Annual Report 2013

IEA Bioenergy

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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 achieve a substantial bioenergy contribution to future global energy demands by accelerating the production and use of environmentally sound, socially accepted and cost-competitive bioenergy on a sustainable basis, thus providing increased security of supply whilst reducing greenhouse gas emissions from energy use.

Cover: Veolia Marchwood Energy-from-Waste Plant, Southampton, UK

Outgoing Chair Birger Kerckow and incoming Chair Paul Grabowski

To: IEA Headquarters, Paris

IEA BIOENERGY ANNUAL REPORT 2013

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 2013. This year, we have presented a special feature 'Integration of Thermal Energy Recovery into Solid Waste Management' prepared by Task 36.

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

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Contents

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

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

Integration of Thermal Energy Recovery into Solid Waste Management

Pat Howes and Kathryn Warren, IEA Bioenergy Task 36

Introduction

Energy from waste (EfW) – the thermal conversion of waste to energy – is regarded as one of the most significant commercially available bioenergy technologies. Its application is growing worldwide and many countries now integrate EfW into their waste management strategies, contributing to their country's heat and power supply. Loenicker (2012) estimates that some 250 EfW plants will be built worldwide between 2012 and 2016. This will result in an estimated total global capacity in 2016 of around 300 million tonnes (Mt). UNEP (2011) estimated the market for EfW to be US $19.9 billion in 2008 and forecast that it would grow by 30% by 2013. They expected more than a third of investments in EfW to be in Asia, with Latin America representing 20% of the investment market and Europe 16%. This increase will be driven by new waste strategies and policies, increasing concerns about landfill and open dumps, rapid urbanisation in emerging economies and rising GDP accompanied by increased waste arisings in some countries.

This paper examines the current global situation for EfW, the drivers that will result in the expansions predicted and where the technology may go in the future.

Box 1 describes the difference between incineration and EfW and Box 2 discusses the waste streams examined in this paper.

Box 1 Thermal combustion: incineration or EfW?

Conventional waste thermal combustion processes are often referred to as 'incineration', but this term was originally used to denote the combustion of waste to decrease volume and mass, with no energy recovery. Developers of most modern plants aim to enable recovery of energy and these plants are referred to as *energy from waste* (EfW) plants to differentiate them from incineration that does not include energy recovery. EfW is a commercially proven technology that is well established globally. However, there are countries where the technology has made little or no inroads and these could benefit from the evolving experience of those countries where EfW is used[1].

[1] Thermal combustion is the most well known technology for energy recovery from waste, but there are other options, including biological technologies and what is frequently called 'advanced' thermal conversion (usually gasification and pyrolysis). Further information on these technologies is available from IEA Bioenergy Task 37 (www.iea-biogas.net) and www.ieabioenergy.com.

Box 2 What waste streams are relevant to EfW?

The major waste stream relevant to EfW is Municipal Solid Waste (MSW) (and similar commercial and industrial waste streams).

The term MSW means different things in different countries, but is usually defined by what is included (e.g. whether or not street, market and commercial waste such as restaurant waste is included). Generally it is true to say that it is the waste that comes under the responsibility of local or regional (waste) authorities. In OECD countries local authorities often develop strategies for waste management for up to 20-25 years. The long-term nature of these plans means that it is possible to invest in technology with a long lifetime and to allow for payback over this period. This can present the local authority with the opportunity to integrate local energy demand with energy generation from waste. Countries that invest in EfW often also have a strong legislative framework for municipal waste management and relative certainty in the market place. These factors decrease the risk in plant development so that investment in EfW plants is feasible and can be designed to deliver local benefits. Consequently this paper concentrates on MSW, as it is the most common feedstock for integration of energy into solid waste management. However, there are other waste feedstocks that are of interest for energy recovery and increasingly refuse derived fuels, perhaps mixed with commercial and industrial waste, and solid recovered fuel (SRF), which may also be manufactured from other waste streams, are becoming more significant in some countries (particularly those in Europe).

Drivers and trends for EfW

Global waste trends indicate that the amount of waste being produced is increasing in most countries (UNEP 2011). In 2010 an estimated 1.7-1.9 billion tonnes of MSW was produced worldwide. UNEP (2011) estimated that power generation from waste in 2010 was about 71,600 GWh, with a capacity of 54 GW, mainly from EfW plants. They modelled future growth and concluded that under business as usual this could grow by over 200 GW by 2050 (corresponding to 0.5 billion tonnes of waste going to EfW each year). This compares to World Bank (2012) estimates that arisings are currently 1.3 billion tonnes/year, rising to 2.2 billion tonnes/year by 2025.

Waste arisings and composition are in general influenced by factors such as wealth/income/GDP, population, urbanisation and culture, which vary between countries. Figure 1 shows the substantial differences in waste arisings in selected countries. Box 3 shows the characteristics of waste that influence the amount of energy that can be recovered.

In examining waste arisings some authors have commented on how there are relationships between typical income in a country, the waste generated and its characteristics. The World Bank (2012) divides countries into high, medium and low income and uses this to generalise about the suitability of the waste for EfW. Chalmin and Gaillochet (2011)

used these relationships but, in addition, introduced size of country and available space as differentiators for waste management trends, particularly for high income countries. Even so, using GDP, waste arisings or geographical characteristics as a proxy for whether or not EfW is suitable for a country is misleading. What really matters are the local factors and drivers in a country, usually policy drivers such as landfill diversion and geographical constraints such as lack of space near areas of high population and high waste production. Warren and Read (2013) examined drivers for EfW in a number of countries globally. They showed the importance of the Landfill Directive in the EU, which requires diversion of waste from landfill, and how it has driven the increase in recycling and EfW in some EU countries. In Sweden energy generation is a major driver. In other countries (e.g. Japan and Singapore) lack of land for landfill has resulted in a drive towards incineration and EfW. Conversely they showed that the presence of abundant space for and low cost of landfill in the absence of drivers to divert waste from landfill can be an important barrier to the development of EfW in countries such as Australia and the USA. In these countries drivers for EfW are more likely to be energy and resource based rather than focussed on environmental impacts or landfill diversion. Other barriers include emissions (to air and in ash), the level of investment in infrastructure relevant to EfW (such as roads and refuse disposal vehicles) and public perception related in particular to the ability to regulate air emissions.

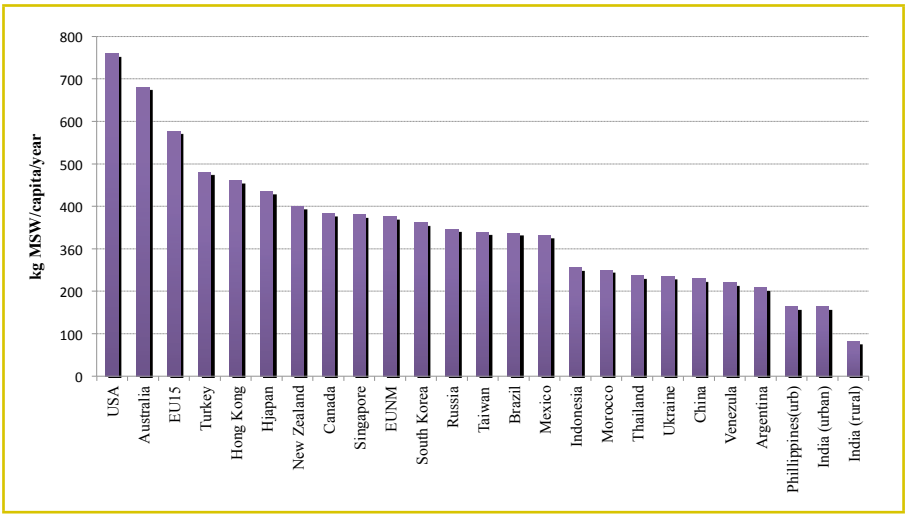


Figure 1 Municipal waste production in selected countries

(Source: based on Chalmin and Gaillochet 2009, which draws from various statistical sources, including OECD, Eurostat, Veolia, UN, UNESCAP and the World Bank)

Box 3 Waste characteristics that influence energy recovery

Calorific value (CV): This is the energy content of the waste. The CV of waste fuels is impacted by moisture content, as with other fuels. Organic waste, which has a high moisture content can make a significant difference to the overall CV of a waste stream. In Europe, Australasia and North America most mixed municipal waste has a calorific value of 7-12 MJ/kg. Residual waste, after recycling (sometimes termed refuse derived fuels) is generally in the higher range, 10-12 MJ/kg (but can be as high as 25 MJ/kg); and the CV of Solid Recovered Fuel (SRF) can range from 3-25 MJ/kg. MSW dominated by organic waste, such as that produced in many low-income countries, has a low calorific value (<4.6 MJ/kg), which is insufficient to support combustion, making the waste unsuitable for EfW unless it is processed further. In urban areas of emerging economies recent figures show an increase in calorific value to around 4-7 MJ/kg (ISWA 2013a,b).

Despite all of these variables there are some important generalisations that can be made about trends in the deployment of EfW and the drivers for EfW:

1. There is no single solution for waste management: the choices made by policy makers and local communities depend on a combination of factors such as costs, quantity of waste produced, composition of waste, space available for disposal (countries with large amounts of space relative to population tend to favour landfilling, regardless of GDP and waste arisings) and the environmental awareness and wealth of the population. EfW tends to be adopted in countries with sophisticated waste management policies and is often driven by a desire to decrease waste to landfill. Other countries investing in EfW are driven by the high cost of land and/or a need for alternative low cost energy.

2. It is common to see policies that aim first to minimise waste production, recover and/or recycle materials from waste and then to recover energy prior to final disposal, with some policies placing a cap on the amount of waste that can be used for energy recovery. This rationalisation of waste management is known as the 'Waste Hierarchy'.

3. A growing theme in OECD countries is the adoption of a target of 'zero waste to landfill'[2]. Countries adopting such policies do so in response to the recognition of the longterm environmental impacts of landfill and set statutory targets for recycling and landfill diversion. These pressures have resulted in significant (and increasing) recycling of waste in many countries, which has in turn impacted the composition of residual waste that cannot be recycled[3]. Most significantly for EfW, reduction and recycling of waste results in changes to the calorific value of the residual waste (usually by decreasing moisture content).

[2] For example, Scotland and Wales have adopted zero waste strategies; as have parts of Asia (e.g. Thailand and Taiwan), Australia and the USA. See, for example: http://www.sfenvironment.org/zero-waste, Natural Waste Scotland (2010), Government of South Australia (2011).

[3] These trends were reviewed by Task 36 in 2009 and the results are presented on the website, See IEA Bioenergy (2009).

4. Increasing urbanisation in low-income countries has important environmental and health issues related to waste disposal. Despite this, waste management is often low on the list of priorities after health care, water sanitation and education (World Bank 2012). As a result there can be low waste management budgets and a lack of support for local authorities to help them invest in improved waste management. Consequently low cost solutions such as landfill and open dumps prevail (Chalmin and Gaillochet 2009).

5. The typically high organic content of waste in low income countries means that opportunities for recovery of energy from these wastes are likely to be related to the organic composition i.e. anaerobic digestion or landfill gas recovery. It is possible to use incineration as a volume/weight reduction or sanitisation process by the addition of fuels to aid combustion. Energy could be recovered in such a process but the efficiency of energy recovery will not be high.

6. Waste recycling in low-income and emerging economies often relies on a network of informal recyclers. It is important to consider the contribution and effectiveness of these recyclers in waste management strategies, particularly if investment in expensive large-scale equipment is being considered (Read 2013). Other strategies with a better fit to local culture, such as anaerobic digestion are also worth considering.

EfW in global regions

Figure 2 presents UN data on percentage of waste incineration (including EfW) on a national basis. This section examines the drivers for EfW and the uptake of EfW in more detail using Europe, North America and Asia as examples.

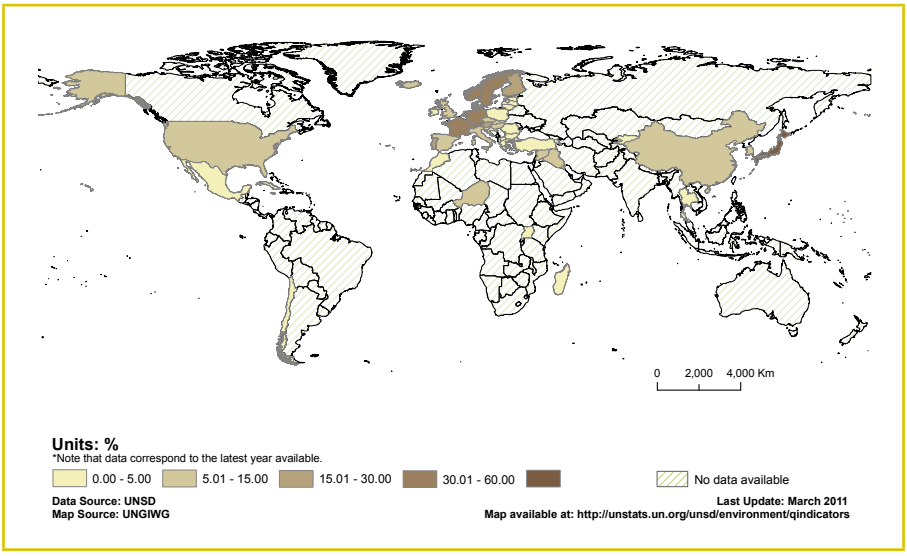


Figure 2 Percentage of municipal waste incinerated

(Source: UN Statistics)

European Union

The European Union is characterised by a high level, sophisticated waste management strategy, including a Waste Framework Directive setting out agreed waste policy, and Directives controlling Landfill and emissions from EfW (the Industrial Emissions Directive). The EU Waste Framework Directive includes an emphasis on the Waste Hierarchy and the inclusion of carbon accounting in decisions concerning waste management. The Landfill Directive sets targets for diversion of biodegradable waste from landfill[4]. EfW is seen as a viable option for residual waste after reuse and recycling. Europe has supported the production of guidance documents to outline Best Available Technology, known as the BREF guides, which provide useful information on what can be achieved[5]. In addition, relatively long, harsh winters result in a significant heat demand in some European countries, so that district heating is cost effective and EfW is seen by municipalities as a useful local source of heat in these areas. All of this means that some of the best data on EfW is available from the EU. European Union policies have resulted in a fall in MSW arisings, a decline in landfill in some countries and a rise in recycling, composting and EfW. Even so, waste arising remain high (in 2010 the figures ranged from <320 kg/person/year in the Czech Republic and Poland to > 650 kg/person/year in Denmark, see Eurostat, 2012).

Figure 3 demonstrates that even in the face of this uniform EU framework of legislation there are diverse national trends. There are countries where 30-45% of waste is treated by incineration[6] and over 30% of waste is recycled; but there are also countries where >90% of waste is landfilled. Overall, incineration has increased over the past decade by 140%[7]: Energy production from MSW reached 15,480 thousand tonnes oil equivalent in 2010 (Eurostat 2011). Figure 4 shows the countries with the most EfW facilities (and that EfW in the EU is dominated by countries such as Germany, Denmark, Sweden and the Netherlands). According to the International Solid Waste Association (ISWA 2012), there are 455 plants across the EU, with an average plant capacity ranging from 9-78 tonnes/hour. The calorific value of the waste going to EfW is 7.0-15 MJ/kg (generally between 8 and 12) (ISWA 2012).

Eurostat observes that in those countries where there are landfill bans in place (such as banning of certain organic components from landfill) there has been a high increase in recycling, composting and incineration. New member countries may be lagging behind in diversion of waste from landfill, but they also produce less waste compared to the countries with higher diversion rates.

4 The Landfill Directive requires Member States to reduce the amount of biodegradable municipal waste going to landfills to 75% by 16th July 2006, to 50% by 16th July 2009 and to 35% by 16th July 2016.

5 The current BREF is EC (2006). This is in the process of being updated.

6 Mainly EfW, but the data is not presented separately.

7 Eurostat notes that there has been a 56% increase in incineration per capita, 159% increase in recycling and 224% increase in composting, with a 35% decrease in landfilling from 1995-2009.

Spittelau Energy-from-Waste Plant, Vienna, Austria

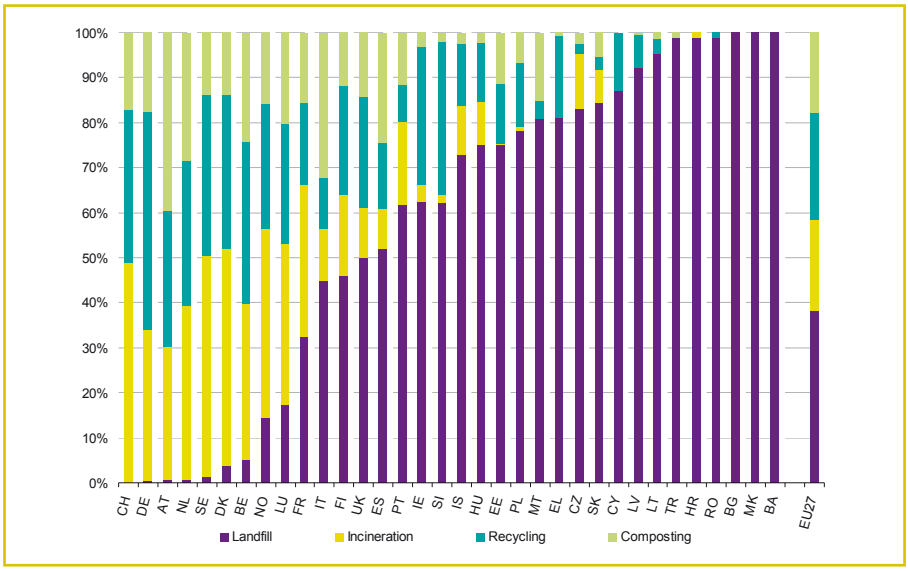


Figure 3 Municipal waste treated in 2009 by country and treatment category, sorted by percentage landfilling (% municipal waste treated)

(Source: Eurostat 2011)

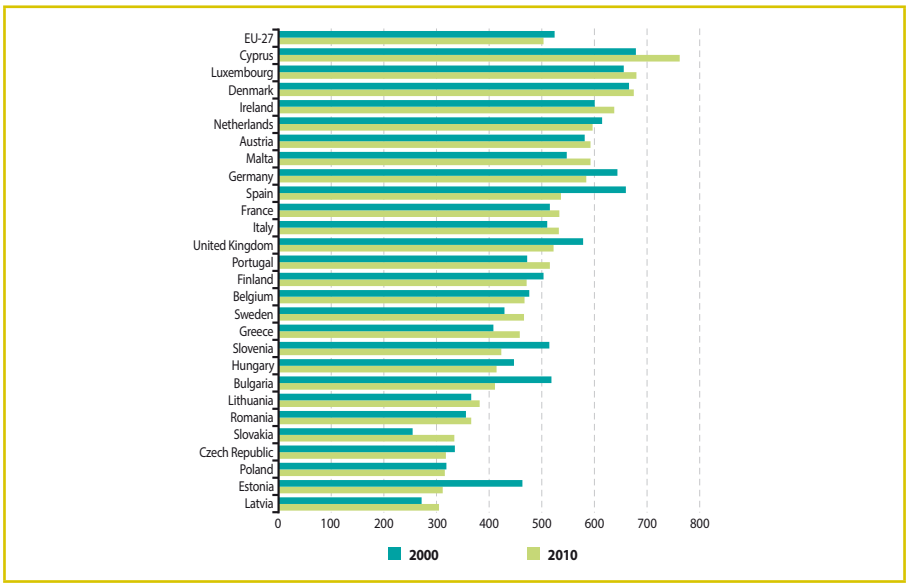


Figure 4 Energy production from MSW incineration (thousand tonnes oil equivalent)

(Source: Eurostat 2012)

North America

Waste disposal in North America is dominated by landfill, which has historically been relatively low cost due to the availability of sites and the low cost of transport. Waste can be transported over considerable distances, across states or even across borders to landfill, although there are examples of waste being prevented from crossing borders to recycling plants[8]. The current increase in the costs for transport and the decreasing landfill void space in some areas is resulting in a re-think, but landfilling remains dominant. The US EPA has adopted the waste hierarchy, which is resulting in overall decreases in waste production and increases in recycling: 250 Mt of MSW was produced in 2011 (around 730 kg/person/year) (EPA 2013); excluding composting, 66.2 Mt of this was recycled (see Figure 5). The organic waste content of US waste is around 52.5% (this includes food waste from commercial premises and restaurants).

8 In general this is to protect the State's own landfill site, i.e. the State will not allow waste to leave its jurisdiction to be recycled.

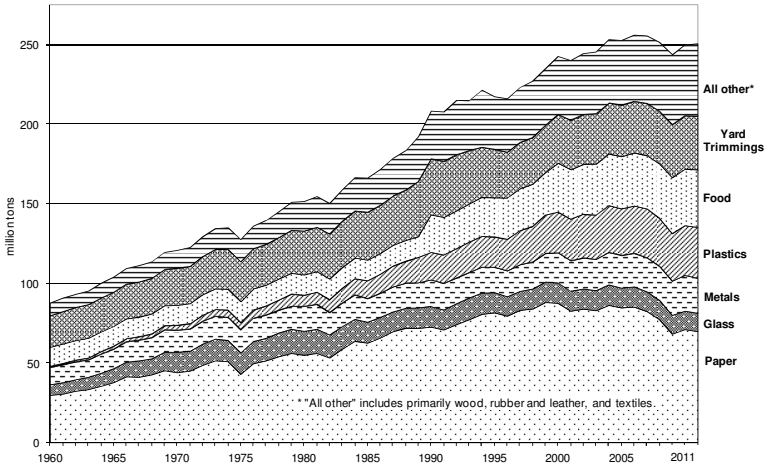


Figure 5 Trends in waste management in USA

(Source: EPA 2011)

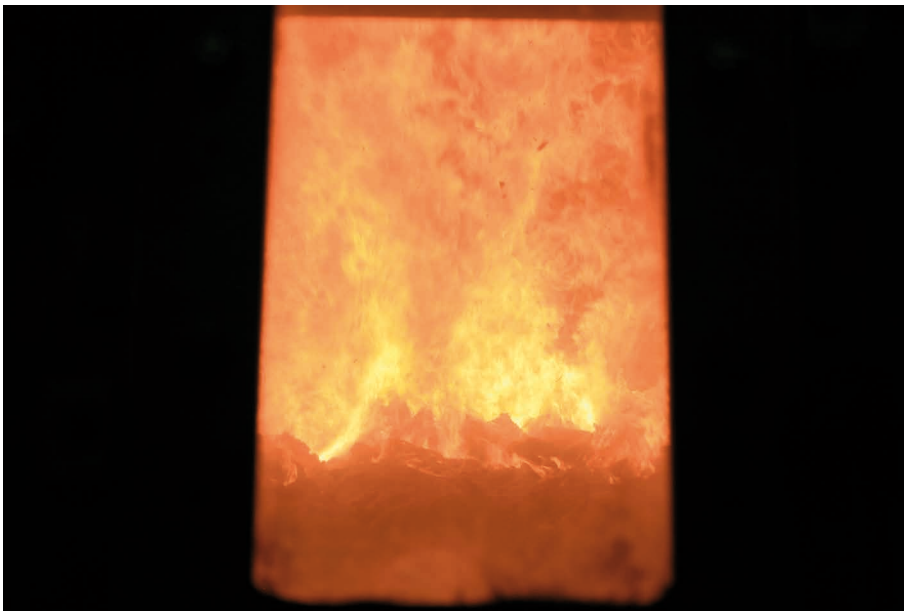
According to data from ISWA (2012) there are 86 EfW plants in operation in the US (in 29 States). Around 29.3 Mt are currently sent to EfW (11.7% of waste arisings)[9], a figure that has not increased since 1990. One of the reasons for this is the relatively high cost; emission limits on these plants can be as strict as in the EU. In addition, due to wide availability of landfill, gate fees remain low. EfW tends to be concentrated in the Northeast USA, near the most densely populated regions.

Canada generated 25 Mt of non-hazardous waste in 2010, of which 9.3 Mt was household waste (Statistics Canada, 2013). Waste arisings were 729 kg/capita in 2010, of which household waste represented 271 kg/capita; and waste recycled was 236 kg/capita. In Canada there are 8 EfW facilities treating 3% of total MSW[10]. However, there is renewed interest in EfW and it is being examined as a part of waste management strategies (e.g. in Vancouver, Ontario[11]). A 100,000 tonnes/year waste gasification facility is being constructed by Enerkem in Edmonton and a 140,000 tonnes/year plant (mass burn) is being constructed by Martin in Durham/York, Ontario.

9 These figures also include EfW for plants that burn rubber tyres in cement kilns, pulp and paper mills, industrial burners and dedicated plants, which amounts to some ~3.3 Mt 2011. Tyres are banned from landfill in many states in the USA.

10 http://www.energyfromwaste.ca/resources/EFW-Worldwide Canadian energy from waste coalition

11 http://www.ec.gc.ca/air/default.asp?lang=En&n=5427E598-1



Energy-from-Waste grate incineration

Asia

According to the World Bank (2012), waste production in Asia is estimated to be around 433 Mt/year (dominated by China with an estimated 190 Mt/year). Data available from the Waste-to-Energy Research and Technology Council (WTERT) and the Confederation of Waste-to-Energy Plants (CEWEP) indicates that 301 EfW facilities treating 70 Mt/year are in operation in Asia. Most of these are in a few countries and predominantly Japan. Outside of Japan the story is very different. In general the waste calorific value (CV) in Asia is low, 4-7 GJ/t (ISWA 2013a), so that the CV of much of the waste produced is too low to support combustion unaided (World Bank, 2011). There are considerable differences across the region. In their 2012 report on South Asia, the Asia Development Bank (ADB) identifies differences between 'low', 'medium' and 'high' income countries:

- Low-income countries are characterised by the lack of a statutory framework and the absence of statistics. Waste is low in calorific value (3.3-4.6 MJ/kg) and less suitable for energy from waste. The ADB (2012) also states that low-income countries tend to spend the bulk of their budget on collection rather than disposal.
- Medium-income countries also have high organic content waste, although the CV is higher (around 4.6-5.4 MJ/kg) and there are often national strategies that provide the framework for waste management. However, these countries are often hampered by a lack of statistics and little application of strategic waste management. Consequently development of EfW can be low, except in highly urbanised areas.
- High-income countries have a mixture of high CV waste and appropriate national frameworks to enable EfW to be applied successfully.

In Asia this provides a useful guide to the adoption of EfW, although the difference between urban and rural areas is important, as densely populated cities may produce waste that is suitable for EfW, whereas rural areas do not. Table 1 shows selected data for Asia.

The population of Asia is expected to grow significantly and this will result in increased urbanisation coupled with an increase in GDP (World Bank 2012). Together these trends are likely to increase future waste arisings. The introduction of more effective waste management strategies could provide a significant opportunity for recycling technologies and for EfW.

A further important point is the regulation of emissions from EfW. Japan has strict emissions limits and residue requirements. This is not the case elsewhere in Asia, a fact that can lead to mistrust of EfW proposals, particularly with regard to their impact on air quality and the disposal of the incinerator ash. If EfW is to be credible for this region, the development of a legislative and regulatory framework for sustainable waste management will be important.

Table 1 Development of EfW in selected Asian countries

Country	EfW status and trends
China	Estimated 140 operational plants; 22 new plants commissioned in 2011. Capacity expected to grow by 40 Mt/year between 2012 and 2016.[a]
Japan	73% of waste incinerated (2005). Strong recycling policy and targets to decrease landfilling[c].
South Korea	Target for energy to be sourced from waste and biomass: 3.17% in 2013 and 4.16% in 2020. All waste facilities planned to be converted to energy recovery by 2020 by building at least 74 RDF and biogas plants, 24 EfW plants and 25 landfill-gas recovery plants. National targets for recycling 61% of waste in 2012.[b] Waste production ~400 kg/person/year (2002)[b].
Singapore	90% waste incinerated (2007)[c].
Sri Lanka	0% waste incinerated (2001), but recent press reports that energy from waste is being considered[c].
India	55 Mt waste produced in 2012. 43 MW EfW (2007).[d] There have been several proposals for EfW in large Indian cities (e.g. Dehli), but the population remains concerned about emissions and ash disposal.
Malaysia	8 MW RDF plant in operation; small scale incineration on tourist islands. The Government has passed a Solid Waste and Public Cleansing management act that proposes phasing out landfill and encourages reuse, reduction and recycling, but it is not clear how EfW would develop[e].

[a] Loenicker 2012 China: 2011; [b] UNEP 2011; [c] World Bank 2011 and http://www.miga.org/projects/index.cfm?pid=1199; [d] National Solid Waste Association of India; [e] Kadir et al (2013).

Technologies for integration of energy into solid waste management

This section examines EfW technologies and their commercial status. There are a number of options for energy recovery from solid waste, as shown in Figure 6:

- Conventional grate combustion plants
- Fluidised bed combustion
- Gasification
- Pyrolysis

There is growing interest in optimising the configuration of EfW in waste management so that waste recycling and recovery options are combined in a variety of configurations to optimise management and use of resources in waste. Further information on these technologies is also available in IEA Bioenergy (2009) and ISWA (2013b).

Table 2 shows the commercial status of the different technical options.

Table 2 Summary of commercial status of EfW technologies

Technology	Commercial status	Size of plant	Efficiency
Grate Combustion	Proven >500 plants in operation globally	3-40 t/h Up to 1.4 Mt/year	Electricity: 21-30% Heat: >70%
	Combustion of untreated waste in air or oxygen enriched atmosphere on a grate. Pre-treatment requirements are minimal. Can take mixed waste or residues from mechanical biological treatment (MBT). Figures 7 and 8 provide flow diagrams of operating plants.		
Fluidised Bed Combustion	Proven. >50 plants in operation globally	3-15 t/h Most plants>50,000 tonnes/year	Electricity: up to 25% Heat: >70%
	Combustion of pre-treated waste in a bed of sand, fluidised by air injection through nozzles in the floor of the furnace. Usually used to treat solid recovered fuel (SRF). Waste particle size normally <200mm. Proportion of waste in the sand is in the region of 2-10%. Performance is dependent on the pre-treatment of the waste to appropriate particle size and the presence of abrasive material in the sand. Figure 9 shows a flow diagram of a fluidised bed EfW plant.		

Technology	Commercial status	Size of plant	Efficiency
Gasification	<100 installations, mainly in Japan Demonstrations in EU and USA	1-11 t/h Most plants <150,000 tonnes/ year (Kymijärvi II takes 250,000 tonnes SRF/year)	Electricity: claims of 22-33% ISWA report net efficiencies: 13-19%
	Involves multi-stage processes with gasification of waste in shaft or fluidised bed furnaces, in gasification chambers, in entrained flow systems or on grates. Combustion takes place under a low oxygen atmosphere. Process results in a synthesis gas, which can be used for chemical synthesis, fed into gas engines, directly burnt or co-combusted in power plants. All processes produce molten solid residues. Plasma gasification includes treatment using a high intensity electron arc, leading to high temperatures. Plasma arcs are used in two ways to break down organic components to their component elements: plasma gasification of waste at >2,000 °C and the use of the plasma arc to clean up the syngas. The former is very energy intensive. Information on the operating performance of waste gasification plants is limited in the open literature. Nevertheless, interest in gasification has increased recently and a number of plants are in planning or under construction in Europe and North America[12].		
Pyrolysis	<25 plants worldwide, most in Japan	2.5-8.3 t/h	Not known
	Thermal breakdown of waste in the absence of air or oxygen, producing char, pyrolysis oil and syngas. Typically pyrolysis of waste is 'slow pyrolysis' in an externally heated rotary drum, with combustion of pyrolysis gas in a high temperature combustion chamber. The pyrolysis coke is separated from inert ash and burnt together with the pyrolysis gas. The residue (char) is a combination of non-combustible materials and carbon (DEFRA 2007). Little information on the costs and operational performance of waste pyrolysis is available in the public domain.		

[12] Proposals listed in Howes (2012) include a 50 MW plasma gasification plant in Tees valley, UK; a gasification plant similar to Lahti Energi in London; a 12 MW plasma gasification plant in France, a proposed plasma gasification plant in Perth, UK; a proposed waste gasification plant in Bilsthorpe in UK; a $40 million gasification contract in Dallas, USA; and a US Air Force plasma gasification contract. Demonstration of three gasification plants is underway in the UK supported by ETI (see: http://www.eti.co.uk/news/article/eti_announces_shortlist_of_companies_in_2.8m_competition_to_design_energy_f).

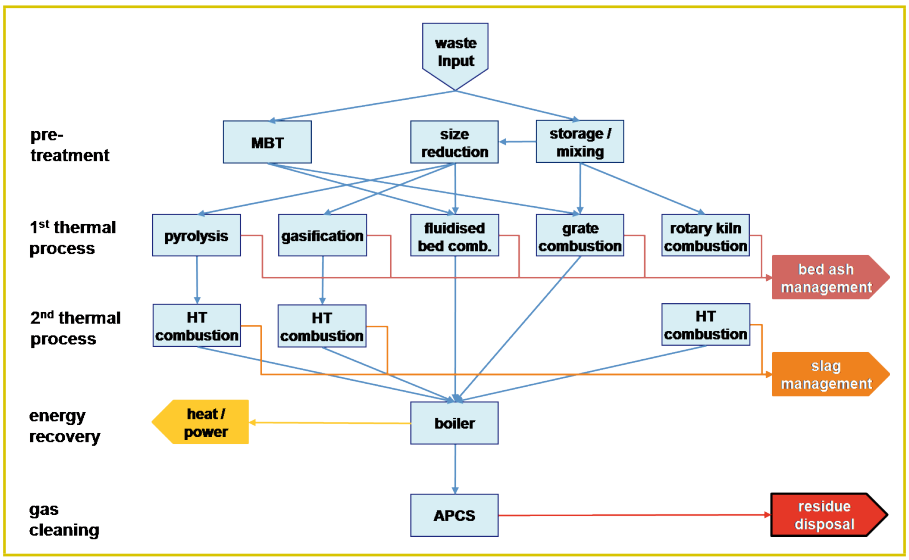


Figure 6 Common configurations for energy from waste plants

HT: high temperature

APCS: air pollution control system.

MBT: mechanical and biological treatment

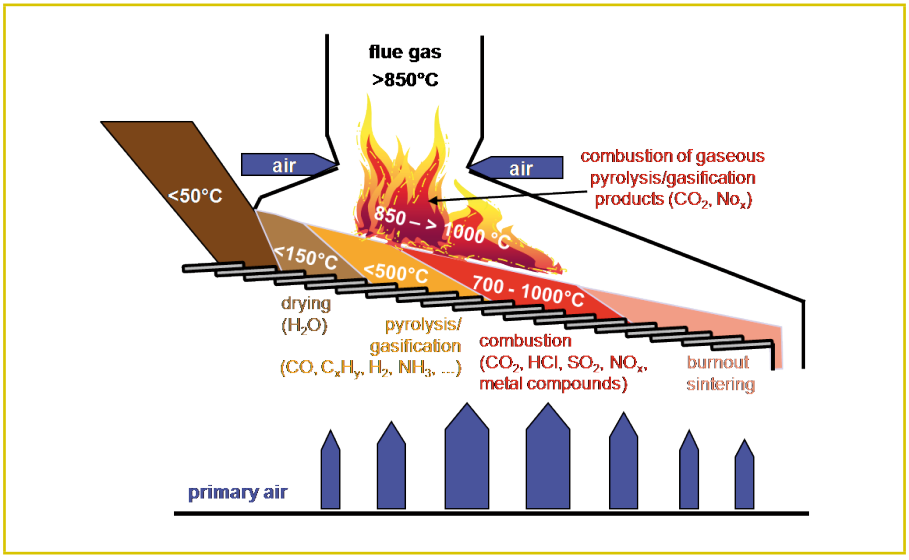


Figure 7 Principles of combustion in a grate furnace

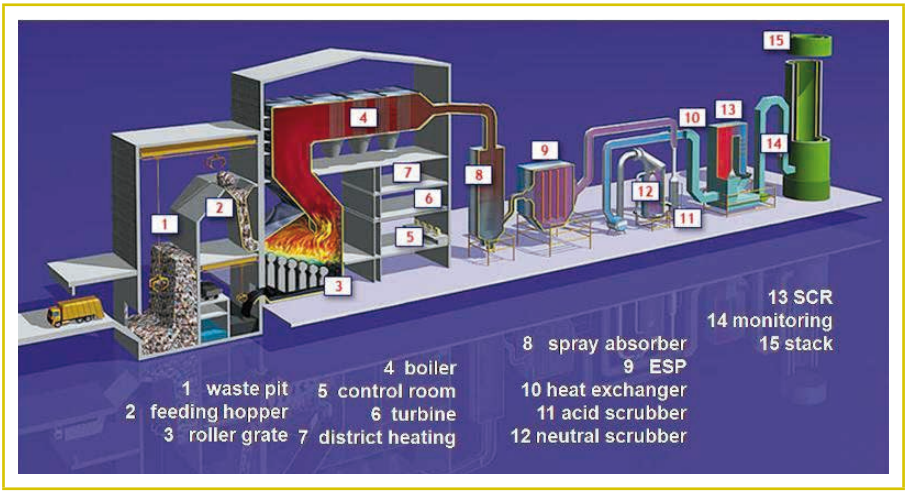


Figure 8 Flow diagram of a MSW grate incinerator equipped with a roller grate, parallel flow combustion chamber, horizontal boiler, wet scrubbing with a spray dryer and SCR for NOx abatement (Offenbach, Germany)

ESP: Electrostatic precipitation (for particulate removal)
SCR: Selective catalytic reduction.

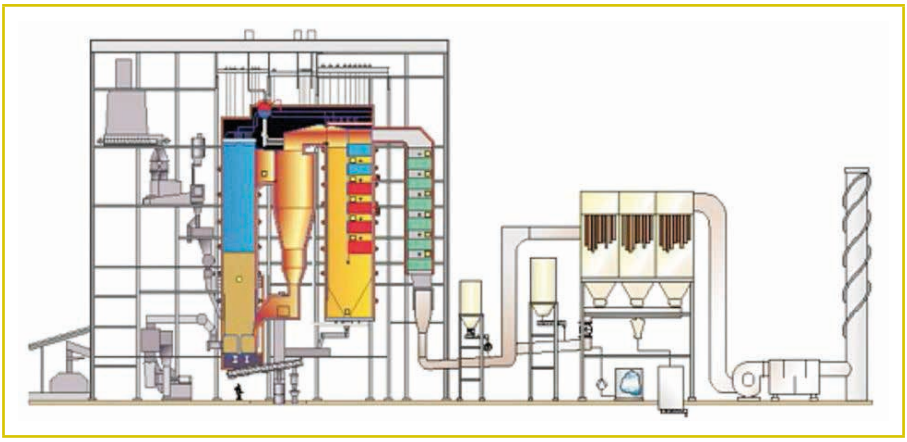


Figure 9 Flow diagram of Norrköping FB incineration waste plant

Other types of EfW plants

It is possible to integrate a number of waste management processes to optimise environmental benefits such as decreased carbon emissions, optimised resource management and energy recovery. The most commonly proposed configuration in Europe is the combination of mechanical and biological treatment (MBT), for example anaerobic digestion with combustion of the residues. Task 36 examined these options in 2012 (Schüssler 2012) and found that energy performance could indeed be improved using such configurations and that use of advanced technologies such as gasification may be advantageous, but that data on gasification is too poor to allow the energy and environmental performance to be realistically assessed.

An alternative option involves the production of biofuels from waste. There are a number of plants in pilot or demonstration stage in North America and the EU. Examples are listed in Box 4. The principle behind many of these processes is "hydro-pulping"[13] of the waste followed by separation of the plastics, glass and other inorganic components, and use of the organic fraction as a feedstock for bioethanol or other biofuel production. The number of proposed fullscale plants is increasing. One attraction is the potential to produce high value chemicals such as solvents, polymer coatings and adhesives in addition to transport fuels. However, as with advanced thermal combustion, more data on energy balance and operational parameters, including environmental performance, is required.

Box 4 Demonstration and proposed biofuels from waste plants

Bluefire (USA): Cellulosic ethanol from the organic fraction of post-sorted MSW. Three plants in planning (2x19 Mgallons/y and one at 3.9 Mgallons/y). Lignin from one plant will be combined with wood to make wood pellets for the EU market[14].

Fiberight (USA): pre-sorting in MBT prior to pulping of the organic residual fraction and fermentation of this fraction to ethanol. Pilot plant in operation. Four full-scale plants proposed. http://Fiberight.com

Enerkem (Canada & USA): production of methanol and ethanol from non-recyclable, non-compostable MSW. Demonstration (100,000 dry tonnes of sorted MSW, expected to be operational in 2013). Developing commercial scale plants for MSW and wood residues to ethanol.

[13] The term 'hydro pulping' is commonly used and rarely defined. It generally refers to a process in which organic material is slurried, enabling breakup or pulping of the organic material and separation from the heavy and light non-organic fractions.

[14] http://www.biomassmagazine.com/articles/9502/bluefire-renewables-adds-pellet-production-to-miss-facility

Box 4 Demonstration and proposed biofuels from waste plants *continued*

Ineos Bio Waste Vero Beach (USA): gasification of vegetal and municipal waste followed by fermentation to bioethanol. Production started in August, 2013. Expected production: 30 ML cellulosic ethanol and 6 MW electricity.

Dong Energy (EU): Renescience waste refinery (demonstration plant). Liquefies waste, followed by recycling of non-degradable fractions and flexible use of organic fraction (currently for biogas production).

PERSEO project (EU): second generation bioethanol production from municipal waste after pre-treatment using thermochemical treatment of waste, followed by fermentation to bioethanol. Preliminary work undertaken on lignocellulose such as cereals (http://www.biofuelstp.eu/spm2/pdfs/PERSEO_presentation.pdf)

Abengoa (EU): Demonstration of bioethanol from municipal waste. Plant proposed (Seville) to process MSW to 28 ML bioethanol. The process involves production of organic fibre from the municipal solid waste and fermentation and enzymatic hydrolysis for bioethanol production.

Figure 10 Ineos Bio's Vero Beach plant in construction, August 2012

(Courtesy Ineos Bio)

Summary

In this paper we have reviewed the implementation of EfW globally. This is a well established bioenergy technology commonly applied to a wide range of wastes, which delivers valuable renewable energy. It can be used as part of a strategy to enhance the recovery of biodegradable resources in waste, to divert waste from landfill and to reduce greenhouse gas emissions. Analysis shows that deployment is likely to increase over the coming decade, particularly in emerging economies.

Modern EfW is deployed typically within a policy framework aimed at effective and efficient waste management, combining environmental, social and economic drivers. To date major drivers have been improved sanitation, energy generation and diversion of waste from landfill, but new drivers related to carbon management and the management of commodities are becoming important. For EfW to be successful, consideration of local culture, waste arisings, the nature of the waste and local infrastructure are important.

We have reviewed the major relevant technologies and the most common type of plant remains conventional combustion using moving grate technology. Advanced thermal treatment options are of increasing interest because of their potential to deliver flexibility in end products, such as biofuels and high value chemicals, as well as heat and power. However, the information available on performance is limited and commercial viability often remains unproven.

EfW continues to evolve and to face new challenges. These include technological challenges resulting from changes in waste management that affect the feedstock for EfW, overcapacity of existing EfW facilities in Europe (Berthoud 2012) and negative public perception globally.

Future drivers are also evolving. Carbon emissions are becoming increasingly important in the EU (particularly in the use of solid recovered fuels and of heat). There is also increasing interest in the development of high value commodities from waste, including high value chemicals and biofuels. These issues and more are being examined by IEA Bioenergy Task 36. Recent topics examined include methodologies for demonstrating the biogenic content of waste; the management of ash residues from EfW plants; the impact of anaerobic digestion on EfW and the development and use of SRF. For further information refer to www.ieabioenergy.com.

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International Energy Agency

The International Energy Agency (IEA) is an autonomous organisation which works to ensure reliable, affordable and clean energy for its 28 Member Countries and beyond. Founded in response to the 1973-74 oil crisis, the IEA's initial role was to help countries co-ordinate a collective response to major disruptions in oil supply through the release of emergency oil stocks to the markets. While this continues to be a key aspect of its work, the IEA has evolved and expanded. It is at the heart of global dialogue on energy, providing authoritative and unbiased research, statistics, analysis and recommendations. Today, the IEA's four main areas of focus are:

- Energy security: Promoting diversity, efficiency and flexibility within all energy sectors;
- Economic development: Ensuring the stable supply of energy to IEA Member Countries and promoting free markets to foster economic growth and eliminate energy poverty;
- Environmental awareness: Enhancing international knowledge of options for tackling climate change; and
- Engagement worldwide: Working closely with non-Member Countries, especially major producers and consumers, to find solutions to shared energy and environmental concerns.

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 promote international collaboration on energy technology.
- To assist in the integration of environmental and energy policies.

Organisation

The IEA is an autonomous agency based in Paris. The main decision-making body is the Governing Board, composed of energy ministers from each Member Country or their senior representatives. A Secretariat, with a staff of energy experts recruited on a competitive basis primarily from OECD Member Countries, supports the work of the Governing Board and subordinate bodies. The Secretariat is headed by an Executive Director appointed by the Governing Board. The Secretariat collects and analyses energy data, organises high-level workshops with world experts on new topics and themes, assesses Member and non-Member Countries' domestic energy policies and programmes, makes global energy projections based on differing scenarios, and prepares studies and concrete policy recommendations for governments on key energy topics.

Members

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

Introducing IEA Bioenergy

Welcome to this Annual Report for 2013 from IEA Bioenergy.

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

Bioenergy is energy derived from biomass. Biomass 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 2013, 24 parties participated in IEA Bioenergy: Australia, Austria, Belgium, Brazil, Canada, Croatia, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the republic of Korea, the Netherlands, New Zealand, Norway, South Africa, Sweden, Switzerland, Turkey, the United Kingdom, the USA and the European Commission.

IEA Bioenergy is now 36 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 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 number of enquiries from potential participants and as a consequence new Members are expected. Three non-Member Countries currently participate in IEA Bioenergy – Brazil, Croatia and South Africa.

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 11 ongoing Tasks during 2013:

- Task 32: Biomass Combustion and Co-firing
- Task 33: Thermal gasification of Biomass
- Task 34: Pyrolysis of Biomass
- Task 36: Integrating Energy recovery into Solid Waste Management
- Task 37: Energy from Biogas
- Task 38: Climate Change Effects of Biomass and Bioenergy Systems
- Task 39: Commercialising of Conventional and Advanced Liquid Biofuels from Biomass
- Task 40: Sustainable International Bioenergy Trade – Securing Supply and Demand
- Task 41, Project 4: Biomethane in Heavy Duty Engines
- Task 42: Biorefining – Sustainable Processing of Biomass into a Spectrum of Marketable Bio-based Products and Bioenergy
- Task 43: Biomass Feedstocks for Energy Markets

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 2013 is shown in Appendix 1.

A progress report for IEA Bioenergy for the year 2013 is given in Sections 1 and 2 of this Annual Report.

ExCo71 study tour group at the Cape Flats Wastewater Treatment Works, South Africa.

Progress Report

1. THE EXECUTIVE COMMITTEE

Introduction and Meetings

The 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 and organises workshops and study tours for the Member Country participants.

The 71st ExCo meeting took place in Cape Town, South Africa on 21st-23rd May. There were 33 participants. The 72nd ExCo meeting was held in Jeju, Korea on 11th-13th November. There were 30 participants. Anselm Eisentraut represented IEA Headquarters at ExCo72.

At ExCo72 Paul Grabowski of the USA was elected Chair and Kees Kwant of the Netherlands was elected Vice-Chair for 2014.

Secretariat

John Tustin retired from IEA Bioenergy at the end of March 2013 after 35 years of outstanding service to the Agreement. His contribution to the development of IEA Bioenergy is greatly appreciated by all Members of the ExCo. *An illustrated record of John Tustin's years with IEA Bioenergy* was produced by Josef Spitzer and is available in the Members area of the website under ExCo Documents/General.

The ExCo Secretariat is currently based in Dublin, Ireland under the Secretary, Pearse Buckley. 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.

The contact details for the Executive Committee 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 2013, is described below.

John Tustin and assistant Danielle Rickard.

Implementing Agreement – Renewal

The current term of the Implementing Agreement ends on the 28th February 2015. A request for an extension to the Agreement will be submitted to the Renewable Energy Working Party (REWP) in June 2014 for consideration at its October 2014 meeting. A recommendation from REWP will be forwarded to the Committee on Energy Research and Technology (CERT) for a decision on the request for extension at the latter's February 2015 meeting.

At ExCo71 in Cape Town, the ExCo unanimously approved the request for an extension of the Implementing Agreement from 2015 to 2020 and established a working group to develop a new Strategic Plan for the period 1st March 2015 to 28th February 2020. The draft Strategic Plan, which was prepared by the working group, was discussed at ExCo72 and, following feedback from the Members and Task Leaders, the final document will be submitted for approval at ExCo73 in Copenhagen. A draft of the End of Term Report 2010-2015 was reviewed at ExCo72 and is to be finalised for approval by the Chair and Vice-chair. Both documents will accompany the request for an extension of the Implementing Agreement to be submitted to IEA Headquarters in June 2014.

Contracting Parties/New Participants

The Tubitak Marmara Research Centre Energy Institute, as contracting party for Turkey, has made a decision to withdraw from the Implementing Agreement and, with the approval of the ExCo, this will take effect on the 1st January 2014.

Following the Executive Committee's approval of an invitation to Russia to join the Implementing Agreement at ExCo70, there have been further discussions. However, Russia has not yet become a Member but has continued throughout 2013 to observe Tasks that are of specific interest.

Other potential Member Countries with whom there has been recent correspondence have included Chile, China, India and Thailand.

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 to the Executive Committee twice per year at the ExCo meetings. The ExCo has continued its policy to invite Task Leaders to each ExCo meeting so that they can make presentations 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 increased the engagement of the ExCo with the Task programmes.

The work within IEA Bioenergy is regularly evaluated by the IEA Committee for Energy Research and Technology (CERT) via its Renewable Energy Working Party (REWP) and is reported to the IEA Governing Board.

Approval of Task and Secretariat Budgets

The budgets for 2013 approved by the Executive Committee for the ExCo Secretariat Fund and for the Tasks are shown in Appendix 2. Total funds invoiced in 2013 were US$1,974,220; comprising US$269,800 of ExCo funds and US$1,704,420 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 Bank of Ireland Global Markets in Dublin is working well. The Trust Account consists of a Call Deposit account and a Fixed Deposit account both of which bear interest. The Call Deposit account is accessed electronically while the Fixed Deposit account is accessed through the Bank's dealers. Both accounts are denominated in US dollars. The currency for the whole of IEA Bioenergy is US dollars. Details for making payments are:

Arrange an International Telegraphic Transfer/Swift Money Transfer to:

Beneficiary Bank:	Bank of Ireland Global Markets
Beneficiary Bank Address:	2 Burlington Plaza, Burlington Road, Dublin 4, Ireland
IBAN Number:	IE26BOFI90139471664020
Swift/BIC Address:	BOFIIE2D
Beneficiary:	ODB Technologies Ltd for and on behalf of IEA Bioenergy Trust Account
Beneficiary Account Number:	71664020
Quoting:	Invoice No. xxx

The main issues faced in fund administration are slow payments from some Member Countries and fluctuations in exchange rates. As at 31st December 2013, there was US$164,520 of Member Country contributions outstanding.

The audited accounts for the ExCo Secretariat Fund for 2012, with KPMG, Hamilton, New Zealand as independent auditor, were approved at ExCo71. At ExCo72, unanimous approval was given to the appointment of KPMG, Dublin as independent auditor for the ExCo Secretariat Fund until 31st December 2015.

The Tasks also produce audited accounts. These are prepared according to guidelines specified by the ExCo. The accounts for the Tasks for 2012 were approved at ExCo71, except for Tasks 38 and 39, which were approved at ExCo72, and Task 43 which were approved by written procedure in December 2013.

The audited accounts for the ExCo Secretariat Fund for the period ended 31st December 2013 have been prepared and these will be presented for approval at ExCo73 in Copenhagen.

Task Administration and Development

Task Participation

In 2013 there were 109 participations in 10 Tasks. Please see Appendix 1 on page 103 for a summary of Task participation. The Netherlands and New Zealand participated in Tasks 38 and 33 respectively for 2013 only and will not be continuing in these tasks for the balance of the triennium (to the end of 2015). Norway has joined Task 38 for 2014 and 2015.

There was one joint project with the Advanced Motor Fuels Implementing Agreement carried out under Task 41 (see page 86).

Strategic Plan

The fourth Strategic Plan for the period 2010-2016 was produced in November 2009 and covers the current term of the Implementing Agreement, which ends on the 28th February 2015. It underpins a stronger emphasis on market deployment of technologies for sustainable energy production from biomass.

As noted above, the fourth Strategic Plan will be superseded by the fifth Strategic Plan, which is currently in draft form. The term of the latter will align with the renewed term of the Implementing Agreement, which will commence on the 1st March 2015, subject to approval by REWP and CERT.

Technical Coordinator

Dr Arthur Wellinger has continued in the role of Technical Coordinator. During 2013, his activities included facilitating and planning increased collaboration between the Tasks, maintaining links with IEA Headquarters, engaging with other international organisations (e.g. GBEP), and organising and publishing (in conjunction with the Secretary) the ExCo workshops. Successful workshops were organised at ExCo71 in Cape Town and ExCo72 in Jeju and the *ExCo68 – Environmental sustainability of Biomass – Summary and Conclusions* has been published.

In an evaluation of the performance of the Technical Coordinator and of the role of Technical Coordinator, which was carried out in 2013 by the ExCo, the importance of pro-active engagement in coordinating the work of the Tasks and in driving policy-relevant outputs were identified as key activities of the Technical Coordinator.

Communication Strategy

The Executive Committee reviewed the communication strategy prepared by the Technical Coordinator at ExCo71. The need for enhanced communication with stakeholders was highlighted against a background of increased public discussion about the role of bioenergy. It was important to examine both the messages to be communicated and the channels through which communcation took place in order to effectively inform the market. A working group was established to develop the communication strategy further. Following discussions at ExCo72, initial actions were identified and some have been implemented, e.g. a share button has been added to the IEA Bioenergy website to facilitate wider distribution of IEA Bioenergy publications.

Strategic Fund/Strategic Outputs

At ExCo53 it was agreed that from 2005, 10% of Task budgets would be reserved for ExCo approved work. The idea was that these 'Strategic Funds' would be used to increase the policy-relevant outputs of IEA Bioenergy.

There has been good progress with strategic initiatives. The summary and conclusions from the ExCo68 workshop 'Environmental Sustainability of Biomass' has been formally published and can be download at http://www.ieabioenergy.com/iea-publications/workshops/, as can the publications from other ExCo workshops.

Health and Safety Aspects of Solid Biomass Storage, Transportation and Feeding: The final report on this project, which summarise the existing knowledge and available research on the issue of safe storage and transportation of different types of solid biomass and waste, was published in May 2013 and can be downloaded at http://www.ieabioenergy.com/publications/health-and-safety-aspects-of-solid-biomass-storage-transportation-and-feeding/.

Monitoring Sustainability Certification of Bioenergy: The final reports from this project (Tasks 1, 2 3 and 4), which address the issues associated with the global proliferation of certification systems, were published in March 2013 (http://www.bioenergytrade.org/publications.html). A short summary was published in June 2013 and can be downloaded at http://www.ieabioenergy.com/publications/monitoring-sustainability-certification-of-bioenergy-short-summary/.

'Mobilising Sustainable Bioenergy Supply Chains': This project continues to make good progress. Five supply chains have emerged:

- Boreal and temperate forests
- Regional biogas production from organic residues
- Agricultural residues for bioenergy and biorefineries
- Integration of lignocellulosic crops into agricultural landscapes
- Cultivating pastures and grasslands: the sugar cane ethanol case

These will be analysed based on a common framework that has been created. The template for the boreal forest case has been issued to collect the data. The project, which is led by Task 43 and involves experts from Tasks 38, 39, 40 and 42, is on schedule to be completed in 2015.

Timing Issues of GHG Emissions: At ExCo71, approval was given for a statement *On the Timing of Greenhouse Gas Mitigation Benefits of Forest-Based Bioenergy*. The statement, which was published in July 2013 and can be downloaded at http://www.ieabioenergy.com/publications/on-the-timing-of-greenhouse-gas-mitigation-benefits-of-forest-based-bioenergy/, addresses the issue of timing of greenhouse gas (GHG) emissions and carbon sequestration

when biomass from existing managed forests is used for energy to displace fossil fuels. The purpose of the statement, which is aimed at policy advisors and policy makers, is to explain the essence of the debate and propose a perspective that considers the broader context of forest management and the role of bioenergy in climate change mitigation.

Quebec Workshop on 'Sustainability': The report *'The Science-Policy Interface on the Environmental Sustainability of Forest Bioenergy – a Strategic Discussion Paper'*, which was published in May 2013 and can be downloaded at http://www.ieabioenergy.com/publications/the-science-policy-interface-on-the-environmental-sustainability-of-forest-bioenergy/, relates the discussions and opinions expressed during the expert workshop on the environmental sustainability of forest bioenergy in Canada, held in Quebec on the 3rd-5th October 2012. Participants from 11 countries in North America and Europe were present at the workshop and included policymakers, industry, academia and civil society, representing a variety of organisations from local groups and governmental agencies to international bodies.

Transatlantic Wood Energy Workshop: This strategic workshop, held in Savannah, Georgia on the 24th and 25th October 2013, built on the success of the Quebec workshop on sustainability and had a goal to inform policy development. It was organised by Tasks 40 and 43 in association with the Pinchot Institute for Conservation. The workshop brought together a diverse group of experts and stakeholders working on various aspects of the growing trade in wood biomass between the southeast US and Europe. It included presentations, facilitated dialogue and field tours examining how global trade in renewable bioenergy, especially wood pellet exports from the US to Europe, can meet broad expectations for sustainability, biodiversity, water quality, greenhouse gas emissions, etc. There were five sessions as follows:

- Factoring the big picture into notions of sustainability: gave an overview of global biomass where the US is the biggest exporter, then looked at forest and harvest stocks in the region, demonstrated that it was cyclical and that over time growth surpasses removal and that absolute carbon storage increased.
- Measuring sustainability and risk, which covered bioenergy sustainability assessment frameworks and highlighted the importance of US forests for biodiversity.
- International sustainability criteria for solid biomass, which was addressed by DG Climate from the EC who spoke through a "gotomeeting" link.
- Environmental risk mitigation and procurement practices, which focused on existing certification processes, which provided a strong backbone to ensure sustainable biomass.
- GHG and forest carbon accounting: there was a strong but constructive debate and lessons included the importance of choosing the correct counter factual and the importance of the assumptions.

The workshop was a very successful engagement of key stakeholders. A summary report is being prepared and is expected to be published in the first quarter of 2014.

Database for IEA Bioenergy

Following a presentation at ExCo72 the ExCo approved the development of a database for IEA Bioenergy, with an on-line interface for each Task that is involved. The principal benefit would be to show bioenergy in an integrated way – having all plants in one scheme, with a link to the website. The development of the database will take place in 2014.

ExCo Workshops

At ExCo53 it was decided to create time for strategic topics at ExCo meetings and to use the first day of each meeting for a technical workshop on a topic of high priority.

Two workshops were held in 2013 and the topics were 'Waste to Energy' (ExCo71) and 'Electricity from biomass – from small to large scale' (ExCo72). Both workshops involved outside experts who brought important insights to the ExCo. All of the presentations given are available on the website at http://www.ieabioenergy.com/iea-publications/workshops/ and workshop summaries are being drafted for publication in 2014.

Seminars, Workshops and Conference Sessions

A large number of seminars, workshops and conference sessions are arranged every year by individual Tasks within IEA Bioenergy. This is a very effective way to exchange information between the participants and to transfer information to stakeholders. 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. Examples of this outreach are:

- Task 32 co-organised a conference with the Biomass group of VGB Powertech on Challenges in Biomass Combustion on 13th-14th November 2013. This was done in the framework of a collaboration agreement of Task 32 with this working group in VGB Powertech, in which most of the European operators of biomass power plants are represented. The conference covered various practical challenges of operating a biomass power plant, related to mitigating high temperature chlorine corrosion and fire and explosion prevention.
- Task 33 organised a joint workshop with IEA Industrial Energy-related Technologies and Systems (IETS) on "System and Integration Aspects of Biomass-based Gasification" in Göteborg, Sweden on 19th-20th November 2013. The aim of the workshop was to initiate a dialogue across the technology/system interface, as well as on methods and results for technical, economic and environmental evaluations of integrated biomass-based gasification systems. The other aim was to identify topics for future international cooperation in these areas. Further information about the workshop can be found at the Task 33 website www.ieatask33.org.

- Task 36 held an expert workshop on solid recovered fuels (SRF) in Milan on the 20th November 2013 The aim of the workshop was to give an overview of the present and future potential and market of SRF in Europe, after the introduction of the classification and specification requirements of EN15359.
- Task 37 joined with the Swiss Federal Office of Energy to hold a half-day technical workshop on biogas process optimisation. There were technical presentations on feedstock process control, optimised digestion systems and biogas and digestate treatment management. All presentation can be found on the Task website http://www.iea-biogas.net/.
- Task 39 organised an informal Task meeting in October 2013 in Nanjing, China. The Chinese government sponsored conference was entitled, the "International Conference on Biomass Energy and Chemicals" and was meant to both profile much of the R&D being carried out on biofuels in China but also provide a forum to show representatives from the Chinese government, industry and academia the benefits of being part of IEA Bioenergy. Several Task 39 members from Australia, Sweden, Denmark, Japan, Korea, USA and Canada presented at the conference.
- Task 40 and Task 43 and the Pinchot Institute organised a workshop on "The Transatlantic Trade in Wood for Energy: A Dialogue on Sustainability Standards" in Savannah, Georgia, USA – see above.

Collaboration with International Organisations and Implementing Agreements

Advanced Motor Fuels Implementing Agreement

Collaboration with the Advanced Motor Fuels (AMF) Implementing Agreement has continued with very positive benefits for both Agreements. This includes joint projects, among which is the following, on-going work:

- Task 41, Project 4 'Enhanced Emission Performance and Fuel Efficiency for HD Methane engines'. This project will present emission and engine performance from state-of-the-art methane-fuelled heavy duty engines, either dedicated gas engines or diesel engines fuelled with a combination of methane (in various forms) and diesel. Two Contracting Parties from IEA Bioenergy (the European Commission and Norway) are participating. Initial results based on measurements in Sweden can be summarised as follows:
  - Diesel Dual Fuel Concepts (DDF, Methane-diesel)
    - Difficult to meet Euro V/VI emission standards for CH4
    - Diesel replacement dependent upon load conditions
    - Not suitable for low load, start/stop driving
    - In best cases GWP not more than with diesel fuel (unless biogas is used)

- Dedicated Gas Engines (SI)
  - No problem with Euro V/EEV technologies
  - Engine efficiency lower (than diesel) especially for lean-mix
  - Lean-mix concept operating mostly on $\lambda 1$

In the continuing discussions between IEA Bioenergy and AMF, other potential collaborations are being considered and examples of potential areas include *Alternative fuels for marine applications and Hydro-treated oils and fats for engine operation*. A joint IEA Bioenergy/AMF workshop on *Infrastructure Compatible Transport Fuels* will be held in Copenhagen in May 2014 as both Implementing Agreements have their ExCo meetings in Denmark at that time.

GBEP

The relationship between IEA Bioenergy and the Global Bioenergy Partnership (GBEP) continues to develop. Discussions and exchanges of information are being facilitated both by the Technical Coordinator and through direct interactions with IEA Bioenergy Tasks. Task 43 is involved in work on GBEP indicators concerning forest biomass and agricultural residues, which has also involved FAO and US DoE. Good progress is being made on the indicators, which should lead to a comprehensive framework for analysis.

FAO

The collaboration with FAO under the MoU signed in 2000 has continued. Olivier Dubois has been identified as the primary contact at FAO for IEA Bioenergy and he submitted a paper 'Summary of FAO work on bioenergy' for consideration by ExCo at the ExCo72 meeting in Jeju. The paper included details of FAO activity including:

- Work on sustainable bioenergy – as part of FAO's programme "Energy-Smart Food for People and Climate
- Specific work on renewable energy for rural isolated communities
- Specific support to SE4All.

The paper was very well received by the ExCo who reiterated their support for enhanced collaboration between the two organisations.

Promotion and Communication

The effective communication of IEA Bioenergy activities and information to stakeholders, in particular to decision makers, is a key priority of ExCo. The wide range of promotional material available through the Secretariat includes Annual reports, technical brochures,

copies of IEA Bioenergy news, the current Strategic Plan, strategic papers and workshop proceedings. The IEA Bioenergy website underpins this publishing activity.

The 2012 Annual report with the special colour section on 'Biomass Feedstocks for Energy Markets', was very well received. Only a few copies from the original print run of 1500 remain, with substantially increased distribution in electronic format.

The newsletter 'IEA Bioenergy News' continues to be widely circulated. Two issues were published in 2013. The first issue featured bioenergy in South Africa and the second issue featured bioenergy in Korea 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. It is produced in electronic format so potential subscribers should ensure that the Secretary has their email addresses. IEA Bioenergy news is also available from the IEA Bioenergy website.

Two contributions under the banner of 'IEA Bioenergy Update' were provided to the journal Biomass and Bioenergy in 2013 bringing the total to 55. This initiative provides excellent access to bioenergy researchers as the journal finds a place in major libraries worldwide.

Interaction with IEA Headquarters

There is continuing contact between the IEA Bioenergy Secretariat and IEA Headquarters in Paris and active participation by ExCo representatives in relevant meetings. The Chairman, Technical Coordinator, Secretary and key Task Leaders have worked closely with Headquarters staff at both administrative and technical levels. For example, Arthur Wellinger and Pearse Buckley held meetings with Adam Brown and colleagues in Paris to exchange information on activities and aims of the respective programmes of work.

Birger Kerckow attended the REWP workshop 'Scaling up financing to expand the renewables portfolio'. The 140 participants at the workshop were an invited group of senior decision makers from the key players worldwide – governments, project developers and investors across a range of asset classes. The aim of the workshop was to address the issue of finding the financing solutions for the required broad portfolio of technologies to meet the challenge of ramping up RE deployment quickly enough to be on track to reduce GHG emissions.

Josef Spitzer attended the *Bioenergy How2Guide Inception workshop* at IEA Headquarters. The goal of the workshop was to inform participants about the How2Guide project, which builds on the International Energy Agency's global energy technology roadmap series. Framed under the IEA's International Low-Carbon Energy Technology Platform, it responds to the growing number of requests for assistance from emerging and developing economies with the development of low-carbon energy technology roadmaps that are tailored to national frameworks, resources and capacities

Anselm Eisentraut attended ExCo72. This participation by Headquarters is appreciated by the Members of the ExCo and helps to strengthen linkages between the Implementing Agreement and relevant Headquarters initiatives.

Status reports were prepared by the Secretary and forwarded to the Desk officer and the REWP following ExCo71 and ExCo72. Information was also sent to Nils-Olof Nylund, Vice Chairman of the End Use Working Party (EUWP) for the Transport sector to assist the report he prepares for the autumn meeting of the EUWP. This forms part of the exchange of information between Implementing Agreements and the Working Party. Regular contributions are provided to the IEA OPEN Energy Technology Bulletin. This provides a very useful platform for distributing the IEA Bioenergy newsletter and publications to stakeholders. The Bulletin is also one of the most used referral mechanisms for introduction to the IEA Bioenergy website.

IEA Bioenergy Website

The IEA Bioenergy website (www.ieabioenergy.com) has been re-developed to produce a more modern, flexible website. All of the preexisting content and functionality has been retained. The redevelopment of the website has resulted in it having

- an updated content management system (CMS)
- increased usability and cleaner information architecture
- a system more easily administered by the non-expert
- search engine optimisation (SEO) and social networking
- easier access to core functionality.

The re-developed website was activated at the beginning of October 2013 and in the months of October, November and December there was an average of approximately 1,800 visits per month.

IEA Bioenergy Conference 2015

At ExCo72 in Jeju, the ExCo approved Germany as host for ExCo76 and the End of Triennium (2013-2015) Conference in the 4th quarter of 2015. A scientific committee led by the Technical Coordinator has been formed to prepare the programme. This will be the third triennial conference, following the very successful conferences in Vancouver in 2009 and Vienna in 2012.

2. PROGRESS IN 2013 IN THE TASKS

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 wider scale. The widespread interest in the work of the Task illustrates the relevance of biomass combustion and co-firing in society. Combustion applications vary from domestic woodstoves to industrial combustion technologies, dedicated power generation and co-firing with conventional fossil fuels.

Generally speaking, biomass combustion technologies are fully mature with high commercial availability and a multitude of options for integration with existing infrastructure on both large and small-scale levels. Nevertheless, there are still a number of challenges for further market introduction, the importance of which varies over time. Priority issues tackled by the Task through different activities in this triennium are:

- Advanced fuel characterisation methods
- Torrefaction of biomass
- The use of CFD tools for optimisation of biomass combustion technologies
- Better designs of woodstoves
- Aerosol emissions from residential solid fuel appliances
- Addressing combustion related challenges in practise
- Increasing co-firing percentages
- 100% conversion projects from pulverised coal to biomass
- Database on biomass co-firing experiences

The specific actions for the Task involve collecting, sharing and analysing the policy aspects of results of international/national R&D programmes that relate to these priorities. The results of these actions are disseminated in workshops, reports, handbooks, databases etc. In addition, a number of specifically designed, strategic actions are carried out by the Task to catalyse this process.

While most of the above actions are of a technical character, Task 32 also addresses non-technical issues on fuel logistics and contracting, environmental constraints and legislation, public acceptance and financial incentives. An overview of relevant policies is included in the Handbook of Biomass Combustion and Co-firing. In addition, the Task produced a number of reports on harnessing the co-firing potential in both existing and new coal-fired power plants.

Participating countries: Austria, Belgium, Denmark, Germany, Ireland, Japan, the Netherlands, Norway, South Africa, Sweden, Switzerland and the United Kingdom.

Task Leader: Ir Jaap Koppejan, Procede BV, the Netherlands

Sub-Task Leader for Co-firing: Ing. Robert van Kessel, KEMA, the Netherlands

Sub-Task Leader for Small Scale Combustion: Ing. Eric Smit, Interfocos, the Netherlands

Operating Agent: Ir Kees Kwant, NL Agency, 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, 4, 5 and 6; the Task website www.ieabioenergytask32.com and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

In 2013, the Task organised two internal meetings and two workshops. The internal meetings were used to monitor progress in different Task activities, reflect on Task-initiated workshops and share recent developments on application of biomass combustion in Member Countries.

Workshops are a proven concept to gather and disseminate information in a structured and effective manner. Invited speakers present the latest insights on one aspect of biomass combustion and/or co-firing, and thereby provide expert information for the participants. These workshops are usually organised in conjunction with high profile bioenergy conferences to attract as wide an audience as possible. The results of the workshops are reported and published on the Task website and key results are fed back to both the Task participants and the ExCo for evaluation and further dissemination.

In May 2013, a workshop on the effectiveness and usability of CFD tools for designing industrial biomass combustion systems was organised in conjunction with the European Biomass Conference and Exhibition in Copenhagen, Denmark. At this workshop, 13 CFD experts from industry and research shared and discussed their approaches for evaluating and improving combustion performance of given furnace designs using various CFD tools.

In November, an expert workshop on challenges in biomass combustion and cofiring was co-organised in Berlin, Germany in cooperation with the VGB industry group. The 2 day workshop attracted about 100 people from predominantly the power sector and was effective in exchanging practical information amongst plant operators.

Both workshops in 2013 were combined with a Task meeting. Workshop reports can be downloaded from the Task 32 website. Reports from internal task meetings are available to member countries only, using login credentials.

Work Programme

The work programme in the triennium 2013-2015 is structured as follows:

1. Fuel characterisation, pretreatment and supply

The following fuel supply related actions are planned in this triennium:

Publication on new fuel characterisation methods, summarising the result of recent EU, ERANET and national projects (D13)

Within the last few years a number of national and international projects were initiated, which are concerned with the development of advanced biomass fuel characterisation techniques that are capable of providing an improved assessment of the behaviour of a fuel during pyrolysis, gasification and combustion processes. The intention is that the advanced fuel characterisation techniques will provide better support to the design of energy conversion plants. Task 32 will compile an overview publication of the available results on the advances in biomass fuel characterisation techniques for selected biomass fuels. Major contributions to this report will come from Sweden, Denmark, Canada and Germany, as well as an ongoing EU R&D project where the conversion behaviour of 15 fuels in 5 different conversion systems is being investigated. The project will involve collaboration with T33 and 34.

Expert workshop on progress in torrefaction technologies (D9)

In 2011, Task 32 and Task 40 organised a workshop on the developments and opportunities for torrefaction technologies and the possible impact on long distance biomass trade, at a biomass conference in Austria. The event attracted approx 250 participants and was very successful. This workshop will be repeated in January 2014 in Graz, which will also provide a platform to disseminate the results of the torrefaction technology review which is currently being carried out by Task 32.

Status report on torrefaction and other pretreatment technologies (D11)

Task 32 produced an assessment of torrefaction report in Triennium 2010-2012. This publication will be updated in 2015, as it is expected that several manufacturers will then have their first demonstration plants operational.

2. Small scale biomass combustion

Small scale biomass combustion is applied in manually or automatic fired boilers and stoves. The key challenges are the reduction of emissions of particularly aerosols, increase of combustion efficiency and reduction of investment and operational costs. The following actions will be carried out:

Expert workshop on highly efficient and clean stoves and boilers (D16)

Manufacturers of residential solid fuel appliances and policy makers will be engaged in a workshop, currently planned for Q3 2014 on the effects of furnace design on combustion quality and emissions, small scale dust removal systems, and the effectiveness of policy measures to promote clean small-scale combustion devices. The workshop will make effective knowledge transfer possible between manufacturers of woodstoves and will be organised in close corporation with the European network of stove manufacturers, established by the EU network EcoSolidFuel.

Expert workshop on the use of CFD as a tool to optimise geometry of biomass combustion systems (D2)

CFD-based design tools have significantly improved in the last decade and are now commonly applied for larger utility boiler installations. There are however also numerous cases where CFD-based design has led to much better combustion quality of smaller scale boilers, avoiding the need of a 'trial and error' approach for boiler design and reducing development expenses. An expert workshop was held in May 2013 for equipment suppliers and researchers to share practical experiences and address the current opportunities and limitations of CFD-based boiler design.

Technical publication on standardisation in particle emission measurement techniques, summarising the status of standardisation regarding particle emission measurements as well as necessary recommendations for future actions (D5)

The standards for particle emission measurement from residential combustion are hard to compare across different European countries. Given the growing awareness of the impact of PM on public health, various attempts to establish a common European method to determine PM emissions has been made within CEN during recent years. Task 32 will compile and share the results of various co-normative and pre-normative research projects that support this process. This report will be published in 2015.

Policy paper and background technical report on the health impact of combustion aerosols (D14)

In the past 5-10 years, several studies (e.g. the EU BIOHEALTH project) have been initiated that address the health impact of biomass combustion based aerosols, with different results. A short policy relevant summary will be prepared, based on the results of these studies which will be documented in a separate background technical report. The paper will address

recent R&D work done on the formation and health impact of aerosols from different types of biomass combustion devices (with emphasis on domestic woodstoves), as well as the cost effectiveness of both primary measures and secondary measures for emission reduction. The work is planned for 2014.

3. Industrial and utility scale biomass combustion and power generation

For the larger industrial combustion installations, economies of scale effects usually make it more interesting to take technical measures in furnace and boiler design as well as flue gas treatment, so that the options increase for using low grade biomass fuels and process residues. There are however significant challenges related to boiler design and operation, for these fuels, most of which are ash-related, i.e. ash deposition, high temperature corrosion and ash utilisation/disposal.

Workshop on approaches to enable combustion of challenging fuels (D6)

A workshop was organised jointly with VGB in Berlin in November 2013, to address the technical challenges associated with the pre-treatment and combustion of challenging residues and wastes such as Solid Recovered Fuels, waste woods, poultry litter, etc. The workshop provided a platform for scientists, equipment suppliers and plant operators to describe the current state of the art and to identify cost effective approaches to deal with challenging biomass types.

Publication on optimal design of biomass fired district heating networks (D18)

In 2013, Task 32 has started an evaluation of existing biomass fired district heating networks. The aim is to evaluate key energy losses in typical district heating plants and the influence of design and operation parameters such as dimensions and insulation of the district heating systems, temperature levels, and other major parameters. The results will be shared amongst equipment suppliers, policy makers and end users to come up with better designs and operational strategies. The work will be completed in 2014.

TEA and 'best practice' combustion for CHP in comparison to pyrolysis and gasification (D18)

In collaboration with Task 33 and Task 34, a techno economic evaluation will be performed on combustion for CHP to compare it to near term alternatives such as flash pyrolysis and gasification. This collaboration will involve development of comparative cost models with the other tasks. Once the models are developed, conclusions can be drawn as to the differences. The evaluation is expected to be finalised in 2015.

4. Biomass co-firing

The co-firing of solid biomass materials in existing coal fired plants is already a reasonably well-established way of producing electricity and heat from biomass, making optimal use of existing assets. In this triennium, the aim is to improve and extend the existing co-operation on co-firing with policy makers and regulators, research and technology providers, equipment suppliers and power producers.

Workshop on high percentages co-firing and increased fuel flexibility (D4)

An expert workshop on the progress that has been achieved, particularly in Northern Europe in the implementation of more advanced biomass co-firing technology. The workshop will highlight practical experiences, co-firing strategies and the developments in biomass supply. This workshop will be organised together with VGB Powertech and IEA Clean Coal Centre (IEA CCC).

Database on biomass co-firing experiences (D20)

The existing web-database on biomass co-firing experiences will be kept updated with the latest information available worldwide.

Technical report on biomass milling and combustion in pulverised fuel boilers (D17)

For combustion and co-combustion in a pulverised fuel boiler it is necessary to mill the biomass to a suitable size, to convey the milled biomass and to combust the milled biomass in a suspension. In most cases, this is achieved in equipment that was originally designed for coal. There have been major technical advances in this subject area over the past 10 years or so and significant development work is on-going. A technical summary report will be prepared in 2014-2015 on the achievements and technical experience to date, which will also identify the key technical requirements both for the co-firing of biomass in existing plants and the design of biomass co-firing systems in new plants.

Website

The Task website (www.ieabioenergytask32.com) attracts about 10,000 visitors every month and is one of the key tools for information dissemination. Main products that are being downloaded from the website are publications and meeting reports, the database on experience with biomass co-firing in different power plants and the databases on the composition of biomass and ash from actual combustion plants. The website is updated on a regular basis. In 2013, two electronic newsletters were produced and distributed to provide information on developments related to the work of the Task, and on biomass combustion and co-firing in general. Task participants and ExCo Members can obtain access to a secured section of the website which includes internal reports and work in progress.

Collaboration with Other Tasks/Networking

The Task collaborates directly with industry and through industrial networks such VGB Powertech. Within the IEA family, interaction is also solicited with other Bioenergy Tasks or other Implementing Agreements such as the IEA Clean Coal Centre. Market relevance is also enhanced by the active involvement of ExCo Members in the selection of Task participants, based on their national programmes. Several power companies are currently directly involved in the Task.

Effective coordination is achieved through joint events and the exchange of meeting minutes and reports. In 2013 a joint workshop was held with VGB on challenges in biomass combustion. The Health and Safety report was finalised early 2013 with input from experts from Tasks 36, 37 and 40.

Deliverables

The following milestones were achieved in 2013. Organising and minuting of two Task meetings. Organising and reporting of two workshops on 'CFD for design of industrial biomass combustion technologies' and 'Challenges in Biomass Combustion'; Publication of a 'Review of Health and Safety aspects of solid biofuels', updating of the international overview of initiatives for biomass co-firing; and maintenance of the Task website. The Task also produced progress reports and audited accounts for the ExCo.

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, and 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, Norway, Sweden, Switzerland, Turkey and USA.

Task Leader: Dr. Kevin Whitty, University of Utah, USA

Operating Agent: Professor Josef Spitzer, JS Consulting, Austria (January-December 2013)
Paul Grabowski, US Department of Energy (from January 2014)

The Task Leader directs and manages the work program. 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, 4, 5 and 6; the Task website www.ieatask33.org and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

The first Task 33 meeting for 2013 was held on 7th-9th May, 2013 in Golden, CO, USA. The Task meeting was held on the first day, the second day included a visit to the Natioanal Renewable Energy Laboratories and a workshop 'Lessons learned' was held on the third day.

The second Task 33 meeting was held on 19th-21st November, 2013 at Chalmers University of Technology in Göteborg, Sweden. On Tuesday and Wednesday a joint workshop between IEA Bioenergy Task 33 and IEA Industrial Energy-related Technologies and Systems (IETS), with the topic "System and Integration Aspects of Biomass-based Gasification", was held and the 20 MW GoBiGas bio-SNG site in Göteborg was visited. On Thursday the Task meeting was held.

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 sub-task studies, promotion of coordinated RD&D among participating countries, selected plant visits and industrial involvement in technical workshops at Task meetings have been very effective. These remain the basic foundations for developing and implementing a program of work that addresses the needs of the participating countries.

Furthermore, the aim is to increase the number of countries participating in Task 33. France, Canada, UK and Spain, for example, are very active in thermal biomass gasification and their membership would be profitable for all participants.

The Task monitors the current status of the critical unit operations and unit processes that constitute the biomass gasification (BMG) process and identifies hurdles to advance further development, operational reliability and reduction of 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 sub-task studies and/or technical workshops that focus on advancing the state-of-the-art technology and identify the options to resolve barriers to technology commercialisation.

The Task has continued the practice of inviting industrial experts to the Task workshops to present their practical experiences and to discuss the options for development of critical process components to advance state-of-the-art BMG systems. The interaction with industry provides the opportunity for the National Team Leaders (NTLs) to evaluate refinements 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 and support basic research needs.

Work Programme/Sub-task Studies

The current work programme includes the following elements:

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

Meeting	Associated Workshop	Dates and Location
1st Task meeting	WS1 'Lessons Learned'	7th-9th May 2013 Golden, CO, USA
2nd Task meeting	WS2 'System and Integration Aspects of Biomass-based Gasification'	19th-21th November 2013 Göteborg, Sweden

- Survey the current global biomass and waste gasification RD&D programmes, commercial operations and market opportunities for BMG, and identify the technical and non-technical barriers to commercialisation of the technology. Use the survey results to prepare and update Country Reports for information dissemination.
- Conduct joint studies, conferences and workshops with related Tasks, Annexes and other international activities to address issues of common interest to advance BMG systems.
- 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 program on the Task website (www.ieatask33.org) for information dissemination. Maintain the website with Task updates.
- Maintain Task 33 database on thermal gasification facilities worldwide.

Observations from WS1: Lessons Learned

At the beginning of the workshop, opportunities for cooperation between Tasks 33 and 34 (pyrolysis) were discussed. The cooperation in techno-economic assessment will be possible.

Table 1: Workshop presentations

Richard Bain, Principal Engineer, NREL **Integrated Pilot Operations for Production of Mixed Alcohols**
Kim Magrini, Group Manager, NREL **Development of Reforming Catalysts**
Jesse Hensley, Senior Engineer, NREL **Development of Mixed Alcohol Catalysts**
Abhijit Dutta, Senior Engineer, NREL **Techno-economics of Biomass Gasification Followed by Mixed Alcohol Production and Alcohol Separation**
Michael Talmadge, Senior Engineer, NREL **Techno-economic and Market Analysis of Pathways from Syngas to Fuels and Chemicals**
Douglas C. Elliott, Task 34 Leader, Pacific Northwest National Laboratory **Task 34 overview**

The presentations given by Richard Bain and Douglas C. Elliott can be found online at the Task 33 website. Other workshop presentations are unfortunately not available to the public at this time.

Attendance at this Task 33 meeting and workshop was weak, likely due in part to the meeting destination and unavailability of European Task 33 members.

Observations from WS 2: System and Integration Aspects of Biomass-based Gasification

Background

In order to meet the policy goal of reducing the dependence on fossil fuels and feedstock, the deployment of bioenergy, biofuels and biomaterials is expected to make a significant contribution to both the reduction of greenhouse gas emissions and to the introduction of more sustainable products. Since biomass is a limited resource and can also be associated with undesirable environmental impacts, this calls for a rational utilisation of biomass and an understanding of the consequences of its utilisation at a system level.

There are on-going technical research, development and demonstration activities in many countries relating to individual processes and products, also including the evaluation of the associated technical and economic performance. There is also a more recent and increasingly active research effort in investigating the system aspects of using biomass-based gasification technology systems, i.e. regarding positive and negative aspects of their use on an industrial and societal level. The importance of the system approach has been recognised in policy-making both in the EU and in the US.

There are several national and international initiatives in this area and such aspects are addressed at different levels, e.g. in both the IEA Bioenergy and the IEA Industrial Energy Related Technologies and Systems (IETS) Implementing Agreements (IA). The main focus of the Bioenergy IA is the technical development status of individual technologies such as gasification, pyrolysis, torrefaction etc. and biorefinery systems as well as the technical and economic potential of such developments. The IETS IA is more directed towards biomass usage by such technologies within a larger industrial system, i.e. a system integration context, also including the societal level.

There is an obvious strong interlink between these two levels, requiring the exchange of data and results, as well as a need to understand the underlying methodologies used in both areas to correctly interpret this information between the levels.

Aim

One main aim of the workshop was to initiate a dialogue across the technology/system interface, as well as on methods and results for technical, economic and environmental evaluations of integrated biomass-based gasification systems. The other main aim was to identify topics for further international cooperation in these areas.

Contents

- System integration and optimisation aspects of pre-treatment, gasification, downstream treatment and end product processing for different technology concepts and products
- Integration of biomass gasification systems with process industries, district heating systems, industrial clusters, etc.
- Methodologies for assessing technical and economic performance (incl. selection of data) of industrial gasification technologies and systems for different future scenarios regarding energy costs and policy instruments
- Methodologies for assessing the green house gas and sustainability impact of products and systems (incl. the generation and selection of data)
- Case studies

Table 2: Workshop presentations

A. Gaspar, RAIZ Institute, Portucel Soporcel, Portugal
IEA Industrial Energy-related Technologies and Systems. Annex XI

K. Whitty, University of Utah, USA
IEA Bioenergy Agreement, Task 33: Thermal gasification of Biomass

H. Wagner, TU of Hamburg-Harburg, Germany
Gasification of Urban Biomass Residues – Possibilities in Hamburg/Germany

M. Möller, DONG Energy, Denmark
Status of DONG Energy´s Pyroneer Gasification Technology for High Alkaline Fuels

C.Breitholz, Metso Power, Sweden
Gasification of Biomass and Waste for Production of Power in Lahti and Vaasa

H.Thunman, Chalmers University of Technology, Sweden
Beyond 80% Efficiency for Standalone Production of Bio-methane from Wet Biomass

T.Kolb, KIT, Germany
Biomass gasification for BtL – The Bioliq Process

I.Landälv, Lulea University of Technology, Sweden
Methanol as Energy Carrier and Bunker Fuel

R.Rauch, Vienna University of Technology, Austria
Dual Fluidized Bed Gasification for CHP and Production of Advanced Biofuels

B.van der Drift, ECN, the Netherlands
Chemicals from Gasification

I. Hannula, VTT, Finland
Production of Synthetic Methanol and Light Olefins from Lignocellulosic Biomass

S. Harvey, Chalmers University of Technology, Sweden
Assessing the Performance of Future Integrated Biorefinery Concepts based on Biomass Gasification

E.D.Larson, Princeton University, USA
Techno-Economic Systems Analysis of Jet Fuel and Electricity Co-Production from Biomass and Coal with CO_2 capture:An Ohio River Valley (USA) Case Study

M. Talmadge, NREL, USA
Techno-economic and Market Analysis of Pathways for Syngas to Fuels and Chemicals

A. Faaij, University of Utrecht, the Netherlands
Bio-CCS: Negative Emissions to Meet the Global Carbon Budget

B.F. Möller, Eon, Sweden
Bio2G – A commercial-scale gasification to SNG plant by Eon

All the workshop presentations will be available at the Task 33 website as soon as possible.

Website and Database

The Task website (www.ieatask33.org) is the most important tool for dissemination of results. Descriptions of the gasification process and a description of the Task including the contact data of national experts are given. Within 2 weeks after each Task meeting, all presentations in PDF form (Country Reports, Workshop presentations) can be found on the Task website. The Minutes are posted on the website as soon as all Task members provide their feedback. The summaries of the workshops can be found on the website in a Report form.

A Google-map based interactive database of implementations of gasification plants was incorporated into the Task website. At the moment, there are over 140 gasification facilities registered in the database. Most of the facilities can be found in the Task member countries. The database is interactive, which means that the technology, type and status of the gasifiers can be chosen to filter all the gasification facilities registered in the database. The database is updated regularly and provides a good overview on gasifiers throughout the world.

Deliverables

The Task deliverables included planning and conducting two semi-annual Task meetings focused on the workshops selected by the Task participants, involving academic and industrial experts; the preparation and distribution of workshop reports and newsletter; updating and publishing Country Reports; conducting joint studies, conferences, and workshops with related Tasks, Annexes, and other international bodies 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

The objective of the Task is to improve the rate of implementation and success of fast pyrolysis of biomass for fuels and chemicals (where this complements the energetic considerations) by contributing to the resolution of critical technical areas and disseminating relevant information particularly to industry and policy makers. The scope of the Task is to monitor, review and contribute to the resolution of issues that will permit more successful and more rapid implementation of biomass pyrolysis technology, including identification of opportunities to provide a substantial contribution to bioenergy. This will be achieved by a programme of work, which addresses the following priority topics: norms and standards; analysis – methods comparison and developments; and country updates and state-of-the-art reviews.

Pyrolysis comprises all steps in a process from reception of biomass in a raw harvested form to delivery of a marketable product as liquid fuel, heat and/or power, chemicals and char by-product. The Task focus is on fast pyrolysis to maximise liquid product. The technology review may focus on the thermal conversion and applications steps, but implementation requires the complete process to be considered. Process components as well as the total process are therefore included in the scope of the Task, which covers optimisation, alternatives, economics and market assessment.

The work of the Task addresses the concerns and expectations of the following stakeholders: pyrolysis technology developers; bio-oil applications developers; equipment manufacturers; bio-oil users; chemical producers; utilities providers; policy makers; decision makers; investors; planners; and researchers.

Industry is actively encouraged to be involved as Task participants, as contributors to workshops or seminars, as consultants, or as technical reviewers of Task outputs to ensure that the orientation and activities of the Task match or meet their requirements. Participants at recent meetings have included representatives from biomass pyrolysis industry leaders, Ensyn and BTG.

Participating countries: Finland, Germany, Netherlands, Sweden, United Kingdom and USA

Task Leader: Mr Douglas Elliott, Pacific Northwest National Laboratory, USA

Operating Agent: Mr Paul Grabowski, US Department of Energy, USA

The Task Leader directs and manages the work. 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, 4, 5 and 6; the Task website www.pyne.co.uk and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Task Meetings

Task 34 members convened in Karlsruhe, Germany, on 16th-18th April, 2013. At the meeting the agenda included Country Reports and presentations from observers from Belgium as well as discussion of advances in Norms and Standards. The work plan for the 2013-2015 triennium was reviewed.

Agenda of the TASK 34 Meeting

Introductions:

Participating countries were represented by their team leads (Douglas Elliott, US; Dietrich Meier, Germany; and Bert van der Beld, Netherlands) except for the Swedish National Team Leader (NTL) who had not been designated yet. Also in attendance were observers Anja Oasmaa from Finland and Tony Bridgwater from the UK in the expectation that these two nations would be joining the Task. Other observer/participants were Nicolaus Dahmen and Nikolaos Boukis, KIT, Germany, Wolter Prins and Diego López, Ghent University, Belgium.

Country Reports:

Presented by representatives from Germany, the Netherlands and the US with input also from Finland and the UK. Nicolaus Dahmen made a presentation on the activities at KIT. Wolter Prins made a presentation on biomass pyrolysis research at the University of Ghent. Diego Lopez made a presentation on algae hydrothermal liquefaction.

Review of the 2013-2015 Triennium Plan:

Activities proposed for the new triennium include:

- Review of Bio-oil Applications;
- Bio-oil Standards Development;
- Round Robin for Analytical Method Validation;
- Collaborative activities with other IEA Bioenergy Tasks, including techno-economic assessment (TEA) development, input to LCA, input to biofuels demonstration database and lignin pyrolysis biorefinery development.

Bio-oil Applications:

Discussion followed on the Bio-oil applications topic and the structure found on the website. Assignments for preparation of input to the website were agreed among the participants on the topics of interest.

Norms and Standards:

- CEN – This standardisation process is moving forward with the Working Group meeting expected in May.
- REACH – SIEF organisation is proceeding with the industrial participants. There remains keen interest in obtaining the formal reports from the BioTox study as a basis for defining properties of bio-oil.

Round Robin:

The details for a round robin were discussed. The decision on the subject was postponed to the next task meeting wherein analytical methods for sulphur and chlorine would be reviewed.

IEA Bioenergy Inter-Task Collaboration:

- Task 32 Combustion – Participants from the Netherlands could work together on a technical comparison of combustion of bio-oil relative to solid biomass combustion. VTT in Finland is also interested in cooperating in such a comparison.
- Task 33 Gasification – KIT in Germany is involved in both ends of this comparison, both bio-oil gasification and solid biomass gasification, and should be able to provide a useful comparison.
- Task 38 GHG – Task 38 would be very willing to perform LCA on good technical process data provided by Task 34. US members will facilitate the needed data transfer.
- Task 39 Liquid Biofuels – Task 39 has a database for demonstration plants for production of liquid fuels from biomass. It has limited input on pyrolysis. An IEA Bioenergy concerted effort will be solicited.
- Task 42 Biorefineries – Both Germany and the Netherlands will follow up as they are interested to interact as a part of this European collaborative project.

Topics for Group Assignment:

- Website Review – Data related to utilisation of the website were reviewed that suggested a high and broad level of interest in the Task website. During group discussion, it was identified that a number of improvements and updates were needed. Input from each participant was solicited.
- Newsletter – Writing assignments were made for the next issue of the newsletter due out in June 2013.

The participants also toured the KIT bio-oil production and gasification facility (bioliq®).

Task 34 members also convened in Chicago, USA, on 3rd-4th September, 2013, in conjunction with the tcbiomass2013 conference on the science of thermochemical conversion of biomass.

Introductions:

Participating countries were represented by their national team leaders (Douglas Elliott, US; Dietrich Meier, Germany; Bert van der Beld, Netherlands; Anja Oasmaa, Finland; Tony Bridgwater, UK) except for the Swedish National Team Leader (NTL) who had not been confirmed yet. Also in attendance were observers Daniel Nowakowski from UK and Alan Zacher from US.

Country Reports:

Reports were presented by representatives from Germany, the Netherlands, Finland, UK and the US.

Review of the 2013-2015 Triennium Plan:

Activities proposed for the new triennium include:

Bio-oil Applications:

Discussion followed on the Bio-oil applications topic and the structure found on the website. Input to the Heat and Power topic was collected and will be formatted for use on the website. Two other topics, Biofuels and Materials and Products were determined to be of value and input will be gathered and formatted for the website.

Norms and Standards:

- CEN – This standardisation process is moving forward. The Working Group meeting included a vote on the Mandate for a standards development work element. The vote was insufficient to move forward and further input will be required to be convincing.
- REACH – SIEF organisation is proceeding with the industrial participants. The reports from the BioTox study had been provided to the group as a basis for defining properties of bio-oil. The registration process was nearly complete.

Round Robin:

The details for a round robin were discussed. The decision was made to go forward in 2014 with a round robin to examine the consistency of bio-oil production within the fast pyrolysis community. It was suggested that the US might be able to provide the feedstock in 2 or 3 standard forms. Participating labs will be identified in the participating countries. An invitation letter will be drafted and reviewed by the Task members before it is distributed to potential participants.

IEA Bioenergy Inter-Task Collaboration:

- Task 32 Combustion – Participants from the Netherlands and Finland had been attempting to establish communications with the Task 32 members to initiate a technical comparison of combustion of bio-oil relative to solid biomass combustion.
- Task 33 Gasification – KIT in Germany is involved in both ends of this comparison, both bio-oil gasification and solid biomass gasification, and will be able to provide a useful comparison. The topic will be further discussed at the upcoming workshop organised by Task 33.
- Task 38 GHG – Task 38 would be very willing to perform LCA on good technical process data provided by Task 34. US members will facilitate the needed data transfer as the material becomes available within the next year.
- Task 39 Liquid Biofuels – An IEA Bioenergy concerted effort will be discussed at the upcoming ExCo meeting in Korea in November. Task 34 would be willing to participate in such an effort and provide the data on pyrolysis systems.
- Task 42 Biorefineries – Both Germany and the Netherlands will follow up as they are interested to interact as a part of a European collaborative project.

Topics for Group Assignment:

- Website Review – Data related to utilisation of the website were reviewed and suggested a high and broad level of interest in the Task website. During group discussion, it was identified that a number of improvements and updates were needed. Input from each participant was solicited.
- Newsletter – Writing assignments were made for the next issue of the newsletter due out in December 2013.

Work Programme and Progress in 2013

The work typically consists of Task meetings, workshops, technical tours and Task projects, in addition to the 'usual' Task management and ExCo support actions. Among the work efforts were the following:

- The standards development effort in Europe continued forward. A mandate for development of an expanded Bio-oil Standard was voted and accepted. A Working Group was organised. Further support to the REACH registration process included providing earlier the results of the BioTox study undertaken in part by Task 34.
- Plans were made for a round robin on bio-oil production and analysis. The round robin will include distribution of two biomass feedstocks to approximately 15 laboratories in the participating countries. The product bio-oils will be collected and analysed by the Task. The results of the Round Robin will be published in a technical journal.

- A continuing effort is the sharing of updated country reports by each of the participants at each of the Task meetings. These country reports are the basis for the continually updated Country Report portion of the Task website. Using these inputs, new discussions of Applications for bio-oil were also generated and placed on the Task website.
- The development of a comparative technoeconomic assessment of fast pyrolysis and hydrothermal liquefaction is being undertaken by two of the Task 34 participants. The process models generated will serve as the basis for inter-Task collaboration with Task 38 in the development of life-cycle analysis.

Newsletter

The Task newsletter continues the tradition of the PyNe newsletter and is an important vehicle for dissemination of relevant information. It is circulated to participants via the Task 34 website in electronic format. Issue 33 was published in June 2013 and Issue 34 was published in December 2013.

Website/Dissemination

The Task 34 website is an important mechanism for information and technology transfer. It is revised and updated under a contract with Aston University.

Collaboration with Other Tasks

The proposed work plan for Task 34 included collaborative efforts with five other tasks. These collaborations are at various stages of organisation and start-up and are expected to be completed as planned by the end of the triennium.

Deliverables

Deliverables for 2013 were: reporting to the ExCo (Annual Report, progress reports and audited accounts); continuation and updating of the Task website; two issues of the Task newsletter; organisation and minuting of two Task meetings; and reporting on Task progress at an international conference and in the literature.

TASK 36: Integrating Energy Recovery from Solid Waste Management

Overview of the Task

The waste and energy sector worldwide is currently undergoing a period of intense legislative and institutional change in Organisation for Economic Co-operation and Development (OECD) and other countries. The prime aim of Task 36 is to keep abreast of both technical and policy developments and to disseminate and exchange information on how energy integrates into these developments. This means that the sharing of good practice and/or new technology and techniques is also a major goal, so a further objective of the Task is to maintain a network of participating countries as a forum for information exchange and dissemination. To achieve these goals the Task participants have chosen a number of key Topic Areas for inclusion in the work programme.

Many countries have different approaches to waste treatment and disposal, but common themes are concerned with the increasing quantities of waste needing to be treated and the impact of landfilling mixed wastes on the environment. For some countries decreasing available landfill void space adds to this pressure. Consequently policy makers are examining alternatives to landfill, including reduction and recycling of waste, followed by recovery of value from waste. For example, within the European Union (EU) the Waste Framework Directive sets out a waste hierarchy that ranks priorities in waste management, puts forward conditions for determining whether or not processing changes waste to a product and sets out the requirements for classifying the incineration of waste as energy recovery (specifically related to the efficiency of energy recovery. This has led to increased interest in recycling and treatment of waste, followed by recovery of energy from the residual waste stream. Elsewhere, notably in North America and Australia, countries continue to rely on landfill, but in these countries there are also increasing pressures to reduce waste production and to recycle or recover where possible, leading to increased interest in recovery of energy from the residual waste. Globally these policy pressures have led to a proliferation of research work on waste management, including policy development, environmental systems analysis, technology development and economic drivers. Whilst this has assisted in the development of more sophisticated waste management systems, in many cases it has also delayed deployment of energy recovery systems (specifically for residual wastes) in particular due to confused policy making, public awareness (and opposition) and uncertainty over environmental performance and technology performance.

Against this background decision makers require guidance and information on all of these aspects if waste and resource management systems that are environmentally and economically sustainable are to be developed. Task 36 provides a unique opportunity to draw together information on how systems, policies and technologies are being applied in different countries to provide guidance for decision makers on key issues. It has already provided a guide to waste management systems in participating countries, which includes an overview

of energy recovery options using combustion systems. It now aims to provide up to date workshops on key topics influencing energy recovery from waste.

Participating countries: France, Germany, Italy, Norway, Sweden and the United Kingdom.

Task Leader: Dr Pat Howes, Ricardo-AEA, United Kingdom

Operating Agent: Dr Elizabeth McDonnell, Department of Energy and Climate Change, 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 the Task website www.ieabioenergyTask36.org and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Progress in R&D

Work Programme

Over the 2013-15 period the Task is holding a series of seminars and workshops in association with Task meetings on topics that are important to energy recovery from waste in each host country. The topics for these workshops cover:

- The interface between anaerobic digestion and energy from waste
- The use of solid recovered fuels derived from waste
- The management of energy from waste systems to optimise efficiency and recovery
- Barriers to energy from waste

In addition two topic reports are being produced on:

- Small-scale energy from waste systems
- Gasification/pyrolysis for waste treatment to produce energy and/or chemicals.

Workshop on the interface between anaerobic digestion (AD) and energy from waste (EfW)

This workshop was held in Stockholm on 8th May 2013. It examined the impact of separation of organic waste for AD and efficient energy recovery if AD is introduced. Presentations at the meeting showed that AD is an important and growing technology. There is evidence that source separation of organic waste followed by AD is energy and carbon efficient, but the use of nutrients in the residue is important to this finding. If the residue cannot be used and is burnt in EfW or buried in landfill this important advantage is lost. However, questions remain. Little work has been done on how recovery of organic residues from AD impacts the

composition of residual waste, particularly the renewable content of residual waste. Nor has research examined the differences source separation of organic waste might make to recovery of energy from the residues. A summary of the findings of the workshop and the presentations are available from the Task 36 website.

Workshop on solid recovered fuel (SRF)

A workshop was held in Milan on 20th November to examine the future for solid recovered fuels. It reported on the work that has been done to legislate to enable solid recovered fuels to be classed as a product, not a waste in Italy, and on the use of solid recovered fuels in Italy. The workshop showed that:

- It is difficult to achieve 'end of waste' for solid recovered fuels in Europe, but it is possible. The legislation introduced in Italy (Ministerial Decree 22/2013, art. 184-ter) is aimed at enhancing consumers' confidence and encouraging the production of high quality SRF, while avoiding unnecessary barriers. The intention is to reduce pollution, increase the sustainable use of biomass in waste and reduce the environmental and economic burden of landfill. The basic principles are that only some SRF types can achieve end of waste and only under specific conditions; and that the production of SRF must be in compliance with the waste hierarchy.
- Experience with using SRF: in Italy most SRF is burnt in incineration with energy recovery or in other combustion plants, including co-combustion in coal power plants and cement kilns. In Germany its use in industrial power plants is increasing and dominating the market for SRF.
- The potential for the SRF market is much higher than is currently being realised in Italy.
- There is a need to create a direct relationship between the producer and user of end of waste SRF.

The workshop also reported on the findings of the RECOMBIO project to examine the use of SRF in heat and power generation plants. A summary of the workshop and the presentations are available from the Task 36 website.

Other work completed in 2013

- Task 36 has worked on a report on the source separation of organic waste with Task 37. This report is in final draft, awaiting publication.
- Task 36 produced an article for the IEA Bioenergy Annual report
- Task 36 supported the workshop in South Africa on Waste to Energy, held in association with the IEA Bioenergy Executive Committee meeting in Cape Town.

Task Meetings and Workshops

The Task held two meetings in 2013. The first took place on 6th-8th May 2013 in Stockholm, Sweden. This meeting was held in association with the workshop described above. A study tour allowed the Task to visit 2 locations:

- Linköping: site visit to an optical sorting and AD plant
- Norrköping: site visit to a bioethanol plant which operates on heat from an energy from waste plant; and the Händelö fluidised bed energy from waste plant, which operates on SRF, some of which is imported from the UK.

The second Task meeting took place in Milan on 20th to 22nd of November in association with the SRF workshop described above. This meeting included a site visit to the ECOPROGETTO Veritas SRF production plant and the ENEL plant at Fusina that co-combusts the SRF produced with coal (at up to 5%) by energy content. A meeting note and note on the site visit is available on the Task 36 website.

Website

The website (www.ieabioenergyTask36.org) is the key tool used for dissemination of information from the Task. It provides access to the latest publications produced by the Task, including the presentations from the two workshops. The website also provides access to past reports, articles, case studies and presentations at workshops associated with Task meetings. In addition, it provides a 'members only' forum, to allow rapid access to the latest drafts of documents and to information on Task meetings. In 2013, there were around 47,400 separate visits over the year. The total number of pages viewed by both during this period was 883,000. Most visitors were interested in what the Task is about and the information included on the site, emphasising the importance of the website for information dissemination. Publication of information on workshops and events stimulates most interest.

Collaboration with Other Tasks

Collaboration with other Tasks has included the successful joint workshop with Task 37 to support the work on the source separation report and to investigate further synergies. In addition Task 36 contributed to the multi-Task 'health and safety' report co-ordinated by Task 32.

Deliverables

The deliverables for the Task in 2013 have included presentations for the two Workshops, presentations at the South African EfW workshop, contributions to the Health and Safety report and the Task 37 source Separation report as well as an article for the IEA Bioenergy Annual report. The Task also prepared two progress reports and an annual audit report for the Executive Committee.

TASK 37: Energy from Biogas

Overview of the Task

The main objective of the Task 37 work programme is to address the challenges related to the economic and environmental sustainability of biogas production and utilisation. While there are many biogas plants in OECD countries, operation in the vast majority of cases can only be sustained with the help of subsidies to be able to compete with the fossil energy industrial sector. There is a clear need to enhance many of the process steps in the biogas production chain in order to reduce both investment and operating costs.

Until recently the environmental performance of biogas production and utilisation was not assessed in a detailed manner and studies have started to highlight concerns about emissions of greenhouse gases at various stages of the biogas production chain. Task 37 started to address emissions in the 2010-2012 work programme and is now directing attention to environmental sustainability of biogas production and utilisation and establishing best practices for emissions reduction.

The Task's approach involves the review and exchange of information and promotion of best practices for all steps of the process chain for anaerobic digestion (AD) of biomass residues and energy crops for the production of biogas as a clean renewable fuel for use either directly in combined heat and power generation or after up-grading to biomethane where it replaces natural gas. The Task also addresses utilisation of the residues of the AD process, the digestate, and the quality management methods for conversion to high quality organic fertiliser. The scope of the work covers biogas production on the farm-scale, in waste water treatment plants, as well as for the treatment of the biodegradable fraction of municipal waste (biowaste).

Through the work of the Task, communication between RD&D programmes, relevant industrial sectors and governmental bodies is encouraged and stimulated. Continuous education is addressed through dissemination of the Task's publications in workshops, conferences and via the website. Information and data collected by the Task is used increasingly for providing support to all levels of policy making and the production of standards in Member Countries.

Participating countries: Austria, Brazil, Denmark, Finland, France, Germany, Ireland, Korea, the Netherlands, Norway, Sweden, Switzerland, United Kingdom and the European Commission

Task Leader: Dr David Baxter, European Commission, JRC Petten, the Netherlands

Operating Agent: Dr Kyriakos Maniatis, European Commission, Brussels, Belgium

The Task Leader directs and manages the work programme. National Team Leaders are responsible for coordinating the national participation in the Task and for coordinating specific topics in the work programme.

For further details on Task 37, please refer to Appendices 2, 4, 5 and 6; the Task website http://www.iea-biogas.net/ and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

Two Task meetings were held in 2013. The first meeting took place on 17th to 19th April in Bern, Switzerland. On 18th April, a technical workshop was held at the Swiss Federal Office of Energy on "biogas process optimisation". The workshop addressed three aspects, feedstock and process control, optimised digestion systems and biogas and digestate management. The workshop was attended by approximately 60 people, with roughly equal numbers from industry and research organisations, as well as local policy makers. Task 37 members visited the biomass centre at Spiez.

The second meeting took place on 13th to 15th November in Seoul, South Korea. On 14th November, a technical workshop was held in collaboration with local business and academic organisations and attended by about 50 people. The workshop, "biogas technologies" focussed on three key areas, anaerobic digestion of food waste, biogas up-grading and anaerobic digestion processes. The workshop was held at a time of intense development activity in Korea directed towards treatment of wastes. Task 37 members visited the massive Seoul municipal waste management site to see the various opportunities taken to integrate biogas production and recovery into municipal waste treatment operations.

Planning of Future Task Meetings and Workshops

Task meetings in 2014 will be held in Foz do Iguacu, Brazil (2nd-4th April) and in Angers, France in September/October (dates to be decided). Technical workshops are scheduled to be included in each meeting. The workshop in Brazil will be co-hosted by the newly formed mirror group for biogas in Brazil and South America, the "International Centre for Renewable Energy – CIBiogas".

Work Programme

In 2013 the work programme consisted of the following topics:

- Completion of technical brochures from the previous work programme and starting new reports
- Collaboration with other Tasks (main activities with Tasks 36 and 40)
- Reports to ExCo71 and ExCo72
- Completion and publication of a new 'biogas handbook'
- Website: updating; maintenance; proceedings, country reports, etc.
- Planning of future Task meetings and workshops

Some of the Task members participated in the 21st European Biomass Conference in Copenhagen at which biogas was a key focus. There has been close cooperation with the EU project VALORGAS and with the European Biogas Association (EBA).

The progress made on Task Topics is summarised below.

New Technical Brochures/Reports

The technical brochure on "Source Separation of Municipal Solid Waste: An overview of the source separation and separate collection of the digestible fraction of household waste, and of other similar wastes from municipalities, to be used as feedstock for anaerobic digestion in biogas plants", was the product of collaboration with Task 36. The report addresses methods for source separation of MSW in detail and approaches for setting up and implementing a municipal source separation plan, including best practices gained from experiences in IEA member countries. The methods are illustrated with practical examples of schemes running in Sweden, South Korea and the United Kingdom.

The first report in a new series of reports addressing biogas process optimisation was published. This first report was produced in the form of a Task 37 technical brochure entitled "Process Monitoring in Biogas Plants" and describes the physical and chemical, on-line and off-line monitoring techniques applied to commercially operated biogas plants. Best practices are described and guidelines provided for the benefit of users aiming to optimise process control and subsequently improve economic performance.

Biogas Handbook

The new 'Biogas Handbook: science, production and applications' was published in 2013. The book has nineteen chapters covering all steps in the production and utilisation of biogas, as well as plant design and engineering of equipment, market development for biomethane and certification of biomethane. Twelve of the nineteen chapters were authored by current or former Task members. The book was edited by two members of the Task and the IEA Bioenergy Technical Coordinator (the former leader of Task 37).

Website

The website (www.iea-biogas.net) is updated with news, biogas data and publications on a regular basis. The Country Reports as well as the Task publications and proceedings of the workshops were made available along with important publications from the participating countries.

Collaboration with Other Tasks

Task 37 collaborated closely with Task 36 on integration of energy recovery into solid waste management. This work included holding a joint workshop in Stockholm in May and publishing the technical brochure on "Source Separation of MSW: An overview of the source separation and separate collection of the digestible fraction of household waste, and of other similar wastes from municipalities, to be used as feedstock for anaerobic digestion in biogas plants".

The Task 32 led 'Health and Safety Aspects of Solid Biomass Storage, Transportation and Feeding' report, to which Tasks 36 and 37 made a joint contribution, was published in May 2013.

Task 37 started collaboration with Task 40 on biomethane trade. The Task was also involved in the planning of the strategic project led by Task 43, "Mobilising sustainable bioenergy supply chains".

Deliverables

The deliverables for the Task included: publication of technical reports and success stories, minutes of the Task meetings, progress reports to ExCo71 and ExCo72, Country Reports, two technical workshops in collaboration with national organisations followed by publication of presentations, and maintenance of the Task website.

TASK 38: Climate Change Effects of Biomass and Bioenergy Systems

Overview of the Task

The main drivers for bioenergy are the mitigation of global climate change, the increase in fossil fuel prices and the concerns about energy security. The reduction of greenhouse gas (GHG) emissions has become an issue of great international importance. Ever increasing evidence of climate change and its impacts, together with developments in emissions trading through international, regional, national, bilateral and multilateral agreements, have greatly augmented interest in reducing GHG emissions and enhancing carbon sequestration. There is a strong debate on the climate change effects of bioenergy systems and the appropriate role for bioenergy in climate policy.

The primary goal of *IEA Bioenergy Task 38 on Climate Change Effects of Biomass and Bioenergy Systems* is to promote the sustainable use of biomass and bioenergy through increased understanding of the climate change effects of biomass production and utilisation for energy. We devise and promote standard methodology for quantifying the climate change effects of forest carbon sequestration and bioenergy systems. Our objective is to support decision makers in government and industry, in the selection of climate change mitigation strategies.

Participating countries: Australia, Brazil, Finland, France, Germany, the Netherlands, Sweden and USA

Task Leader: Annette Cowie, University of New England/New South Wales

Operating Agent: Stephen Schuck, Bioenergy Australia, Australia

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 38, please refer to Appendices 2, 4, 5 and 6, the Task 38 website http://task38.org/ and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

1. *Business meeting: Rotterdam: 12th-13th March*
   a. The seven (at that time) participating countries were represented at the business meeting.
   b. Key discussion points:
      - updating NTLs on recent developments in each of the participating countries,
      - revising the work plan for the new triennium based on the changes in participation,
      - devising new working procedures for the Task as a result of the handover of task leadership to Australia, and
      - planning for the next meeting in Australia in late 2013.

2. *Web Business Meeting: 9th September*
   a. The nine (including two "new") participating countries were represented at the web meeting.
   b. Key discussion points:
      - Planning the Task 38 session at the Bioenergy Australia 2013 Conference;
      - Planning the next Expert Working Meeting in Sydney;
      - Status and future plans of the Timing Statement; and
      - Progress of papers in development.

3. *Workshop: Hunter Valley, NSW, 25th November*
   Special session in Bioenergy Australia conference – see details below

4. Business meeting and Expert meeting: Sydney: 28th-29h November

a. Seven of the nine participating countries were represented at the business/working meeting. Three experts from NZ also participated, to join the discussions on the papers in development, in which they make key contributions.

b. Key discussion points:

- Progress of papers in development: Metrics and choice of reference system for quantifying climate change effects
- Update of developments of relevance to T38 members
- Status and future plans for contribution to the inter-Task project on mobilising sustainable bioenergy supply chains.

The business meeting was scheduled to directly follow on from the Bioenergy Australia 2013 Conference, 25th-27th November.

Work Programme

In 2013 the Task:

- Coordinated and completed the statement on "On the Timing of Greenhouse Gas Mitigation Benefits of Forest-Based Bioenergy", in conjunction with Tasks 43 and 40, which was published by ExCo in July
- Organised two Task 38 business meetings (see above)
- Organised one expert working meeting on the theme of quantifying climate change effects of bioenergy (see above)
- Participated at ExCo71 in Cape Town and at ExCo72 in Korea
- Organised one session on *"Quantifying climate change effects of bioenergy systems"* at the Bioenergy Australia Conference in Hunter Valley, NSW (25th-27th November)
- Finalised case studies from the previous triennium
- Progressed the preparation of scientific papers:
  - Updating the Standard Methodology
  - Timing of emissions from bioenergy in LCA and GHG accounting. Metrics, associated uncertainties and discounting
  - Reference Systems for evaluating climate effects of bioenergy
- Contributed to the inter-Task Project: *"Mobilising sustainable bioenergy supply chains"*
- Established a new Task website

1. Case Studies

Several case studies were carried-over from the previous triennium. The following case studies have been successfully completed in 2013.

1. Environmental Assessment of Liquid Biofuel from Woody Biomass, (GE);
2. Greenhouse Gas and Oil Use Impacts of Fischer-Tropsch Diesel and DME Production Integrated with Pulp and Paper Mills, (SE);
3. EU Biofuel Targets, Costs and GHG Balance of the Finnish Energy Sector and Forests, (FI);
4. Impact on GHG balance of utilising biochar as a soil amendment (AUS); and
5. Alternatives to Use Sugarcane Residues to Reduce GHG Emissions, (BRA).

2. Scientific Papers

The following scientific papers are under preparation:

Updating the Standard Methodology
The standard methodology for calculation of GHG emissions for different bioenergy systems developed by Task 38 has to be up-dated as new issues emerge. The Task is currently working on a paper which will give information on how to integrate new topics such as the timing of forest based GHG emissions, land use change impacts and non-greenhouse gas effects (e.g. Albedo effect) and how to deal with e.g. harvested wood products.

Reference systems for evaluating climate effects of bioenergy
Stemming from the two expert meetings in 2012, this paper will discuss the importance of the reference system in evaluating the climate effects of bioenergy. It will develop the concept that policy makers have different needs (for example, implications of a policy or selection of a particular bioenergy technology within a policy) hence the reference system should be selected to meet these requirements.

Timing of emissions from bioenergy in LCA and GHG accounting: Metrics, associated uncertainties and discounting
Also stemming from the two expert meetings is a paper that will discuss the implications of different metrics and discounting in evaluating the climate impacts of bioenergy. We generally use greenhouse gas emissions (using GWP_{100} to combine impacts of different gases) as the indicator, but other indicators such as radiative forcing or global temperature potential could be used. These metrics include other climate forcing factors such as changes in surface albedo.

3. Inter-Task Projects

Monitoring Sustainability Certification of Bioenergy

Tasks 38, 40 and 43 collaborated in this project led by Task 40. Task 38 provided input to development of project plan, development design and dissemination of survey to stakeholders, and reviewed survey results, reviewed existing schemes and provided a visual summary highlighting the relationships amongst schemes, provided input to the abstract for the Vienna conference and several other conferences to gather input on the survey (see table)

Helena Chum, who represented Task 38 on the certification project, presented on the topic "Task Multi-stakeholder Development of Biofuel Schemes" at the IEA Bioenergy Workshop, a session within the World Biofuels Conference (*How can sustainability certification support bioenergy markets?*). She also participated in the round table discussion.

Mobilising sustainable bioenergy supply chains

Task 38 is collaborating in this large project led by Task 43. Task 38 representatives met with other Tasks in March (Netherlands) to progress scope and direction of the project in the implementation phase. Task 38 is contributing to three of the supply chain case studies.

4. Next Meeting

The next Task 38 Business Meeting will be held in conjunction with the Joint workshop planned for 19th-20th May, 2014 in Copenhagen, Denmark. It has been scheduled to precede the next ExCo meeting being held in Copenhagen on 20th-22nd May. The workshop is a joint initiative of Tasks 38, 40, 43 and the JRC, and will continue the discussions between experts on the topic of the climate change effects of forest-based energy. ExCo72 approved a contribution of $10,000 which will be utilised to fund the travel of invited experts from outside IEA Bioenergy.

Website/Communication

Task Website

A new website has been created (www.task38.org) and is now the repository of all current and/or relevant resources from the previous Joanneum site (which is expected to be soon discontinued as Austria is not a current Task 38 member).

Information on the new site includes:

- presentations from all previous Business Meetings and Workshops
- case studies (identified by both country and process)
- publications of Task 38

- journal publications of Task 38 members
- Guidance on methods for quantifying greenhouse gas balance of bioenergy systems
- FAQ page
- list and contact details of member countries and delegates.

Collaboration with Other Tasks

See the section above on inter-Task projects.

Within the inter-Task project "Mobilising sustainable bioenergy supply chains" (a collaboration of Tasks 43, 42, 40 and 38) Task 38 will demonstrate the utility of the updated standard methodology by assessing case studies from participating countries. Task 38 will also work with Tasks 34, 36 and 37, to review GHG assessment for fast pyrolysis processes, waste to energy and biogas applications.

Networking

5. Bioenergy Australia 2013 Conference: Hunter Valley, NSW, 25th-27th November

Task 38 led the Monday afternoon parallel session "Quantifying Climate Change Effects of Bioenergy" at the Bioenergy Australia 2013 Conference. Contributions in the session were:

- Annette Cowie (Australia): *Perspectives on the Timing of Benefits of Forest-Based Bioenergy*.
- Kati Koponen (Finland): *Reconsideration of the Land Use – Baseline May Have a Significant Impact on the GHG Balances of Agro-Bioenergy*.
- Sampo Soimakallio (Finland): *GHG Impact Dynamics of Bioenergy from Boreal Forests*.
- Helena Chum (USA): *Status of Global Regulatory LCA Use in the Implementation of Biofuels Programmes*.
- Leif Gustavsson (Sweden): *Climate Mitigation of Woody Biomass Systems*.
- Jan Ros (Netherlands): *GHG Balances for Biofuels from Wood*.
- Regis Leal (Brazil): *Land Use Change and Other Factors Affecting Climate Change Benefits of Sugarcane Ethanol in Brazil*.
- Ryan Bright (Norway): *Recent Insights in Assessment of Climate Forcing Associated with Bioenergy Systems.*

Deliverables

Apart from the wide range of deliverables mentioned above, the Task also produced progress reports and audited accounts for the ExCo and minutes of the Task meetings (Appendix 4). In addition, individual task members published scientific papers that were informed by interactions with task members and some of these outputs were formally reviewed by task members.

TASK 39: Commercialising Conventional and Advanced Liquid Biofuels from Biomass

Overview of the Task

The goal of Task 39 is to support the commercialisation of liquid biofuels from biomass, with a primary focus on conventional and advanced technologies, but with a mandate that includes 'next-generation' fuels (for example, algal and 'drop-in' biofuels). Through a coordinated focus on policy and technical aspects, the Task assists participants in their efforts to develop and deploy biofuels, including ethanol from lignocellulosics, Fischer-Tropsch fuels, and biomass-to-liquid (BTL) biosyndiesel (biodiesel made from synthesis gas), etc. It also continues to identify and facilitate opportunities for comparative technical assessment and support for policy development. The success of the Task has been, in large part, a direct result of providing a forum for these types of integrated discussions, with the active involvement of participants from industry, government and academia. The Task objectives are to:

- Catalyse cooperative research and development projects to help participants:
  - develop and commercialise improved, cost-effective bio-based processes for the generation of advanced biofuels, particularly biomass to biofuels;
  - work with other Tasks to develop and commercialise improved, cost-effective thermochemical-based processes, such as the Fischer-Tropsch process for converting syngas to synthetic biodiesel and other advanced biofuels; and
  - understand advancements in 'next-generation' liquid biofuel technologies, including biomass-to-hydrogen, algae-to-biofuel processes and the development of so-called 'drop-in' biofuels.
- Provide information and analyses on policy, markets and implementation issues (including regulatory and infrastructure development) that will help participants encourage commercialisation of liquid biofuels as a replacement for fossil-based biofuels, by continuing the deployment of conventional (so called first generation) biofuels and supporting development of advanced (so called 2nd generation) biofuels and (potentially) 'next-generation' biofuels.
- Provide information dissemination, outreach to stakeholders and coordinate with related groups both within IEA Bioenergy and externally.

The Task structure allows participants to work together in the broad area of liquid/transportation biofuels in a comprehensive manner.

Participating countries: Australia, Austria, Brazil, Canada, Denmark, Germany, Italy, Japan, South Korea, the Netherlands, New Zealand, Norway, South Africa, Sweden and USA

Task Leader: Dr Jim McMillan, NREL, USA

Co-Task Leader: Dr Jack Saddler, University of British Columbia, Canada

Operating Agent: Mr Ed Hogan, Natural Resources Canada, Canada

The Task leadership is shared between the National Renewable Energy Laboratory (USA) as represented by Jim McMillan and the University of British Columbia (Canada) as represented by Jack Saddler. Both Task Leaders are engaged in all aspects of the Task's operations. Sub-Task Leaders for Technology and Commercialisation include Michael Persson and Axel Munack. Sub-Task Leaders for Policy, Markets and Implementation include Manfred Wörgetter and Warren Mabee. The Task leadership is assisted by Drs Sergios Karatzos and Susan van Dyk (UBC), who act as Editors of the Task Newsletter and Webmasters. Dina Bacovsky (Austria) manages the demonstration plant database. Axel Munack has been acting as the liaison person with the Advanced Motor Fuels Implementing Agreement. A National Team Leader for each country is responsible for coordinating the national participation in the Task.

For further details on Task 39, please refer to Appendices 2, 4, 5 and 6; the Task website (www.Task39.org) and the IEA Bioenergy website (www.ieabioenergy.com) under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

Task 39 remains highly active in terms of both business meetings (which involve significant knowledge exchange between participants in the form of Country Reports) as well as special sessions hosted in conjunction with established biofuels events. In 2013, the Task held one business meeting (Stellenbosch, South Africa), as well as two informal Task meetings (Portland, Oregon, USA; Nanjing, China).

The business meeting took place in March 2013 in Stellenbosch, South Africa, in conjunction with the 20th International Symposium on Alcohol Fuels (ISAF). The Task organised a special session titled 'IEA Bioenergy Task 39' within the ISAF symposium. The business meeting took place immediately before the main ISAF conference and most of the member countries attended the meeting. The full day business meeting covered country updates on

the status of biofuels in the majority of Task 39 member countries and reviewed progress on the various completed and planned reports for the Task during the 2013-2015 triennium. Plans were also updated for upcoming workshops, symposia and meetings that the Task 39 network will organise or participate in during this new triennium. The 20th ISAF conference was attended by close to 200 participants from around the world and included two dedicated half-day sessions organised by IEA Bioenergy Task 39. Task 39 members presented a total of 10 talks at this meeting, including 4 plenary talks. Plenary speakers described RD&D progress in Africa (South Africa in particular), as well in Brazil, the US and Italy. South Africa is the world's biggest producer of oil derived from coal. The presentation from Sasol described the many challenges that had to be overcome to make their Fischer-Tropsch based technology a reality and, by analogy, provided many useful lessons to consider when trying to commercialise biomass derived biofuels.

The Task also organised a special session entitled "International Demonstrations and Commercialisation Updates" within the 35th Symposium on Biotechnology for Biofuels and Chemicals which was held in Portland, USA in May 2013 (http://sim.confex.com/sim/35th/webprogram/Session2441.html). This proved to be of immeasurable interest as the room was filled to over its 400 capacity. Participation from industry was excellent as leading biorefining and cellulosic ethanol companies (Borregaard, Catchlight, Chemtex, DuPont and Lignol) presented their updates describing some of the world's first commercial and demonstration facilities.

In response to an invitation from colleagues in China working in the biofuels area, an informal Task 39 meeting was organised in October, 2013 in Nanjing, China. This Chinese government sponsored conference was entitled, the "International Conference on Biomass Energy and Chemicals" and was meant to both profile much of the R&D being carried out on biofuels in China but also provide a forum to show representatives from the Chinese government, industry and academia about the benefits of being part of IEA Bioenergy. Several Task 39 members from Australia, Sweden, Denmark, Japan, Korea, USA and Canada presented at the conference and the government officials from the central government were encouraged to contact the Chair/Secretary of IEA Bioenergy to see if they might be invited as observers to the next IEA Bioenergy Executive Committee meeting. More details on the conference can be found at the following link (http://icbec2013.njfu.edu.cn/index.asp).

The excellent participation of most country team leaders at many of the Task 39 meetings would seem to confirm the value that the network plays in facilitating excellent information exchange.

Work Programme

The programme-of-work for the Task included the following elements:

Providing Information on Policy, Regulatory and Infrastructure Issues

The overall objective of this component of the Task is to provide governments and policy makers with information that will help them identify and eliminate non-technical barriers to liquid biofuels deployment.

The Task 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 the Task's role as a central source of relevant information on biofuels. The business meetings allocate time for country representatives to present updates on developments in their respective regions. However, this often leaves less time for 'brainstorming' and discussion. Future meetings will try to ensure that there is more time allocated to these aspects of networking to provide effective interaction. Country report presentations along with the meeting minutes and other presentations from the South Africa meeting are posted in the 'members only' section of the Task website.

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 primarily focused on the technical and economic aspects of biomass-to-biofuels. The Task continues to update the database on advanced biofuels facilities (coordinated by our Austrian colleagues). This database provides up-to-date information on over 100 companies which includes biochemical, thermochemical and hybrid conversion approaches to producing biofuels. However, it is proving increasingly difficult to obtain detailed and accurate information from many of the companies as the various processes approach commercialisation. This is expected to be an increasingly difficult problem as companies understandably want to protect their proprietary information.

Another study to which Task 39 has contributed is the IEA Bioenergy special inter-Task project entitled, "Mobilising Sustainable Bioenergy Supply Chains". This project is being led by Task 43 (Feedstocks). Task 39 has provided short high level overview write ups of three potential case studies to be considered for more detailed study. These cases are: 1) softwoods in northwest Canada (authored by Jack Saddler and Sergios Karatzos), wheat straw in Denmark (Henning Jorgensen), and corn stover in the United States (Jim McMillan). The potential benefits of integrating biochemical and thermochemical conversion approaches has been emphasised and encouraged in previous Task 39 business meetings, and the Task has also recommended that the project consider case studies on approaches using these types of hybrid or mixed conversion platform technologies.

Major Reports

Two major reports were completed during 2013 and are summarised below:

a) Advanced Biofuels – GHG Emissions and Energy Balances

Information is generally lacking on the energy and greenhouse gas (GHG) balances of biofuels production from lignocellulosic biomass or algal biomass feedstocks, including advanced "drop-in" hydrocarbon biofuels. This report applied the GHGenius LCA model to the best data available for a variety of leading process options using a 'cradle-to-grave'

LCA approach. Analyses were compared across feedstock types (woody, herbaceous), conversion technology routes (biochemical, thermochemical and hybrid) for different biofuels products (ethanol or diesel) and compared to reference fossil fuel baselines. Data was mainly derived from publically available company presentations and from the US national laboratory (NREL and PNNL) techno-economic analyses. The results indicated that, depending on the choice of finished fuel and feedstock, a variety of technology pathways can provide quite variable energy and GHG balances. The study also demonstrated how biofuels' LCAs are sensitive to production yield, but even more sensitive to the source of power (biomass or fossil) used for the process, as well as the value of any co-product electricity produced by the process. After review, the report was published in 2013.

b) The Potential and Challenges of Drop-in Biofuels

Conventional biofuels (formerly called "first generation" biofuels) such as sugar- and starch-derived ethanol and vegetable/seed oil-derived fatty acid methyl esters (FAME) have limited compatibility with the existing petroleum/oil refining infrastructure. Blend walls, storage instability and lower energy content are some of the disadvantages of these conventional biofuels (bioethanol/biodiesel) compared to petroleum fuels. In response to these shortcomings, coupled with recent advancements in microbe engineering and catalyst science, new longer chain alcohols and more 'petroleum-like' hydrocarbon biofuels are being developed. These so-called "drop-in" biofuels currently represent a major area of development/interest by many governments and are being actively pursued by many research labs and companies around the world. The report describes and classifies this new class of biofuels and provides an early stage assessment of the technical and commercial potential of a variety of "drop in" biofuels. This was done by examining leading technology platforms and company strategies as well as relevant market and policy trends. Technological issues or gaps that must be overcome to realise the "commercialisation potential" of various "drop-in" biofuels were assessed and described.

Newsletter

The Task has published three newsletters in 2013 (featuring the country reports of South Africa, Norway and Canada). The newsletters provide information about the Task activities and international events related to biofuels. The newsletter has an active distribution list of nearly 3,000 individuals worldwide and copies are routinely downloaded from the Task website.

Website

The Task continues to build on its already considerable influence on the international community working in the liquid biofuels area. The recently redesigned website (www.Task39.org) and the newsletter have had very positive reviews. The website is heavily visited/cited and has generated many enquires that are typically handled by the Task coordinators and webmaster, or referred to experts within the Task 39 network.

Collaboration with Other Tasks/Networking

The Task has on-going interactions with the other Tasks, IEAHQ, other Implementing Agreements and with external groups such as USDOE, the Global Bioenergy Partnership and the FAO. Task 39 also contributed 3 short inputs to the on-going inter-Task project on biomass feedstock supply chains.

Deliverables

The deliverables for the Task in 2013 included: organisation of several meetings throughout the year; two progress reports and audited accounts (as required by ExCo); development and maintenance of the Task 39 website; three newsletters and two technical reports on GHG emissions and Drop-in biofuels. The full library of Task reports, country specific reports, etc. are available through the Task website (www.Task39.org). These are detailed in Appendix 4.

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

Overview of the Task

In the first decade of the 21st century, a strong increase in the trade of both solid and liquid biofuels has been observed. Global biodiesel trade has increased from 30 PJ in 2000 to 572 PJ in 2009, while the fuel ethanol trade is estimated to have increased from 340 PJ in 2000 to 1,540 PJ in 2009[15]. The global solid biomass trade is estimated to have grown from roughly 10 PJ in 2000 to 300 PJ in 2010[16]. While the recent economic crisis may have reduced activity, it is likely that global bioenergy trade will further increase strongly until 2020. This will be driven by the renewable energy targets in the EU (as defined in the NREAPs[17]), and subsequent demand for both solid and liquid biomass, as well as increasing demand from East Asian countries – especially South Korea and Japan – driven by current renewable energy policies. More speculative additional drivers may be a search for alternatives to nuclear energy (after Fukushima), the upcoming development of the bio-based economy, and further increases in oil prices. Thus, there is increasing need to develop biomass

[15] Lamers, P., Hamelinck, C., Junginger, M., Faaij, A., (2011) International bioenergy trade – a review of past developments in the liquid biofuels market. Renewable and Sustainable Energy Reviews, 15 (2011) 2655-2676.

[16] Lamers, P., Junginger, M., Hamelinck, C, Faaij, A. Developments in international solid biofuel trade – an analysis of volumes, policies, and market Factors. Renewable and Sustainable Energy Reviews, 16 (2012) 3176-3199.

[17] National renewable energy action plans: Member States have notified their national renewable energy action plans to the EC by 30th June 2010. Member States set out the sectoral targets, the technology mix they expect to use, the trajectory they will follow and the measures and reforms they will undertake to overcome the barriers to developing renewable energy.

resources and exploit biomass production potentials in a sustainable way and to understand what this means in different settings. In some markets, prices of biomass resources and fuels are already rising, causing indirect effects on raw material prices, for example in the forest and food industries (e.g. sugar). Biomass markets are still immature and vulnerable, and this is particularly true for the demand side of the market. Many biomass markets, e.g. solid biofuels, rely on policy support and incentives.

It is important to develop both supply and demand for biomass and energy carriers derived from biomass, in a balanced way and to avoid distortions and instability that can threaten investments in biomass production, infrastructure and conversion capacity. Understanding how this is best organised and managed needs further investigation. International biomass markets have been mapped by the Task, but the analyses, statistics and modelling exercises undertaken so far still have limitations.

The core objective of the Task remains 'to support the development of a sustainable, international, bioenergy market, recognising the diversity in resources and biomass applications'. Developing a sustainable and stable, international, bioenergy market is a long-term process. The Task aims to provide a vital contribution to policy making decisions by market players, policy makers, international bodies and NGO's. It will do this by providing high quality information and analyses, and overviews of developments. It will also provide a link between different sectors and act as a clearing-house for information through targeted dissemination activities.

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

Participating countries: Austria, Belgium, Brazil, Denmark, Finland, Germany, Italy, the Netherlands, Norway, Sweden, United Kingdom and USA.

Task Leader (Scientific): Dr Martin Junginger, Copernicus Institute, Utrecht University, the Netherlands

Task Leader (Industry): Mr Peter-Paul Schouwenberg, RWE Essent, the Netherlands

Operating Agent: Ir Kees Kwant, NL Agency, the Netherlands

As of January 2013, Prof Dr André Faaij was succeeded by Dr Martin Junginger. Chun Sheng Goh (Utrecht University, the Netherlands) is assisting and logistically supporting the Task.

For further details on Task 40, please refer to Appendices 2, 4, 5 and 6; the Task website (www.bioenergytrade.org) and the IEA Bioenergy website (www.ieabioenergy.com) under 'Our Work: Tasks'.

Task Meetings and Workshops

The Task organised several workshops in 2013. The programme and presentations (and in some cases summaries) can be downloaded from the Task website: www.bioenergytrade.org

In March, the first workshop took place at the 8th Annual World Biofuels Markets (WBM) Conference in Rotterdam. During the workshop, the strategic study by IEA Bioenergy Tasks 40, 43 and 38 was presented and discussed. This study aimed to monitor the actual implementation process of sustainability certification of bioenergy and to obtain a view on how certification schemes are operating and impacting markets, taking into account the point of view of different stakeholder groups. Based on input from over 200 stakeholders, recommendations were made on how sustainability certification can work in bioenergy markets and in fact actually support further deployment. This event attracted 60-70 attendees from different capacities, including industry, government, academics and NGOs. During the workshop, the main findings were presented and discussed with the audience. The panel debate (roundtable) confirmed most of the conclusions. The interaction and communication between different capacities have further improved the understanding of the systems. The participants indicated that certification systems are not easy, but they have a clear purpose and the markets can work with them. Nevertheless it was agreed that there was still a lot to do to improve their functioning and various issues were still to be resolved. The project leader, Luc Pelkmans, made a closing remark that it was important to use the lessons beyond the energy sector and then also translate these to land use, agriculture, forestry and other biomass applications.

In October, a workshop "The Transatlantic Trade in Wood for Energy: A Dialogue on Sustainability Standards" was held in Savannah, GA, USA. The Savannah workshop explored the potential application of sustainability criteria being developed by European governments and industry within U.S. forests. Sponsors of the dialogue included the IEA Bioenergy Executive Committee and Tasks 40 and 43, Sustainable Forestry Initiative Inc. (SFI), Programme for the Endorsement of Forest Certification (PEFC), E.ON, Georgia Forestry Commission, Weyerhaeuser, MeadWestvaco Foundation and Plum Creek. Representatives of US pellet producers, European purchasers, US, Canadian, and European policy makers, and conservation organisations met over two days to analyse and debate complex sustainability issues. Participants toured industrial timberlands certified to SFI's Forest Management standard, a non-industrial family forest and the Georgia Biomass LLC pellet mill. The field tour showcased several tools to mitigate environmental risks along the biomass supply chain. A summary report from the workshop will be available in early 2014 and will identify opportunities for aligning U.S. forestry systems and European Union sustainability criteria. The project team will also use feedback gathered at the workshop to provide recommendations to SFI, which is currently undergoing a Standard revision process.

In November, a Task 40 technical workshop was held at the 3rd Annual Exporting Pellets Conference on 29th October 2013. The workshop was divided into two section. Section 1 covered safety issues of biomass from production, transportation and storage to handling at the furnace. The speakers included Harold Arnold, the chairman of USIPA, Mieke Vandewal from Control Union, Peter-Paul Schouwenberg from RWE Essent and Jonas Dahl from Danisch Technological Institute. Section 2 focused on torrefaction of biomass. The speakers included Jacob Jacobson from INL, Doris Thamer from Andritz, Jeese Dickerman from Zilkha and Michael Wild from Wild & Partner. The workshop attracted about 80 participants. The programmes, presentations and summaries are available on the Task website.

In addition to these workshops and meetings, Task 40 also held 1 to 2 day meetings in Rotterdam, the Netherlands in March; in Copenhagen, Denmark in June; and in Miami, USA in October to discuss current business, including the progress of several studies and the planning of the work programme for the new triennium.

Future Meetings and Workshops

The first meeting of Task 40 in 2014 is scheduled in January 2014 and will be held in Graz, Austria. It will be linked to a joint workshop with Task 32 and SECTOR on the topic of biomass torrefaction at the 4th Central European Biomass Conference. The following meetings are planned to be in Lappeenranta, Finland, and Brussels, Belgium.

Work Programme and Outputs

As outlined in the 2013-2015 work programme, the core objective of the Task is: 'to support the development of sustainable, international bioenergy markets and international trade, recognising the diversity in resources and biomass applications'. The proposed work programme consists of the following five topics:

1. Mobilisation of sustainable biomass resources for the international market across different regions in the world.
2. Analysis of the future market demand for biomass from the broader biobased economy perspective.
3. Sustainability and certification.
4. Support of business model development for biomass supply and value chains.
5. Assisting the development and deployment of advanced analysis tools to improve the understanding of potential future market developments, implications and impacts of policies.

In 2013, the Task produced a number of significant deliverables. These deliverables are mostly work carried out from the last triennium, but also closely related to the above mentioned topics. All reports are available for free download from the Task 40 website www.bioenergytrade.org.

Book: International Bioenergy Trade: History, status & outlook on securing sustainable bioenergy supply, demand and markets

The trade of global bioenergy commodities, such as ethanol, biodiesel and wood pellets has been growing exponentially in the past decade and has by 2013 reached true "commodity" volumes, i.e. tens of millions of tonnes traded each year and billions (both in US$/EUR) of annual turnover. IEA Bioenergy Task 40 was founded in 2004 and is now in its 4th triennium. For the past 9 years, Task 40 has monitored the developments in international bioenergy trade, including the organisation of about 20 workshops on trade-related topics, and the publication of over 100 studies, country reports, newsletters, etc. The amount of material produced over the years and insights gained, in how biomass markets and international trade of biomass and biofuels has developed, is impressive. Besides that, the group has produced overviews and insights; also a large amount of practical experience has been brought together in what works and what doesn't. Last but not least, based on all this, there are clear(er) views on how to proceed to build working sustainable international biomass markets in the future. This book compiles those lessons and insights into an easily accessible book publication. This deliverable is a compilation of Task 40 work in the past trienniums.

Monitoring Sustainability Certification of Bioenergy (Task 1): Examining Sustainability Certification of Bioenergy

This Task, in line with topic 3, focuses on initiatives which are having, or are expected to have, an important impact on the bioenergy market. Major initiatives are for example those approved by the EU, or national systems in countries with high bioenergy use or relatively high imports or exports of biomass and biofuels. The schemes mentioned in this report are among the best known, but many others exist. The comparisons presented are not intended to be comprehensive but rather provide illustrative examples of how existing schemes and initiatives have been and are being implemented. This should provide the reader with an overview and a clearer picture of how these schemes work, and how they are similar or different, and how they are interlinked. In addition, most of these systems have continuous improvement practices built in and evolve over time.

Monitoring Sustainability Certification of Bioenergy (Task 2): Survey on governance and certification of sustainable biomass and bioenergy

The objectives of this study closely linked to topic 3 are to: (1) Determine the views and operational experiences of people involved in all aspects of bioenergy production systems, such as producers, traders, end-users, certifying bodies and auditors; (2) Evaluate how all actors along the bioenergy supply chain are affected by bioenergy related governance mechanisms, including binding and voluntary standards, legislation, regulation, and certification schemes; (3) Evaluate options for improving the effectiveness and cost-efficiency of governance and certification systems for sustainable bioenergy deployment. This has been accomplished by developing a survey concerning three central themes: 1) existing governance and general sustainability challenges, 2) trade, markets and costs, and 3) challenges specific to voluntary

certification schemes. It was hypothesised that responses might depend on the respondents' backgrounds, such as the capacity in which they are involved in the bioenergy supply chain, their geographical location or experiences, or the certification scheme or initiative for which answers are provided. This report presents and discusses the results from the survey and gives preliminary suggestions on how to overcome major challenges identified by the respondents.

Monitoring Sustainability Certification of Bioenergy (Task 3): Impacts of sustainability certification on bioenergy markets and trade

The central question this Task investigates is: to what extent has the requirement (or the voluntary commitment) to meet sustainability criteria (proven by the use of certification schemes) been changing bioenergy markets and trade flows? In this study that is closely linked to topics 1 and 3, an analysis of global bioenergy trade flows was undertaken. Two categories of modern bioenergy were investigated: liquid biofuels used for transportation, and solid biofuels used for household heating and power generation. The latter group focused on wood pellets due to the relatively large scale of international wood pellet trade. This investigation was fraught with difficulty, largely due to strict confidentiality maintained by the private stakeholders. The proliferation of sustainability schemes complicates the analysis further. Due to these limitations, the Netherlands and the United Kingdom were selected for in-depth case studies rather than compiling data on entire global trade flows. These two countries are the forerunners in the development and implementation of sustainability certification and have quite detailed statistics on amounts and origins of imported biomass and biofuels. As both countries have been importing substantial amounts of solid biomass and liquid biofuels over the past decade with increasing sustainability requirements, these certified bioenergy trade flows can be used to analyse the potential impact of certification on bioenergy trade flows.

Monitoring Sustainability Certification of Bioenergy (Task 4): Recommendations for improvement of sustainability certified markets

With the myriad of international and national regulations, initiatives and agreements related to sustainable biomass, biofuel and bioenergy, it is difficult for industry and other stakeholders to see the best solutions to suit their sustainability policies. Certification has been deemed to be necessary and valuable, leading to a considerable rise in the number of schemes developed over the last decade and the acceptance of voluntary schemes to show compliance with legislation, cf. the EU RED approach. The main findings and knowledge gained through the project are summarised in this final Task. The conclusions are mainly derived from the responses to the survey developed and analysed in Task 2. Additionally, recommendations on how to move forward are proposed. This report falls under topic 3.

Low cost, Long Distance Biomass Supply Chains

This report focuses on long-distance biomass supply chains, including ground-based supply of raw biomass to densification plants and transportation of densified biomass to ports in other continents. In line with topics 1, 2 and 4, it aims to: (i) provide an overview of the

characteristics of three densified biomass forms; solid wood pellets, solid torrefied wood and liquid pyrolysis oil; (ii) outline existing and future markets and specific supply chains for these products and explore large sources of biomass worldwide; some well-established and already being developed either for local use or trade, some only identified as possible future potential sources; (iii) highlight the importance of the costs of logistics in biomass supply chains; (iv) illustrate current cost structures of existing long-distance biomass supply chains, and (v) explore how the cost of current and future long-distance supply chains of wood pellets, torrefied pellets and pyrolysis oil could be lowered, and what this would require from the stakeholders involved.

Future Perspectives of International Bioenergy Trade

This study, related to A and 5, aims to provide insights into "possible futures" of bioenergy trade and to discuss implications and challenges related to different developments. The sub-objectives of this study are:

- Investigate to which extent various global energy models and scenarios take into account bioenergy trade,
- Identify the implications of different global bioenergy scenarios on bioenergy trade,
- Summarise the range of results into 3-5 storylines of future international bioenergy trade.

The insight into future scenarios and perspectives of bioenergy trade revealed that substantial challenges for the future development of global and international bioenergy trade may be expected in the coming decades, if a low carbon energy system is to be developed. The theoretical and technical biomass potentials in many models are often quite optimistic and sustainable biomass potentials are only included to a limited extent, as these are often hard to quantify and are also not the main aim of the models. It remains to be seen how global, stringent mandatory sustainability requirements (e.g. on water use, biodiversity, forest carbon accounting and iLUC) would limit the production, trade and use of feedstocks in the first place, but also how practical certification of biomass would affect bioenergy trade.

Large Industrial Users of Energy Biomass

The objective of the study is to obtain a global overview of the biomass use in industrial and transport sectors and to compose lists of the largest users of energy biomass in the world. Various statistics, databases, reports and reviews, most of them publicly available, have been utilised during the study to examine plants that either refine biomass for use in transportation and heating purposes or plants that convert biomass into heat and power. The plant lists presented are based on the prevailing situation at the end of the year 2012; due to a lack of comprehensive and accurate plant-specific information and the rapidly changing situation, the results should be used with care. This study is relevant to topic 2.

Workshops

In addition to written deliverables, workshops are linked to the work programme objectives as follows:

- The workshop in Rotterdam related to topic 3, as it focused on monitoring sustainability certifications of biomass and bioenergy.
- The joint workshop in Savannah had a large sustainability aspect, was related to mobilising biomass from the US to the EU (topics 1 and 3), and was covering the topics a better understanding of on-the-ground practices, how science can inform and support policy-making, and how levels of governance from the local to the global level can interact.
- The workshop in Miami basically covered topics 2 and 4, providing opportunities for communication among market actors across Europe and the US.

On-going and New Topics (2013-2014)

- Within IEA Bioenergy, an inter-Task Strategic Project *"Sustainability of certified solid wood bioenergy feedstock supply chains: Ecological, operational and international policy perspectives"* is being performed to provide background information on the operational and scientific aspects of sustainability criteria for solid woody bioenergy feedstocks. The information is intended for policymakers and other stakeholders for the development and possible extensions of the EU RED, certification systems and national sustainability schemes. Furthermore, this is also seen as a possible input into the GBEP. This project involves Tasks 40 and 43.
- Also within IEA Bioenergy, another inter-Task project "Mobilising sustainable bioenergy supply chains" is being carried out. This project involves Tasks 38, 39, 40, 42 and 43. The purpose of this project is to identify sustainable biomass systems and promote their implementation through a series of case studies. Utilising the expertise from across the Tasks and focusing on issues specific to bioenergy, the case studies will highlight successful systems and challenges requiring further consideration.
- Task 40 is conducting a joint study with Task 37 on *"Biomethane"*. This study investigates technical background, requirements for biomethane grid injection, expectations of future development and stepping stones towards market deployment for biomethane.
- A study is being carried out on *"Impact of promotion mechanisms for advanced biofuels on biomass markets"*. While technologically challenging lignocellulosic ('2nd generation') biofuels are developing slower than expected, markets have so far focused on using waste and residues in more conventional biofuel technologies to take advantage of these extra incentives. In this study some typical cases are presented where promotion mechanisms for advanced biofuels have had an impact or may be anticipated to impact markets in the future.
- In line with topic 2 in the work programme, a project on *"Logistics and bio-based economy"* is also planned. The work program for topic 2 covers a study on biomass trade for biorefining (primarily fuels) and biochemicals (including cooperation with

Task 42). The ultimate aim will be to integrate the above into a larger picture of the implications of the developing Biobased economy for biomass supplies and trade at the international level.

- A new project on *"Torrefaction"* has been kick-started. It aims to build a live technology database with new updates and the latest market information. The project will also include a workshop in Graz organised jointly with Task 32 and IBTC.

Website

The Task website is a key tool for dissemination of information. In 2013, the number of hits has reached more than 540,000 up to November (expecting 600,000 for the whole year). Meanwhile, the number of visits varied between 7000-10,000 per month (figures for January to September), on average higher than in 2012. The number of visits reached its peaks in January 2013 at 10,000, due to the publication of a number of new reports. Since 2007, visitor numbers have been relatively stable, with a five year average of 6,200 visits per month. However, the amount of monthly downloaded data has been continuously increasing over the past 9 years, from 19 GB/month in 2012 to 27 GB/month on average from January to August 2013. As in previous years, every month at least 10 documents are downloaded over 1,000 times, with hits on one of the reports (Global wood pellet study) at more than 40,000 views between December 2011 and September 2013 (still recording an average of 3,000 views per month in 2013). Annually 2-3 Task 40 newsletters were circulated to about 1,400 subscribers. All Task deliverables (e.g., country reports, market studies, etc.) and presentations given at the Task workshops are available for downloading.

Collaboration with Other Tasks/Networking

As described above, events were organised jointly with Tasks 38 and 43. At these events, the work of the Task was disseminated via presentations. The Task's work was also presented to a large number of other audiences during 2013, such as the workshops (jointly) organised by Task 40 with many other parties like World Biofuel Market conference in Rotterdam, Pinchot Institute in Savannah and USIPA in Miami. Task 40 will also continue this effort in 2014, collaborating with Task 32 and SECTOR to organise a workshop on torrefaction of biomass in Graz, Austria, in January 2014. In terms of studies, Task 40 has conducted a number of studies in cooperation with other tasks, such as Tasks 37, 38, 39, 42 and 43. The Task will continue this outreach and collaboration in 2014.

IEA Bioenergy Task 40 Foundation

Task 40 set up a foundation in August 2013. The financial administration was transferred from Essent NV to this Foundation. The transfer document has been approved by IEA Bioenergy. The foundation was launched after the Rotterdam meeting. Peter-Paul Schouwenberg, Martin Junginger and Bo Hektor are the board members.

Deliverables

Deliverables in 2013 included 3 workshops, various types of reports, several market studies, 1 newsletter (circulation of 1400), minutes from three Task meetings, two progress reports, 1 triennium report and audited accounts to the ExCo; plus several presentations at various international workshops and conferences. These are detailed in Appendix 4.

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, economic, and environmental data in its work. The Task's activities build upon existing data, information sources, and conclusions. It does not intend to produce new primary scientific data.

The Task differs from the other Tasks in that it does not have networking as one of its prime objectives, nor do the Task's activities have continuous and repeating components, e.g., biannual meetings, country updates, etc. The work programme has a pronounced project emphasis with each project having very specific and closely defined objectives. Because of its special character in terms of participation, financing and cross-cutting orientation, the Task aims to become a valuable resource and instrument to the ExCo serving the ExCo with highly qualified resources to carry out projects, involving several parties (e.g., other Tasks and organisations) as requested by the ExCo. Due to the close contact with the other Tasks, Task 41 is intended to develop into a platform for joint Task work and a catalyst for proposals from the Tasks to the ExCo.

A project leader directs and manages the work of each project. For new projects an appropriate project leader is appointed by the project participants acting through the Executive Committee. 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, 4 and 5; and the IEA Bioenergy website www.ieabioenergy.com under 'our Work: Tasks'.

Work Programme

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 outputs. Four projects have been initiated to date and three have been completed. Details are:

Project 1: Bioenergy – Competition and Synergies

Participating countries: Germany, Sweden, United Kingdom, USA and the European Commission

Project Leader: Mr Sven-Olov Ericson, Ministry for Sustainable Development, Sweden

Operating Agent: Dr Björn Telenius, Ministry of Enterprise, Energy and Communications, Sweden

Status: Completed in December 2008

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

Participating countries: Finland, the Netherlands, Sweden, United Kingdom, USA and the European Commission

Project Leader: Dr Michael Ladisch, Purdue University, USA

Operating Agent: Mr Paul Grabowski, US Department of Energy, USA

Status: Completed in July 2008

Project 3: Joint project with the Advanced Motor Fuels Implementing Agreement, Annex XXXVII 'Fuel and Technology Alternatives for Buses: Overall Energy Efficiency and Emission Performance'

Participating countries: Finland, Germany and the European Commission

Project Leader: Professor Kai Sipilä, VTT, Finland

Operating Agent: Professor Kai Sipilä, VTT, Finland

Status: Completed in September 2012

Project 4: Joint project with the Advanced Motor Fuels Implementing Agreement, Annex XXXIX 'Enhanced Emission Performance and Fuel Efficiency for Heavy Duty Methane Engines'

Participating countries: European Commission and Norway

Project Leader: Dr Kyriakos Maniatis, European Commission, Belgium

Operating Agent: Professor Kai Sipilä, VTT, Finland

Status: Ongoing with completion expected in 2014.

Phase 1 of the project consisted of a literature survey, which has been completed. A final report can be downloaded from http://www.iea-amf.org/content/projects/annexes/39

Phase two is evaluating emission and engine performance from state-of-the-art methane fuelled heavy duty engines, either dedicated gas engines or diesel engines fuelled with a combination of methane (in various forms) and diesel. These concepts are called diesel-dual fuel or methane-diesel. Results to date based on measurements in Sweden can be summarised as follows:

- Diesel Dual Fuel Concepts (DDF, Methane-diesel)
  - Difficult to meet Euro V/VI emission standards for CH4
  - Diesel replacement dependent upon load conditions
  - Not suitable for low load, start/stop driving
  - In best cases GWP not more than with diesel fuel (unless biogas is used)
- Dedicated Gas Engines (SI)
  - No problem with Euro V/EEV technologies
  - Engine efficiency lower (than diesel) especially for lean-mix
  - Lean-mix concept operating mostly on $\lambda 1$

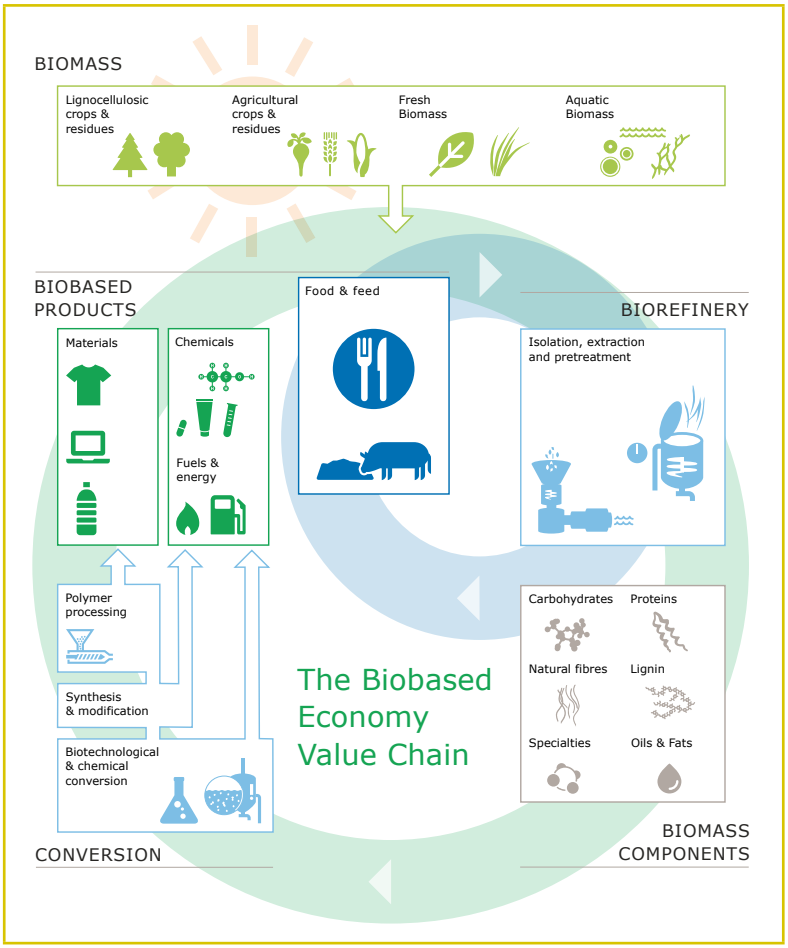
Deliverables

The deliverables may consist of progress reports and financial accounts to the ExCo, and a final report on each project – see details in Appendix 4.

TASK 42: Biorefining: Sustainable Processing of Biomass into a Spectrum of Marketable Bio-Based Products and Bioenergy

Overview of the Task

In a future bio-economy sustainable production and valorisation of biomass to both food and non-food applications will be the framework of operation. Sustainably produced biomass (crops, algae, residues) has to be used as efficiently as possible – using bio-cascading and biorefining approaches – to meet future demands of food, feed, bio-based products (chemicals, materials) and bioenergy (fuels, power, heat).



Biorefineries are already being applied for some considerable time in for example the food industry. Large-scale implementation of biorefineries for non-food (incl. bioenergy) applications, however, is still lacking. The major reasons for this are that: some of the key technologies (fractionation and product separation), which are part of integrated biorefinery plants, are still not mature enough for commercial market implementation; there is still no level-playing-field for sustainable biomass use for food and non-food applications; market sectors that should co-operate (food, feed, agro, chemistry, energy, fuels, logistics, ...) for the development and commercialisation of fully sustainable biomass value chains, including highly-efficient biorefinery processes, are often still not working together, and there is still a lack of knowledge/expertise on the advantages of biorefinery processes for optimal sustainable biomass use at both industrial, SME and (regional) governmental level.

The aim of the Task is to contribute to the development and implementation of sustainable biorefineries – as part of highly efficient, zero waste value chains – synergistically producing bio-based food and non-food products as a base for a global bioeconomy.

Challenges to be Tackled

- Develop industry legitimacy and a level-playing field for sustainable biomass use
- Multi-sectorial stakeholder involvement in the deployment of sustainable value chains
- Technology development and biorefinery scale-up using best practices
- Unlock available expertise energy/fuel, agri/food, material and chemical manufacturing sectors
- Develop the necessary human capital by training students and other stakeholders to become the biorefinery experts of tomorrow

The Task commenced in January 2007.

Participating countries: Australia, Austria, Canada, Denmark, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand and the USA.

Task Leader: Drs Ing René van Ree, Wageningen UR – Food and Bio-based Research, the Netherlands

Assistant Task Leader: Dr Ed de Jong, Avantium Technologies BV, the Netherlands

Operating Agent: Ir Kees Kwant, NL Agency, 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 42, please refer to Appendices 2, 4, 5 and 6; the Task website www.IEA-Bioenergy.Task42-Biorefineries.com and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

The 13th Task 42 meeting took place on Thursday 11th April 2013 in Wageningen, the Netherlands. The meeting was coupled with the International Biomass for Food, Fuels & Materials Symposium that was organised from 8th-10th April 2013 at the same place. Task 42 partners were invited by the Task to participate in this conference and the related

excursion programme to the Algae pilot-plant facility in Wageningen (AlgaePARC) and the Biorefining Piloting Area and facilities (Acrres) in Lelystad both owned by Wageningen UR. During the Task meeting the 2013-2015 activities were further specified, responsible partners to coordinate the different activities were appointed and the dates and places of the next Task meetings were settled for as far forward as possible.

The 14th Task 42 Progress Meeting was organised from 23rd-25th October 2014 in Graz, Austria. This Task 42 Progress Meeting was coupled with an Austrian stakeholder meeting on Thursday 24th October in which Task 42 presented 5 lectures (AT, NL, GER, DEN, IT) and chaired the whole day. Both the programme, attendees, conclusions and copies of the ppts of the lectures given can be found at: http://ress400.joanneum.at/IEFDownloads/Files/The%20Role%20of%20Biorefining_presentations.zip

For the next Task 42 Progress Meetings the following locations and dates have been selected:

- 15th Task 42 Progress Meeting: 22nd-23rd January 2014, Berlin, Germany; including a joint Task 42/Task 39 workshop; coupled with the International Conference Fuels-of-the-Future 20th-21st January 2014.
- 16th Task 42 Progress Meeting: Friday 27th June 2014, Hamburg, Germany; coupled with the 22nd European Biomass Conference and Exhibition (EU BC&E 2014) 23rd-26th June 2014.
- 17th Task 42 Progress Meeting: 4th-5th December 2014, Toronto, Canada; including excursions; coupled with the Canadian Bioeconomy Summit 1st-3rd December 2014.
- 18th Task 42 Progress Meeting: 2nd quarter 2015. Location: Italy.
- 19th Task 42 Progress Meeting": 4th quarter 2015. Coupled to the end-of-triennium IEA Bioenergy Conference in Berlin Germany.

All presentations given at the Task meetings can be found on the Task website.

Work Programme

The 2013-2015 work programme of the Task is based on a prioritisation of activities agreed upon by the participating countries and is as follows:

1. Assessment of the market deployment potential of integrated biorefineries

- Technical and non-technical critical success factors
- Disruptive/game changing technologies
- Centralised vs. decentralised processing
- Biorefinery-Complexity-Index (BCI)

2. Support of industrial/SME stakeholders finding their position in a future BioEconomy

- Role involved market sectors in the transition to a bioeconomy
- Upgrading strategies for existing industrial infrastructures
- Factsheets on major biorefineries/national case studies
- Updating of bio-chemicals report

3. Analysis of optimal sustainable biomass valorisation using the market-pull perspective approach

- Sustainability assessment toolbox
- Mobilising sustainable bioenergy supply chains
- Future market demand for biomass from a bioeconomy perspective
- Optimal sustainable biomass valorisation

4. Preparation of advice for policy makers on current status, future potential and priority needs

- Biorefinery roadmap
- Biorefinery (related) policies in participating countries
- Country reporting

5. Biorefinery knowledge dissemination

- Bi-annual task and stakeholder meetings, incl. excursions
- Annual task meetings at national level
- Task website (public internet and closed members area)
- Task newsletters
- Glossy task brochure, poster, leaflet
- International workshops and conferences

6. Delivery of biorefinery training activities

- Annual training school on biorefining

The progress achieved is described below.

1. Assessment of the market deployment potential of integrated biorefineries

In 2013 a first specification of the work plan concerning the assessment of the technical and non-technical critical success factors has been prepared by the U.S. In spite of the fact that there are already operating commercial examples available, large scale implementation of highly-efficient integrated biorefinery facilities is still lacking. This is caused by a variety of non-technical (policies/regulations, level-playing-field, full chain stakeholder involvement, ...) and technical barriers. An assessment is made of the major critical success factors existing and on the way these are handled in the participating countries. By learning from each other and by consulting experts within the different areas concerned, market deployment trajectories can potentially be shortened. The results of this activity, including contributions of all country representatives, will be reported in 2014.

In 2013 a first specification of the work plan concerning the assessment of disruptive/game changing technologies has been prepared by the Netherlands. A web and literature assessment has been made of potential game changing technology developments in both the participating countries and beyond, that potentially will make it possible to significantly improve the overall sustainable processing of biomass for food and non-food applications. Issues that have been identified are: type of technology, state-of-the-art, stakeholder(s) involved. The goal of identifying these new technologies and disseminating knowledge on them, is to accelerate their joint development, shortening the time-to-market of highly-efficient sustainable value chains incorporating these technologies. The results of this activity, including contributions of all country representatives, will be reported in 2014.

In 2012 a start was made with the development of a Biorefinery Complexity Index (BCI), with the main goal to give an indication on the complexity of a biorefinery facility, i.e. on the time-to-market, the number of stakeholders to be involved, the initial investment and final operational costs. A high BCI has the disadvantage that the initial investment costs will be high and that a variety of stakeholders will be involved, potentially increasing the time-to-market. However, the advantages are that when an implementation decision is taken, it will be clearly possible to co-produce significant amounts of bio-based products and bioenergy in a profitable way. The BCI was further developed in 2013 at a low-profile level with a few countries (AT, NL, ...) involved. Because of a lack of consensus in the Task on the added-value or potential disadvantages of this BCI-methodology on biorefinery market deployment at the 14th Task Progress Meeting in Graz (23-25/10/13) – for the time being – it was decided to stop the further development of the BCI and focus the efforts on other Task activities that have more internal Task support.

2. Support of industrial/SME stakeholders finding their position in a future bioeconomy

In 2013 a first set-up of the work plans concerning the analysis of a) the role of involved market sectors in the transition to a bioeconomy and b) potential upgrading strategies of existing industrial infrastructures to highly-efficient biorefinery facilities has been prepared by respectively the Danish and Austrian task representatives. A stakeholder workshop will

be organised in mid-2014 to present the draft results and to further incorporate specific market and stakeholder data in the assessment work. The results of both activities, including contributions of all country representatives, will be reported in 2014.

In 2013 a start was made with the set-up of factsheets of major operating biorefinery facilities ('success stories'). The goal of this factsheet set-up is to present major biorefineries and national case studies in a clear and similar way for dissemination of best-practices to stakeholders active in the bioeconomy to accelerate the market deployment. Joanneum Research (AT) – with the contribution of the other Task partners – has developed a generic set-up of a 3-page factsheet to present the main data of major biorefineries and national case studies. Data that are included in the factsheet are: Part A (generic) – classification (naming) biorefinery, description biorefinery, block scheme and/or photo biorefinery, mass balance and revenues biorefinery; Part B (country and site specific) – sustainability assessment biorefinery, including cumulated energy demand [PJ/a], cumulated greenhouse gas emissions [kt CO_2-eq/a], and cumulated costs/revenues [MEuros/a]; Annex – method and data sustainability assessment and main assumptions and modelling choices.

In 2014 several factsheets will be produced, that will be put on the Task 42 website for dissemination purposes. Both biofuel and pyrolysis based biorefineries will be included in the factsheets, where data will be provided by Tasks 39 and 34 respectively.

In 2013 a start was made with the set-up of a report on "Proteins for Food, Feed and Bio-based Applications". The main goal of this report is to give stakeholders of the bioeconomy a better insight in a) the potential economic optimisation of biofuel production processes by giving higher added-value to the protein fraction of the biomass sources used (bio transportation fuel sector), and b) the refinery options to synergistically and sustainably process protein-rich biomass sources to food/feed ingredients, bio-based products for non-food technical applications, and energy (fuels, power and/or heat). This report will be finalised in 2014 and will give an overview of the potential financial added-value of upstream separation of proteins and protein fractions from raw materials prior to downstream processing of these materials to bio-based products and/or bioenergy/biofuels.

3. Analysis of optimal sustainable biomass valorisation using the market-pull perspective approach

In 2013 Canada developed the so called LEEAFF indicators for the sustainability assessment of integrated biorefineries.

A strategically funded inter-Task project – coordinated by Task 43 – was started at the end of 2012. This project was organised around 5 case studies, viz.:

1. Agricultural residues for bioenergy and biorefineries
2. Mobilising temperate and boreal forest supply chains
3. Integration of lignocellulosic crops into agricultural landscapes
4. Regional biogas production
5. Cultivating pastures and grasslands

From a Task 42 point-of-view this project should consider both the assessment of conventional reference supply – valorisation chains (bioethanol, biogas, ...) and more advanced and optimised refinery chains in which chain and process residues are valorised to added-value bio-based products to improve overall economics. Task 42 contributes to this project by bringing its specific biorefinery knowledge and assisting in the sustainability assessments, specifically in case studies 1 and 4; in addition, Task 42 potentially will bring in their factsheet set-up for dissemination of the assessment results of all cases.

In 2013 a joint project activity of Task 40 and Task 42 was started. Within this project the potential international supply, trade and demand for biomass for energy and fuel applications within a competing bioeconomy market is assessed, including the identification of improved and new value chains. Task 42 contributes to this project by providing information on: which types of biorefineries are expected to be implemented as a function of time, which feedstocks they will use, and where they will be located. Task 42 will also give input concerning the specification of bio-based commodities and potential biomass trade chains (UCR-NL and COL-NL). Task 40 will provide complementary analysis in which the possible feedstock supply in terms of available quantities, countries of origins, types of supply chains, and feedstock cost levels at the biorefinery gate will be investigated. In 2014 a workshop will be organised to incorporate real market data in the project analysis, to present preliminary results, and to obtain feedback from stakeholders from within the Tasks' participating countries.

4. Preparation of advice for policy makers on current status, future potential and priority needs

In contrast to what was expected earlier, IEA Headquarters is not setting-up a Project (Roadmap) on Sustainable Biomass Valorisation by the Biorefining Approach. Therefore, Task 42 will not be participating in such an initiative and therefore this activity has been deleted from the 2013 work programme.

In 2013 a Power-point format for country reporting concerning the status and developments of biorefineries and biorefinery-related policy issues was prepared by the Netherlands. These country reports, including: country specific energy consumption, biomass use for energy and non-energetic applications, biomass related (national) policy issues, biomass related sustainability aspects, operating commercial biorefineries, biorefinery demonstration

and pilot plants, major R&D projects, and major national stakeholders involved in the field of biorefining will be prepared once for all participating countries, and updated during the 2013-2015 period. (Updated) Country reports will be available at the Task website.

5. Biorefinery knowledge dissemination

In 2013 two bi-annual Task 42 meetings were organised. The first one took place in Wageningen (the Netherlands) on 11th April 2013. The meeting was coupled with the International Biomass for Food, Fuels & Materials Symposium that was organised from 8th-10th April 2013 at the same location. The second one took place from 23rd-25th October 2014 in Graz, Austria. This meeting was coupled with an Austrian stakeholder meeting.

In the Netherlands – on 7th February 2013, AgentschapNL organised the "Praktijkdag Bio-energie" in the Amsterdam ArenA. At this event, an IEA Bioenergy information stand was organised, with the goal to disseminate IEA Bioenergy information in general, with a focus on information produced by the Tasks in which the Netherlands is participating, to interested Dutch stakeholders. With a few hundred participants this event was very successful and also the dissemination of IEA Bioenergy results to this large audience was facilitated. A similar event took place on the 22nd of November 2013 in Utrecht, the Netherlands. In Canada – a biorefinery page has been established on a Canadian federal government website accessible only through a government network connected computer. This page contains information on Task 42 meetings and project activities, including the inter-Task project: *Mobilising sustainable bioenergy supply chains*. IEA Bioenergy Task 42 updates are also given at the meetings of the Federal-Provincial-Territorial Bio-products Working Group (an inter-governmental forum on the bioeconomy).

No Task newsletters were produced so far. At the Task meeting in Graz it was decided to produce a newsletter in the month following the (bi-annual) Task 42 Progress Meetings. The newsletter will contain biorefinery news from partnering countries (presented at the roundtable Task Progress meeting), such as: new commercial/demonstration/pilot plants, new projects, new regional initiatives, policy issues, new publications and biorefinery related events from the international calendar.

An updated Task 42 poster/leaflet was prepared in the first quarter of 2013. A first set-up of a draft glossy Task 42 brochure (about 60 pages) was made in 2013. This brochure will be finalised in the first quarter of 2014 and will have the following content: biorefining: current status and future challenges; biorefining: country specific challenges; vision and contribution of IEA Bioenergy Task 42; biorefining: definition, classification and factsheets; sustainability issues of biofuel-driven biorefineries; value-added products from biorefineries: food and feed ingredients, chemicals and materials, energy and fuels; training activities; website; commercial, demonstration and pilot plants in participating countries; activity plan 2013-2015; annex: table with full overview of biorefinery plants in participating countries.

6. Delivery of biorefinery training activities

In 2013 no training activities were carried out. The 3rd European Biorefining Training School will be organised from 7th-10th July 2014 in Budapest, Hungary. This training course, including lectures, site visits and in-depth training modules for (PhD) students is organised within the European Climate-KIC Programme. Task 42 contributes to this course by providing 3 lectures. More information on: http://klimainnovacio.hu/biorefineryschool

Task Website

At the Task 42 Progress Meeting in Wageningen in April 2013 it was decided to set-up a new website for Task 42. The main reasons to do so were: the site was outdated containing mainly information of the older trienniums, it was very difficult to find the relevant info, and it was difficult to keep the site up-to-date. A new less complicated and more easy to use website has been set-up with the following content: horizontal navigation: partners, links, publications, country reports, factsheets (classification); vertical navigation: 2013-2015 activities (6); central on the site: news, calendar, recent publications; password protected intranet-site for document sharing. The web manager will further actively contact all partners regularly to provide website information, to keep it as up-to-date as possible. The new website went live on the 1st of December 2013. The address has remained the same: www.iea-bioenergy.task42-biorefineries.com

Collaboration with Other Tasks/Networking

In 2013 co-operation was established with international activities, such as: other Tasks, European-based Technology Platforms, International Council of Chemical Association (ICCA), Specific Support Actions, and EC FP7 Integrated Projects. This co-operation will be enhanced in this triennium by organising joint events, e.g. workshops and meeting regularly with on-going EU-initiatives.

Deliverables

Deliverables in 2013 included: organising and reporting of two Task Progress Meetings coupled to a related Dutch conference and an Austrian industrial stakeholder meeting; reporting to the ExCo (two progress reports, audited accounts and a contribution to the Annual Report); set-up of a new Task website and further specification of the activities of the 2013-2015 work programme. Most results will be reported in 2014 and 2015.

TASK 43: Biomass Feedstocks for Energy Markets

Overview of the Task

Work in the current triennium is based on the premise that in many countries biomass demand for energy will enter a period of expansion as a way to ensure sustainable and secure energy sources. Feedstocks from many land uses and cropping systems (e.g. agriculture, forestry, dedicated energy crops) can become a plausible energy source if production systems are economically and environmentally attractive. New science, tools and technology must be developed to support this era of rapid expansion. Such developments will ensure that suitable production systems are established and can be relied on to help achieve the energy policy targets in many countries.

The objective of the Task is to promote sound bioenergy development that is driven by well-informed decisions in business, governments and elsewhere. This will be achieved by providing relevant actors with timely and topical analyses, syntheses and conclusions on all matters relating to biomass feedstocks, including biomass markets and the socio-economic and environmental consequences of feedstock production.

The work programme has a global scope and includes commercial, near-commercial and promising production systems in agriculture and forestry. The primary focus is on land use and bioenergy feedstock production systems. The Task will be concerned with issues related to the linking of sustainable biomass feedstocks to energy markets, explicitly considering environmental and socio-economic aspects.

Participating countries (Dec 2013): Australia, Canada, Croatia, Denmark, European Commission, Finland, Germany, Ireland, the Netherlands, Norway, Sweden, United Kingdom and the USA

Task Leader: Associate Professor Göran Berndes, Chalmers University of Technology, Sweden

Associate Task Leaders: Professor Tat Smith, University of Toronto, Canada and Dr. Julije Domac, Managing Director, North-West Croatia Regional Energy Agency, Andrije žaje, Zagreb.

Task Secretary: Assistant Professor Sally Krigstin, University of Toronto, Canada

Operating Agent: Dr Åsa Karlsson, Swedish Energy Agency, Sweden

The Task Leader directs and manages the work programme assisted by an international team. A National Team Leader (NTL) from each country is responsible for coordinating the national participation in the Task. The Task capacity is further increased through the NTLs engaging support persons within their countries and through establishing cooperation with

other organisations in specific areas. The aim is that all participating countries should have a national team consisting of participants actively supporting the NTL at the national level as well as being engaged in Task activities at the international level.

For further details on Task 43, please refer to Appendices 2, 4, 5 and 6; the Task website www.ieabioenergytask43.org and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

Three business/planning meetings were held in 2013: (i) Rotterdam, Netherlands, 13th and 15th March (13th March: meeting, inter-Task project "Mobilising sustainable bioenergy supply chains", 15th March: Task 43 business meeting); (ii) Copenhagen, Denmark, 5th June: meeting, inter-Task project "Mobilising sustainable bioenergy supply chains"; (iii) Tuheljske toplice near Zagreb, Croatia, 2nd October: Task 43 business meeting.

The Task has organised five international workshops/conference sessions in 2013: (i) Dissemination workshop (with Task 38 and Task 40): *How Can Sustainability Certification Support Bioenergy Markets?* at the World Biofuels Markets conference, Rotterdam, 12th March; (ii) 1-day conference session: *Governing water quality and quantity in bioenergy feedstock production* at the World Biofuels Markets conference, Rotterdam, 14th March; (iii) Workshop: *Developing a binding sustainability scheme for solid biomass for electricitiy and heat under the RED*, Arona, Italy, 1st-2th July (organised by JRC and IINAS with support from T40 and T43); (iv) Half-day conference session: *Biomass energy markets – financing perspective* at COENEREGY 2013 – Sustainable Energy Finance and Investment Summit, Tuheljske toplice, Zagreb, Croatia, 2th-4th October; (v) Workshop: *The transatlantic trade in wood energy: a dialogue on sustainability standards*, Savannah, GA, USA, 23rd-24th October (organised in collaboration with The Pinchot Institute and Task 40).

Work Programme

The Task engages in a number of activities that concern aspects that are central to sustainable bioenergy feedstock production and supply, noting the need to go beyond environmental sustainability and socioeconomic analysis and address a wider set of questions that are critical to mobilising sustainable bioenergy supply chains globally. The technical view on biomass production systems and supply chains is complemented with a perspective of producers and the obstacles they face in changing from conventional production systems or integrating energy into conventional production systems. This adds an integrated view on feedstock production and energy markets including policies and other factors that can shape market development and economic opportunities.

As outlined in the 2013-2015 work programme, the Task identified three thematic areas for its work:

Land use and sustainable bioenergy feedstock supply systems, where the Task takes a landscape perspective to exploring options for expanding bioenergy feedstock production in agriculture and forestry. Specifically, the Task addresses the question of how bioenergy feedstock production systems can be located, designed and managed so as to optimise the contribution to sustainability objectives at a local, regional and global scale. The Task pays special attention to the producer perspective and the factors that influence the operating conditions for biomass producers. A key question raised is: *what are the necessary and sufficient conditions for financial investment in developing attractive biomass production systems?*

One important deliverable in this area during 2013 was the report *Economic sustainability of biomass feedstock supply* (Task 43 report TR2013:01) that addresses key contributing factors toward economic sustainability that can ensure more viable bioenergy development and use, such as increasing operational efficiency and integration into traditional supply chains. Another highlight was the 1-day conference session *Governing water quality and quantity in bioenergy feedstock production*, during the World Biofuels Markets conference in Rotterdam, where the Task gathered speakers from a diverse geographic and expertise background to discuss water related challenges and how bioenergy systems can provide new solutions for addressing existing water challenges.

Assessment and certification of sustainability, where Task 43 works with other Tasks and also other organisations active in the area of certification. The Task provides expert advice concerning criteria and indicators for sustainable biomass production and collects and synthesises technical information on biomass supply systems and their performance in relation to sustainability criteria. The Task also engages in the development and evaluation of methods and tools for sustainability assessment of bioenergy feedstock supply systems. Three out of five workshops arranged in 2013 addressed issues within this thematic area (see above section "Task meetings and workshops").

Several Task NTLs and associates have roles (e.g., national experts, advisors, board members) in relation to the development of legal regulations, certification systems and standards. They can in these capacities link the work in the Task with important processes in the area of sustainability certification. Task 43 also worked with Task 38 to produce the ExCo report *On the timing of greenhouse gas mitigation benefits of forest-based bioenergy* (IEA Bioenergy ExCo: 2013:04).

Socio-economic drivers in implementing sustainable bioenergy production and supply, includes investigations of (i) options for improving and enhancing the use of biomass by poorer groups of society facing fuel poverty; and (ii) ways of financing bioenergy projects using innovative financial instruments. The work under (i) includes both addressing barriers to

bioenergy use and promotion of best practices for using bioenergy, often in hybrid or multi-technology solutions including other renewables and embracing novel business model solutions (such as co-operatives or social enterprises). The work under (ii) highlights the importance of investment and regional cooperation to promote biomass utilisation. The Task also contributes to the development of energy service company models for bioenergy. The conference session *Biomass energy markets and financing perspective* at the COENEREGY 2013 – Sustainable Energy Finance and Investment Summit provided an overview of Task 43 work done so far.

Systematic knowledge transfer is achieved through the website, reports and briefs, international collaboration, and IEA networks to educate and inform the bioenergy sector. The Task is engaged with several scientific journals: (i) *Journal of Forest Energy* (managed by the Finnish Task 43 team); which this year merged with the *International Journal of Forest Engineering;* (ii) *WIREs: Energy and Environment* (Associate Editor for the bioenergy area); (iii) *Biofuels, Bioproducts and Biorefining* (Consultant Editor). These and other journals offer valuable opportunities for outreach via special issue publications, occasional articles and editorials.

Website

The Task website (www.ieabioenergytask43.org) was re-designed and launched in October 2013, with the objective of obtaining a wider Task exposure. The website gives information about Task 43 and presents the outcomes of Task activities. It also provides web-based archives to the previous Tasks 29, 30 and 31, as well as a link to the Forest Energy Portal (see: www.forestenergy.org), which is managed by the Finnish Task 43 team. The Dutch Task 43 team has also developed a web based dissemination tool – *Perennial Biomass Crops on the Map* (see: http://www.pbconthemap.org). The website contains a members only section which allows for ease of access and quick review of task projects.

Collaboration with Other Tasks/Networking

Task 43 collaborated with Tasks 38 and 40 in the finalisation and subsequent dissemination of results in the inter-Task project proposal *Monitoring Sustainability Certification of Bioenergy*. Task 43 further collaborates with several other Tasks in the inter-Task project – *Mobilising Sustainable Bioenergy Supply Chains* – which runs during the period 2013-2015 and is coordinated by Task 43.

The events and collaborations presented above have involved interactions with several international organisations outside IEA Bioenergy, including GBEP, UNEP, IINAS, JRC and Winrock Institute. Task 43 also collaborated with national organisations, including: (i) the Swedish network Focali, which is a part of The Forest Initiative – a strategic partnership between the Swedish International Development Cooperation Agency, the Swedish Forest Agency and the Swedish Forestry Association. Focali develops new and synthesises existing

knowledge, and increases the flow of relevant information between scientists, industry, government and civil society (see www.focali.se/en); (ii) The Pinchot Institute that acted as planning coordinator and host for the workshop in Savannah, described above; (iii) The Canadian Institute of Forestry/Institut forestier du Canada (CIF/IFC), which has a long history of supporting and delivering timely, relevant and successful forest science, and fostering professional and public awareness. CIF/IFC has assumed responsibility for coordinating Canada's involvement in IEA's Bioenergy Task 43 for 2013-2015. With the support of several project partners and sponsors – including financial support from Ontario Power Generation, the British Columbia Ministry of Forests, Lands and Natural Resource Operations (Competitiveness and Innovation Branch), and the Canadian Council of Forest Ministers (Forest in Mind Program) – CIF/IFC will also cover Task 43 fees that allow Canada to continue to be significantly involved in this program.

Deliverables

Deliverables for 2013 included: (i) Technical and more popular reports (see section "Library" on the Task 43 website) as well as publications in scientific journals; (ii) reporting to the ExCo (a final task report for Exco 71 presented in May 2013 in Cape Town, South Africa (included audited accounts and a contribution to the Annual Report), contribution to ExCo 72 report on IEA Bioenergy activities 2010-2012. A Task 43 overview article was prepared and is available on the Task 43 website. Also the organisation and minuting of Task meetings and updating of the Task website. Please see Appendix.

TASK PARTICIPATION IN 2013

TASK	AUS	AUT	BEL	BRA	CAN	CRO	DEN	FIN	FRA	GER	IRE	ITL	JAP	KOR	NEL	NZE	NOR	SA	SWE	SWI	TUR	UK	USA	EC	Total
32		•	•				•			•	•		•		⊗		•	•	•	•		•			12
33		⊗					•	•		•		•			•	•	•		•	•	•		•		12
34								•		•					•				•			•	⊗		6
36									•	•		•					•		•			⊗			6
37		•		•			•	•	•	•	•			•	•		•		•	•		•		⊗	14
38	⊗			•				•	•	•					•				•				•		8
39	•	•		•	⊗		•			•		•	•	•	•	•	•	•	•				•		15
40		•	•	•			•	•		•		•			⊗		•		•			•	•		12
42	•	•			•		•			•	•	•	•		⊗	•							•		11
43	•				•	•	•	•		•	•				•		•		⊗			•	•	•	13
Total	4	6	2	4	3	1	7	6	3	10	4	5	3	2	9	3	7	2	9	3	1	6	7	2	109

⊗ = Operating Agents • = Participant

Note: In addition to the above the following Task was ongoing in 2013: Task 41, Project 4 (participants are the EC and Norway). This is a joint projects with the AMF Implementing Agreement.

BUDGET IN 2013 – SUMMARY TABLES

Budget for 2013 by Member Country (US$)

Contracting Party	ExCo funds	Task funds	Total
Australia	10,700	63,500	74,200
Austria	12,700	93,000	105,700
Belgium	8,700	32,500	41,200
Brazil	10,700	61,500	72,200
Canada	9,700	47,500	57,200
Croatia	7,700	15,000	22,700
Denmark	13,700	108,000	121,200
Finland	12,700	96,500	109,200
France	9,700	44,320	54,020
Germany	16,700	159,320	176,020
Ireland	10,700	60,500	71,200
Italy	11,700	80,320	92,020
Japan	9,700	47,500	57,200
Korea	8,700	28,000	36,700
Netherlands	15,700	144,000	159,700
New Zealand	9,700	47,500	57,200
Norway	13,700	105,820	119,520
South Africa	8,700	30,000	38,700
Sweden	15,700	141,820	157,520
Switzerland	9,700	43,000	52,200
Turkey	7,700	15,000	22,700
UK	12,700	98,820	108,520
USA	13,700	116,000	129,700
European Commission	8,700	28,000	36,700
Total	**269,800**	**1,704,420**	**1,974,220**

BUDGET IN 2013 – SUMMARY TABLES

Budget for 2013 by Task (US$)

Task	Number of participants	Annual contribution per participant	Total Task funds
Task 32: Biomass Combustion and Co-firing	12	15,000	180,000
Task 33: Thermal Gasification of Biomass	12	15,000	180,000
Task 34: Pyrolysis of Biomass	6	20,000	120,000
Task 36: Integrating Energy Recovery into Solid Waste Management	6	15,320	91,920
Task 37: Energy from Biogas	14	13,000	182,000
Task 38: Greenhouse Gas Balances of Biomass and Bioenergy Systems	8	16,000	128,000
Task 39: Commercialising Liquid Biofuels from Biomass	15	15,000	225,000
Task 40: Sustainable International Bioenergy Trade – Securing Supply and Demand	12	17,500	210,000
Task 41: Bioenergy Systems Analysis	3	0	0
Task 42: Biorefineries: Co-production of Fuels, Chemicals, Power and Materials from Biomass	11	17,500	192,500
Task 43: Biomass Feedstocks for Energy Markets	13	15,000	195,000
Total			**1,704,420**

CONTRACTING PARTIES

Bioenergy Australia (Forum) Ltd

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

Commission of the European Union

Tekes, Finnish Funding Agency for Technology and Innovation

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

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

The Sustainable Energy Authority of Ireland (SEAI)

Gestore dei Servisi Energetici – GSE (Italy)

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

Ministry of Knowledge Economy, the Republic of Korea

NL Agency (the Netherlands)

The New Zealand Forest Research Institute Limited

The Research Council of Norway

South African National Energy Development Institute (SANEDI)

Swedish Energy Agency

Swiss Federal Office of Energy

Tubitak Marmara Research Center Energy Institute (Turkey)

Department of Energy and Climate Change (United Kingdom)

The United States Department of Energy

LIST OF REPORTS AND PUBLICATIONS

The Executive Committee

Final Minutes of the ExCo71 meeting, Cape Town, South Africa, May 2013.

Final Minutes of the ExCo72 meeting, Jeju, Korea, November 2013.

IEA Bioenergy News Volume 25(1), June 2013.

IEA Bioenergy News Volume 25(2), December 2013.

IEA Bioenergy Update. Number 54. Biomass and Bioenergy. Published, JBB 57, October 2013.

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Anon. IEA Bioenergy Annual Report 2012. IEA Bioenergy ExCo:2013:01.

Anon. Environmental Sustainability of Biomass. Summary and Conclusions from the IEA Bioenergy ExCo68 Workshop. IEA Bioenergy ExCo:2013:02.

Anon. The Science-Policy Interface on the Environmental Sustainability of Forest Bioenergy – A Strategic Discussion Paper. IEA Bioenergy ExCo:2013:03.

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Trois, C.: Status and future of MSW treatment in South Africa.

Haukohl, J.: Sustainable waste management worldwide.

Huisman, H.: Drivers for an optimised waste management in low and medium income countries.

Baxter, D.: AD of the organic fraction of MSW: System overview for source and central separated waste.

Vehlow, J.: Overview of incineration technologies.

Koldenhof, E.: Energy from Waste – Amsterdam.

Read, A.: Best practice of waste management in low and medium income countries.

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Eisentraut, A.: Medium-term outlook for renewable energy – what's next for bioenergy?

Wellinger, A.: Situation and strategy on biomass electricity in Europe.

Cleaves, B.: Situation and strategy on biomass electricity in North America.

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Park, SC.: Electricity generation using biogas from waste food in Korea.

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Livingston, B.: Co-combustion of biomass with coal.

All publications listed are available on the IEA Bioenergy website: www.ieabioenergy.com

TASK 32

Minutes of the Task meeting in Copenhagen, Denmark, June 2013.

Minutes of the Task meeting in Berlin, Germany, November 2013.

IEA Bioenergy Task 32 Newsletter, Issue 7, June, 2013.

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Anon. Tasks 32, 36, 37 & 40 Report 'Health and Safety Aspects of Solid Biomass Storage, Transportation and Feeding', May 2013.

Lönnermark, A., Persson, H., Larsson, I., Nikolaisen, L., Koppejan, J., Wheeler, P, Howes, P., Al Seadi, T., Southgate, J., Godley, A., Melin, S., Health and Safety issues in handling, storage and transportation of solid biofuels, Jan 2013.

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Progress report for ExCo72, Jeju, Korea, November 2013.

Koppejan, J. Report from the Workshop 'CFD as a tool to optimise geometry of biomass combustion systems', Copenhagen, 6th June 2013:

Andersen, K., Force Technology, Denmark, Overview – CFD simulations of biomass combustion plants – present applications.

Scharler, R., BE2020+/TUG/BIOS, Overview – CFD simulation of biomass combustion plants – new developments.

Thunman, H., Chalmers University, Sweden, Single particle modelling for implementation into CFD.

Wirtz, S., LEAT, Ruhr-University Bochum, Germany, DEM modelling of biomass packed bed combustion with DEM and link with CFD furnace models.

Mehrablan, R., BE2020+, Austria, 3D CFD modelling of solid biomass combustion in grate furnaces.

Nussbaumer, T., ETH Zürich, Verenum, Moving Grate Combustion Optimisation with CFD And PIV.

Glarborg, P., DTU, Denmark, Modelling of SOx formation and subsequent sulphation for CFD applications.

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Schnell, U., IFK Universität Stuttgart, Germany, CFD modelling of co-combustion of coal and biomass including NOx and SOx.

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Shiehnejad, A., BE2020+, Austria, Automatic CFD optimisation of biomass combustion plants.

Brink, A., Abo Akademi (ABO), Finland, CFD modelling of fluidised bed combustion plants.

Koppejan, J. Report from the workshop 'Challenges in Biomass Combustion', Berlin, Germany, November 2013:

Carling, A., E.ON Climate & Renewables, Coventry, United Kingdom, Conversion of Ironbridge power plant.

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Willeboer, W., RWE Essent Productie B.V., Geertruidenberg, the Netherlands, Biomass in RWE Essent: Over ten years of development and experience.

Moenkert, P., Alstom Boiler Deutschland GmbH, Stuttgart, Germany, Operational experience with a 15 MWth biomass burner – investigation of combustion and emission performance.

Oikkonen, R., Pohjolan Voima Oy, Helsinki, Finland, Utilisation of biomass ash – an European overview.

Grammelis, P., Center for Research & Technology Hellas CERTH/Chemical Process and Energy Resources Institute CPERI, Athens, Greece, The biomass technology roadmap of the RHC-platform: Priorities for high efficient large-scale CHP units.

Ullrich, C., Peter Körner, VGB Materials Laboratory, Essen, Germany, High temperature chlorine corrosion and its damage mechanism.

Berg, M., ChlorOut AB, Stockholm, Sweden, Operational experiences from the ChlorOut concept.

Kubiczek, H., EDF Polska S.A., Krakow, Poland, Additives as method for preventing fouling – results of large scale tests.

Sanders, B., Dong Energy Thermal Power, Fredericia, Denmark, Operational experiences with coal fly ash injection.

Zimmerling, S., VGB PowerTech e.V., Essen, Germany, VGB – Standard: Fire and explosion prevention in biomass fired power plants.

van den Auweele, J., Laborelec, Linkebeek, Belgium, Biomass: Fire and explosions – prevention measurements.

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Wollner, L., Boehringer Ingelheim Pharma GmbH & Co. KG, Ingelheim am Rhein, Germany, Fire and explosion protection at Boehringer Ingelheim power plant.

Persson, H., SP Technical Research Institute of Sweden, Boras, Sweden, Fire fighting in silos.

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www.ieabioenergytask32.com

TASK 33

Report from the workshop 'Lessons learned':

Bain, R., Principal Engineer, NREL, Integrated Pilot Operations for Production of Mixed Alcohols.

Magrini, K., Group Manager, NREL, Development of Reforming Catalysts.

Hensley, J., Senior Engineer, NREL, Development of Mixed Alcohol Catalysts.

Dutta, A., Senior Engineer, NREL, Techno-economics of Biomass Gasification Followed by Mixed Alcohol Production and Alcohol Separation.

Talmadge, M., Senior Engineer, NREL, Techno-economic and Market Analysis of Pathways from Syngas to Fuels and Chemicals.

Task 34 Biomass Pyrolysis: Task Overview.

Discussion of Potential Task Interactions with Task 34.

Report from the workshop 'System and Integration Aspects of Biomass-based Gasification', 19th and 20th November 2013:

Berntsson, T., Chalmers Technical University, Sweden, Welcome address.

Gasper, A., RAIZ Institute, Portocel Soporcel Portugal, IEA Industrial Energy-related Technologies and Systems Annex 11 Industry-based biorefineries.

Whitty, K., University of Utah, USA, IEA Bioenergy Agreement Task 33 ''Thermochemical gasification of biomass''.

Session 1 Biomass gasification into syngas Part 1; Upstream and internal integration:

Wagner, H., Technical Univ. Hamburg Harburg, Germany, Gasification of urban biomass residues. Possibilities in Hamburg/Germany.

Möller, M., DONG Energy, Denmark, Status of DONG Energy's Pyroneer gasification technology for high alkaline fuels like straw: an efficient and sustainable method to replace fossil fuels in our energy system.

Breitholtz, C., Metso Power, Sweden, Gasification of biomass and waste for production of power, the cases in Lathi and Vaasa.

Session discussion, highlights.

Session 2 Biomass gasification into syngas Part 2; Downstream and product integration:

Thunman, H., Chalmers Technical University, Sweden, Beyond 80% efficiency for standalone production of bio-methane from wet biomass.

Kolb, T., Karlsruher Institut für Technologie, Germany, Biomass gasification for BtL-the bioliq® process.

Landälv, I., Luleå Technical University, Sweden, Methanol as energy carrier and bunker fuel.

Session discussion, highlights.

Session 3 Biomass gasification to fuel gas; Iintegration into power and CHP utilities:

Rauch, R., Techical University Vienna, Austria, Dual fluidized bed gasification for CHP and production of advanced biofuels.

van der Drift, B., ECN, the Netherlands, Chemicals from gasification.

Hannula, I., VTT, Finland, Production of synthetic methanol and light olefins from lignocellulosic biomass.

Session discussion, highlights.

Session 4 Analyses of techno-economic performance and climate impact:

Harvey, S., Chalmers Technical University, Sweden, Assessing the performance of future integrated biorefinery concepts based on biomass gasification.

Larson, E., Princeton University, USA, Techno-Economic Systems Analysis of Jet Fuel and Electricity Co-Production from Biomass and Coal with CO_2 Capture: an Ohio River Valley (USA) Case Study.

Talmadge, M., National Renewable Energy Laboratory, USA, Techno-economic and Market Analysis of Pathways from Syngas to Fuels and Chemicals.

Faaij, A., University of Utrecht, the Netherlands, Bio-CCS *title to be confirmed*

Session discussion, highlights.

General discussion.

Thore Berntsson Chalmers Technical University, Sweden
Lars Waldheim Waldheim Consulting, Sweden, Closing note.

Please also visit the Task website: www.ieaTask33.org

TASK 34

Minutes of the Task meeting in Karlsruhe, Germany, April 2013.

Minutes of the Task meeting in Chicago, US, November 2013.

Progress report for ExCo71, Cape Town, South Africa, May 2013.

Progress report for ExCo72, Jeju, South Korea, November 2013.

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Oasmaa A., Elliott, D.C. *"Stability of fast pyrolysis bio-oils and upgraded products"* oral presentation by Anja Oasmaa at tcbiomass2013, Chicago, IL, USA, 5th September, 2013.

Elliott, D.C., Meier, D., van de Beld, B., Oasmaa, A., Bridgwater, A.V., Preto, F., *"Progress in the IEA Bioenergy Task 34 on Pyrolysis"*. Poster presented by Douglas C. Elliott at tcbiomass2013, Chicago, IL, USA, 5th September, 2013.

Please also visit the Task website: www.pyne.co.uk

TASK 36

Minutes of the Task meeting in Stockholm, Sweden May 2013.

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Progress report for ExCo71, Cape Town, South Africa, May 2013.

Progress report for ExCo70, Jeju, South Korea, November 2013.

Presentations:

Howes P S (2013) Municipal waste as a feedstock for next generation biofuels. Presented at F O Lichts Next Generation Conference Copenhagen February 2013.

Howes P S (2013) Trends influencing energy recovery from waste.

Vehlow J (2013) Technology Overview of incineration technologies.

Read A (2013) Best practice of waste management in low and medium income countries.

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Gandy S (2013) Life cycle assessment modelling of IAWARES Published on Task website.

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The publications are available from Pat Howes, please email: pat.howes@ricardo-aea.co.uk

TASK 37

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Minutes from the Task meeting in Seoul, South Korea, November 2013.

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Mutzner, S., Ökostrom Schweiz (CH) – Energy from biogas for smart grids.

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Banks, C., University of Southampton, Task 37 – The anaerobic digestion of food waste – technical issues and solutions.

Hyo, H.N., Samchully ES (Korea) – Current status of biogas upgrading business in South Korea.

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Ho, B.J., INHA University (Korea) – Biogas recovery from domestic wastewater with anaerobic membrane reactor.

Rintala, J., Tampere University of Technology, Task 37 – Future directions for AD.

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TASK 38

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Minutes from the Task Business Meeting in Sydney, Australia. November 2013.

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TASK 39

Minutes from the Task meeting in Stellenbosch, South Africa, March 2013.

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TASK 40

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TASK 43

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Please also visit the Task 43 website: www.ieabioenergytask43.org for access to more publications.

KEY PARTICIPANTS IN EACH TASK

TASK 32 – Biomass Combustion and Co-firing

Operating Agent: Kees Kwant, NL Agency, the Netherlands.
For contacts see Appendix 7.

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TASK 33 – Thermal Gasification of Biomass

Operating Agent: Josef Spitzer, JS Consulting, Austria (1st January to 31st December 2013)

Paul Grabowski, US Department of Energy, USA (from 1st January 2014). For contacts see Appendix 7.

Task Leader: Kevin Whitty, University of Utah, USA.
For contacts see Appendix 6.

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TASK 34 – Pyrolysis of Biomass

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Germany	Dietrich Meier	Thünen Institute for Wood Research
The Netherlands	Bert van de Beld	BTG (Biomass Technology Group)
Sweden	Magnus Marklund	ETC (Energy Technology Centre)
United Kingdom	Anthony Bridgwater	Aston University
USA	Douglas Elliott	PNNL (Pacific Northwest National Laboratory)

TASK 36 – Energy Recovery from Municipal Solid Waste Management

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Task Leader: Pat Howes, AEA Energy & Environment, UK. For contacts see Appendix 6.

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TASK 37 – Energy from Biogas

Operating Agent: Kyriakos Maniatis, European Commission, Belgium.
For contacts see Appendix 7.

Task Leader: David Baxter, EC JRC Petten, the Netherlands.
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Norway	Roald Sørheim	Bioforsk
Sweden	Tobias Persson	Swedish Gas Centre
Switzerland	Nathalie Bachmann	EREP
United Kingdom	Clare Lukehurst	Probiogas UK

TASK 38 – Climate Change Effects of Biomass and Bioenergy Systems

Operating Agent: Stephen Schuck, Bioenergy Australia Manager.
For contacts see Appendix 7.

Task Leader: Annette Cowie, University of New England, Australia.
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Germany	Sebastian Rüter	Thünen Institute of Wood Research

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	Matti Parikka	Swedish Energy Agency
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	Helena Chum	National Renewable Energy Laboratory

TASK 39 – Commercialising Conventional and Advanced Liquid Biofuels from Biomass

Operating Agent: Ed Hogan, Natural Resources Canada, Canada.

Task Leader: Jim McMillan, NREL, USA.

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	Maria Nyquist	Swedish Energy Agency
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TASK 40 – Sustainable International Bioenergy Trade: Securing Supply and Demand

Operating Agent: Kees Kwant, NL Agency, the Netherlands.

Task Leader: (Scientific) Martin Junginger, Copernicus Institute, Utrecht University, the Netherlands.

Task Leader: (Industry) Peter-Paul Schouwenberg, RWE Essent, the Netherlands.

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	Daniela Thrän	Deutsches BiomasseForschungsZentrum
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Sweden	Bo Hektor	Svebio
	Lena Dahlman	Svebio
UK	Rocio Diaz-Chavez	Imperial College
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TASK 41 – Bioenergy Systems Analysis

Project 4:	Joint Project with AMF: Biomethane in Heavy Duty Engines
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Project Leader:	Dr Kyriakos Maniatis, European Commission, Belgium. For contacts see Appendix 7.

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European Commission	Kyriakos Maniatis	DG Energy, European Commission

TASK 42 – Biorefining: sustainable processing of biomass into a spectrum of marketable bio-based products and bioenergy

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Germany	Heinz Stichnothe	Thunen-Institute of Agricultural Technology
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TASK 43 – Biomass Feedstocks for Energy Markets

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