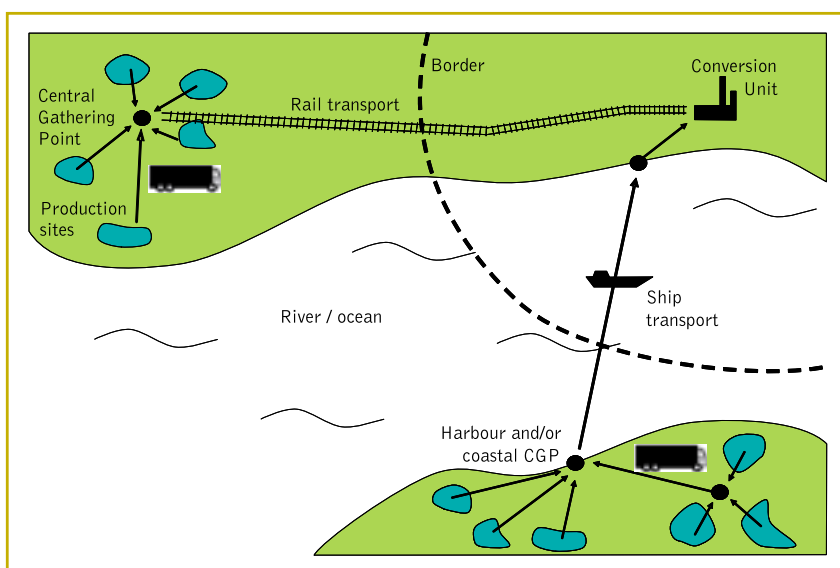
Some world regions (for example Latin America and Eastern Europe) have a larger bioenergy production potential than others, a combination of large land areas with good crop production potential, low population density, and often extensive agricultural practices. Consequently, various countries may become net suppliers of renewable bioenergy to countries that are net importers of energy. For example, there is growing interest in exporting bio-ethanol from Brazil to Japan and the USA. In order for bioenergy to be available to importing regions, transport of biofuels over relatively long distances is necessary. This, however, implies extra costs, more complex logistics, and additional energy losses compared to more local utilisation.

The possibilities for exporting biomass-derived commodities to the world's energy markets can provide a stable and reliable demand for rural communities in many (developing) countries, thus creating an important incentive and market access that is much needed in many areas of the world. For many rural communities in developing countries such a situation would offer good opportunities for socio-economic development.



*International bioenergy trade can include direct transport of biomass materials (chips, logs, and bales), intermediate energy carriers (such as bio-oil or charcoal), or high quality energy carriers such as ethanol, methanol, Fischer-Tropsch liquids, and hydrogen (Source: Joanneum Research).*

Factors such as the biomass production method, the transport type, and the order and choice of pre-treatment operations are of importance. The design of the supply chain will influence the costs and energy efficiency, via a large number of variables, such as transport distance, dry matter losses, fuel prices, total volumes transported, and equipment performance.



*International bioenergy logistics - schematic representation of possible biomass and bioenergy trade chains (Source: Copernicus Institute)*

Various drivers for international bioenergy trade can be distinguished:

- **Cost-effective GHG emission reduction.** At present, the demand for biomass is growing due to climate policies of various countries. Where indigenous resources are insufficient at the required quality and cost, imported material may be an attractive alternative to local biomass supplies.

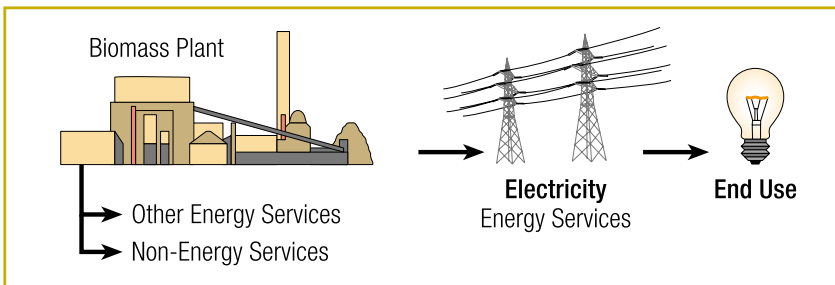
Use of proper reference systems is crucial: the GHG mitigation potential of biomass use is strongly affected by, for example, the carbon intensity of power

generation in both the importing and exporting countries. This is true for bio-oil export from Karelia (Russia) to the Netherlands. The possibilities for using biomass for CHP in Karelia (as well as the relatively low distribution density of forest residues) and the relatively efficient power generation in the Netherlands indicate that local use of biomass resources may be preferred over export in this particular case. In the case of wood pellet export from Canada to the Netherlands and other Western European countries, the opposite is true.

- *Socio-economic development.* Many institutions and much research have indicated the potential strong positive link between developing bioenergy use and local development. For various countries, exporting bioenergy in the future may provide substantial benefits for their trade balances.
- *Sustainable management and use of natural resources.* Large-scale production and use of biomass for energy will involve use of (additional) land. When biomass production can be combined with better agricultural methods, or restoration of degraded and marginal lands it can provide a sustainable source of income for rural communities.
- *Fuel supply security.* Biomass may diversify the total portfolio of fuels used and imported by countries, thereby reducing the risks of supply disruptions in terms of both quantity and price, especially in the case of biofuels for transport since they replace oil imports.

## Electricity

International trading of electricity is already established. Electricity produced from biomass will usually be CO<sub>2</sub> neutral, and can be an effective means of meeting energy demands of the electricity importer while at the same time not adding to the CO<sub>2</sub> emissions of the exporting country. That is, neither the importing nor the exporting country experiences any GHG emissions from the transaction.



*International trade in electricity produced from biomass. (Source: Joanneum Research)*

Countries may be importers or exporters of electricity for only parts of the year, parts of the day etc., depending on peak load demands, electricity price variations, and other factors. When electricity is traded, CO<sub>2</sub> emissions will be accounted for in the national GHG inventory of the country where the emission from electricity production occurs. Thus, it is conceivable to meet an emission reduction target by reducing domestic electricity

generation and making up the shortfall through imports. This is most likely to occur where not all countries in a region are subject to emission limitation and reduction commitments.

Both biomass and electricity trade will lead to GHG emission reductions in the inventory of the importing country. The magnitude of reductions, and thus the viability of these two options, will depend on the GHG intensity of the energy system in the importing country, i.e., what type of energy carrier and conversion system is displaced (baseline scenario). Usually this will be a marginal power plant that would have gone into operation (or would have increased its level of output) in the absence of the electricity import. If this marginal production system is a rather inefficient coal-fired power plant, then the GHG reductions will be greater (by a factor as high as three) than if the marginal plant works on natural gas using state-of-the-art technology.



*The Amer biomass co-firing power plant in the Netherlands. (Courtesy Essent, the Netherlands)*

One of the key advantages of this trading option is that production of renewable energy can be optimised in power plants with better technologies and economies of scale that could not be realised without the increased flexibility and increased demand of trade.

Logically, electricity trading is limited to areas where the grid offers sufficient capacity and the effectiveness decreases with increasing distance. It is important to ensure that there is appropriate labelling when electricity from renewable sources is purchased.

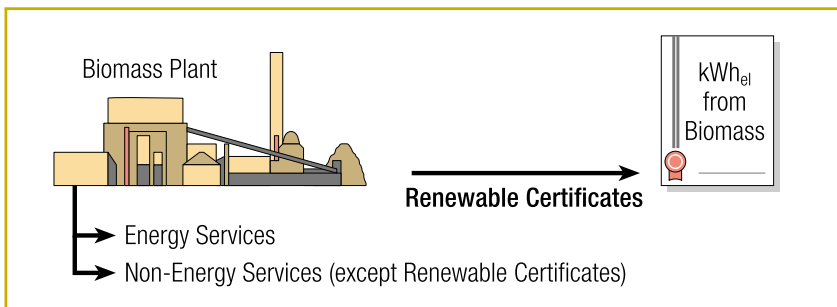
## Trading Non-energy Services

'Non-energy services' include benefits from biomass energy that are unrelated to the energy as such. Examples are environmental, social, and emission reduction benefits compared to other energy sources. The emission reduction benefits are packaged in various forms and, for example, change their owner in emissions trading schemes. Industry tends to be supportive of emissions trading since it enables a given emissions target to be met at lower cost than with conventional regulations. The cost savings are possible because there is more flexibility in the choice of where emissions are reduced. Sources with low-cost reduction opportunities can implement larger reductions and sell their surplus reductions. Sources with high-cost reduction options can save money by purchasing surplus reductions from other participants instead.

## Renewable Certificates

'Renewable certificates' can be used to meet the demand for the renewable energy, e.g., in the context of national renewable energy targets. The 'renewable certificates' represent the local services and benefits of the renewable energy, such as pollution abatement and jobs, but not necessarily the CO<sub>2</sub> emission reduction as this could lead to double counting, if for example CO<sub>2</sub> is covered by a cap-and-trade programme.

This option allows Country S to produce renewable energy above and beyond its own national targets and then sell the remaining amount in renewable certificates to Country D, while using the electricity in domestic markets. Country D in turn will be able to meet domestic targets of renewable energy sources by importing certificates to the extent that their national legislation on renewables accepts certificates from other countries. Policy makers in Country D may want to allow imported certificates only when Country S already meets any standards it may have domestically.



*Trading renewable certificates (Source: Joanneum Research)*

Much flexibility exists, as Country S could also sell the electricity without the renewable certificates separately (see 'Electricity' above). In any event, the renewable aspect of the energy must not be double counted. The renewable certificates of the energy can either be attached to the energy purchase, or removed and sold separately to those buyers that only need a renewable energy quota for their own portfolio. Flexibility also comes from the fact that both electricity and certificates can be sold to different purchasers at different times, so that maximum revenues can be achieved.

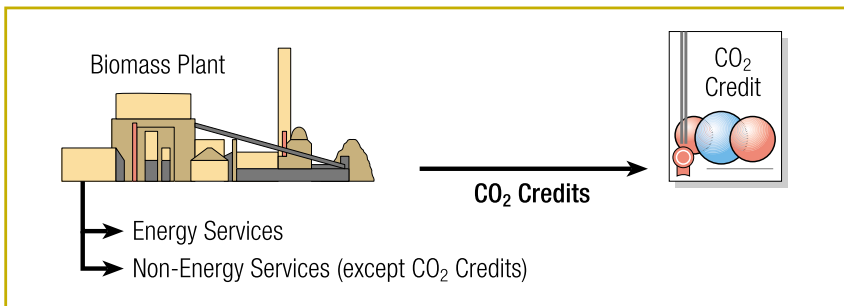
Green certificates are already traded within the EU. For example, utilities in the Netherlands have been importing significant amounts of green certificates for the last few years. Currently, certificates can be imported and sold as 'green electricity' in the Netherlands only from countries whose system of issuing Guarantees of Origin has been approved by the EU. Currently, these countries are Sweden, Finland, Denmark, Austria, the UK, and the Netherlands.

## CO<sub>2</sub> Credits

Concerns about global climate change have led to limits on emissions of GHG. One outcome of this concern is the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) which places limits on the emissions of industrialised nations in the period 2008 - 2012 (the 'first commitment period').

The Kyoto Protocol foresees flexibility in meeting the targets, using the concept of emissions trading. For example, countries that over-comply with their targets can sell emission allowances to countries that would otherwise not meet their targets. CO<sub>2</sub> trading provides the flexibility of investing in those places where energy investments (either replacement of existing facilities or investments to meet new energy demand) are due anyway, thus reducing the costs of CO<sub>2</sub> mitigation.

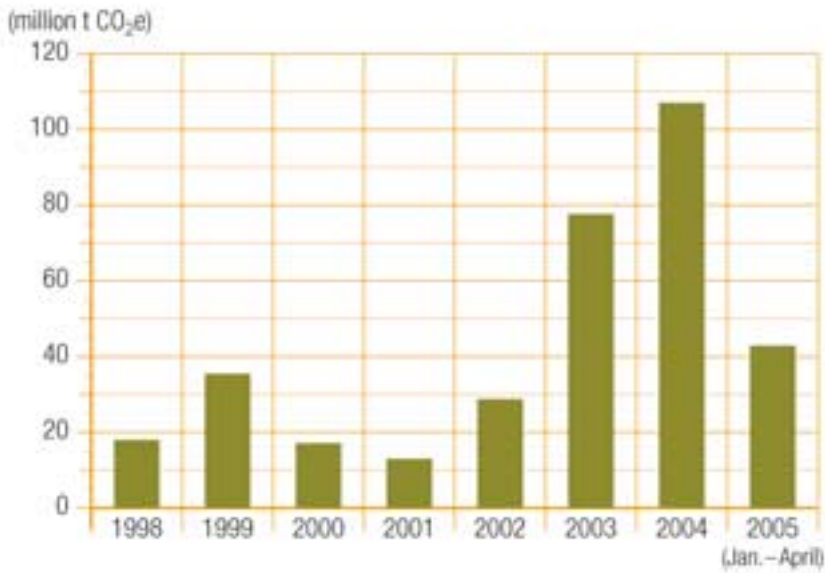
The Protocol also foresees that emission-reducing projects carried out in other industrialised nations (Joint Implementation - JI) or in developing countries (Clean Development Mechanism - CDM) can generate GHG credits that are tradable. Governments of industrialised countries with Kyoto commitments have begun to invest in JI and CDM projects, for example the Netherlands or Austria - see examples below.



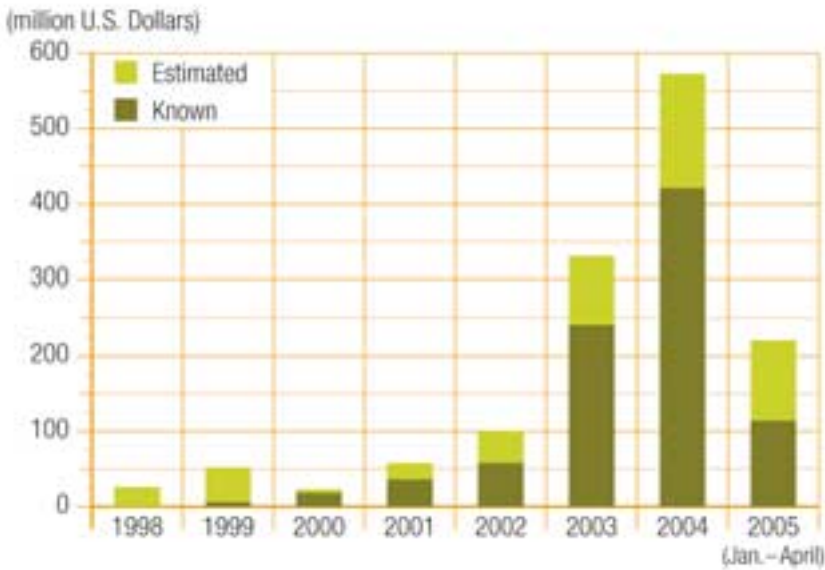
*Trading bioenergy CO<sub>2</sub> credits (Source: Joanneum Research)*

In the case of bioenergy, trading CO<sub>2</sub> credits would mean that a biomass conversion plant is put in place in the 'seller' country and CO<sub>2</sub> credits are sold to the 'buyer' country. The amount of credits will depend on the baseline scenario of the 'buyer' country whereas for physical biomass or electricity trade the baseline scenario of the 'seller' country is of interest. That is, JI and CDM projects may be especially worthwhile where the marginal energy supply is very GHG intensive.

There are several arrangements in which corporations, governments, or groups of these, purchase carbon credits either directly or indirectly through 'carbon funds'. Examples of the fund approach are the World Bank's Prototype Carbon Fund (PCF), the Community Development Carbon Fund and the Biocarbon Fund. For further details see [www.carbonfinance.org](http://www.carbonfinance.org).

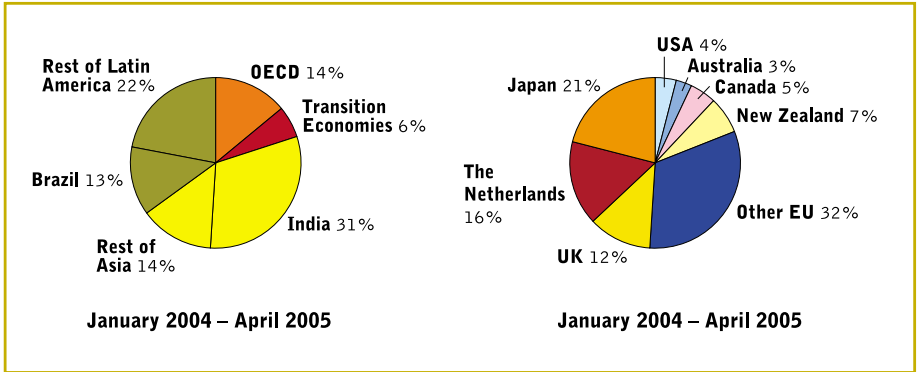


Annual volumes (million t CO<sub>2</sub>e) of project-based emission reductions traded up to 2012 vintages (Source: Lecocq, F. and Capoor, K. 2005. State and Trends of the Carbon Market 2005. Carbon Finance Business, World Bank, [www.carbonfinance.org](http://www.carbonfinance.org))



Estimated total market value per year in million US dollars, nominal (Source: Lecocq, F. and Capoor, K. 2005. State and Trends of the Carbon Market 2005. Carbon Finance Business, World Bank, [www.carbonfinance.org](http://www.carbonfinance.org))

Another example is the European Emissions Trading System (ETS) which caps the emissions of combustion installations with a rated thermal input exceeding 20 MW, as well as those from other companies in the metal, mineral and pulp and paper industries above certain thresholds. The ETS also allows companies to invest in JI and CDM projects, and thereby provides a link with the Kyoto Protocol Mechanisms.



*Pie chart on left: Location of emission reduction projects and share of volume supplied.  
Pie chart on right: Buyers of emission reductions and share of volume purchased.  
(Source: Lecocq, F. and Capoor, K. 2005. State and Trends of the Carbon Market 2005. Carbon Finance Business, World Bank, www.carbonfinance.org).*

## Effectiveness of Trading Options

Policy and business decision makers will consider a host of criteria when determining the way to most efficiently reconcile supply of and demand for renewable energy. Questions to be addressed are whether a cost-effective biomass potential, and whether applications for biomass, exist domestically. If both biomass resource and applications are available locally then the trading options explained in this paper might be less attractive. However, if local resources are scarce but domestic applications exist then the biomass trading option might be of interest. If neither the resources nor the applications exist, then the purchase of renewable certificates and/or CO<sub>2</sub> credits is the only remaining option.

Decision makers must also evaluate the environmental and social aspects of the different options. Biomass energy can, among other benefits, help diversify energy sources and supply local jobs. It is important that environmental, socio-economic, agricultural, energy, climate, and trade aspects are considered in policymaking.

Listed below are groups of criteria that may be important to policymakers, as well as decision makers in the energy sector, and the general public (energy users). This list is indicative, as there may be additional criteria that apply in specific situations, and some of the criteria below may not apply in all cases. For simplification, the term 'services' is used as a generic term to mean the energy content, CO<sub>2</sub> reductions, and other features of renewables.

## Criteria for the Decision Between Different Trading Options

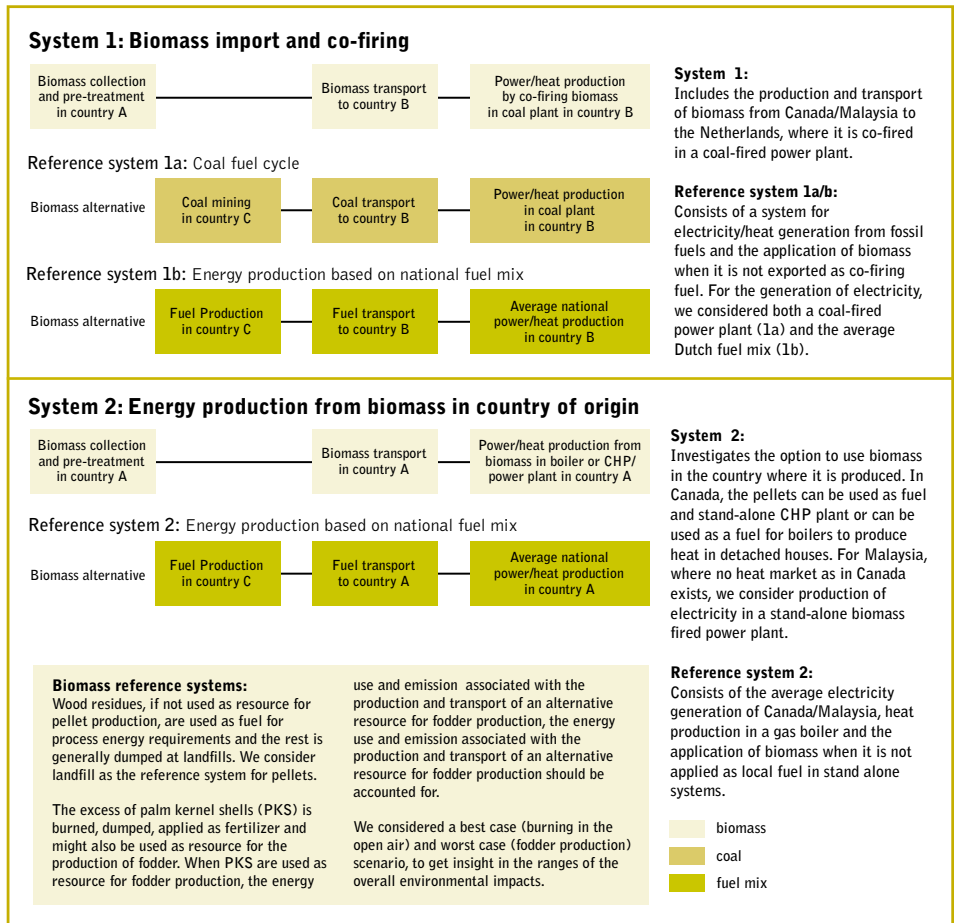
<b>Supply Potential</b>	What is the technical and economic potential for a sustainable supply of 'services' of the exporting region? Consider factors such as competition with food production, other biomass uses, pressure on existing forests (e.g., deforestation) and local energy demand.
<b>Secure Demand</b>	How will demand for 'services' develop in the importing region e.g., competing (renewable) energy options, development of conversion capacity and indigenous biomass resources, future markets for certificates and credits.
<b>Logistical Capacity</b>	What logistical and conversion capacity is available in importing and exporting countries? Examples are transport infrastructure (harbours, roads), possibilities for co-fired systems, power lines etc. Another example is existing energy infrastructure in the importing country that may be more costly to change than importing certificates/credits.
<b>Reference Systems</b>	What is the reference energy system for importing and exporting countries? For example a low carbon intensity for importer and high carbon intensity for exporter indicate it may be better to use biomass locally and trade bio-electricity, credits, or certificates, or a combination. Similarly, the ability to use CHP in either location can enhance the amount of fossil fuel displaced.
<b>Sustainable Development</b>	What are the opportunities for matching 'services' production and export with rural and sustainable development? This includes issues of job creation, local air pollution etc.
<b>Diversification</b>	Is there a need for diversification of the energy supply mix in exporting and importing countries?
<b>Policies and Regulations</b>	Which trading options are favoured under existing policies such as renewable energy or CO <sub>2</sub> targets and regulations e.g., trade barriers, carbon accounting rules?
<b>Flexibility and Risks</b>	Which options allow more flexibility over time than others? For example, CO <sub>2</sub> credits and green certificates are traded at spot markets and will only be needed at the end of a longer period to close accounts, whereas physical energy carriers have to be imported at the time the demand occurs, i.e., on a continuous basis.

## Examples of Different Trading Options

### The Netherlands

In the Netherlands, several of the different trade options described above are currently used simultaneously. Regarding the physical import of biomass, in 2004 the Netherlands produced approximately 4.9 TWh renewable electricity, of which about 3 TWh were produced from biomass. In turn, of these 3 TWh roughly 1 TWh was produced from imported biomass (e.g., pellets, palm oil, and agro-residues). Most of these biomass

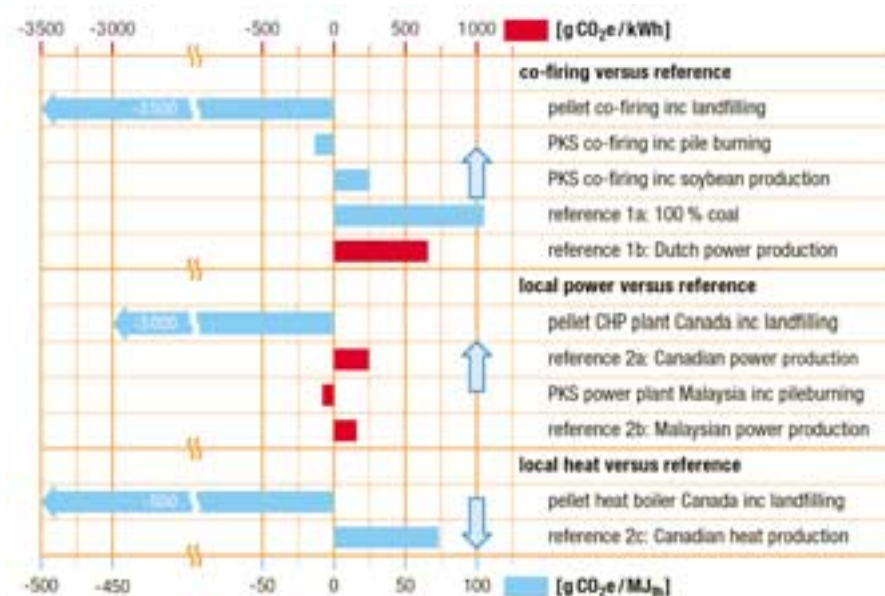
streams were imported from Canada and South-East Asia. The Copernicus Institute (the Task 38 team of the Netherlands) carried out a case study on 'GHG Balances of Biomass Import Chains for Green Electricity Production in the Netherlands. For further information see: [www.joanneum.at/iea-bioenergy-task38/projects/task38casestudies/netherlands-brochure.pdf](http://www.joanneum.at/iea-bioenergy-task38/projects/task38casestudies/netherlands-brochure.pdf)). Results of this case study are presented below.



*Biomass chains versus reference system as documented in the Task 38 case study for the Netherlands.*

In terms of physical import of electricity, the Netherlands is a net importer of electricity. In 2003, the Netherlands imported about 17 TWh of electricity, mainly from Belgium and Germany, probably from coal-fired and nuclear power plants.

Regarding the trade in renewable electricity certificates, the Netherlands have imported large amounts of certificates over the last few years. The Dutch demand-side support for renewables was relatively generous from 1999 onwards, causing the number of households using renewable electricity to surge to over two million. As domestic renewable electricity production cannot cover this demand, in 2004 the Netherlands imported approximately 10 TWh of renewable electricity certificates, of which about 75% was from biomass, mainly originating from Finland and Sweden.



GHG emissions of pellets and palm kernel shells (PKS) import and co-firing and use as a fuel in stand-alone combustion systems in country of origin versus reference power/heat production. Axis above: CO<sub>2</sub> equivalents for electricity systems (g CO<sub>2</sub>e/kWh). Axis below: CO<sub>2</sub> equivalents for heat systems (g CO<sub>2</sub>e/MJ<sub>th</sub>).

Finally, regarding the trade of emission reduction certificates, the Netherlands is actively involved in JI and CDM projects. Carbon credits (see [www.carboncredits.nl](http://www.carboncredits.nl)) buy emission reductions for the Dutch government via JI and CDM, and their portfolio includes 23 JI and CDM projects. The total contacted volume was 16 million tonnes of CO<sub>2</sub> in November 2005. Current JI projects in the Dutch programme include mainly wind energy, biomass energy, hydroelectricity, and landfill gas utilisation. The market price is around 5 Euros per tonne of CO<sub>2</sub>.

## Austria

The amount of biomass energy imported and exported is rather small because Austria has large forest resources. In 2003 2.5 PJ of fuel wood were imported, and 0.9 PJ exported. As well, 4.5 PJ of biofuels were imported, and 6.9 PJ exported.

The Austrian Government has also started its JI and CDM programme (see [www.ji-cdm-austria.at](http://www.ji-cdm-austria.at)). One of the seven JI projects under contract so far is a biogas plant in Hungary. Of the other 34 JI projects that are being assessed, four deal with biomass. Also two of the eight CDM projects under contract are biomass power plants based on agricultural residues in India. Another 22 biomass-based CDM projects are being assessed as at December 2005.

### JI and CDM Biomass Projects Contracted by Austria

Type of Flexible Mechanism	Title of Project	Country	Technology	Emission Reductions by 2012 (t CO <sub>2</sub> equiv)
JI	Palhalma Biogas Plant	Hungary	Biogas Plant (Digester)	162,608
CDM	APCL mustard crop residue power project	India	Biomass Power Plant	244,000
CDM	Biomass CHP Plant using rice husk	India	Biomass Power Plant	147,000

(Source: Kommunalkredit Public Consulting GmbH)

## Concluding Remarks

International trade in biomass or energy carriers from biomass has only recently become part of the portfolio of energy companies and countries to increase the share of biomass in their fuel mix and to meet environmental objectives. This trade is growing rapidly and in the longer term a global market of renewable energy carriers derived from biomass may emerge. There are many potential advantages of such a market. For example, CO<sub>2</sub>-neutral biomass resources are utilised efficiently on a large scale; new markets may generate substantial income sources for relatively poor world regions; and energy markets worldwide may become more stable due to a larger number of energy suppliers compared to the current situation. Most important



Long-distance transportation of palm kernel shells from Indonesia to Italy. (Courtesy M. Wild, EBES AG)



*Wood pellets being loaded in Canada for long-distance transportation. (Courtesy J. Douglas, Solidaridad)*

may be that such a market may lead to development and sustainable use of the vast bioenergy production potential in many regions of the world.

Despite the rapidly developing international bioenergy trade (both liquid and solid fuels) physical trade of biomass (or energy carriers derived from biomass such as liquid fuels) is not always the optimal solution from both a cost and a GHG mitigation perspective. International logistics lead to higher costs and energy use compared to local or regional utilisation of resources. Although with optimised chain design (e.g., involving large-scale transport, transport of high energy-density commodities) such additional costs and energy uses remain modest. Local use and subsequent trading of electricity, CO<sub>2</sub> credits or renewable certificates provide important alternatives.

All these options can contribute to building sustainable biomass markets and increasing the share of biomass in the global energy mix. The variety of products (physical biomass, electricity, carbon credits, and renewable energy certificates) allows countries to select the most efficient mechanism for each unique situation.



*Unloading facility at the Amer Power Plant in the Netherlands. (Courtesy Essent, the Netherlands)*

## Acknowledgements

This article was prepared by B. Schlamadinger, A. Faaij, M. Junginger, S. Woess-Gallasch and E. Daugherty based on the work of Tasks 35, 38 and 40. Further information can be found on the Task websites; at [www.joanneum.at/iea-bioenergy-task38/](http://www.joanneum.at/iea-bioenergy-task38/), and [www.bioenergytrade.org](http://www.bioenergytrade.org) and also through the weblinks listed in the text.

# International Energy Agency

The International Energy Agency (IEA) acts as energy policy advisor for its 26 Member Countries in their effort to ensure reliable, affordable, and clean energy for their citizens. Founded during the oil crisis of 1973-74, its initial role was to coordinate measures in times of oil supply emergencies. But during the last decades, the energy markets have changed, and so has the IEA. It now focuses well beyond oil crisis management on broader energy issues, including climate change policies, market reform, energy technology collaboration, and outreach to the rest of the world. With a staff of around 150, mainly energy experts and statisticians from its 26 Members 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. IEA publications are known worldwide for their objectivity.

## 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 2005 from IEA Bioenergy!

IEA Bioenergy is the short name for the international bioenergy collaboration within the International Energy Agency. 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 the end of 2005, 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 28 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 2005:

- 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 2005 is shown in Appendix 1.

A progress report for IEA Bioenergy for the year 2005 is provided from page 23 of this Annual Report.



*The ExCo56 study tour group at the Balcas CHP/wood pellet production plant, Enniskillen, Ireland.*

# 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 55<sup>th</sup> ExCo meeting took place in Copenhagen, Denmark on 25-26 May 2005. There were 32 participants at this meeting. The 56<sup>th</sup> ExCo meeting was held in Dublin, Ireland on 12-13 October 2005, with 27 participants including observers. A representative from IEA Headquarters attended each meeting.

During 2005, Kyriakos Maniatis from the European Commission was Chairman and J. Peter Hall from Canada was Vice Chairman. At the ExCo56 meeting, Kyriakos Maniatis was re-elected Chairman for 2006 and J. Peter Hall was re-elected Vice Chairman.

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 ExCo51, John Tustin will provide the Secretariat and Fund Administration service for the period to 31 December 2006. 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 2005, 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.

Following on from the decision by the IEA Governing Board to approve the Framework for International Energy Technology Cooperation in April 2003, the Executive Committee approved harmonisation of the text of the Implementing Agreement with this 'Framework' at ExCo56. The main thrusts of the new 'Framework' are greater OECD non-Member country and private sector participation in the Implementing Agreements and the setting of minimum conditions for such participation as Contracting Parties and Sponsors. However, the Executive Committee can impose greater restrictions on such participation if it wishes.

## New Participants/Contracting Parties

Interest from potential Member Countries continued to be strong in 2005. Germany signed the Implementing Agreement on 15 August with the Federal Ministry of Consumer Protection, Food and Agriculture as the German Contracting Party. Initially Germany will participate in Task 32 (Dr Hans Hartmann); Task 33 (Prof Eckhard Dinjus); Task 34 (Dr Dietrich Meier); Task 37 (Prof Peter Weiland); Task 39 (Prof Axel Munack); and Task 41 (Mr Birger Kerckow).



*Gerhard Justinger the ExCo Member for Germany (left) with Arthur Wellinger the Leader of Task 37*

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 CERT via its Renewable Energy Working Party (REWP) and reported to the IEA Governing Board.

### Approval of Task and Secretariat Budgets

The budgets for 2005 approved by the Executive Committee for the ExCo Secretariat Fund and for the Tasks are shown in Appendix 2. Total funds invoiced in 2005 were US\$1,576,580; comprising US\$216,000 of ExCo funds and US\$1,360,580 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. This account is 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 National Bank of New Zealand (part of ANZ National Bank Ltd), Head Office, 1 Victoria Street, Wellington, New Zealand. Swift/BIC Address: NBNZ22 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 National Bank of New Zealand's US Dollar Correspondent Bank is JPMorgan Chase Bank, New York, NY, USA (Chips UID 174291 or Federal Wire Number 021000021) 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 2005, there was US\$161,138 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 2004 were approved at ExCo55. The Tasks also produce audited accounts. These are prepared according to guidelines specified by the ExCo. The accounts for the Tasks for 2004 were also approved at ExCo55.

The audited accounts for the ExCo Secretariat Fund for the period ended 31 December 2005 have been prepared and these will be presented for approval at ExCo57.

## Task Administration and Development

At ExCo54 it was decided that the reporting by the Tasks needed to be extended if the expectations of the ExCo were to be fully satisfied. Important elements currently often missing were provision of authoritative status reports in the various fields covered by the Tasks; more emphasis on bioenergy deployment strategies; and Task input on barriers to technology deployment and how to remove these. To address these issues the following changes were approved.

- At the start of a new Task or at the start of a new triennium, the Tasks will now produce a state-of-the-art report on the various topics in the Task. This will include a description of the main issues that the Task will address during the triennium and the barriers (technical or non-technical) they aim to overcome.
- The administrative reports which are currently produced for each ExCo meeting will include a Gantt diagram presenting 'planned activities' and 'progress achieved'; a table of deviations from the work schedule and actions to overcome these; and a table of planned meetings.
- A technology progress report will be prepared once a year for the October ExCo meeting. This will address one of the technology issues the Task considers of importance and will be presented in a way that facilitates easy incorporation into the Final (end of triennium) Task report. This initiative made a promising start at ExCo56. For a list of the Technology Reports tabled at this meeting please see Appendix 4.
- Also, a final Task report will be produced at the end of each triennium. This will include the scope of work executed, a summary of the results of the Task (including the sequential technical progress reports) and actions recommended.

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. Since that time some of the Tasks have made suggestions on how these funds could be used. However, the ExCo has not committed any of these funds to specific project work or outputs at this time. It has decided that the first priority for use of these 10% 2005 funds will be to produce information in support of a position paper on 'global bioenergy potential'.

A new Task 'Bioenergy Systems Analysis' (Task 41) commenced on 1 January. It will provide the ExCo with highly qualified teams to carry out carefully selected projects. Due to the character of the Task and its close contact with the other Tasks, it is expected to develop into a platform for joint work and to be a catalyst for policy-related proposals to the ExCo. The first project 'Bioenergy - competition and synergies' will research situations where bioenergy is synergistic with other policies or developments as well as situations where bioenergy developments are limited by competition.

Participation in the Tasks has continued to increase. In 2005 there were 106 participations in 12 Tasks. Please see Appendix 1 on page 79 for a summary of Task participation in 2005.

### 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.

### Position Paper 'global bioenergy potential'

At ExCo53 in Lucerne it was agreed to form a taskforce to advise the ExCo on strategic outputs from the Tasks. This led to a questionnaire which was circulated to the ExCo to identify the most important policy relevant outputs. As a result of this exercise it was decided the most urgent item was production of a position paper for an international audience on the subject of 'the potential contribution of bioenergy to meet future global energy demand' and a 'working group' - comprised of Josef Spitzer and Kees Kwant - was formed to action this. They reported back to the ExCo that to produce this output a project plan needed to be developed. The paper would, in part, be based on existing information from the Tasks which would use part of the 10% held back funds to service requests from the project leader. At ExCo56 a proposal from Andre Faaij, as project leader, to produce the strategic position paper was approved subject to certain amendments to the draft. The project is scheduled to be completed in late 2006.

### Workshops

Following the decision at ExCo53 to create time for strategic topics at ExCo meetings, very successful workshops were held at ExCo55 on 'Co-utilisation of Biomass with Fossil Fuels' and at ExCo56 on 'Integrated Waste Management and Utilisation of the Products'. 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 presentations are available on the IEA Bioenergy website.

## Collaboration with FAO

The collaboration with FAO under the MoU signed in 2000 has continued. Overall the level of collaboration is significant and still growing. 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:

- Development of a methodology for the eligibility of bioenergy projects by CDM - Task 38.
- Collaboration in the preparation of a wood fuel paper and participation at meetings - Task 40.
- Possible FAO contributions to a 'certification' study - Task 31.
- FAO input to the analysis of global bioenergy potentialities - ExCo strategic position paper.

## 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.

The Executive Committee was a co-sponsor of the 14<sup>th</sup> European Biomass Conference and Exhibition held in Paris on 17-21 October.

## 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 2004 Annual Report with the special colour section on 'Biogas Production and Utilisation' was very well received. This coloured section was also produced as an independent booklet. Only a few copies of the Annual Report from the original print run of 700 remain with substantially increased distribution in electronic format. Both publications are available from the IEA Bioenergy website.

The newsletter IEA Bioenergy News remains popular. Two issues were published in 2005. The first issue featured bioenergy in Denmark and the second issue featured bioenergy in Ireland 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.

Six contributions under the banner of 'IEA Bioenergy Update' were provided to the journal Biomass and Bioenergy in 2005. These covered news from the Executive Committee, events, overviews of progress in the Tasks, and short articles about bioenergy in the Member Countries. They also included a comprehensive review paper 'Observations on the Current Status of Biomass Gasification' prepared by Suresh Babu, Leader of Task 33. This initiative provides excellent access to bioenergy researchers as the journal finds a place in major libraries worldwide.

A major position paper titled 'Benefits of Bioenergy' was published in January. It presents bioenergy in the context of energy choices and outlines the wide range of biomass sources and conversion technologies available. Case studies from Member Countries provide practical examples of bioenergy solutions. This publication has proved very popular with a range of audiences worldwide. It was produced by an editorial group convened by J. Peter Hall, the Member for Canada.

## 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 2005 the Chairman, Secretary, and key Members of Executive Committee have worked closely with the IEA Headquarters in Paris at both administrative and technical levels. Peter Tulej attended both ExCo55 in Copenhagen and ExCo56 in Dublin. 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.

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 ExCo55 and ExCo56. 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.

## Task Leader Recognised

Keith Richards, the new Leader of Task 29, was made an Officer of the British Empire (OBE) in the Queen's Birthday Honours list for 2005. The investiture took place at Buckingham Palace on 18 October. This prestigious award was made to Keith for his services to 'sustainable development' over the past 25 years, recognising his work for both the UK Government and more recently the Southeast Region of England on renewable energy, including his contributions to IEA Bioenergy and other international fora.



*Keith Richards being presented with his OBE by Her Majesty Queen Elizabeth II*

## IEA Bioenergy Website

The IEA Bioenergy website was substantially upgraded during the latter half of 2005. The website exhibits the same general appearance and style, but with significant improvements in usability. For end-users, this has resulted in improvements in convenience and consistency. For the Secretariat it means improved maintainability, adaptability for the future, and statistical reporting functionality. The new version of the website was launched in early 2006.

## ExCo55 Study Tour

Straw from agriculture is an important biomass resource in Denmark. Renewable energy contributes 12% of total energy consumption.



*Harvesting bales of straw in Denmark. (Courtesy Jan Bünger, Danish Energy Authority)*



*At full capacity, Avedøre 2's straw boiler burns 1200 bales per day. Each bale weighs 500kg. (Courtesy Thomas Scott Lund, Energi E2, Denmark)*



*The Avedøre Power Station, south of Copenhagen, shows prize winning architecture. Avedøre 2 is the second unit. (Courtesy Thomas Scott Lund, Energi E2, Denmark)*

## 2. PROGRESS IN 2005 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 impacts and opportunities of bioenergy systems to communities at the local, regional and international level;
- synthesise and transfer important knowledge and new information in order to foster multi-disciplinary partnerships of key stakeholders in forest biomass production and utilisation research, planning and operations;
- improve the assessment of the 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, which will include the sharing of research results, stimulation of new research directions in national, regional, and local programmes of participating countries, and technology transfer from researchers to resource managers, planners and industry.

**Participating countries:** Austria, Canada, Croatia, Ireland, Japan, Norway, Sweden, and the United Kingdom.

**Task Leader:** Mr Julije Domac, Energy Institute Hrvoje Pozar, Croatia.

**Operating Agent:** Dr Branka Jelavic, Energy Institute Hrvoje Pozar, Croatia.

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 29, please refer to Appendices 2-6 inclusive; the Task website: [www.iea-bioenergy-Task29.hr](http://www.iea-bioenergy-Task29.hr), the biomass and bioenergy educational website: [www.aboutbioenergy.info](http://www.aboutbioenergy.info) and the IEA Bioenergy website [www.ieabioenergy.com](http://www.ieabioenergy.com) under 'Our Work: Tasks'.

### Task Meetings and Workshops

Task 29, together with Task 40 and the Energy and Poverty Thematic Group of the World Bank, organised a workshop on 'International Bioenergy Trade and Development', on 17-18 March at the World Bank Headquarters, Washington DC, USA. This was part of the World Bank's Energy Week 2005. The main goals of the workshop were to explore the links between international bioenergy trade and socio-economic development and to investigate how sustainable bioenergy production for the world market could be realised. This involved the following elements:

- experiences with developing the use of bioenergy in a sustainable development setting;
- the socio-economic implications and benefits of bioenergy use (by Task 29); and
- the impacts of international bioenergy trade; how international trade contributes to sustainable development and how this is secured (by Task 40).

Besides an overview of expertise on areas dealt with by the respective networks and organisations, a key element of the workshop was to discuss how projects involving development of rural areas and biomass production could be realised and organised. This jointly organised event allowed for the inclusion of Energy Week participants, many of whom were from developing countries that might directly benefit from this initiative and from the expertise represented by the IEA Bioenergy Tasks involved. Such participant involvement is expected to yield suggestions, experiences, and recommendations which will be extremely helpful in formulating further concrete actions in this field.

Task 29 National Team Leaders (NTLs) and invited guests met on 6-9 June at Bezanec, Croatia, for a four day bioenergy workshop 'Local, Regional and Cross-boundary Partnerships in Implementing Bioenergy Projects'. The workshop was hosted and organised by the Energy Institute Hrvoje Pozar, Croatia, and had a special session and study tour jointly organised with Slovenian Forestry Institute, Ljubljana, Slovenia. The workshop consisted of three main parts:

- A technical seminar with invited papers from participating countries members and guests. Altogether 13 papers were presented. These will be published in workshop proceedings.
- A Task business session which reviewed the past Task activities and mapped the future programme.
- A two-day technical excursion in Croatia and Slovenia.

During the technical excursion participants visited the Gerovo-Finvest wood processing industry and its industrial biomass heating plant, which is the most important wood industry in central Croatia. The second day was dedicated to a visit to Skocjan National Park in Slovenia and a biomass-fired district heating plant at Vransko.

A meeting of NTLs was organised on 26-28 October in Trondheim, Norway, as part of the Nordic Bioenergy Conference. This international conference focussed on bioenergy markets and technologies in the Nordic Region as well as all the European countries. In addition to the Task business meeting there was a special study tour organised for the group which included:

- A meeting with owners (farmers) and planners of a 3 GWh district heating system which was under construction, to discuss the planning process and socio-economic impacts.
- A visit to a biodiesel production facility based on fish residues.

## **Work Programme**

The Task work programme in 2005 included completion of the biomass and bioenergy educational website, redesign and development of the Task 29 informational website, 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. There will be two case studies from each participating country, presented in a common format and structure devised by the Task team. The completed case studies will be available as a pdf file on the Task website and each case study will be made available in html format on the educational website.

Other activities consisted of planning and organising the Task workshops and events, the publication of workshop proceedings and preparation and publication of the Task brochure. The most recent Task results and findings were published as two invited papers in the well-recognised journals; Renewable Energy World and IEA OPEN Energy Technology Bulletin.

### *Educational website*

The 'flagship' project of Task 29 for the whole three year period was the development of the educational website about biomass and bioenergy, which can be visited at [www.aboutbioenergy.info](http://www.aboutbioenergy.info). The final product is a source of information for the non-expert population, mainly students, who are interested to learn more about the subject. Since May 2004, more than 35,000 visits have been logged from 132 countries. The website is also linked to a considerable number of other prominent websites.

## **Collaboration with other Tasks/Networking**

The Task has actively collaborated with the following Tasks:

- *Task 31*: Apart from the ongoing development of the web-based 'Electronic Information System' with the objective of synthesising and transferring to stakeholders important knowledge and new technical information, Tasks 31 and 29 jointly prepared a paper 'Sustainable Biomass Production for Energy from Forestry: Technology Transfer for Science-Based Decision-making' and presented it at the IUFRO World Congress in Brisbane, Australia.

- *Task 38:* Tasks 29 and 38 are collaborating on a joint case study of a bioenergy project in South Africa. The project involves co-generating heat and power through combustion of woody biomass arising from plantation and sawmill residues, with the intent to offset coal-based electricity with biomass-based electricity. The objective of the case study is to map the relative energy, GHG and socio-economic benefits. Task 29 will analyse the socio-economic aspects of this project, including new jobs generation, and Task 38 will be concerned with the GHG emission reduction.
- *Task 40:* Tasks 29 and 40, together with the Energy and Poverty Thematic Group of the World Bank have successfully completed the organisation of the workshop 'International Bioenergy Trade and Development', held in Washington D.C., USA. One of the follow-up activities includes contribution and joint work on IEI's journal Energy for Sustainable Development - ESD ([www.ieiglobal.org](http://www.ieiglobal.org)). Other activities are also in preparation.

### Website

The Task website ([www.iea-bioenergy-Task29.hr](http://www.iea-bioenergy-Task29.hr)), which was created at the beginning of the Task period, has been substantially redesigned, reorganised, and updated. This activity will continue throughout the current and future working periods. 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 also available to download or view online. Currently the visual identity of the website is being redeveloped and additional material (including presentations from Task workshops) is being added.

### Deliverables

Deliverables in 2005 included workshop proceedings containing a selection of papers presented at the Task international workshop, two invited papers published in recognised international journals, several papers presented at major international events, the Task 29 brochure, two progress reports and an annual audit report to the Executive Committee, and the biomass and bioenergy educational website.



*The Task 29 brochure*

## 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 lignocellulosic 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](http://www.shortrotationcrops.com) and the IEA Bioenergy website [www.ieabioenergy.com](http://www.ieabioenergy.com) under 'Our Work: Tasks'.

### Progress in R&D

#### Task Meetings

The annual Task business meeting was held on 5 August in Perth, Australia on occasion of the joint workshop of Tasks 30 and 31 'Multiple benefits from sustainable bioenergy systems' on 31 July - 5 August.

Task 30 was represented at the IUFRO World Congress held in Brisbane, with a paper by the Task Leader in the session 'The role of the International Energy Agency in creating a carbohydrate-based economy: bioenergy, biofuels and bioproducts'.

A joint Task 30, 31 and 40 workshop was held on 30 November - 2 December at Campinas University, Brazil, with a focus on sustainable biomass production systems for the global market. The workshop also included a business forum on bioenergy trade, and the possible role of the Brazilian industry.

The NTLs from New Zealand and Australia contributed with presentations at the Bioenergy Australia Conference on 12-15 December in Melbourne, Australia, with an 'Overview of Task Activities' and a focus case study on 'The Need for Multiple Benefits' respectively.

### **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 from planning, layout, site selection, species selection, planting, site prep, cultivation, harvest, silviculture and farming, comminution, transportation, sorting, utilisation, recovery, economics, nutrient management, 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 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 - plus 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 30 website ([www.shortrotationcrops.com](http://www.shortrotationcrops.com)) designed with the objective of obtaining a wider Task 30 exposure was updated regularly during 2005. 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**

Workshops were organised jointly with Task 31 in Perth, Australia and with Tasks 40 and 31 in Campinas, Brazil.

### **Deliverables**

The references to published abstracts and papers are provided in Appendix 4. Most reports and publications are distributed electronically. Negotiations are ongoing to get a selection of papers published in an international scientific journal. The high-priority report 'Full-Scale Implementation of SRC Systems: Assessment of Technical and Non-Technical Barriers' was updated and has been uploaded to the Task website. A condensed version (Technical Report) was submitted to ExCo56.

## **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, 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](http://www.ieabioenergytask31.org) and the IEA Bioenergy website [www.ieabioenergy.com](http://www.ieabioenergy.com) under 'Our Work: Tasks'.

## Progress in R&D

### Task Meetings and Workshops

Almost 50 participants from eight countries took part in a joint workshop of Tasks 30 and 31 held on 1-5 August near Perth, Western Australia. Australian hosts were the Forest Products Commission and the Department of Conservation and Land Management, Western Australia, and Bioenergy Australia. The workshop theme was 'Multiple Benefits from Sustainable Bioenergy Systems' and this was elaborated over two days of study tour followed by three days of technical sessions, during which a total of 33 presentations were made. The event culminated in an Industry Day during which regional stakeholders and international participants discussed strategies for reducing barriers to bioenergy implementation in Western Australia with particular reference to two major production systems. A CD has been produced and distributed, containing all the presentations given at the workshop, as well as annotated photos from the field visits. 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 future workshops.

## 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 field 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 focused on means of removing some of the significant barriers that prevent increased use of forest biomass for energy in many regions of the world. Specifically, certification of sustainable forest fuel production systems is being addressed as a potential tool to satisfy concerns about the possible environmental, economic, and social effects of greatly increased use of biomass from conventional forestry systems for energy. A preliminary analysis of criteria to incorporate in a certification procedure for forest energy was presented to the World Renewable Energy Congress (WREC) Regional Conference in May in Aberdeen, UK, and to a Task 29 workshop in June in Croatia. The certification focus also provided an umbrella for synthesis efforts on topics likely to be part of the criteria for certification, including long-term site productivity involving forest biomass removal for energy use, and life cycle analysis of forest operations systems. Reports were presented at the joint Task 30/31 workshop and other events, including the IUFRO World Congress, a joint workshop, and business forum of Task 40 with Tasks 30 and 31 in Brazil, a BIOCAP Canada parallel event to the IPCC COP 11 meetings in Montreal, and a UNIDO workshop on industrial biotechnology in Vienna. Preliminary plans have been made for further development of this work in collaboration with FAO.

The major synthesis publication, produced in 2002-2003, is still being distributed while copies are available and has proved an invaluable, and often-cited, source of information on all aspects of sustainable biomass production for energy from conventional forestry systems.

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, which now has a new URL ([www.ieabioenergytask31.org](http://www.ieabioenergytask31.org)), is the primary vehicle for information dissemination. 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, and the extensive output of related past Tasks and Activities has been added. Basic Task information continues to be provided also on the IEA Bioenergy website, where Task informational materials, such as workshop announcements, are made available. Collaborative efforts with other Tasks related to the Electronic Information System, including the Task 29 educational website, continue to be pursued.

The concept of Industry Days has continued. These are designed to take advantage of the presence of international experts who have participated in a Task workshop, by having them meet and share issues and ideas with invited regional guests representing the forestry, energy and policy sectors.

### **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 joint workshops. The Task Leader participated in the Task 29 workshop in Croatia giving a presentation on the forest certification work of Task 31. Input and content have also been provided to the Task 29 website aimed at education and general public audiences. A similar close level of collaboration exists with Task 30. This included the joint workshop held in August in Western Australia. In addition, the Task leadership team participated in a joint workshop and business forum in Brazil on 'Sustainable biomass production for the world market' with Tasks 40 and 30 - presentations provided related to sustainable forest management and certification issues.

Opportunities for collaboration and cooperation with other international researchers, organisations and activities, including IUFRO, are also pursued, particularly those involved in issues of sustainability of forest ecosystems. In conjunction with Task 29, a presentation was given at a special IEA Bioenergy session during the IUFRO World Congress in Brisbane. An invited presentation on forest biomass sustainability was given by the Task Leader at a BIOCAP Canada Parallel Event during the IPCC COP 11 meetings in Montreal. One of the Associate Task Leaders also participated with presentations at the STEM and FORMAS seminar of Sveriges Energiting 2005 in Sweden, and at an IUFRO conference on 'Transfer of forest science knowledge and technology' in Oregon, USA.

### **Deliverables**

The proceedings of the third annual workshop, held in October 2003 in Flagstaff, Arizona, USA, are in press as a special issue of Biomass and Bioenergy. Sixteen invited and volunteer papers were included in the special issue following peer review. PowerPoint presentations made at the workshop have also been made available to workshop participants on CD.

The proceedings of the fourth annual workshop, held in September 2004 in Garpenberg, Sweden and Gran, Norway, have been peer reviewed by workshop participants and other Task collaborators and 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 Task 30, in August 2005 in Western Australia 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<sub>x</sub> reduction; and
- the improvement of existing systems and development of new concepts.

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:** Mr Jaap Koppejan, TNO, the Netherlands.

**Operating Agent:** Mr Erik Wissema, Ministry of Economic Affairs, the Netherlands

**Alternate Operating Agent:** Ir Kees Kwant, SenterNovem, Netherlands Agency for Energy and the Environment, 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](http://www.ieabcc.nl) and the IEA Bioenergy website [www.ieabioenergy.com](http://www.ieabioenergy.com) under 'Our Work: Tasks'.

## Progress in R&D

### Task Meetings and Workshops

The Task organised two meetings in 2005, one in Graz and the other in Paris. These meetings were used to measure the progress of Task activities against the work plan, discuss Task initiated workshops, plan future activities and share recent developments in biomass combustion in participating countries. A topic of continuing importance at both Task meetings was the preparation of the second edition of the 'Handbook of Biomass Combustion and Co-firing'.

The first Task meeting was held on 16-17 March in Graz, Austria in combination with an international workshop on 'Aerosols from Biomass Combustion'. The workshop was organised by Ingwald Obernberger of the Institute for Resource Efficient and Sustainable

Systems, TU Graz, with support from Task 32 and the Austrian Bioenergy Centre GmbH. It attracted 75 participants and was considered very successful as it contained recent information on the formation and health impacts of aerosols originating from the combustion of biomass. The presentations are available on the Task website. The proceedings of the workshop are available as a separate book - Volume 6 of the Thermal Biomass Utilisation book series of BIOS BIOENERGIESYSTEME, see [www.ieabcc.nl](http://www.ieabcc.nl) for information on how to order this publication. Apart from the workshop, an important part of this meeting was the visit to three innovative biomass combustion based CHP demonstrations plants (with Stirling engine, ORC cycle and screw steam expander as prime movers).

The second Task meeting was held on 18 October in Paris, in conjunction with the 14<sup>th</sup> European Biomass Conference. This Task meeting was used again to discuss progress in Task activities, but also to set priorities for the next triennium. A voting procedure formed the basis for a draft work plan for the new triennium. As part of the European Bioenergy Conference, the Task organised a workshop titled 'Recent Developments in Small-scale Biomass Combustion'.

The Task also provided input to two other workshops: one on 'modelling and controlling biomass grate furnaces', at an European expert workshop in the framework of the EU ThermalNet project; and the other on 'co-utilisation of biomass with fossil fuels', held as part of ExCo55 in Copenhagen, Denmark.

The reports of Task meetings and workshops can be downloaded from the Task website at [www.ieabcc.nl](http://www.ieabcc.nl). An overview of workshops organised in this triennium by the Task is provided below.

Topic	Host	Location and Timing
Co-firing	Netherlands	Rome, Italy, May 2004
Public perception of biomass co-firing	Canada	Victoria, Canada, August 2004
Aerosols from biomass Combustion	Austria	Graz, Austria, March, 2005
Process control and sensor development	Netherlands	Innsbruck, Austria, September 2005
Recent developments in small scale systems	Netherlands	Paris, France, October 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 is based on a prioritisation of topics agreed in 2003. These are:

- 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<sub>x</sub> reduction.
- Improvement of existing systems and development of new concepts.

Progress achieved on these topics in 2005 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); and
- determination of efficiency for automatic biomass combustion plants and comparison of efficiency and emissions for different operational modes (Switzerland, March 2004).

Completion of the study 'Energetic Assessment of Energy Systems with Biomass Combustion' by Switzerland has been postponed to 2006 due to some delays in performing test trials under practical conditions. In March, three field trips to biomass combustion CHP plants with innovative designs were organised.

### ***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 in 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-fired power plants, was updated. This makes it easy for anyone to trace power plants with experiences of co-firing certain types of biomass/wastes.

Upcoming activities in this area are:

- Organisation of a workshop on ash related issues with biomass combustion and co-firing on 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 draft report on 'Formation of Striated Flows During Biomass-coal Co-firing', by former Task participant USA is to be finalised.

#### ***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. It 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' will be organised as part of the World Bioenergy Conference, to be held in May/June in Jönköping, Sweden. Attempts to organise this workshop jointly with the IEA Implementing Agreement on Fluidised Bed Conversion did not work out due to other 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.

#### ***Corrosion and deposit formation mechanisms***

This topic relates to fireside issues such as agglomeration, deposit formation, and corrosion. A Task 32 workshop on this topic is planned for September 2006 in Glasgow.

### ***Formation and emission of particulates (aerosols) and primary measures for NO<sub>x</sub> reduction***

The relevance of mitigation of aerosol emissions from biomass combustion has been discussed previously by the Task. In some countries, biomass combustion forms a major source of aerosols with significant health impacts. In 2001, the Task organised a workshop on the formation of aerosols and ways to reduce aerosol emissions cost-effectively. A statement was then produced and disseminated by the Task on the importance of aerosols from biomass combustion. Another workshop on this topic was held in March in Graz. At this workshop, recent progress with regard to understanding and mitigating emissions of aerosols from biomass combustion systems was presented and discussed. The findings of this workshop were published as a book in the TU Graz series on 'Thermal Biomass Utilisation', while a summary of the results was published as a Technical Report to ExCo56.

### ***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 'Optimisation of Small-scale Combustion Systems' was held in October as part of the 14<sup>th</sup> 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.

### **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.

The programme of the Task is closely related to those of other IEA Bioenergy Tasks, especially to activities in the field of biomass gasification (Task 33) and energy recovery from MSW (Task 36). Collaboration is enhanced by joint events with other Tasks, and also by exchange of meeting minutes and reports.

### **Deliverables**

Deliverables in 2005 included: organising and minuting of two Task meetings; organising and reporting a workshop 'Recent Innovations in Small-scale Biomass Combustion'; organising and reporting a workshop on 'Aerosols from Biomass Combustion'; and co-organisation of a workshop on 'Modelling and Control of Biomass Grate Furnaces'; Also,

finalisation and publication of a statement on the relevance and opportunities for biomass co-firing; updating of the international overview of initiatives for biomass co-firing (by the Netherlands); finalisation of the study on Biomass Impacts on SCR Catalyst Performance; reporting to the ExCo including a Technical Report on 'Aerosols from Biomass Combustion'; and maintenance of the Task website.

In addition to the outputs above, the Task has continued preparation of a second edition of the 'Handbook of Biomass Combustion and Co-firing'. The first edition was published in two print 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 also to divide the work involved in authoring and editing the second edition. James and James have agreed to publish this new edition, which is scheduled for release in early 2006. Once the second edition is available, the text of the first edition will be made available through the website.

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. Publication of this version of the Handbook has been delayed until early 2006.

## **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/iea](http://www.gastechnology.org/iea) and the IEA Bioenergy website [www.ieabioenergy.com](http://www.ieabioenergy.com) under 'Our Work: Tasks'.

## Progress in R&D

### Task Meetings and Workshops

The third Task meeting was held from 17-19 May in Stockholm, Sweden, in conjunction with the Swedish SYNBIOS Conference. Selected presentations from the two-day conference constituted the technical background for the third workshop (WS3), 'Hydrogen and Synthesis Gas for Fuels and Chemicals.' The third and final day was dedicated to discussing Task related matters. The NTL from Netherlands is preparing the workshop report.

The fourth Task meeting was held from 26-28 September in Innsbruck, Austria, in cooperation with the European GasNet/ThermalNet activity. A one day workshop (WS4) 'Health, Safety, and Environmental Impact of Small-scale Biomass Gasification Systems' was held jointly with GasNet. The remaining two days were dedicated to discussing Task related matters. The NTL from Switzerland and the Austrian representatives from GasNet are jointly preparing the workshop report.

#### *Future workshops*

The remaining two Task meetings and workshops to be conducted at these meetings for the current triennium are:

- Fifth Task Meeting and WS5 'Biomass Gasification and Gas Clean-up', to be held on 5-7 June 2006 in Freiberg, Germany.
- Sixth Task Meeting and WS6 'Biomass Gasification Success Stories and Lessons Learnt' to be held on 16-18 October 2006 at GTI, Des Plaines, IL. and NREL, Golden, CO, USA.

### 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 NTL 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 research needs.

### **Work Programme/Subtask Studies**

The current work programme includes the following elements:

- 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.
  
- 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:
  - 1st Task meeting and WS1 'Short, Medium, and Long Term Perspectives on BMG', 3-5 May 2004, Vienna, Austria.
  - 2nd Task meeting and WS2 'Gas Cleaning and Gas Engines for Small-scale Applications', 25-27 October 2004, Copenhagen, Denmark.
  - 3rd Task meeting and 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 and 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 and WS5 'Biomass Gasification Gas Clean-up', 5-7 June 2006, Freiberg, Germany.
  - 6th Task Meeting and WS6 'Biomass Gasification Success Stories and Lessons Learnt', 16-18 October 2006, GTI, Des Plaines, IL. and NREL, Golden, CO, USA.
  
- 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/jea](http://www.gastechnology.org/jea)) for information dissemination. Maintain the website.

## **Observations from the Workshop (WS3) 'Hydrogen and Synthesis Gas for Fuels and Chemicals'**

### *Background*

At present, Europe produces 98% of the transportation fuels from petroleum; imports make up more than 50% of European petroleum needs. Sweden, the host country for the SYNBIOS conference, produces over 2% of its transportation fuels from biomass. The present CO<sub>2</sub> related tax exemptions in Sweden provided the incentive to build three commercial bio-liquid fuel plants that will supply 'green' transportation fuel. Although, the present tax benefits were developed primarily for ethanol, additional measures are expected to be introduced in 2008 which should provide new incentives to convert indigenous biomass to bio-liquid fuels. Sweden may have to revise its tax laws to provide the economic support needed to introduce either 5% or higher bio-liquid fuel blending for transportation purposes. Bio-liquid fuel vehicles are now sold in Sweden with several incentives such as reduced taxes and free parking.

### *Biomass conversion*

The beneficial impacts of bio-liquid fuels can be fully realised when the overall process economics of collecting and transportation of biomass to gasification plants and the conversion of synthesis gas to fuels and chemicals can compete with fossil fuels. It is generally believed that the basic infrastructure could be developed to provide adequate feed stock to produce significant quantities of bio-liquid fuels; however, resources are needed to resolve several infrastructure related hurdles and also to optimise process design to reduce the cost of producing these fuels.

The technical hurdles to produce clean synthesis gas and its subsequent conversion to liquid fuels are well defined; the principal issues being gas cleaning and reducing the cost of producing fuels, while scaling-down the process. This is in contrast to scaling up processes to reduce product cost, as it is commonly practiced in petroleum refineries and chemical plants. Japan is developing an efficient direct synthesis process to produce DME. A 100 TPD demonstration project, using a slurry phase synthesis reactor is being planned for testing and evaluation in Hokkaido. Initial tests will be carried out with synthesis gas from natural gas. Sweden believes that black liquor gasification (BLG) could be used to produce synthesis gas for subsequent conversion to bio-liquid fuels that could compete with conventional liquid fuels.

### *Automobile manufacturers*

Starting in 1995, Volvo commissioned research into DME and the first generation prototype vehicle tests were conducted in 1999. Subsequent improvements led to introducing demonstration test vehicles in 2005 in Sweden and Germany that could meet the Euro-5 standards. Volvo has been working with the Chemrec, to evaluate the performance of DME produced from synthesis gas derived from BLG as a transportation fuel of the future. The results are encouraging with low NO<sub>x</sub> and particulate emissions. DME will very likely be introduced initially for fleets of trucks and buses, to be followed by a wider distribution when the LPG type of fuel distribution and fuelling system is put in place.

Volkswagen is conducting RD&D pursuing the scenario of adding bio-liquid fuels to existing fuels. Volkswagen is developing a 'combined IC engine', which combines the emission features of a gasoline engine with the efficiency of a diesel engine. At present, diversification of transportation fuels to include, diesel, LPG, biodiesel, DME etc. is not considered economical.

### *Refineries*

Neste Oil Corporation, Finland reported that starting in 2007, it will produce NExBTL, a biomass based liquid diesel, with an annual production capacity of 170,000 tonnes.

The 'Shell Global Solutions' presentation showed that market penetration of bio-liquid fuel volume can be expedited by blending with conventional fuels. The proposed strategy is to try several fuel options and let the market forces determine the preferable fuels and/or additives. This whole process of sorting out the various options for developing the biomass based transportation liquid fuels may take up to 15 years before practical, optimal, and economical schemes can be deployed on a large scale.

Complete presentations from the Conference can be accessed at the following website: [www.ecotraffic.se/Synbios/Conference/SYNBIOS\\_Conference.htm](http://www.ecotraffic.se/Synbios/Conference/SYNBIOS_Conference.htm). In addition, the NTL from the Netherlands is in the process of preparing a detailed report on 'Biomass Gasification: Hydrogen and Synthesis Gas for Fuels and Chemicals'.

## **Observations from the Workshop (WS4) 'Health, Safety and Environmental Impact of Small-scale Biomass Gasification Systems'**

### *Background*

Small-scale biomass gasification technologies are employed in a variety of heat, CHP, and power generation applications. They should be designed and operated for efficient use of fuels, safety, as well as with compliant environmental performance. Experts participating in the Task and the EU GasNet/ThermalNet project recognised health, safety and environment (HSE) issues could be a barrier to the deployment of these technologies. In addition, gasifier manufacturers and users of the technology confirm the need for certain HSE guidelines.

### *Work in progress*

Based on discussions with gasifier manufacturers and experts in the field, it is determined that safety in gasifier operation can be addressed during: plant design and configuration; integration of a safety control system; estimation of operational risk; and development of operating instructions for safety and trouble shooting.

From an operational point of view, the primary focus is on prevention of unforeseen explosions. The explosion assessments are based on potential temperature excursions, changes in operating pressure, and the flammability limits of gas mixtures. The development of safety standards will be based on:

- evaluation of the state of the art of HSE issues in gasification plants;
- definition of minimum HSE standard for such plants;
- gas treatment and conditioning;
- emissions regulation for gas handling and utilisation in IC engines;
- operational features of IC engines and their emissions;
- waste water characteristics, treatment, and disposal; and
- measurement of critical process parameters.

It is anticipated that the following information will be developed during completion of the work related to WS4 on health, safety and environmental impacts of small-scale biomass gasification systems. Development of HSE guidelines; validation of the guidelines by case studies, and dissemination of the results from these studies to an agency for formalising and implementing HSE impact guidelines.

The HSE impact study is partly financed by the 'Energy Systems of Tomorrow' program of the Austrian Federal Ministry of Traffic, Innovation and Technology, GasNet/ThermalNet, and IEA Bioenergy Agreement Task 33. This study is being coordinated by Mr. Ruedi Bühler, Umwelt + Energie, the NTL from Switzerland, representing Task 33 and Mr. Friedrich Lettner, Graz University of Technology, Institute of Thermal Engineering, Austria, representing GasNet. Besides these investigators, the project team is expected to include other experts from the Institute of Chemical Engineering, TU Vienna; GE Jenbacher AG; REPOTEC Umwelttechnik GmbH.; and authorisation experts from the province of Styria.

### **Collaboration with Other Tasks/Networking**

Task 33 continues to collaborate with some of the IEA Bioenergy Tasks, IEA Hydrogen Annex 16, IEA Pulp and Paper Annex XV 'Gasification Technology for Black Liquor and Biomass', and European GasNet.

In addition, as reported above 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 members, 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 is shown in the figure on page 54. An interesting feature of these Tasks is the close interactions and complementarity between the three technology areas that encourages a high level of interaction in areas of mutual interest. To reflect the particular interests of the USA, an additional Task was added to the PyNe area at the kick-off meeting in May 2005 on the subject of 'biorefineries'.

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; and
- collation and dissemination of relevant information through the regular PyNe newsletter, the PyNe website, and direct contact between Task members and invited guests through the planned programme of meetings, workshops, and conferences.

**Participating countries:** 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](http://www.pyne.co.uk) and the IEA Bioenergy website [www.ieabioenergy.com](http://www.ieabioenergy.com) under 'Our Work: Tasks'.

ThermalNet				
	CombNet Combustion	GasNet Gasification	PyNe Pyrolysis	
<b>Technology</b> Technology and applications Policy and strategy				<b>Co-ordinators</b>
<b>Technical Tasks</b> Characterisation and analysis Co-processing and co-firing Feedstocks, standards Fouling, corrosion, erosion Gas treatment Science and modelling Transport fuels	<b>Experts</b>	<b>Experts</b>	<b>Experts</b>	<b>Task Leaders</b>
<b>Non-Technical Tasks</b> Barriers Economics Education, training Environment, health, safety	<b>Experts</b>	<b>Experts</b>	<b>Experts</b>	<b>Task Leaders</b>
<b>Dissemination</b>				
<b>Management</b>				

Structure of the Task 34 work programme.

## Progress in R&D

### Task Meetings and Workshops

The kick-off meeting for ThermalNet, which includes PyNe, was held in May in Heidelberg, Germany. In addition there was a dedicated session on pyrolysis to reflect the historical long term status of the fast pyrolysis network in IEA Bioenergy and the EC, as well as to ensure that all IEA Bioenergy interests were fully represented. This resulted in an additional task for the pyrolysis area on biorefineries which will be led by Doug Elliott, the USA representative. The meeting included a visit to Jenbacher, who are a leading manufacturer of engines for use with biomass gasification.

The next ThermalNet meeting was held on 29-30 September in Innsbruck, Austria, along with the PyNe meeting also held on 27-28 September.

### Work Programme

The proposed work programme for the new EC supported ThermalNet project was reviewed in Victoria in September 2004. The new activity - biorefineries - was confirmed and agreed at the Heidelberg meeting with a detailed workplan.

## Newsletter

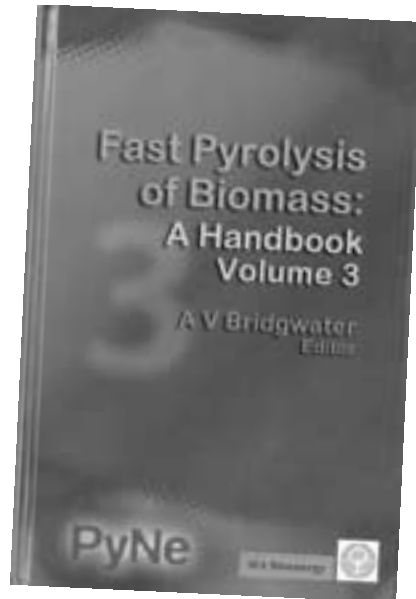
The PyNe newsletter continues to be an important vehicle for dissemination and is circulated to Member Countries for distribution. The last issue was published in April 2005. The next issue will be a combined newsletter for the whole of ThermalNet including a dedicated section on pyrolysis. This will have a circulation of around 5000. These will continue to be published biannually.

## Website/Dissemination

The PyNe Website is being maintained and is in being updated and revised.

## Deliverables

Progress Reports to the Executive Committee were produced in May 2005 for ExCo55 in Copenhagen, and in October 2005 for ExCo56 in Dublin. The minutes from the Task meetings held during 2005 - Heidelberg in May and Innsbruck in September have been published and distributed. The Final Report of Task 34 was published as Volume 3 of the 'Fast Pyrolysis of Biomass: A Handbook' series.



## 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, Japan, Norway, Sweden, United Kingdom and the European Commission.

**Task Leader:** Dr Niranjana 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](http://www.ieabioenergytask36.org) and the IEA Bioenergy website [www.ieabioenergy.com](http://www.ieabioenergy.com) under 'Our Work: Tasks'.

### Task Meetings and Workshops

Task 36 held two meetings in 2005. The first meeting took place on 25-27 April in Bath, UK and included site visits to the Compact Power Plant at Avonmouth and the Crymlyn Burrows Material Recycling and Energy Centre (MREC) in Wales. The meeting included speakers from Compact Power, Department for Environment Food and Rural Affairs (Defra), Hampshire County Council, and the Department of Trade and Industry (DTI). The second meeting was held on 12-15 December in Melbourne, Australia in conjunction with the Bioenergy Australia 2005 Conference 'Biomass for Energy the Environment and Society' at which there was a Task 36 session. The conference was very successful and attracted 198 delegates.

### 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 life cycle 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.

This Topic is being led by the Waste Management Association of Australia. The EC, the UK and France will also contribute. It is being undertaken in three stages:

- Stage 1 - Background paper on the 'perfect world' potential of EPR/PS/PR schemes.
- Stage 2 - To assess actual performance/experiences and case studies to measure results and highlight determining issues.
- Stage 3 - To synthesise Stages 1 and 2 to project future EfW demand/potential and the projected demand for facilities and capabilities infrastructure.

The Stage 1 report has now been published, and Stage 2 is now underway. The contributions from industry and sponsorship for this topic amount 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 will shortly be uploaded onto the Task 36 website. The next stage will be to prepare three case studies on MBT plants. The case studies will comprise of the following:

- a plant whose primary objective is energy recovery;
- a plant whose objective is to stabilise the waste and then to landfill it; and
- something between the two extremes.

### *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 'Integrated Solid Waste Management Tools' (IWM). This model is able to evaluate the life cycle 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 are now:

- Provision of a waste management optimisation tool: technology ranking on a GHG basis; the ability to compare both cost and ultimate CO<sub>2</sub> capture simultaneously; comparison of capital and O&M costs; and optimisation.
- Development of a comprehensive spreadsheet that will encompass both GHG implications and economics of management strategies for MSW.

The work undertaken in 2005 was ASPEN Model Development. 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.
- Preparation of economic analyses for five waste management technologies using ASPEN/ICARUS.
- Development, testing and debugging of the comprehensive economics spreadsheet model.

The work programme in 2006 will involve project completion/exporting model to participating countries. Specifically:

- Preparation of three waste management case studies and economic analyses using ASPEN/ICARUS and incorporation into the model.
- Running the model (performing optimisation exercises) on a number of scenarios, in conjunction with runs on IWM Tools.
- Fine-tuning of the model and updating of data.
- Provision of instruction in model modification/use to those participating countries desiring this assistance.
- Preparation/delivery of final report/model.

The Topic Leader will liaise with Task 38 to ensure that any suitable opportunity for collaboration or joint working is exploited.

### *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 project has 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; and
- to optimise the size and order of flue gas cleaning equipment according to the quality of waste.

The modelling work was undertaken from April - October 2005 and the report will be completed in early 2006. This Topic is being led by VTT in Finland.

### *Thermal treatment of sewage sludge*

This Topic is 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 who 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 of 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 2005 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. Literature has been gathered and approximately 70-80% of the reporting has been completed.

### **Collaboration with Other Tasks**

The Topics 'Greenhouse Gas Balances for MSW Systems' and 'Mechanical Biological Treatment' overlaps with interests of Tasks 38 and 37 respectively. Where appropriate it is anticipated that Topic Leaders will liaise to coordinate programmes of work and share in any benefits that arise.

### **Deliverables**

The deliverables for the Task in 2005 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:** Mr 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.novaenergie.ch/iea-bioenergy-Task37](http://www.novaenergie.ch/iea-bioenergy-Task37) and the IEA Bioenergy website [www.ieabioenergy.com](http://www.ieabioenergy.com) under 'Our Work: Tasks'.

## Progress in R&D

### Task Meetings and Workshops

Two major Task meetings were held in 2005. The first meeting took place on 19-21 May in Switzerland, just prior to ExCo55. Half a day was dedicated to a new project on continuous education. Four invited experts from Austria, Germany, and Switzerland presented their different training courses and shared their experiences with the Task participants. During the second day of the seminar a site visit was organised. Two of the newest Kompogas installations - a Swiss brand specialising in the dry digestion of source separated waste - were visited. The second plant was equipped with a new gas upgrading plant operated with a chemical scrubber. The study tour was completed with visits to an agricultural co-digestion plant and another upgrading plant at a sewage treatment plant operating with a pressure swing adsorption system.

The second Task meeting was held on 20-22 September, 2005 in Utrecht, the Netherlands. In connection with this meeting the Task organised, together with the EU-project CROPGEN, a research exchange workshop on 'Energy Crops and Biogas - Pathways to Success?' The goal was to improve the information transfer of the different research groups in the fields of plant breeding, microbiology and process engineering and to stimulate new collaborative research projects.

During the first day of the meeting a visit was organised to two industrial digestion plants with new concepts. The first one in Heerenveen was a mechanical-biological treatment plant where household waste is mechanically separated into an organic fraction, a metal fraction, a washed glass and sand fraction, and a high calorific fraction going into incineration (RDF). The organic fraction is digested and the biogas used for a CHP. The digestate is separated into a stabilised solid fraction which is land filled and a liquid fraction which is aerobically upgraded. The second plant in Lichtenvoorde was designed to digest industrial waste water and sludge and in a second step Category 2 and 3 animal by-products.

## **Work Programme**

In 2005 the work programme consisted of the following topics:

- Business meetings.
- Website: update; maintenance; proceedings.
- Workshop on continuous education.
- Industry forum.
- Success stories.
- Research exchange seminar.
- Gas upgrading and gas vehicles.
- Workshop on Integrated Waste Management and Utilisation of the Products.

The progress made on each Topic is summarised below.

### *Business meetings*

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

### *Website*

The website ([www.novaenergie.ch/iea-bioenergy-task37](http://www.novaenergie.ch/iea-bioenergy-task37)) was updated on a monthly basis with news and meeting dates. Three new topics were introduced: the industry forum, the success stories and the country reports. The proceedings of the Utrecht seminar was also included.

### *Workshop on continuous education*

In most of the Member Countries educational training is offered to AD plant operators. Particularly in the German speaking Member Countries a series of educational training courses have been elaborated and widely applied. The Task wanted to learn about the experiences gained. Four experts from Austria, Germany and Switzerland were invited to present their different training courses and to share their experience. The goal of the workshop was to find out if the Task could play a role in providing basic information to lecturers in order to save the time and cost of specialists in the Member Countries.

After the presentations of the programmes and an in-depth discussion, the Task came to the conclusion that all technical and biological topics are of general interest to all countries. It was therefore decided that the Task would establish an 'information pool' in the form of Powerpoint presentations, which could serve as a common background for all training courses, and other presentations.

The major focus of the information will be oriented towards policy makers. The Task participants considered this of high relevance. This target group has never been approached. Out of the general 'information pool' a specific introduction into 'biogas for policy makers' could therefore be established. All aspects could be covered except country specific legislation.

### *Industry forum*

There is a continuous exchange of information with most of the plant providers. In order to improve the information exchange with industry, a database has been designed where equipment providers can register and fill in information on their products. A number of other information categories such as publications, conferences, and news have also been added. All of this information is available on the Task's website.

### *Success stories*

A database was established to describe outstanding plants (case studies) in a standard format. Every participant has a template of the data bank and is encouraged to fill in data on plants that he has visited or has performance data on. The plant description is brought into a layout of a folder by a professional and placed on the web. This information can be downloaded from the Task's website.

### *Research exchange seminar*

The programme of work of the Task includes detailed information exchange with the major research groups working in the field of biogas. To stimulate this exchange the Task organised jointly with CROPGEN, a EU-project of FP5, a research exchange workshop on 'Energy Crops and Biogas - Pathways to success?' The goal was to improve the information transfer of the different research groups in the fields of plant breeding, microbiology and process engineering, and to stimulate new collaborative research projects. Participation was limited to a maximum of 50 searchers. Some of the most outstanding personalities in the field were invited to give a brief overview on the respective topic. The following research areas were covered:

- identification and development of crops for energy production;
- biomass processing concepts, storage, pre- and post treatment, technologies and impacts;
- overall energy balance of crop to Biogas systems; and
- potential of integrated Biogas systems.

The presentations made on each research topic as well as other short contributions can be downloaded from the Task's website.

### *Gas upgrading and gas vehicles*

Biogas as a fuel becomes increasingly interesting, especially in Europe under the pressure of the ambitious EU target that in 2005 and 2010, 2% and 5.75%, respectively of the fuel consumption in every country should be achieved with fuel from biomass.

In 2001 the Task produced a brochure on biogas upgrading and utilisation. The basic technologies described are still valid, however new processes and applications have been introduced since. Task participants are carefully collecting the relevant information and making it available in an increasing number of seminars, they are invited to. Thanks to the support of the ExCo Chairman Kyriakos Maniatis, the Task Leader had the opportunity to share this 'know-how' with the European Commission's DG Research 'vision group' on biofuels.

Preparatory work has been done to publish a new brochure on 'biogas upgrading and utilisation' in the first half of 2006 together with the City of Stockholm, who are participants of the FP6 EU project 'Biogasmax', dealing with biogas as fuel in public transport.

#### *Workshop on integrated waste management and utilisation of the products*

In collaboration with the Chairman, the ExCo Members of Finland, the Netherlands and Ireland, and Task 36, the Task organised a workshop for ExCo56 on integrated waste management. Seven speakers presented excellent contributions on policies, resource management and ecobalances, mechanical-biological treatment and incineration and finally on the utilisation of rendered animal fat.

#### **Collaboration with other Tasks**

The workshop above was organised in collaboration with Task 36 and the ExCo. Also, through discussions with Task 36 a collaborative project has been agreed on the potentials and limits of MBT.

#### **Deliverables**

The deliverables for the Task in 2005 included: the website, two progress reports, minutes of the Task meetings, the presentations of the research exchange seminar in Utrecht, a paper on MBT for the ExCo workshop, a Technical Report on biogas as a vehicle fuel and a case study as reported above and detailed in Appendix 4.

## **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, 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). 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.joanneum.at/iea-bioenergy-task38](http://www.joanneum.at/iea-bioenergy-task38) and the IEA Bioenergy website [www.ieabioenergy.com](http://www.ieabioenergy.com) under 'Our Work: Tasks'.

## Progress in R&D

### Task Meetings and Workshops

In collaboration with University College Dublin, University College Cork and Sustainable Energy Ireland, the Task organised the following meetings on 25-28 April in Dublin.

- A joint workshop 'Greenhouse Gas Aspects of Biomass Cascading - Reuse, Recycling and Energy Generation' with Cost Action E31 - Management of Recovered Wood. The programme and presentations can be found at [www.joanneum.at/iea-bioenergy-task38/workshops/dublin05/](http://www.joanneum.at/iea-bioenergy-task38/workshops/dublin05/)
- A field tour of peat harvesting and the Edenderry power plant where peat is used for energy production.
- An internal Task meeting which covered the following: progress in 2004; the work programme for 2005; new case studies; BIOMITRE; an information note on 'Trading biomass, bio-electricity, green certificates, or CO<sub>2</sub> credits'; a paper on 'Optimising the GHG benefits of bioenergy and carbon sequestration'; and other business.

### Work Programme

In 2005 the Task worked mainly on the following:

- organisation of one Task meeting in Dublin, Ireland,
- the planning and continuation of special projects such as case studies,
- a special issue of the journal 'Mitigation and Adaptation Strategies for Climate Change',
- the feature article for the IEA Bioenergy 2005 Annual Report,
- a paper titled 'Optimising the GHG benefits of bioenergy and carbon sequestration systems',
- a paper titled 'Key terms used in greenhouse gas reporting and accounting for the land use, land use change and forestry sector',
- documentation of methodology, development of estimation tools, and methodologies for GHG cost assessment for the EU project BIOMITRE,
- an online calculator,
- country reports from the participants,
- a second edition of the FAQs publication,
- the Task presentation for the IUFRO World Congress in Brisbane, and
- a paper titled 'The reduction of emissions from non-renewable biomass use should become an eligible CDM project activity'.

### *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 completed and published. They are available at [www.joanneum.at/iea-bioenergy-task38/projects/task38casestudies/](http://www.joanneum.at/iea-bioenergy-task38/projects/task38casestudies/)

The following case studies have been approved for the 2004-2006 Task period:

- 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).
- Canada: Use of pellets (from mountain pine beetle infested wood, hybrid poplar and sawmill residues) to produce bioenergy.
- 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.
- Ireland: Use of MSW for energy production arising from thermal treatment.
- Australia: Utilising char as a soil amendment
- USA/Netherlands: Greenhouse gas balance of biofuels produced via gasification.

### *2005 Annual Report.*

In cooperation with Task 40, the Task produced the feature article for this Annual Report. A brochure based on this article will become available in 2006. This contribution describes different trading options that exist to reconcile the geographical disparities between supply and demand for bioenergy and bioenergy services, depending upon the specific situation of the 'exporting' and 'importing' country. Trade in biomass fuels, electricity, renewable certificates, and CO<sub>2</sub> credits are presented as options for business and policy makers as they try to meet increasing energy demands while at the same time addressing national and international commitments to reducing CO<sub>2</sub> emissions.

### *A special issue of the journal 'Mitigation and Adaptation Strategies for Climate Change'*

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

### *Optimising the GHG benefits of bioenergy and carbon sequestration systems*

This paper discusses ways for optimising GHG benefits when energy strategies based on biomass are considered by policymakers at the macro-level. Energy choices by companies are usually driven by economics, which may or may not reflect GHG implications (e.g., energy from fossil fuels subjected to carbon taxes, cap-and-trade restrictions etc.). A poster on this topic was prepared for the 14th European Biomass Conference in Paris and will be published in the proceedings of this conference.

### ***Key terms used in greenhouse gas reporting and accounting for the land use, land use change and forestry sector***

This paper collates definitions of key terms commonly used in relation to greenhouse gas reporting and accounting for the land use, land use change, and forestry (LULUCF) sector and highlights areas of ambiguity and divergent interpretations. Confusion and differences over interpretations of key terminology can be a major barrier to effective communication. Our intention is to facilitate clear communication between the many players participating in the various processes dealing with estimation and reporting of greenhouse gas emissions and removals. The paper is available at: [www.joanneum.at/iea-bioenergy-task38/publications/keydefinitions.pdf](http://www.joanneum.at/iea-bioenergy-task38/publications/keydefinitions.pdf)

### ***Biomitre***

The joint Task 38 and EU project BIOMITRE was finalised. The results from this project include finalisation of the BIOMITRE standard, a user-friendly software tool that can be used to analyse GHG balances and cost-effectiveness of different biomass energy technologies, a manual for this software tool, and a review of methodologies for evaluating GHG balances and mitigation costs of bioenergy systems. These main results are documented in the 'Methodological Toolbox' of the Task website.

### ***Online calculator***

The Task started work on a simple online calculator for biomass CHP and heating systems. This tool facilitates comparisons of different bioenergy systems with fossil fuel systems and the calculation of greenhouse gas emissions. It will be available on the Task website.

### ***Country reports***

For EU countries information on renewable energy sources including bioenergy and the main supporting policies have been updated. These can be found at [www.joanneum.at/iea-bioenergy-task38/countryreports/](http://www.joanneum.at/iea-bioenergy-task38/countryreports/)

### ***FAQ publication***

The publication 'Answers to 10 frequently asked questions about bioenergy, carbon sinks and their role in global climate change' has been updated in a second edition and printed as a coloured brochure.

### ***IUFRO world congress***

Annette Cowie gave a Task presentation on 'Bioenergy for Reducing Greenhouse Gas Emissions' at the IUFRO World Congress. This paper was co-authored with B. Schlamadinger.

### ***Joint project with FAO***

The Task collaborated with FAO on CDM issues concerning the eligibility of bioenergy projects. A paper titled 'The Reduction of Emissions from Non-renewable Biomass Use Should Become an Eligible CDM Project Activity' was produced by B. Schlamadinger and I. Jürgens.

## **Collaboration with Other Tasks/Networking**

The Task collaborates widely with other IEA Bioenergy Tasks and also external organisations. A joint workshop is planned with Task 40 in 2006. The Danish case study will be carried out with Task 29. The Irish case study will include input from Task 36. Task 37 will be involved in the Austrian case study. Collaboration with FAO is detailed above.

The workshop in Dublin was organised with Cost Action E31 - Management of Recovered Wood. For more detailed information on COST Action E31, its output and previous events please see [www.ctib-tchn.be/coste31](http://www.ctib-tchn.be/coste31)

The EU project BIOMITRE, developed by a consortium of European Task 38 participants and other groups, was undertaken from April 2003 to October 2004. A cooperative financing scheme using European Commission funds and Task 38 funds was developed. The Task case studies constituted the Task contribution, while funding from BIOMITRE allowed for improvement of methodologies and the development of a computer model.

## **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.

## **Deliverables**

Apart from the wide range of deliverables mentioned above, the Task also produced progress reports for ExCo55 and 56, minutes of the Task Meetings, 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](http://www.task39.org) and the IEA Bioenergy website [www.ieabioenergy.com](http://www.ieabioenergy.com) under 'Our Work: Tasks'.

## Progress in R&D

### Task Meetings and Workshops

The Task was active in 2005. On 2 May, a Task business meeting was held at the 27th Symposium on Biotechnology for Fuels and Chemicals in Denver, USA. This was followed by a 'Special Session' organised by the Task. On 9 August, another 'Special Session' was hosted by the Task in conjunction with other IEA Bioenergy Tasks at the IUFRO World Congress. On 13-15 October, a Task 39 workshop was held in Ystad, Sweden. 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.

*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.

*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.

*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.

#### ***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. In early 2005, the proceedings of the workshop held in Kyoto, Japan were produced and are available on CD.

In May, a 'Special Session' was held in connection with the 27th Symposium on Biotechnology for Fuels and Chemicals. Organised by the Task, this session featured 10 speakers, including four industry representatives, from seven Member Countries. Discussion at this workshop considered the current state of commercialising industrial conversion of biomass-to-ethanol. A summary of this session is available in Issue 13 of the Task newsletter.

In August, the Task organised a second 'Special Session' in connection with the IUFRO World Congress. This session was organised in conjunction with Tasks 30, 31, and 38 as well as Bioenergy Australia. It met its objective of raising the profile of IEA Bioenergy activities within the more traditional forest research community that IUFRO represents. A summary of this session is available in Issue 14 of the Task newsletter.

At the Task workshop held in Ystad, Sweden, several sessions focused on lignocellulosic biomass-to-ethanol. The overall focus was to continue the theme begun in the previous Task workshop in Kyoto and to explore the links that exist between technical and policy issues as they impact biofuels implementation. Sessions examined country-specific policies and technical programs, as well as progress toward commercialisation from an industry

point of view. The sessions were restructured in order to provide more opportunities for networking and dialogue. Summaries of the sessions are provided in the Issue 15 of the Task newsletter. In late 2005, the proceedings of the workshop held in Ystad were produced and are available on CD.

### ***Specialised topics related to biodiesel***

Task 39 includes efforts to address the specific issues related to implementation of biodiesel. These include policy and regulatory issues that apply to the implementation of this fuel plus specialised technical issues. On 17 June, IEA Bioenergy representatives, including Manfred Wörgetter from Task 39, Hermann Hofbauer from Task 33, and Josef Spitzer the Austrian ExCo Member, hosted a national workshop 'Biofuels today, tomorrow and in future' in Vienna. The workshop was dedicated to 1st, 2nd and 3rd generation biofuels with a focus on Austria. For a summary of the workshop including copies of presentations, please visit [www.task39.org](http://www.task39.org)

### **Newsletter**

The Task published four newsletters in 2005. 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. The Task has worked closely with Tasks 30, 31 and 38 to host a joint conference session that appealed to a wide audience interested in bioenergy and biofuels. The Task also held discussions with Task 40 on international trade of biofuels. The success of the joint session in Brisbane has led the Task to plan an 'end-of-triennium' workshop with Tasks 29, 31 and 40. This will be held in Vancouver in August 2006. In addition, the Task participated in the EC-funded VIEWLS project which completed most of its activities in 2005 and continues to provide information for newsletters and reports.

### **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](http://www.task39.org)

### **Deliverables**

The deliverables for the Task in 2005 included: two progress reports, one technical 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 four newsletters and technical reports on the issues relating to the implementation of ethanol from lignocellulosics, and on biodiesel implementation in North America. Reports on financial instruments for biofuel development and trade issues impacting the international trade of biofuels are in preparation. Finally, the Task published the proceedings of a workshop held in the previous year, in Kyoto, Japan. These are detailed in Appendix 4.

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

### **Overview of the Task**

The objective of the Task is to investigate what is needed to create a 'commodity market' for bioenergy. Through the international platform provided by IEA Bioenergy, combined with industry partners, government bodies and NGO's, the Task will contribute to the development of sustainable bioenergy markets both in the short- and long-term and on different scales (from regional to global). The goal is that this platform will set the agenda and initiate a host of new activities relevant to the development of biomass potentials worldwide. 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, the Netherlands, Norway, and Sweden. In addition, the United Kingdom will join in 2006.

**Task Leader (Scientific):** Dr André Faaij, Copernicus Institute, Utrecht University, the Netherlands.

**Task Leader (Administrative):** Mr Martijn Wagener, Essent Energy, the Netherlands, (until October 2005). Mr Peter-Paul Schouwenberg, Essent Energy, assumed this role from November 2005.

**Operating Agent:** Mr Erik Wissema, Ministry of Economic Affairs, the Netherlands.

**Alternate 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](http://www.bioenergytrade.org) and the IEA Bioenergy website [www.ieabioenergy.com](http://www.ieabioenergy.com) under 'Our Work: Tasks'.

### Task Meetings and Workshops

Two workshops were organised in 2005. The first was organised jointly between the Task, the Energy and Poverty Thematic Group of the World Bank and Task 29. This workshop was organised during the Annual Energy Week of the World Bank which allowed for the inclusion of Energy Week participants, many of whom are from developing countries that might directly benefit from this initiative and from the expertise represented by the Tasks involved. It explored the links between international bioenergy trade and socio-economic development and how sustainable bioenergy production for the world market could be realised. This involved elements such as the socio-economic implications and benefits of bioenergy use (Task 29) and the impacts of international bioenergy trade; how international trade contributes to sustainable development and how can this be secured (Task 40). Besides an overview of expertise on areas dealt with by the respective networks and organisations, a key element of the workshop was to discuss how projects involving development of rural areas and biomass production could be realised and organised. Based on the contributions and results of this workshop, a special issue of 'Energy for Sustainable Development' will be published in March 2006.

The next workshop was the combined Task 30, 31 and 40 event held on 31 November - 2 December, in Campinas, Brazil. The first day included presentations from Task 30 on the development of sustainable SRC systems to date, presentations from Task 31 on sustainable forestry management and industrial scale production of biomass for energy, and presentations from various international bodies such as UNCTAD, UNEP, and FAO. On day two, Task 40 illustrated the experience of international biotrade on company perspectives on developing international bioenergy markets. In addition, on day two and three, a business forum on sustainable international bioenergy trade was organised specifically focused on Brazilian industry, with major representatives from the Brazilian forestry and bio-ethanol sectors, as well as selected international players. Topics that were discussed during the workshop included the Brazilian experiences with sugarcane and *Eucalyptus* spp., and the future Brazilian alcohol and biodiesel programs, barriers for trade from both exporting and importing countries, the development of sustainability criteria for biomass, and existing certification systems and their applicability to biomass trade. Finally, there was a study tour to a *Eucalyptus* plantation and research centre. In total, about 70 participants from different countries and global organisations contributed to a very successful event. The presentations given at these workshops and meeting reports are available from the Task 40 website [www.bioenergytrade.org](http://www.bioenergytrade.org)

The Task had two formal internal meetings in 2005, both preceding the workshops mentioned above. During these meetings the progress with various deliverables was reviewed and plans were made on how to continue the Task for a second triennium. In addition, a number of Task participants convened for a working meeting during the 14<sup>th</sup> European Biomass Conference in October.

### *Future Meetings*

An overview of Task activities scheduled for 2006 is provided below:

Date	Location	Description
January 2006	Utrecht, the Netherlands	A workshop 'Future visions of biomass trade', jointly organised by Task 40 and EUBIONET II
April 2006	Trondheim, Norway	A joint event with Task 38 on 'Bioenergy trade, GHG accounting and emission trading', combined with an internal Task meeting
August 2006	Vancouver, Canada	A joint workshop with Tasks 29, 31 and 39 is under consideration
Sept/Oct 2006	Finland	An internal end of Task meeting possibly combined with an open workshop. Suggested topic 'Business opportunities for European forestry and the bioenergy industry in Russia' - in cooperation with EUBIONET II

### **Work Programme and Outputs**

An overview of the work programme is given below.

#### *Market experience. Coordinator: Sweden - supported by all participants*

Deliverables were Country Reports (all participants); a business forum; and an edited synthesis report based on the Country Reports.

#### *Strategic advice on barriers, opportunities and strategy. Coordinator: Netherlands - supported by all participants*

Deliverables were a conference paper 'towards a strategic advice', presented at the 14<sup>th</sup> European Biomass Conference; and strategic advice on how to develop and support bioenergy trade, e.g., for the EC, IEA Bioenergy ExCo, and FAO to be delivered in 2006.

#### *Modelling markets. Coordinators: Norway, Netherlands, Finland*

Deliverables will be targeted at setting up research project(s) linked, for example, to VIEWLS, ENFA, etc.

#### *Supply chain analysis. Coordinators: Finland, Canada, Norway, Sweden, Netherlands*

Deliverables were reports on Finnish, Canadian, and Norwegian case studies.

#### *Certification systems. Coordinators: Netherlands, FAO, UK*

This was a theme at the Campinas workshop; input for strategic advice to the ExCo; and

a review paper on an existing certification system and possible design of biomass certification systems.

***Pilot projects. Coordinators: World Bank/FAO; Netherlands, UK, Canada***

Deliverables were a plan of action/work programme on setting up pilot projects, based on initiatives from the World Bank, selection of potential projects, and an event hosted by the World Bank in Washington during the Energy Week in collaboration with Task 29.

***Case studies - Impact Analysis. Coordinators: FAO, Netherlands, UK, World Bank***

Deliverables were specific case studies, in particular in developing countries; and a theme at the World Bank event in Washington.

***Evaluation of markets - Ethanol. Coordinators: Brazil, UK, Canada***

The deliverable was a report on the Brazilian ethanol market. Reports on other commodities are being considered.

***Dissemination. Coordinator: Netherlands - supported by all participants***

Deliverables were a website; information leaflet; contribution to newsletters; and numerous lectures at international workshops and conferences

## **Collaboration with other Tasks/Networking**

As described above, several events were organised jointly with Tasks 29, 30 and 31. In addition, two international institutions, FAO and the World Bank are affiliated to the Task and participate fully in its activities. UNCTAD has also shown interest to cooperate with Task 40.

The work of the Task was presented to a number of audiences including: a meeting of German NGO's in Bonn; the Heinrich Böll Stiftung and European Climate Forum in Berlin; the ICCEPT and SEI workshop in London; the IEA/OECD meeting in Paris; the DoE/EC meeting in Washington D.C.; the Global Environmental Fund meeting in New Delhi; an IIASA meeting in Austria; and the 14<sup>th</sup> European Biomass Conference in Paris. These illustrate the cross-cutting character of the Task.

This wide collaboration will continue in 2006. A joint workshop with Task 38 is scheduled for April 2006, focussing on GHG emission trading versus physical biomass trade. Task 40 will probably contribute to the workshop planned by Tasks 29, 31 and 39 for August 2006. In addition, a biomass trade scenario workshop will be organised by Jussi Heinimö (NTL Finland) in January 2006. This will include participants from EUBIONET II. The last Task meeting in 2006 will be in Finland and a workshop with EUBIONET II is envisaged.

## Website

The website has been developed over 2005 and will be upgraded further in 2006. In 2005 visitor numbers increased strongly to around 1600 visitors per month. Recent additions were the presentations from the Washington DC and Campinas meetings, various country reports, the Task leaflet etc.

## Deliverables

The following deliverables were produced in 2005. Country reports; a conference paper 'towards a strategic advice'; expansion of the Task website, a Task leaflet; organisation of two workshops; two progress reports to the ExCo; minutes of the Task meetings; and a contribution to the feature article of this Annual Report. Other publications and reports in 2005 included a special issue of the 'Journal Energy for Sustainable Development' on bioenergy trade and sustainable development (to be published in early 2006); a synthesis report based on the various country reports; three reports on logistic chain studies in Canada, Finland and Norway respectively; and an evaluation of the Brazilian ethanol market.

# 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. It provides the ExCo with a highly qualified team of generalists with the capability and 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](http://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 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.

#### *Project 1: Bioenergy - competition and synergies*

In 2005 a proposal for Project 1 'Bioenergy - Competition and Synergies', was circulated to the participants and agreed by them to proceed. A core team of two experts: Sven-Olov Ericson (Sweden) and Michael Wang (USA) was formed and work commenced. The tentative budget is US\$60,000. Reporting is expected to commence in the first quarter of 2006.

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. 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.

The project will cover relevant aspects of bioenergy connected to agriculture, forestry, and waste management. It will also cover environmental aspects related to management/preservation of soil, ecosystems, sustainable heavy metal flows, and bioenergy's interaction with relevant infrastructures.

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 which was approved by written procedure and came into force on 13 January 2006. At the time of the preparation of this Annual Report details on participation and the specific work programme are still being finalised. Dr Michael Ladisch, Professor at the Agricultural and Biological Engineering Department of Purdue University is the proposed Project Leader.

TABLE 1 - IEA BIOENERGY TASK PARTICIPATION IN 2005

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-economic		•			•	⊖					•		•			•		•		•			8
30: SRC	•			•	•										•			⊖		•	•		7
31: Forestry	•		•		⊖		•									•		•		•	•		8
32: Combustion	•	•	•		•		•			•				⊖		•		•	•	•		•	12
33: Gasification		•					•	•		•		•		•	•			•	•	•	⊖	•	12
34: Pyrolysis*										•						•					•	⊖	4
36: MSW	•				•		•	•	•				•			•		•		⊖		•	9
37: Biogas		•					•	•		•				•				•	⊖	•		•	9
38: GHG	•	⊖			•		•	•			•			•	•	•		•			•		12
39: Biofuels		•			⊖		•	•		•	•	•		•			•	•		•	•	•	13
40: Trade			•	•	•			•						⊖		•		•					7
41: Systems										•								⊖		•	•	•	5
<b>Total Task Participation</b>	<b>5</b>	<b>6</b>	<b>3</b>	<b>2</b>	<b>8</b>	<b>2</b>	<b>6</b>	<b>6</b>	<b>1</b>	<b>6</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>6</b>	<b>3</b>	<b>7</b>	<b>1</b>	<b>11</b>	<b>3</b>	<b>9</b>	<b>7</b>	<b>7</b>	<b>106</b>

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

• = Task Participant

⊖ = Operating Agent for the Task.

## BUDGET IN 2005: SUMMARY TABLES

**Table 2: Budget in 2005 by Member Country (\$US)**

<b>Contracting Party</b>	<b>ExCo Funds</b>	<b>Task Funds</b>	<b>Total</b>
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	11,000	79,820	90,820
France	6,000	15,320	21,320
Germany	11,000	68,000	79,000
Ireland	8,000	36,500	44,500
Italy	7,000	21,500	28,500
Japan	7,000	27,320	34,320
Netherlands	11,000	76,000	87,000
New Zealand	8,000	38,000	46,000
Norway	12,000	82,220	94,220
South Africa	6,000	10,500	16,500
Sweden	16,000	151,720	167,720
Switzerland	8,000	36,500	44,500
UK	14,000	122,720	136,720
USA	12,000	93,900	105,900
European Commission	12,000	83,320	95,320
<b>Total</b>	<b>216,000</b>	<b>1,360,580</b>	<b>1,576,580</b>

## BUDGET IN 2005: SUMMARY TABLES

**Table 3: Budget for 2005 by Task (\$US)**

Task	Number of participants	Annual contribution per participant	Total Task funds
Task 29: Socio-economic Drivers in Implementing Bioenergy Projects	8	12,000	96,000
Task 30: Short Rotation Crops for Bioenergy Systems	7	13,000	91,000
Task 31: Biomass Production for Energy from Sustainable Forestry	8	14,400	115,200
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 *	3	10,000	10,000
Task 36: Energy Recovery from Municipal Solid Waste	9	15,320	137,880
Task 37: Energy from Biogas and Landfill Gas	9	14,000	126,000
Task 38: Greenhouse Gas Balances of Biomass and Bioenergy Systems	12	14,000	168,000
Task 39: Liquid Biofuels from Biomass	13	10,500	136,500
Task 40: Sustainable International Bioenergy Trade: Securing Supply and Demand	7	15,000	105,000
Task 41: Bioenergy Systems Analysis	5	21,000	105,000
<b>Total</b>			<b>1,360,580</b>

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

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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)

Sustainable Energy Ireland

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

New Energy and Industrial Technology Development Organisation (NEDO)  
(Japan)

SenterNovem (The Netherlands)

New Zealand Forest Research Institute Limited

The Research Council of Norway

The 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)

United States Department of Energy

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Grönkvist, S., Möllersten, K., and Pingoud, K. Equal opportunity for biomass in greenhouse gas accounting of CO<sub>2</sub> capture and storage: a step towards more cost-effective climate change mitigation regimes.

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## Task 40

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