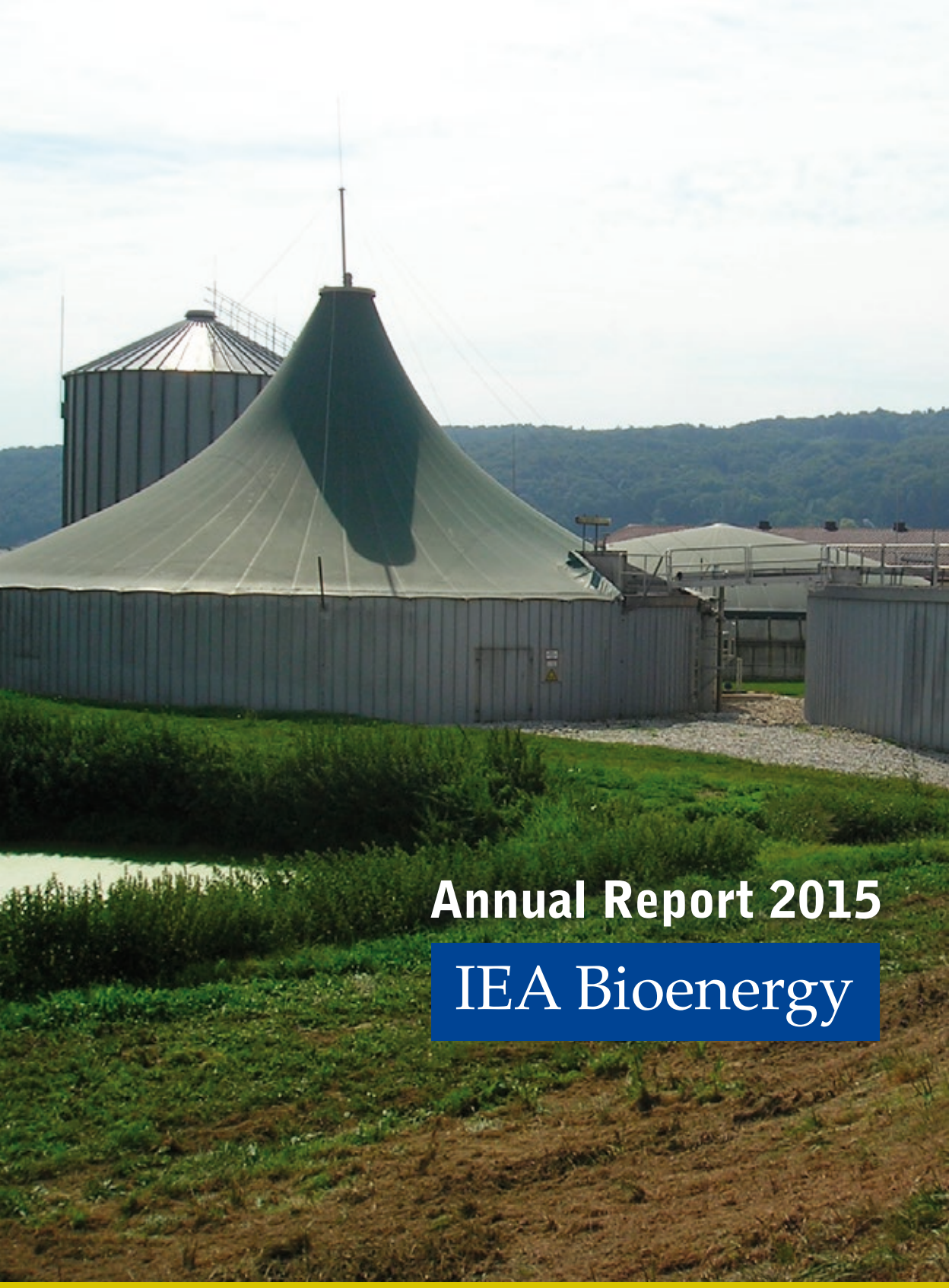


Annual Report 2015

IEA Bioenergy

IEA BIOENERGY : EXCO : 2016 : 01

IEA Bioenergy is an international collaborative agreement set up in 1978 by the International Energy Agency (IEA) to improve international co-operation and information exchange between national bioenergy RD&D programmes. IEA Bioenergy aims to 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.

Front Cover: Austrian agricultural biogas plant using both crops and agricultural residues for heat and power generation

Chair Kees Kwant and Vice-chair Sandra Hermle.

To: IEA Headquarters, Paris

IEA BIOENERGY ANNUAL REPORT 2015

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 2015. This year, we have presented a special feature 'Energy, Fuels and Fertiliser from Biogas' prepared by Task 37.

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

Kees Kwant
Chairman

Pearse Buckley
Secretary

Contents

Editor: Pearse Buckley, IEA Bioenergy Secretary, Dublin, Ireland

Design and layout: Clever Cat Design, Dublin, Ireland

Preparation, of colour section: David Baxter and Jerry Murphy

Preparation of text and tables: Paul Derham, Dublin, Ireland.

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

IEA Bioenergy – Selected Highlights From 2015

1. IEA Bioenergy Conference 2015

The *IEA Bioenergy Conference 2015,* which took place in Berlin from the 27-29 October 2015 under the patronage of the German Federal Minister of Food and Agriculture Christian Schmidt, was the third in a very successful series of IEA Bioenergy end-of-triennium conferences (2009 in Vancouver and 2012 in Vienna). In the context of the COP21 meeting in Paris, which started on the 30th of November 2015, the conference had as its focus *'Realising the world's sustainable bioenergy potential'.* It included ten topics with more than 40 expert presentations and four technical excursions. Industrial developments and applications were at the centre of the event. Different sessions covered a wide thematic range. Innovative biobased aviation fuels, liquid fuels from woody biomass and other lignocellulosic sources and modern combustion for cooking solutions in developing countries were just a few examples. Moreover cross-cutting issues such as trade, socio-economic conditions and sustainability were explored. The abstracts and contributions provided by the speakers were indicative of a high standard and deep insight into the most up-to-date status of bioenergy production and utilisation. A summary, including conclusions from the conference, can be viewed at http://www.ieabioenergy.com/publications/iea-bioenergy-conference-2015-conclusions/.

Christian Schmidt, German Federal Minister of Food and Agriculture and Kees Kwant, Chair of IEA Bioenergy

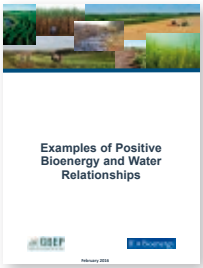
Delegates at IEA Bioenergy Conference 2015

2. Mobilisation Of Sustainable Bioenergy Supply Chains

This report summarises the results of an IEA Bioenergy inter-Task project involving collaborators from Tasks 37 (Energy from Biogas), 38 (Climate Change Effects of Biomass and Bioenergy Systems), 39 (Commercialising Conventional and Advanced Liquid Biofuels from Biomass), 40 (Sustainable International Bioenergy Trade: Securing Supply and Demand), 42 (Biorefining – Sustainable Processing of Biomass into a Spectrum of Marketable Bio-based Products and Bioenergy), and 43 (Biomass Feedstocks for Energy

Markets). The purpose of the collaboration was to analyse prospects for large-scale mobilisation of major bioenergy resources through five case studies that determine the factors critical to their sustainable mobilisation. Analysis of the five globally significant supply chains – boreal and temperate forests, agricultural crop residues, biogas, lignocellulosic crops, and cultivated grasslands and pastures in Brazil – has confirmed that feedstocks produced using logistically efficient production systems can be mobilised to make significant contributions to achieving global targets for bioenergy. However, the very significant challenges identified in this report indicate that changes by all key members of society in public and private institutions and along the whole length of the supply chains from feedstock production to energy product consumption are required to mobilise adequate feedstock resources to make a sustainable and significant contribution to climate change mitigation and provide the social and economic services possible. Notably, this report reveals that all globally significant bioenergy development has been underpinned by political backing, which is necessary for passing legislation in the form of mandates, renewable energy portfolios, carbon trading schemes, and the like. The mobilisation potential identified in this report will depend on even greater policy support than achieved to date internationally. The report can be downloaded from http://www.ieabioenergy.com/publications/mobilizing-sustainable-bioenergy-supply-chains/.

3. Collaboration In GBEP Activity Group 6 "Bioenergy And Water"



Bioenergy is, and will continue to be, a substantial part of the global renewable energy supply in a low carbon economy. Sustainable production and use of bioenergy offers tremendous opportunities for creating positive socio-economic and environmental impacts. The water-energy nexus has been identified as one of those opportunities. Presenting innovative examples is a means of demonstrating how bioenergy systems – in both the feedstock production and conversion phases – can generate positive impacts on water and energy. In order to illustrate this, the Global Bioenergy Partnership (GBEP) and the International Energy Agency (IEA) Bioenergy Technology Cooperation Programme (IEA Bioenergy) have joined forces to collect information, analyse it and present the results. This report is the product of the GBEP/IEA Bioenergy collaboration The examples presented in this publication illustrate an encouraging variety both in terms of bioenergy systems and geographical distribution, and they all show how solutions can be found that produce bioenergy while contributing positively to the state of water. These experiences are also meant to serve as sources of inspiration that other bioenergy producers can use to enhance the sustainability of their own activities. However, there are significant barriers to scaling up and replicating these good examples, not the least of which are the limited awareness and capacity of relevant actors. Through this publication, and generally through our work, GBEP and IEA Bioenergy hope to contribute to the removal of such barriers and to the creation of an enabling environment for sustainable bioenergy production and the improvement of the management of water resources. The report can be downloaded from http://www.ieabioenergy.com/publications/examples-of-positive-bioenergy-and-water-relationships/.

Energy, Fuels and Fertiliser from Biogas

David Baxter and Jerry Murphy, IEA Bioenergy Task 37.

Introduction

Biogas is formed in nature by the biological degradation of biomass under anaerobic conditions. The naturally occurring biogas escapes into the atmosphere where its main component, methane, is a significant contributor to global warming. Biogas is also an energy carrier and this has been recognised for hundreds of years, if not longer. Used as a simple fuel, biogas has been, and still is, used for cooking, heating and lighting at small scale in millions of units around the world. What has changed over the last hundred years or so is the industrialisation of biogas production. Initially, the aim was simply to generate energy in the form of heat and electricity. While electricity and heat are still the main products of biogas utilisation, other interests in the use of biogas have steadily grown and now include utilisation as a vehicle fuel and all applications that natural gas has found over the last century. In addition to energy, the anaerobic digestion (AD) process has a residue, the digestate, which contains valuable nutrients and can therefore be used as a biofertiliser. This short summary describes the developments in the biogas sector in terms of the drivers for AD deployment, the technologies adopted, and utilisation of the products, biogas and digestate.

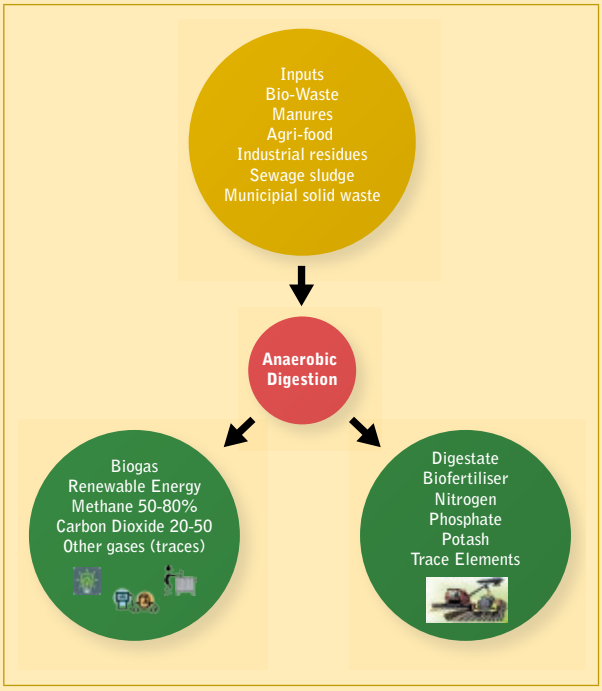


Fig. 1. A simple overview of biogas production from wastes and residues and nutrient recycling (Lukehurst et al., 2010)

Drivers for Biogas

There is no single driver for the production and utilisation of biogas. Moreover, for individual biogas plants there are often multiple drivers behind their construction, each of which derives from one of three main pillars: economic; environmental; and social. The main drivers are briefly described below.

Maximising resource efficiency

Traditionally, there has been a need to use local resources as efficiently as possible. This was particularly true in the time before the industrial revolution, before the great transportation systems and widespread trade. The very earliest examples used biogas formed in closed storage pits for animal and human excrement for households and very small communities. The biogas was captured and, without further treatment, used as fuel for lighting and to generate heat. These simple biogas systems still have applications when it is considered that 15% of the world's population (over 1 billion people) still do not have access to electricity (World Bank, 2015). Resource efficiency is still at the heart of many biogas projects, and is recognised again even in economically developed countries to provide a fuel for local security of supply along with local employment and associated economic activity. Industrialisation, population growth and urbanisation have simply increased the scale of biogas production and the complexity of the systems. Biogas is often produced as part of another industrial process, for example to treat process residues in order to recover inherent energy and to reduce volumes of waste for disposal.

Management of waste for the mitigation of land, water and air pollution

The first industrial scale production of biogas took place in the wastewater treatment sector. Since the 1930s, anaerobic digestion has been widely adopted around the world as part of the process of stabilising sewage sludge with the biogas produced used to provide energy for the wastewater treatment. While the amount of biogas produced is usually insufficient to meet the total energy demand of wastewater treatment systems, a number of approaches have been adopted in recent years to achieve energy self-sufficiency. For example, in some countries AD of other waste materials is carried out on integrated sites treating a range of solid and liquid wastes from municipalities. Co-digestion of different wastes to increase the rate and amount of biogas production is possible and heat from boilers and Combined Heat and Power (CHP) systems can be readily utilised in different processes located in close proximity to one another, thus maximising overall energy efficiency. One key limiting factor is whether the AD digestate from sewage sludge is allowed to be used as a fertiliser. In some countries sewage sludge, even after AD, is not allowed to be used as a fertiliser and must be incinerated. Anaerobic digestion of sewage sludge is addressed in a dedicated Task 37 report (Bachmann, 2015).

Municipal solid waste (MSW) treatment presents a huge challenge to local authorities. Waste is increasingly seen as a resource from which valuable materials, nutrients and energy, can be recovered. This was not always the case, and even now disposal by landfill is common practice in many parts of the world. However, the introduction of landfill bans on biodegradable waste over the last 20 years (such as the 1999 European Council Directive 1999/31/EC on the landfill of waste) has resulted in substantial diversion of these materials to recovery operations. Some biodegradable wastes are suitable for AD and biogas is produced from these sources at many municipal waste treatment sites. Unfortunately, digestate arising from AD of poorly separated waste can rarely be used safely as a fertiliser in agriculture due to contamination. Separation of food waste at source is an important step in providing high quality feedstock for efficient biogas production (see Task 37 report by Al Seadi et al., 2013, on source separation of food waste). Careful preparation and selection of AD feedstocks ensures that the resulting digestate can be used as a biofertiliser in agriculture (see Task 37 report on digestate quality (Al Seadi et al., 2012)).

Protection of ground water is the main objective of a number of national regulations, including the 1991 EU Nitrates Directive. In agriculture, anaerobic digestion of animal manure and slurries (with subsequent careful management of the digestate) is considered a key process to reduce negative impacts on ground water (eutrophication) caused by excess runoff of nutrients rich in phosphorus and nitrogen. A primary reason for anaerobic digestion of slurries and manures was reduction of the impacts on ground waters in nitrate vulnerable zones, for example in areas with intense rearing of animals. Ground water protection was a key driver for the original implementation of AD in Denmark and Brazil.

Reducing greenhouse gas (GHG) emissions

Until the late twentieth century landfilling of mixed municipal solid waste was widely practiced in most countries. Capture of methane formed under the anaerobic conditions of a well-managed landfill can partially mitigate greenhouse gas emissions from landfills and is strongly encouraged (US EPA, 2012). In developing countries where municipal wastes are often relatively wet and containing high proportions of organic material (e.g. food waste) the rate of methane production is high. As a consequence, landfill gas recovery projects should be implemented very soon after waste is deposited, before methane (with a global warming potential (GWP) of 25 over a 100 year time frame) is emitted to the atmosphere. Research indicates 73% of the total potential landfill gas is generated within the first five years and 93% is generated within ten years of landfilling the organic waste (McBean, 2011).

On-farm AD also has significant potential to capture methane, both mitigating methane emissions and providing a source of renewable energy. In fact, capture of methane that would otherwise be released during storage and handling of animal manures and slurries is a key driver for AD. Avoided methane emissions from conventional manure and slurry management and storage are an important component of the calculated GHG savings from livestock farming and can, under the right conditions, result in negative GHG emissions when all steps in the process pathway from animal manure/slurry to renewable energy and biofertiliser are taken into account (Battini et al., 2014).

Exploiting a source of renewable energy

In some instances, for example for small landfills and in remote locations, recovered biogas is flared rather than used to generate energy; this results in emissions of CO_2 (with a GWP of 1) rather than methane (with a GWP of 25). Biogas may also be flared for safety reasons. However, in most cases where biogas is either recovered, in the case of landfills and for some manure storage facilities, it is used to generate energy and to provide income to the biogas plant operator. The biogenic origins of feedstocks used to produce biogas mean that energy generated is counted as renewable energy.

Renewables targets have spurred the growth of biogas production specifically to reduce the contribution of fossil fuel to the energy mix. Biomass wastes and residues are prime targets for use as AD feedstocks and over the last 2 decades increasing amounts of dedicated energy crops have been produced as additional feedstocks. The most dramatic rise in numbers of biogas plants since the start of the 21st century has been in Germany (see Fig. 2), where whole crop maize is used as a feedstock in biogas plants to produce renewable energy. Biogas from crop digestion is discussed in detail in a Task 37 report by Murphy et al. 2011.

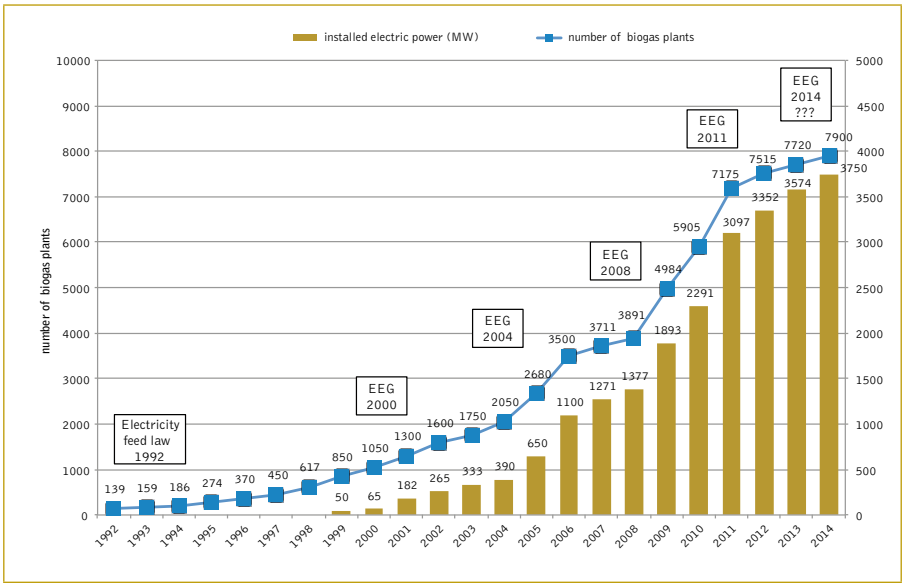


Fig. 2. The expansion of biogas production in Germany.

"EEG" refers to different versions of financial support instruments; the 2014 version of EEG reduced dramatically the income in the form of feed-in tariffs.

(Source: German Biogas Association, 11/2013, adapted by Linke, 2014)

Biogas is also produced in resource recovery operations in biofuel or biorefinery installations, in order to improve the energy balance of the process. In these cases, AD is used for example for treating process residues and wastewaters to increase resource efficiency.

Starting or expanding an economic enterprise

One of the biggest challenges facing biogas plant operators is to achieve an attractive return on capital investment. This is most applicable in developed countries, where biogas technologies operate at relatively large scale and with a relatively high level of technology complexity. Biogas gained a boost in 2014 when the Renewable Fuel Standard (RFS) in the United States was extended from only liquid biofuels to include biogas; typically biogas upgrading to biomethane (transport fuel specification) requires large scale. European countries generally provide generous subsidies to make biogas plant construction and operation economically feasible. Nevertheless, there are cases where biogas production can provide an income without governmental subsidies. Gate fees or tipping fees allow for cost efficient modern waste treatment technologies in municipalities.

During the early years of the 21st century relatively large biogas plants with an equivalent electricity generating capacity of ca. 0.5 MWe were built. In more recent times, smaller scale biogas plants have been preferred in order to keep feedstock and disgestate transport distances short. As with many technologies, specific investment costs increase with decreasing plant size and so there is a challenge to achieve economic viability for small-scale plants. Given the interest in small scale systems a number of studies have been carried out (e.g. Mesa-Dominguez et al., 2015). This topic has also been addressed by Task 37 (Lukehurst et al., 2015).

Local energy security and supporting integrated energy systems

In developing countries small biogas plants at household or small community scale are used to provide a local source of fuel for heating and cooking. This is fundamental local security of energy supply. In OECD countries with centralised energy supply systems heavily dependent on fossil fuels there is a strong desire to increase the contribution of renewables to the energy mix. Intermittent renewable forms of energy such as wind and solar cannot be easily regulated and so there is a general need for a controllable supply of energy from biomass. The easy storability of biogas (in suitable bag systems) and biomethane (in natural gas grids) presents a possible new role for biogas plants to play in balancing electricity grids in the future. This topic is described in more detail later in this report.

Biogas Feedstocks

Anaerobic Digestion can process almost any organic material. The selected material, referred to either as feedstock or substrate, can include animal slurries and manures, agricultural crops, agri-food processing residues, food residues, the organic fraction of household waste, organic fractions of industrial wastes and by-products, sewage sludge, municipal solid waste and indeed crops grown specifically for the purpose of producing biogas (such as maize and grasses). The feedstock can be either a single input (mono-digestion) or a mixture of two or more feedstock types (co-digestion). Most biogas plants use more than one substrate. Fig. 3 illustrates the percentages of substrates digested in 108 biogas plants, which produce biomethane in Germany. AD technologies are described in chapters 6 and 8 of the Biogas Handbook (2013). Monitoring of the AD process is

a vital part of process control, allowing optimisation of biogas production, and equally important, obtaining an early warning of potential process inhibition that in the worst cases can lead to total process failure. Process monitoring has been described in detail in a Task 37 report (Drosg, 2013).

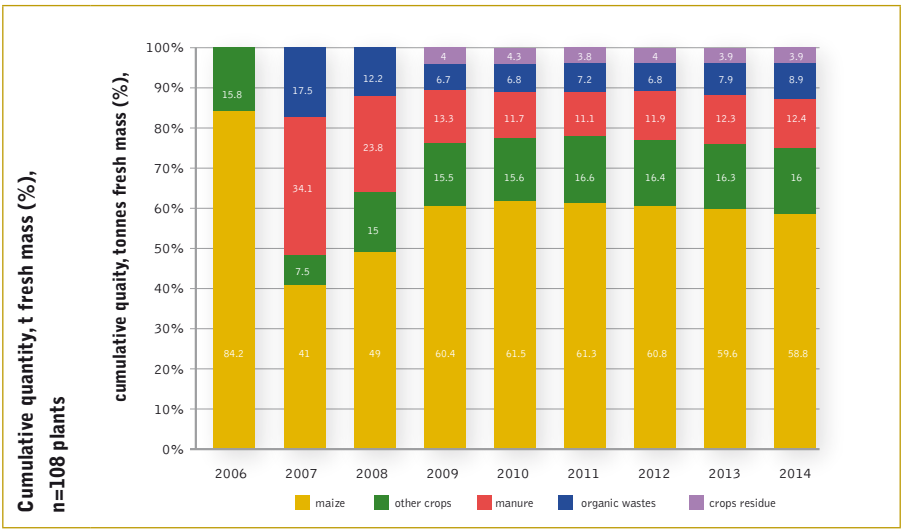


Fig. 3. An illustration of the proportion of feedstocks used in Germany in 108 biogas plants, which produced biomethane, for the period 2006 to 2014. (Source, German Energy Agency, dena)

Regardless of origin, most feedstocks need some kind of pretreatment before injection in the digester. Some pretreatments are simply designed to exclude foreign objects that will not contribute to biogas production and might block pipes and pumps. On the other hand, a range of mechanical, chemical, thermal and biological pretreatments are sometimes needed to achieve optimum biogas production in terms of amount and rate, and to ensure that the digestion process is not inhibited. Pretreatment processes for biogas feedstocks have been described in detail in a Task 37 report (Montgomery et al., 2014). Pretreatment technologies for biogas feedstocks are closely similar or identical to those used for lignocellulosic materials (such as straw, giant grasses, etc.) used for the production of advanced liquid biofuels.

AD Product Utilisation

Heat

The simplest, and usually the lowest cost, use of biogas is for heating. Indeed, in developing countries heat for hot water and cooking is the main energy product from household or small farm installations, along with a small amount of biofertiliser from application of digestate to crops. These very small scale systems also provide a degree of local energy security. Small farm-scale biogas plants in close proximity to one another can be linked by biogas pipelines to make electricity generation a viable option. This concept has been demonstrated in Paraná State in Brazil where 33 farms, each with typically

less than 10 head of livestock, inject most of their biogas (produced from 10 m^3 digesters as seen in Fig. 4) into a pipeline that leads to a central CHP unit. Electricity is distributed back to the farms and heat is used centrally for drying crops, mainly maize.

Fig. 4. Picture of one of 33 small scale (10 m^3) digesters on 33 small family farms in Parana State in Brazil

Electricity

Larger scale biogas plants most commonly use CHP engines to generate electricity for export to the grid. In Germany for example, the installed electricity generating capacity at the end of 2014 was 3750 MWe (Fig. 2) including biogas from all sectors (Task 37 Country Reports, 2015). With larger scale biogas plants typically in the range 100-500 kWe, electrical conversion efficiencies up to 45% can be achieved with optimised CHP installations. There is clearly an advantage of scale with CHP systems and hence the attraction of linking individual smaller plants by biogas pipelines. The major challenge for large biogas CHP systems is effective utilisation of heat. In remote farm locations heat utilisation can be a major challenge, even for smaller biogas plants. Careful energy infrastructure, industry and town planning can help this situation considerably as demonstrated in Denmark where waste heat from biogas production is utilised in extensive district heating systems. One example of a new scheme in Denmark is described in a Task 37 Case Story (May 2015) for the Ringkøbing-Skjern Municipality in western Jutland, where biogas produced in around 60 distributed biogas plants will be piped to a number of strategically located CHP plants (typically 4 MWe output electricity capacity) to ensure high conversion efficiency to electricity and maximum use of the heat in district heating systems.

Upgrading to biomethane

One way to avoid non-use of heat from a CHP system is to upgrade biogas to biomethane. Biogas contains in the region 50% to 60% methane, with a balance of mainly carbon dioxide. It is necessary to remove most of the carbon dioxide in order to obtain biomethane, which has very similar properties to those of natural gas. This option can provide the best utilisation of energy in the original biogas unless almost all heat from a CHP system can be used effectively.

Biomethane can be injected into natural gas grids and used in all natural gas applications. Numerous countries have formulated standards to ensure the maintenance of gas quality for biomethane natural gas grid injection. The European committee for standards (CEN) has developed a draft standard for gas grid injection of biomethane based on national inputs; this is scheduled to be adopted in 2017. Two associated biomethane standards from CEN will cover biomethane use for road transport. One of these covers use as a vehicle fuel of biomethane transported by natural gas grids, and the other covers biomethane produced for dedicated vehicle use and not supplied via the gas grid. In the latter case, higher purity methane gas is the main advantage, which can lead to higher performance as a fuel.

Grid injection provides the most practical option for off-site gas storage, and for very long times (Fig. 5), but there are challenges on the horizon when large volumes of gas are injected into low pressure local distribution grids where demand may be less than supply in summer months. As a consequence, additional pressurisation will be needed at additional cost to take biomethane into the larger capacity and higher pressure parts of the gas grid; this is described in chapter 16 of the Biogas Handbook (2013).

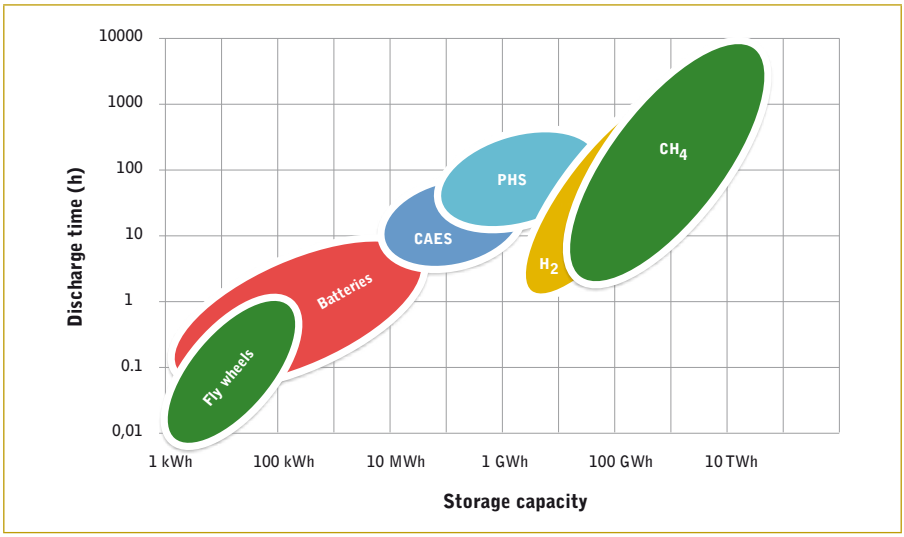


Fig. 5. Comparison of various energy storage systems with respect to discharge time and storage capacity (modified by Persson et al. (2014) from Specht et al., 2011). (CAES: Compressed Air Energy Storage, PHS: Pumped Hydro Storage, H_2: Hydrogen, Methane: CH_4)

Biogas upgrading can be performed by one of a number of well-established technologies. A detailed review of the technologies has been undertaken by Task 37 (Petersson et al., 2009). Over recent years the installed capacity for biogas upgrading has increased exponentially and performance has been steadily improved by reducing energy consumption and methane emissions as described in chapter 15 of the Biogas Handbook (2013).

Upgrading is increasingly followed by liquefaction to give a product equivalent to liquefied natural gas that is used as heavy-duty vehicle fuel to facilitate long distance travel between refuelling stops. The liquefied biomethane option is also attractive for regions

that lack a natural gas grid such as described in the Task 37 Case Story, Lidköping, (September 2014). Although not yet common on the market, cryogenic upgrading of biogas is well suited to producing liquefied biomethane.

Utilisation as vehicle fuel

Compressed Natural Gas (CNG) use as vehicle fuel has been growing at an exponential rate since about 1990. There were about 20 million vehicles by the end of 2012. CNG is used as a transport fuel in many countries, most notably in non-OECD countries such as Iran, Pakistan, Argentina, Brazil and India, although increasingly in OECD countries. Biomethane is used as a direct replacement for natural gas in natural gas vehicles (NGV) and results in the same engine performance as natural gas, but with lower GHG emissions. According to IEA (2010), the average reduction of GHG emissions from light duty vehicles operated on fossil CNG is 25% as compared with gasoline. While GHG emissions for diesel and CNG seem to be more dependent on type of vehicle, emissions of particle matter and NOx are significantly lower for CNG and biomethane. This gap is closing with time as general emissions regulations are becoming more stringent. CNG and biomethane have significant benefits in terms of noise compared with traditional liquid fossil fuel powered vehicles.

Existing gasoline fuelled vehicles can be readily retrofitted to run on CNG/biomethane, and can be either dedicated to run only on gas or they can be bi-fuel or dual fuel (running on either gasoline or gas). Diesel engines for heavy duty trucks and buses can also be retrofitted with the spark ignition systems for dedicated running on gas, or with a blend of diesel and gas, in which case diesel provides the ignition source. Nowadays, many original equipment manufacturers produce vehicles to run on natural gas/biomethane.

Digestate and nutrients

Digestate is the mixed solid and liquid residue from anaerobic digestion that contains all the nutrients present in the original feedstock. One of the strengths of AD is that nutrients are preserved and can be readily recovered for use as biofertiliser in the next cycle of agricultural production (Table 1). A simplified illustration of carbon and nutrient flows on a livestock farm is shown in Fig. 6. It is necessary however, that care must be taken in the treatment and use of digestate to ensure that the amounts of unwanted heavy metals, pollutants and pathogens as well as weed seeds are minimised.

Table 1. Nutrients present in plant and animal products (Lukehurst et al., 2010)

Macro nutrients	Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulphur (S)
Micro nutrients/ trace elements	Boron (B), Cobalt (Co), Copper (Cu), Chlorine (Cl), Iron (Fe), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), Selenium (Se), Zinc (Zn)
Heavy metals	Lead (Pb), Chromium (Cr), Cadmium (Cd), Mercury (Hg)

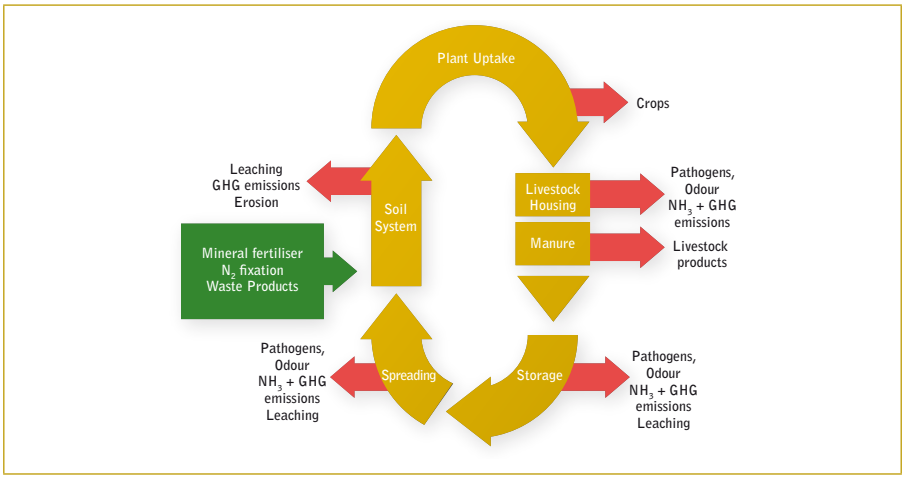


Fig. 6. Simplified illustration of carbon and nutrient flows and environmental impacts on a livestock farm (Source: Petersen et al., 2006).

Practices for digestate management differ according to the origin of biogas feedstock. The key principle is that tight control of feedstock composition will enable high quality biofertiliser to be produced, whereas slack control will lead to a high risk of contamination that cannot subsequently be removed in a cost effective manner. A common strategy, and one adopted in many national regulations, is that animal slurry is collected and stored for extended periods so that field spreading can take place during crop growing seasons. That way, crops get the maximum benefit from available nutrients in the biofertiliser. The fact that crops are taken away from farms and animal feed is often brought in from other areas, even imported from other countries, means that balancing nutrients available from biogas plants to nutrient needs in arable farming is a significant challenge and requires careful management. Ensuring high quality of digestate and its use as a biofertiliser are topics addressed in detail in two Task 37 reports (Al Seadi et al., 2012 and Lukehurst et al., 2010) and one case story from Sweden (Task 37 Case Story, April 2015). Processing digestate to separate out key nutrients (e.g. phosphorus and nitrogen) is particularly important in nitrate vulnerable zones and where eutrophication of ground water is a high risk. While extra processing of digestate results in higher investment and operating costs, this may be necessary in order to meet the level of environmental protection required in regulations. Digestate processing is addressed in a Task 37 report by Drosg et al., 2015.

Storage of biogas and controllable electricity generation

The amount of variable renewable electricity generated in the world is rapidly increasing and with it there is a need to address the challenges of maintaining grid stability. Energy storage and controllable electricity generation are vital components of a stable electricity network and the biogas sector has the possibility to contribute to both of these. Biogas, or better still biomethane, can be readily stored as a gas for periods of hours to months in very high volumes, and equally important, energy can be recovered within a very short period (Fig. 5).

There are various types of gas storage at biogas plants (Fig. 7). At a steady rate of biogas production gas can typically be stored for between 1 to 16 hours and then used in a combined heat and power (CHP) engine running at full capacity. Interestingly, 16 hours is roughly an overnight period of operation and could enable higher sales ofelectricity over one of the daily peaks of demand (such as between 7am and 9am).Some gas storage is in any case needed to smooth out fluctuations in the biogas composition for optimum CHP engine performance. Short-term biogas storage facilities are an integral part of a biogas plant and thus included in the cost of investment. Longer term storage inevitably means additional cost of investment.

Fig. 7. Examples of biogas storage facilities: (left) a simple inflatable bag store on a very small farm; (middle) a flexible cover integrated into a digester; (right) a separate on-site gas store.

Biogas facilities acting together as energy suppliers

Numerous biogas plants can be linked by biogas pipelines to centralised gas utilisation to benefit from the economies of scale and higher conversion efficiencies achieved with larger CHP units or larger biogas upgrading systems. This concept of sharing larger scale facilities to reduce overall cost has already been adopted in a number of places. For example in Brazil, thirty three very small family farms have been linked to a central CHP which also makes better use of waste heat in crop driers (Task 37 Case Stories, September 2013). Another example of a biogas pipeline is in the Netherlands where de-sulphurised and dried biogas is transported from one farm to a local community about 5 km away for use in a CHP (Task 37 Success Stories, October 2011). The CHP provides electricity to

the grid and injects waste heat into a district heat grid in the vicinity of the CHP. There are numerous other examples, including the Ringkøbing-Skjern Municipality project (Task 37 Case Story, May 2015) described above. Local gas grids have also been introduced in places like Sweden where the natural gas grid haslimited coverage (Task 37 Case Stories, September 2014). In the Swedish case the local grid is used to transport biogas to a central upgrading plant and to distribute biomethane to vehicle filling stations. Long term and larger capacity storage can readily be afforded by the natural gas grid after biogas has been upgraded to biomethane. This of course requires a suitable injection point into the natural gas grid.

There is an ambitious concept developed in Bavaria to pool the resources of approximately two thousand three hundred biogas plants to form a single virtual power plant that can be managed centrally in a manner that is better than if plants are operated independently (Schmidt et al., 2013). This nevertheless means increasing biogas storage capacity for the concept to have a significant impact. In the Bavaria example, flexible operation would provide 450 MWe of additional power, which is approximately 15% of the fluctuating demand of electricity.

Demand driven biogas techniques

One approach gaining attention is satisfying fluctuating energy demand by regulating biogas output from the AD process. This can reduce the need for additional biogas storage capacity, although a number of additional steps have to be taken to maintain control of the AD process. For example, loading of fresh feedstock to the biogas reactor can be limited to particular times of the day, ahead of predicted peaks in energy demand. The Sobacken biogas plant near Borås in Sweden has a feeding pattern set to allow compliance with the hygiene requirements associated with food waste. The digester is fed for 10 hours, feeding is then stopped and nothing is either injected or discharged for the next 10 hours. For the final 4 hours of the day digestate is discharged until the starting volume of liquor in the digester is reached. It may be noted in Figure 8 that biogas production varies from 100 to 450 Nm^3 per day. Thus while not intended to match electricity demand from the grid, the stop start nature of feeding allows a peak to trough biogas output of 4.5 to 1. This feeding approach has been in operation for several years and AD process performance has not been adversely affected. These issues are addressed in a Task 37 report by Persson et al. (2015).

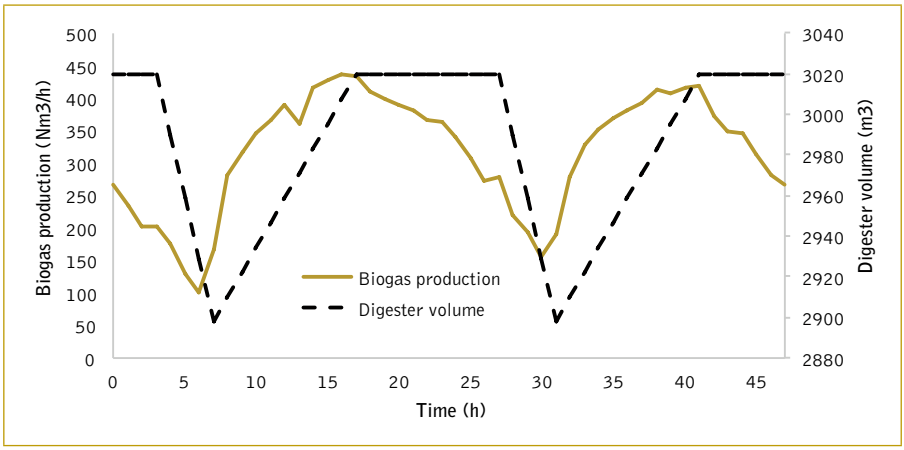


Fig. 8. Biogas production and feed injection during a 48 hour period at the Sobacken biogas plant in Borås. (Source: Borås Energi och Miljö)

Power to Gas systems

Many countries have embraced renewable intermittent electricity sourced from wind, wave and sun. Of issue is that the time and rate of electricity production is dependent on the weather and not on demand for electricity. Thus at times (for example by night in summer) electricity generation can exceed demand. Storage of electricity is not straightforward. Power to Gas (P2G) is a flexible decentralised option not requiring large scale, such as would be required for a pumped hydroelectric scheme. The existing natural gas grid can supply significant storage (Fig. 5) in combination with P2G.

Power to hydrogen involves use of electrolysis systems to convert electricity to hydrogen which may be injected straight to the natural gas grid (Fig. 9). However hydrogen, the smallest of gas molecules, can escape from natural gas pipes. The levels of hydrogen allowed in many gas grids, is as such limited.

Fig. 9. 2MW Power to Gas unit based on alkaline electrolysis in Falkenhagen, Germany. The hydrogen is injected into the gas grid without methanation.(Source: E.ON)

Power to methane requires a further step known as methanation. The stoichiometric equation (Eq.1) describes how 4 moles of hydrogen react with 1 mole of carbon dioxide to give a mole of methane.

$$CO_2\ (g) + 4\ H2\ (g) = CH_4\ (g) + 2\ H_2O\ (g) + \text{heat} \qquad \Delta Hr = -165\ \text{kJ/mole}\ [\text{Eq. 1}]$$

Biological methanation allows a biological upgrading of biogas to biomethane. Hydrogen from surplus electricity may be added to biogas (ca. 50% CH_4 and 50% CO_2) to convert CO_2 in the biogas to CH_4. The end result is upgrading of biogas to biomethane with an almost doubling of total methane output of the digester. The capital cost of the electrolysis/ biomethanation combination is offset by savings on the traditional biogas upgrading process, which is not required (Ahern et al., 2014).

The potential role of biogas in smart energy grids

Biogas systems can facilitate increased proportions of variable renewable electricity on the electricity grid through the combined use of two different technologies:

- Demand driven biogas systems, which increase generation of electricity from biogas at times of high demand for electricity;
- Power to Gas systems, which allow conversion of surplus electricity to gas, when demand for electricity is less than supply.

A new model proposes co-location of demand driven biogas production, CHP systems and Power to Gas systems with gas grid injection (Persson et al. 2014; Ahern et al., 2014). In this model the biogas developer can produce electricity over the few hours of peak demand per day and during periods of low demand can produce hydrogen which can then be used to upgrade biogas to biomethane for gas grid injection.

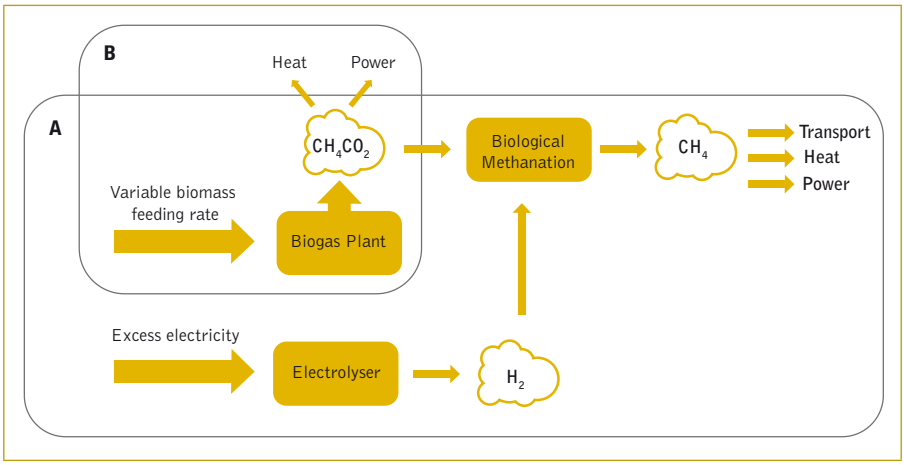


Fig. 10. Co-location of CHP and biological methanation (from Ahern et al., 2015)
A: Gas grid injection after biological methanation at times of low power demand
B: CHP production at times of peak power demand

Six EU gas grids (Denmark, Sweden, Belgium, the Netherlands, France and Switzerland) have signed up to 100% carbon neutral gas by 2050 under the green gas commitment. This greening of the gas grid is proposed through biological production of biomethane, thermo-chemical production of synthetic natural gas (SNG) through gasification of woody crops and Power to Gas systems.

Seaweed biogas as a source of transport biofuel

The European Renewable Energy Directive (2009/28/EC) sets a target of 10% of energy in transport to be renewable by 2020. The Environment Committee of the European Parliament suggested that "advanced biofuels sourced from seaweed or certain types of waste should account for at least 1.25% by 2020." The rationale for producing biofuel or biogas from seaweed is driven by the food-fuel debate and indirect land use change (ILUC). Seaweed takes bioenergy off agriculture land. The quantities of seaweed required to match a significant portion of renewable energy are very large and it is as yet unknown as to how this can be achieved in a sustainable manner. Moreover, certain seaweeds are used for food and have high economic value. A sustainable significant seaweed biofuel industry would probably require the scale associated with aquaculture. Cultivating seaweed adjacent to fish farms can be extremely beneficial both in terms of growth rate of seaweed and in removing excess nutrients from receiving waters. Cost sustainable seaweed biogas will probably require integration with food and fuel systems such as fish farms and biorefineries. Seaweed biogas is addressed in a Task 37 report by Murphy et al. (2015).

Microalgae as a source of biogas

Micro-algae cultivation may take place in open ponds (which are open to contamination) or in closed photobioreactors (which are more expensive in terms of energy input and financial investment and operation). For biodiesel production the ambition is to maximise lipid production for esterification. The big advantage of anaerobically digesting microalgae is that neither a pure culture is needed, nor a specific compound (e.g. lipids for biodiesel) needs to be produced. Both these advantages can significantly reduce the costs of producing microalgae biomass. Microalgae may be used to capture CO_2 produced by power plants. The scale of raceway ponds or photobioreactors for significant carbon capture is very large. The energy input in mixing, harvesting and conversion of microalgae to biogas is very significant and may be of a scale that more energy is used in the process than generated in the biogas. A micro-algal biogas industry is far from commercialisation. Again for a sustainable significant micro-algae biogas system innovation and integration is required. Micro-algae could be cultivated whilst capturing the CO_2 from renewable energy such as biogas facilities thereby reducing the need for biogas upgrading and thus improving the net energy return. High value products are needed to offset high production costs in a biorefinery model. Algal biogas is addressed in a Task 37 report by Murphy et al. (2015).

Summary and Recommendations

Biogas technologies have evolved greatly over recent decades. The role of biogas systems has expanded from waste treatment processes to facilitating technologies for smart energy systems. Energy outputs can be managed both in terms of rate and timing of output. The feedstocks available now also include for seaweed and micro-algae. Biogas systems are now a source of second generation (from grasses) and third generation (from algae) transport biofuels. Multiple choices are now available to the biogas developer:

- Treat wastes from municipalities, from agriculture and from process industries or treat crop systems to maximise energy output.
- Produce relatively constant electricity generation or demand driven (time dependent) biogas electricity;
- Act alone or pool resources with many other biogas developers to act as a single larger energy entity.
- Upgrade biogas to biomethane using traditional CO_2 scrubbing techniques or through reaction of CO_2 in biogas with hydrogen from surplus electricity or by allowing microalgae to remove CO_2 from biogas and then use the algae as feedstock;
- Sell advanced transport biofuel on site or downstream after upgrading.
- Facilitate greening of the gas grid (use of biomethane in the gas grid to generate a renewable gas as a substitute for all natural gas processes).
- Act as a facilitator of intermittent renewable electricity through a combination of demand driven biogas and Power to Gas concepts.

Challenges remain. The economics of biogas production must improve. With the exception of some waste treatment processes, some form of financial support is needed to ensure economic viability of many biogas plants. It is necessary to design systems that minimise capex and opex. For example, HDPE digester systems may offer considerable cost advantages over reinforced concrete tank digesters. With appropriate planning, markets can be exploited for heat from biogas. Electricity may achieve higher prices when the electrical demand is high. Sale of electricity and transport biofuels at different times may optimise financial return.

Research and development is required to maximise methane concentration in biogas and reaction kinetics. This may be achieved through pretreatment and/or through co-digestion with other suitable substrates.

Environmental sustainability must be ensured through minimisation of methane leaks (see Task 37 report by Linke et al. 2015), reduction in parasitic energy demands of the process, minimal use of fossil based fertilisers in energy crop production; and integration of biogas systems with other suitable processes, such as aquaculture, or alcohol or biorefinery systems.

Acknowledgements

We would like to thank all national representatives of Task 37 for their active enthusiastic contributions to the constructive discussions and wide ranging publications of the Task.

References

Ahern, E., Deane, P., Persson, T., O' Gallachoir, B., Murphy, J.d. (2015) A perspective on the potential role of renewable gas in a smart energy island system. Renewable Energy, 78 (2015) 648–656

Al Seadi, T., Lukehurst, C.T., (2012) Quality management of digestate from biogas plants used as fertiliser, IEA Bioenergy Task 37 report, May 2012. Available from: http://www.iea-biogas.net/files/daten-redaktion/download/publi-task37/digestate_quality_web_new.pdf

Al Seadi, T., Owen, N., Hellström, H., Kang, H., (2013) *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, aimed to be used as feedstock for anaerobic digestion in biogas plants,* IEA Bioenergy Task 37 report, November 2013. ISBN 978-1-910154-00-7 (printed) ISBN 978-1-910154-01-4 (eBook)

Bachmann, N. (2015) *Sustainable biogas production in municipal wastewater treatment plants, IEA Bioenergy Task 37 report, September 2015.* ISBN 978-1-910154-21-2 (printed) ISBN 978-1-910154-22-9 (eBook)

Battini, F., Agostini, A., Boulamanti, A.K., Giuntoli, J., Amaducci, S., (2014) *Mitigating the environmental impacts of milk production via anaerobic digestion of manure: Case study of a dairy farm in the Po Valley,* Science of the Total Environment, 481, 196–208

Biogas Handbook (2013) *The Biogas Handbook: science, production and application,* Edited by Wellinger, A., Murphy, J.D., Baxter, D., Woodhead Publishing Series in Energy No. 52. ISBN 978-0-85709-498-8 (printed) ISBN 978-0-85709-741-5 (online)

Drosg, B., (2013) *Process Monitoring in Biogas Plants,* IEA Bioenergy Task 37 report, December 2013. ISBN 978-1-910154-02-1 (printed) ISBN 978-1-910154-03-8 (eBook)

Drosg, B., Fuchs, W., Al Seadi, T., Madsen, M., Linke, B., (2015) *Nutrient Recovery by Biogas Digestate Processing,* IEA Bioenergy Task 37 report, June 2015. ISBN 978-1-910154-15-1 (printed) ISBN 978-1-910154-16-8 (eBook)

EU Nitrates Directive, (1991) *Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources.* Available from: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31991L0676

IEA, (2010) *The contribution of natural gas vehicles to sustainable transport,* International Energy Agency Working Paper, Michiel Nijboer

Linke, B., Liebetrau, J., Agostini, A., (2015) *Methane emissions from biogas plants – Measurement, calculation and evaluation,* IEA Bioenergy Task 37 report, In Press

Lukehurst, C.T., Bywater, A., (2015) Exploring the viability of small scale anaerobic digesters in livestock farming. IEA Bioenergy Task 37 report, in press

Lukehurst, C.T., Frost, F., Al Seadi, T., (2010) *Utilisation of digestate from biogas plants as biofertiliser,* IEA Bioenergy Task 37 report, June 2010. Available from: http://www.iea-biogas.net/files/daten-redaktion/download/publi-task37/Digestate_Brochure_Revised_12-2010.pdf

Mesa-Dominguez, E., Styles, D., Zennaro, K., Thompson, P., (2015) *Evaluating cost-effective greenhouse gas abatement by small-scale anaerobic digestion,* REA and Bangor University (UK), July 2015

McBean, E.A., (2011) In-situ estimation of the methane generation rate for a wet and highly organic solid waste landfill, International Journal of Environment and Waste Management, 8(1/2) 123 – 132

Montgomery, L.F.R., Bochmann, G., (2014) *Pretreatment of feedstock for enhanced biogas production,* IEA Bioenergy Task 37 report, February 2014. ISBN 978-1-910154-04-5 (printed) ISBN 978-1-910154-05-2 (eBook)

Murphy, J.O., Drosg, B., Allen, E., Jerney, J., Xia, A., Herrmann, C., (2015) *A perspective an algal biogas,* IEA Bioenergy Task 37 report, August 2015. ISBN 978-1-910154-17-5 (printed) ISBN 978-1-910154-18-2 (eBook)

Persson, T., Murphy, J.D., Jannasch, A-K., Ahern, E., Liebetrau, J., Trommler, M., Toyama, J., (2014) *A perspective on the potential role of biogas in smart energy grids,* IEA Bioenergy Task 37 report, December 2014. ISBN 978-1-910154-12-0 (printed) ISBN 978-1-910154-13-7 (eBook)

Petersen, S.O., Sommer, S.G., Bernal, M.P., Burton, C., Böhm, R., Dach, J., Dourmad, J.Y., Juhász, C., Leip, A., Mihelic, R., Misselbrook, T., Martinez, J., Nicholson, F., Poulsen, H.D., Provolo, G., Sørensen, P., Weiske, A., (2006) *Recycling of manure and organic wastes – a whole-farm perspective,* 12th Ramiran International conference – Technology for Recycling of Manure and Organic Residues in a Whole-Farm Perspective, DIAS report Plant production No. 122, August 2006, Volume 1, pp. 9-15 ISBN 87-88976-99-8

Petersson, A., Wellinger, A., (2009) Biogas upgrading technologies – developments and innovations, IEA Bioenergy Task 37 report, October 2009. Available from: http://www.iea-biogas.net/files/daten-redaktion/download/publi-task37/upgrading_rz_low_final.pdf

Schmidt, M., Schäfer, R., Ortinger, W., (2013) *Bayernplan: An Innovative Business Concept for Biogas,* 21st European Biomass Conference and Exhibition, June 2013, ISBN 978-88-89407-53-0

Specht, M., Zuberbuhler, U., Baumgart, F., Feigl, B., Frick, V., Sturmer, B., Sterner M., Waldstein, G., et al., (2011) *Storing Renewable Energy in the Natural Gas Grid: Methane via Power-to-Gas (P2G): A Renewable Fuel for Mobility,* October 2011

Task 37 Case Stories, (2015) Available from: http://www.iea-biogas.net/case-studies.html

Task 37 Country Reports, (2015) *IEA Bioenergy Task 37 Country Reports Summary 2014.* ISBN 978-1-910154-11-3

Task 37 Success Stories. Available from: http://www.iea-biogas.net/success-stories.html

US EPA, (2012) *Landfill Gas Energy: A Guide to Developing and Implementing Greenhouse Gas Reduction Programs,* U.s. Environmental Protection Agency Report, EPA-430-R-09-047. Available from: http://www.epa.gov/statelocalclimate/documents/pdf/landfill_methane_utilization.pdf

World Bank (2015) Access to Electricity (% population). Available from: http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS/countries?display=graph.

International Energy Agency

The International Energy Agency (IEA) is an autonomous organisation which works to ensure reliable, affordable and clean energy for its 29 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, Estonia, 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 2015 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 2015, 23 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, the United Kingdom, the USA, and the European Commission.

IEA Bioenergy is now 38 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 10 ongoing Tasks during 2015:

- 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 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 2015 is shown in Appendix 1.

A progress report for IEA Bioenergy for the year 2015 is given in Sections 1 and 2 of this Annual Report.

ExCo75 study tour group on visit to AFBI, Hillsborough, Northern Ireland.

Progress Reports

1. THE EXECUTIVE COMMITTEE

Introduction and Meetings

The Executive Committee (ExCo) 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 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 75th ExCo meeting took place in Dublin, Ireland on 19-21 May with 39 participants. The 76th ExCo meeting was held in Berlin, Germany on 26th October and there were 46 participants. The IEA Bioenergy Conference 2015 was held in conjunction with the Berlin meeting. Pharoah Le Feuvre represented IEA Headquarters at both ExCo75 and ExCo76.

Kees Kwant of The Netherlands chaired both ExCo meetings in 2015 with Sandra Hermle of Switzerland in the role of Vice-chair. At ExCo76, Kees Kwant and Sandra Hermle were re-elected as Chair and Vice-chair respectively for 2016.

Secretariat

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 and newsletters, 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 of the ExCo, with some of the achievements and issues during 2015, is described below.

Implementing Agreement

The Committee on Energy Research and Technology (CERT), at its meeting on the 17-18 February 2015, approved the extension of the Implementing Agreement for the period 1st March 2015 to the 29th February 2020.

Contracting Parties/New Participants

A complete list of the Contracting Parties to IEA Bioenergy is included in Appendix 3.

The dialogue with Estonia regarding membership of the Agreement is continuing. There are also ongoing discussions with China, India, Russia and Thailand with a view to engaging them in IEA Bioenergy.

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 2015 approved by the Executive Committee for the ExCo Secretariat Fund and for the Tasks are shown in Appendix 2. Total funds invoiced in 2015 were US$1,970,520, comprising US$263,100 of ExCo funds and US$1,707,420 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 in **US$ only** 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 of 31 December 2015, there was US$74,000 of Member Country contributions outstanding.

At ExCo72, unanimous approval was given to the appointment of KPMG, Dublin as independent auditor for the ExCo Secretariat Fund until 31 December 2015. The audited accounts for the ExCo Secretariat Fund for 2014 were approved at ExCo75.

The Tasks also produce audited accounts. These are prepared according to guidelines specified by the ExCo. The accounts for the Tasks for 2014 were approved at ExCo75.

The audited accounts for the ExCo Secretariat Fund for the period ended 31 December 2015 have been prepared and these will be presented for approval at ExCo77 in Rome.

Task Administration and Development

Task Participation

In 2015 there were 109 participations in 10 Tasks. Please see Appendix 1 on page 97 for a summary of Task participation.

The joint project with the Advanced Motor Fuels Implementing Agreement on 'Enhanced Emission Performance and Fuel Efficiency for Heavy Duty Methane Engines', which was carried out under Task 41 Project 4 was completed and the final report was published in 2015. The report can be downloaded at http://www.ieabioenergy.com/publications/enhanced-emission-performance-fuel-efficiency-hd-methane-engines-2014-final-report/.

Strategic Planning and Strategic Initiatives

Strategic Plan

The new Strategic Plan 2015-2020 with an emphasis on optimising the economic, environmental and social value of sustainable bioenergy, including some focus on biorefinery value chains, became operational in 2015. The implementation of the plan can be expected to

- promote the optimisation of the economic, environmental and social value of bioenergy through
  - research and development collaboration
  - identification of best practices in bioenergy policy
  - pro-active communication with the main stakeholders
- increase participation in our Agreement, particularly by leading players in IEA non-member countries
- facilitate accelerated deployment of bioenergy globally.

Technical Coordinator

Dr Arthur Wellinger retired from the role of Technical Coordinator at the end of 2015. During his time as Technical Coordinator inter-Task projects have become standard resulting in enhanced outputs from IEA Bioenergy, and collaboration with IEA Headquarters and other relevant international organisations has been strengthened. A Core Group has been established to facilitate more effective management of the Agreement with regular telephone meetings and an IEA Bioenergy communication strategy has been agreed at ExCo71 and is being implemented. Arthur has been involved in all three End of Triennium conferences and has played a leading role in the organisation of the latter two, in Vienna in 2012 and in Berlin in 2015. The Chair availed of a break during the IEA Bioenergy Conference 2015 to gather ExCo members and Task Leaders in order to express the gratitude of the Agreement for his contribution to IEA Bioenergy dating back more than 20 years and Arthur, in response, noted his appreciation to IEA Bioenergy for being a "wonderful collaboration" and having a continuous commitment to the development of bioenergy.

Following a *Call for Applications* and presentations by a number of applicants at ExCo76 in Berlin, Luc Pelkmans was appointed as the new Technical Coordinator beginning on the

1st January 2016. Luc has been involved with IEA Bioenergy since 2008, being the Belgian National Team Leader in Task 40, the Alternate Member for Belgian between 2009 and 2012 and then the Member since January 2013. He has led the IEA Bioenergy Communications Team. He has also coordinated the inter-Task project on *Monitoring Sustainability Certification of Bioenergy* and has been involved in the preparation of the inter-Task project on *Mobilising Sustainable Bioenergy Supply Chains*.

Communication Strategy

The Executive Committee has supported the continuing work of the Communications' Team. A number of initiatives in social media have been implemented. An IEA Bioenergy LinkedIn company (IEA Bioenergy Implementing Agreement – https://www.linkedin.com/company/iea-bioenergy-implementing-agreement) has been set up. In addition, an IEA Bioenergy Twitter account has been opened, with automatic tweets of all new publications and event listings. At ExCo76 in Berlin, a five month contract was awarded to the Canadian Institute of Forestry/ Institut forestier du Canada to expand the IEA Bioenergy Twitter 'followers'. The contract also included the development of three IEA Bioenergy webinars over the period, including providing the required technical support, the associated advertising campaigns and the assessment of impact. A decision has been taken to harmonise and integrate as far as possible the IEA Bioenergy website and the various Tasks' websites, the goal being to enhance the effectiveness of the dissemination of Agreement outputs.

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.

Progress with strategic initiatives has continued. The summary and conclusions from the ExCo72 workshop 'Electricity from Biomass: from small to large scale' and those from the ExCo74 workshop 'Bioenergy: land use and mitigating iLUC' have been formally published and can be download at http://www.ieabioenergy.com/publications/exco72-electricity-from-biomass-from-small-to-large-scale-summary-and-conclusions/ and http://www.ieabioenergy.com/publications/exco74-bioenergy-land-use-and-mitigating-iluc-summary-and-conclusions-01-10-15/ respectively, as can the publications from other ExCo workshops.

'Mobilising Sustainable Bioenergy Supply Chains': The Strategic Project *Mobilising Sustainable Bioenergy Supply Chains* was completed in 2015 and the final report was launched at the *IEA Bioenergy Conference 2015* in Berlin in October. The report can be downloaded from http://www.ieabioenergy.com/wp-content/uploads/2015/11/IEA-Bioenergy-inter-task-project-synthesis-report-mobilizing-sustainable-bioenergy-supply-chains-28ot2015.pdf. Please refer also to page 2 of this Annual Report.

Algae Review: Although most of the work has been carried out, completion of the final report has been delayed due to unforeseen circumstances. It is expected that it will be published in the second quarter of 2016.

Pre-study – Bioenergy boosted RES Hybrids: The pre-study was completed with a workshop on the 4th December 2015 followed by a final report, which briefly describes the idea and state of art of technologies that combine bioenergy with at least one other renewable energy source. The report formed the basis for the development of a special project on Bioenergy RES Hybrids to be carried out in 2016.

Database for IEA Bioenergy

Work on the database, which will present IEA Bioenergy data in a common format with a focus on the technology Tasks, is continuing. It is expected that the work will be completed in early 2016.

ExCo Workshops

At ExCo75 in May a very successful internal workshop themed 'Planning for the new triennium' was held. Detailed proposals for programmes of work for the triennium 2016-2018 were presented by Task Leaders. The ExCo also considered proposals for strategic projects which were seen as important accompanying actions. Several topics were subsequently developed for Executive Committee review and decisions at ExCo76 in Berlin.

There was no internal workshop at ExCo76. The meeting was held in conjunction with the *IEA Bioenergy Conference 2015* in Berlin – see section at the beginning of this Annual Report.

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 facilitates effective exchange of information between the participants and information transfer 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 33 organised an expert workshop on the topic of "Renewable Energy and Products from Biomass and Waste, hosted by University of Seville and CIUDEN in Ponferrada, Spain in May, 2015
- Task 38 took part in a 2-day "Climate Change Effects of Biomass and Bioenergy Systems Conference" hosted by Linnaeus University in Växjö Sweden in May, 2015.

- Task 39 members participated in the 21st International Symposium on Alcohol Fuels (ISAF) held in Gwangju, Korea in March 2015
- Task 40 coorganised a workshop on Biomass Trade and Supply in a Global Bio-Based Economy with the European Commission funded project DiaCore in Sassari, Sardinia, Italy in May 2015
- Task 43 was co-organiser of the conference "Mobilization of woody biomass for energy and industrial use – Smart logistics for forest residues, prunings and dedicated plantations" at FAO Headquarters in Rome in May 2015

Collaboration with International Organisations and Implementing Agreements

Advanced Motor Fuels Implementing Agreement

IEA Bioenergy and the Advanced Motor Fuels (AMF) Implementing Agreement have completed two joint projects and continue to maintain close communications. This is facilitated, particularly through participants who are directly involved in both Agreements. The work programmes of each are reviewed regularly to identify further opportunities for collaboration.

GBEP

The collaboration between IEA Bioenergy and the Global Bioenergy Partnership (GBEP) within the GBEP Activity Group 6 "Bioenergy and Water" continued, co-chaired by Task 43 with the assistance of Task 40. At a workshop on "*Examples of Positive Bioenergy and Water Relationships*" in Stockholm in August, 2015 presenters showed an encouraging variety of examples in terms of geographical distribution, bioenergy system design (feedstock supply and conversion technology) and water-related challenges addressed. They highlighted the multiple environmental, social and economic benefits of good practices in bioenergy production and management of water resources. Selected examples also provided insights into governance aspects. The final report is expected to be published in the first quarter of 2016. There are on-going discussions about further collaborative work.

FAO

The collaboration with FAO under the MoU signed in 2000 has continued with discussions between the IEA Bioenergy Chair and Olivier Dubois of FAO. It is planned to hold a joint workshop in conjunction with the IEA Bioenergy ExCo77 meeting in Rome in May 2016.

IRENA

Jeffrey Skeer of IRENA attended ExCo76 in Berlin and Dolf Gielen of IRENA was a panel member in the closing session of the *IEA Bioenergy Conference 2015* in Berlin. Collaboration between the two organisations is developing, including agreement to provide reviews for documents prior to publication and to cooperate in organising joint workshops, where appropriate.

SE4ALL

IEA Bioenergy has signed a Memorandum of Understanding on participation in the Steering Committee of SE4ALL's high impact opportunities (HIO) initiative. The initiative, which includes partners from FAO, RSB, KLM and Novozymes, seeks to enable industries to set up new supply chains in biomass.

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, which is re-emphasised in the new Strategic Plan 2015-2020. The wide range of promotional material available through the Secretariat includes Annual reports, technical brochures, copies of IEA Bioenergy news, the new Strategic Plan, strategic papers, and workshop proceedings. The IEA Bioenergy website is central to this publishing activity.

The 2014 Annual report with the special colour section on *"Quantifying the Climate Effects of Forest-Based Bioenergy: Dealing with spatial and temporal boundaries"*, was very well received. Some copies from the original print run of 600 remain, with substantially increased distribution in electronic format.

The newsletter 'IEA Bioenergy News', which is distributed in June and December each year following the ExCo meetings, continues to be widely circulated. Two issues were published in 2015. As a special theme the first issue featured bioenergy in Ireland and the second issue featured bioenergy in Germany. The newsletter is also produced in electronic format and is available from the IEA Bioenergy website. A single page electronic newsletter covering recent ExCo and Tasks' activities was also produced and distributed at the end of March and September 2015. A free subscription to the Agreement newsletters is offered to all interested and there is a wide distribution outside of the normal IEA Bioenergy network.

Two contributions under the banner of 'IEA Bioenergy Update' were provided to the journal Biomass and Bioenergy in 2015 bringing the total to 59. 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. In 2015 the Technical Coordinator has reviewed a number of IEA documents for publication, including Energy Technology Perspectives and the Medium Term Report 2015. He has also had regular engagements to facilitate data exchange from IEA Bioenergy to IEA Headquarters and vice-versa.

The Chair of IEA Bioenergy, Kees Kwant, attended the REWP meeting in Paris in March. At an IEA workshop on renewable energy in industry in Paris in May he gave a presentation on a biorefinery approach. In September the Chair attended an Energy Technology Network meeting called by the new Executive Director of IEA, Dr Fatih Birol. The aim of the meeting was to discuss ways to raise awareness of the accomplishments of the IAs and to empower a bigger role for the IAs in the IEA strategic activities.

Pharoah Le Feuvre attended both ExCo75 and ExCo76 on behalf of IEA Headquarters. 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 ExCo75 and ExCo76. Information was also sent to Nils-Olof Nylund, Vice Chair of the End Use Working Party (EUWP) for the Transport sector. This forms part of the exchange of information between Implementing Agreements and the Working Parties. 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 stake holders. 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 had incremental development in 2015. The content has been updated as required during the year.

From the website statistics for the year 2015 the key data were as follows:

- Total number of users: 25,000
- Total number of sessions: 33,500
- Total number of page views: 85,700

Awards and Colleagues Recognised

Doctor Clare Lukehurst, the UK National Team Leader in Task 37, was made an Officer of the British Empire (OBE) in the Queen's Birthday Honours list for 2015. The award was for services to the Anaerobic Digestion industry. Clare is widely acknowledged as one of the UK's leading experts in AD and has been a fellow of the British Institute of Agricultural Consultants for over 15 years, specialising in renewable energy and rural development, in particular biogas.

At the 23rd European Biomass Conference and Exhibition in Vienna on the 1-4 June 2015, the Task 42 poster entitled "*BioEconomy Strategies in the Member Countries of the IEA Bioenergy Implementing Agreement – Current Status, Approaches and Opportunities*" was deemed to be a particularly valuable contribution. Further details can be found at http://www.ieabioenergy.com/publications/poster-award-for-iea-bioenergy-task-42/.

2. PROGRESS IN 2015 IN THE TASKS

TASK 32: Biomass Combustion and Co-firing

Overview of the Task

Task 32 aims 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.

Biomass combustion technologies are commercially established with high 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 the past triennium were:

- 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
- 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 Enterprise 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 2015, the Task organised two internal meetings and an expert workshop. The internal meetings were used to monitor progress in different Task activities, plan and reflect on Task-initiated workshops, and share recent developments on application of biomass combustion in member countries of the task.

Workshops are a proven concept to gather and disseminate information in a structured and effective manner, and in the past triennium five workshops were held on various topics. Normally, 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 October 2015, a workshop on 'highly efficient and clean wood log stoves' was organised in conjunction with the IEA Bioenergy conference, with support from several national associations of stove manufacturers. It was attended by approximately 70 participants, mainly representatives from stove manufacturing industries. The workshop provided insight into the effectiveness of various technical measures that can help to further improve efficiency and emissions of typical woodstoves sold today. This includes a properly designed furnace chamber, eventually by using CFD design tools. Successful innovations include automatic controlled air supply, catalysts and PM filters. Important factors on emissions are the use of

wood with suitable moisture content, proper user behaviour and an adequate installation and integration of the stove into the building. These factors can be addressed by user trainings organised by stove suppliers and by quality certification schemes for installers.

Several other workshops were held earlier in this triennium. All 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 progress achieved during 2015 in the work programme of the triennium 2013-2015 is shown below:

1. Fuel characterisation, pretreatment, and supply

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

In 2015 Task 32 published an overview of advanced biomass fuel characterisation techniques. Major contributions to this report came from Sweden, Denmark, Canada and Germany, as well as an EU R&D project where the conversion behaviour of 15 fuels in 5 different conversion systems were investigated. The project involved collaboration with Tasks 33 and 34. The report provides a good overview of the merits and downsides of various new methods available for characterising biomass fuels for thermal conversion, and gives direction to which method to use in what case.

Status report on torrefaction technologies (D11)

In 2015 a report was published on the technology status of biomass torrefaction technologies. The report provides an updated overview individual technology suppliers, and also provides key results from recent research on torrefaction.

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 are carried out:

Expert workshop on highly efficient and clean stoves (D16)

This well visited workshop for policy makers and stove manufacturers was held on 29 Oct 2015 in parallel to the IEA Bioenergy Conference in Berlin. Wood stoves contribute

significantly to renewable energy use. However, where obsolete technologies are applied or the stove is not properly operated, there may be significant adverse effects on public health. The workshop focused 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 woodstoves.

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. In 2015 Task 32 will compile the results of various co-normative and pre-normative research projects that support this process.

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

This task project aims to produce a short policy relevant summary and a separate background technical report of recent studies on the health impacts of combustion aerosols. The action will address recent R&D work done on the formation and health impacts 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. A start was made in 2015, and it is intended to publish both reports shortly after a planned expert workshop on the same topic in June 2016.

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.

TEA and 'best practice' combustion for CHP (D18)

In 2015 Task 32 published a techno economic evaluation of various typical combustion based CHP projects. The report with case studies provides insight into the actual costs faced with these projects, which is useful for project developers.

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 held in September 2015 at Drax Power Station, jointly 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 is kept updated with the latest information available worldwide. In 2015 the database was restructured as a collaborative action with other tasks.

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

This concerns a technical summary report on the achievements and technical experience for biomass cofiring to date. The report includes case studies and country reports for various Task 32 member countries. It was prepared mostly in 2015, and will be published in February 2016.

Website

The Task website (www.ieabioenergytask32.com) attracts about 4,000 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 2015, 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 as 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.

Deliverables

The following milestones were achieved in 2015. Organising and minuting of two Task meetings. Organising and reporting of a workshop on 'Highly Efficient and Clean Wood Log Stoves'; Publication of reports on 'Advanced Biomass Fuel Characterisation Methods for Solid Fuels', 'Status overview of torrefaction technologies', 'Techno-economic Evaluation of Selected Decentralised CHP Applications Based on Biomass Combustion with steam turbine and ORC processes', 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, Norway, Sweden, Switzerland and USA.

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

Operating Agent: Jim Spaeth, U.S. Department of Energy, USA

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 the Task website www.ieatask33.org and the IEA Bioenergy website www.ieabioenergy.com under "Our Work: Tasks."

Task Meetings and Workshops

The first Task 33 meeting for 2015 was held May 11-13, 2015 in Ponferrada, Spain. The Task meeting was held on the first day and the workshop "Symposium on Renewable Energy and Products from Biomass and Waste" was held on the second and third day.

The second Task 33 meeting was held October 27-29, 2015 in Berlin, Germany, together with the IEA Bioenergy Conference 2015. The session "Commercial success of biomass gasification for power, heat and fuels" was the first session on the program of the conference. The half-day Task meeting was held in the afternoon of October 29, after the site visits.

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, Spain and Brazil, 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 Program/Sub-task Studies

The current work program 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 "Symposium on Renewable Energy and Products from Biomass and Waste"	11-13 May 2015 Ponferrada, Spain
2nd Task meeting	IEA Bioenergy Conference 2015	27-29 October 2015 Berlin, Germany

- 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 Workshop 1: Symposium on Renewable Energy and Products from Biomass and Waste

The workshop took place in the area of CIUDEN, where one of the European large scale projects was carried out by Foundation *Ciudad de la Energía* (CIUDEN). Firstly, worth mentioning is the layout of CIUDEN´s plant in order to have a clear idea about the size of the installations and, consequently, the representative results that could be obtained. More information regarding the facility can be found at the Task 33 website. Workshop presentations are summarised below.

Session 1: Gasification, CO_2 capture and synthesis

- **Thermal conversion of wastes: The separation of steps**
  Bo Leckner, Chalmers University of Technology, Sweden
- **Process developments for CO_2 capture and valorisation methods at CIEMAT**
  Jose Maria Sanchez Hervas, CIEMAT, Spain
- **CO_2 valorisation in a biomass to fuel process: experimental gasification study and process evaluation**
  Sylvie Valin, CEA, France
- **Time-integrated greenhouse gas emissions in the thermochemical conversion of municipal waste and forest residues**
  Leif Gustavsson, Linnaeus University, Sweden

Session 2: Design of new concepts of thermochemical biorefineries

- **Advanced biorefinery concept based on cultivated macroalgae**
  Judit Sandquist, SINTEF, Norway
- **Thermochemical biorefineries with multiproduction: hydrocarbonylation of DME into fuels and chemicals**
  Pedro Haro, University of Sevilla, Spain
- **Doubling of synthetic biofuels production via hydrogen from renewable electricity**
  Ilkka Hannula, VTT, Finland

Session 3: Demonstration and commercialisation

- **INERCO technology for biomass gasification**
  Juan Luis Cruz, INERCO, Spain
- **Progress in commercial scale CFB gasification for waste and biomass**
  Juhani Isaksson, Valmet, Sweden
- **Commercialisation of WtE through gasification technology developed by ECN**
  Bram van der Drift, ECN, The Netherlands
- **Carbon capture challenges and CIUDEN**
  Miguel Angel Delgado, CIUDEN, Spain

- **Development and demonstration of solar-biomass hybridisation technologies**
  Manuel Silva Perez, CTAER, Spain
- **Biomass and vaste valorisation in an Irish perspective**
  JJ Leahy, University of Limerick, Ireland
- **The Life Programm as a driver for the development of more efficient technologies for carbon capture and biomass/waste utilisation**
  Carlos de la Paz, Life, EU Commission

All of the workshop presentations as well as the workshop report can be found at the Task 33 website (www.ieatask33.org).

Observations from IEA Bioenergy Conference 2015

Task 33 was responsible for arranging Session I on Commercial Success of Biomass Gasification for Power, Heat and Fuels. The presentations in that session were:

- **The GoBiGas-plant is now producing biogas from forest residues**
  Ingemar Gunnarsson, Göteborg Energi, Sweden
- **Commercial scale gasification to replace fossil fuel in power generation – Vaskiluodon Voima 140 MW CFB gasification project**
  Juhani Isaksson, Valmet Technologies, Finland
- **Latest developments in German biomass gasification processes**
  Georg Wagener-Lohse, Fördergesellschaft Erneuerbare Energien (FEE), Germany
- **Catalytic and electrochemical conversion of biomass resources**
  John Bøgild Hansen, Haldor Topsøe, Denmark

All conference presentations can be found at the Task 33 website (www.ieatask33.org) or at the conference website.

Website and database

The Task website (www.ieatask33.org) is the most important tool for dissemination of information and results from this Task. In autumn 2015 the new design of the website and database was set up.

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 has been incorporated into the Task website. At the moment, there are over 150 gasification facilities, mostly in member countries, registered in the database. 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 around the world.

At the moment, a status report on thermal biomass gasification in member countries is finishing. The report will include the description of the technology, synthesis gas applications and a list of all biomass gasification facilities in member countries, which are active in the Task 33 database.

Deliverables

The Task deliverables include 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 IEA Bioenergy Excecutive Committtee (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, Norway, and USA

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

Operating Agent: Mr Jim Spaeth, 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'.

Progress in R&D

Task Meetings

Task 34 members convened in Hengelo, Netherlands, on May 19-21, 2015. On May 19, many of the meeting participants gathered for technical tours. The tour stops included OPRA, Twente University, and BTG.

The Task meeting convened on May 20.

Introductions:

Participating countries were represented by their national team leaders: Douglas Elliott, US; Dietrich Meier, Germany; Anja Oasmaa, Finland; Bert van der Beld, Netherlands; Tony Bridgwater, UK; Magnus Marklund, Sweden; and Kai Toven, Norway. Also in attendance were observers from participating countries: Irene Watkinson, UK; Tim Schulzke and

Axel Funke, Germany; Weihong Yang, Sweden; and Paul de Wild, Ron van der Laan, Gerrit Brem, Sascha Kersten and Robbie Venderbosch, Netherlands. The participants also included observers from Italy, David Chiaramonti and Andrea Rizzo.

The IEA Bioenergy Task 34 members and observers

Country Reports:

Reports on current activities of interest were presented by representatives from US, UK, Finland, Germany, Sweden, Norway and the Netherlands.

Pyrolysis Brochure:

A publication plan for the information collected on bio-oil applications is underway. The effort involves an update of the earlier IEA Bioenergy Biomass Pyrolysis document. Input from the various participants was identified. A limited run of paper copies will be printed.

Round Robin:

The round robin to examine the consistency of bio-oil production within the fast pyrolysis community is nearing completion. Three standard feedstock forms were tested in 16 participating laboratories. Analysis of samples is nearing completion at the Thünen Institute. Results of the Round Robin will be distributed to the participants and published by the end of the year. An important initial finding is that all laboratories produced a two-phase bio-oil product when processing the wheat straw feedstock provided.

Norms and Standards:

Developments within the CEN working group were presented and discussed. An update paper on bio-oil norms and standards has been published with Anja Oasmaa as the lead author.

Newsletter:

Writing assignments were made for the next issue of the newsletter due out in June 2015.

Task Plan for Next Triennium:

The full proposal, prepared based on Task member input, was presented and accepted at the ExCo meeting in Dublin on May 19th. At the ExCo meeting five countries indicated their plan to participate (US, Germany, Sweden, Netherlands and new member, New Zealand) while three others (UK, Norway and Canada) indicated interest in the task. Finland was not represented but is expected to participate. Denmark was also not represented at the meeting, but back channel communication suggests their participation as well. Based on the expanded membership it is likely that the per country participation fee may be reduced. Confirmation is expected in the final proposal to ExCo to be prepared by September. After further discussion, a techno-economic assessment (TEA) work element was included into the Task plan at the request of the UK.

On May 21st the Task members participated in the Empyro Symposium at the BTG fast pyrolysis site in Hengelo. The morning agenda included presentations given on IEA Bioenergy Task 34 by Task Leader Doug Elliott, European status by Kyriakos Maniatis, and on the status of the Empyro plant by Gerhard Muggen and Ardy Toussaint of BTG-BTL. Tours of the plant followed. In the afternoon the symposium continued with presentations on sustainability by Martijn Vis of BTG, CEN standardisation by Pia Saari of Fortum, Bio-oil firing at Friesland Campina, and in OPRA turbines and tests in catalytic cracking by Petrobras with a final overview by Patrick Reumerman of BTG.

The second Task 34 meeting for 2015 was held at the campus of the Technical University of Berlin on October 29, 2015. All seven National Team Leaders (NTLs) were in attendance as well as the proposed replacements for the two soon-to-retire NTLs.

Prior to the Task meeting, Task Leader, Doug Elliott, presented the Task 34 proposal at ExCo76 in Berlin on October 26.

The same six members who indicated interest at the previous meeting agreed to join the task, including new member – New Zealand. Four countries are still undecided. The budget, and related participation in intertask collaborations and strategic projects, cannot be finalised until decisions are made relative to the number of participants, which could be as high as ten or as low as six.

Task 34 organised the pyrolysis session at the IEA Bioenergy Conference on October 27. Four speakers representing the four leading organisations in commercialisation of biomass fast pyrolysis made presentations with Task Leader Doug Elliott as the session chair.

The final issues open in the Triennium were discussed at the Task meeting.

The Round Robin write-up is being drafted and further improvements identified, which will be undertaken over the next few weeks.

The pyrolysis brochure is still being developed at Aston and a formal draft is expected by the end of November. Publication requirements, including the number and distribution of hard copies, were discussed.

The input for the final newsletter for the year were discussed. The newsletter should be out by the end of December.

The demo database is coming together and is now online on the Task website. Some needing data revisions were identified.

Work Programme and Progress in 2015

The work typically consists of Task meetings, seminars, 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 Working Group was organised. Two of the NTLs from Task 34 are active members of the Working Group. Input was provided to the Working Group on bio-oil analytical methods. Several of the task participants collaborated with other WG members in a technical publication on norms and standards for bio-oil. (see below)
- The round robin on bio-oil production was completed. Sixteen laboratories in the six participating countries returned bio-oil samples produced from the three biomass feedstocks distributed. The product bio-oils were analysed by Thünen Institute. The results of the Round Robin along with distributions and conclusions were prepared in draft form and 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 the input collected in 2013 on Applications for bio-oil, planning for a new descriptive brochure on biomass pyrolysis was underway.
- A web-based demo plant database developed by Bioenergy 2020+ was provided with the initial data by the task members and launched on the Task 34 website.

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 37 was published in July 2015 and Issue 38 was published in December 2015.

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 were completed to various stages by the end of the year.

Collaboration with Task 32 on bio-oil combustion did not proceed beyond discussions when the original country participants changed internal plans and priorities.

The collaboration with Task 33 involving bio-oil gasification was undertaken in Germany. The desired scope expanded to such a level that there was insufficient resources to complete and rescoping is being considered.

The Collaboration with Task 38 on LCA was complete in 2014.

The collaboration with Task 39 led to the web-based database expansion described above, including pyrolysis systems. A further collaboration with Task 39 was providing input on thermochemical conversion of algae for the updated report on algae to biofuels. The text was provided to the report organisers, and it was incorporated in significant part into the final report. In addition, the text was the basis for a technical journal article recently published. (see below)

The collaboration with Task 40 and Task 42 resulted in drafting chapters on pyrolysis for the book, *Logistics of a Biobased Economy*.

Deliverables

Deliverables for 2015 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. Completion and reporting of a Round Robin on bio-oil production.

TASK 36: Integrating Energy Recovery into Solid Waste Management

Overview of the Task

In 2012 the World Bank estimated that there was around 1.3 billion tonnes of waste produced per annum globally and that this would grow to 2.2 billion tonnes/year by 2025. They attributed this rise in waste production to increased urbanisation in developing and emerging economies and the increase in per capita production of waste as a result of this trend. This trend is a considerable challenge for many countries. To meet the challenge there will need to be intensive legislative, managerial and institutional changes, including the introduction of strategic direction aimed at decreasing and controlling waste production; and the development of recycling, reduction and re-use as well as energy technologies to decrease the impact of waste. IEA Bioenergy Task 36 investigates the interface between waste management and energy recovery. Our prime aim is to understand the implications of technical and policy changes in the waste area that impact the integration of energy into solid waste management; and to provide support by disseminating and exchanging information on these developments.

Waste production varies markedly across the world, in terms of composition and quantity. Strategies and solutions that are appropriate in one region may not be right elsewhere. The consequence of this is that countries have different approaches to challenges in waste arisings, reflected in different mixtures of treatment and disposal. Nevertheless there are also common themes. Uppermost in these are concerns relating to the increasing quantities of waste needing to be treated and the impact of landfilling mixed wastes on the environment. In some regions additional pressures arise from decreasing available landfill void space. This is driving policy makers to examine alternatives to landfill, including reduction and recycling of waste, and recovery of value from waste, commonly encompassed in the 'Waste Hierarchy', which is governed by a set of principles dedicated to minimising the impacts of waste and improving resource use. In some regions there are calls for 'zero waste to landfill' and for policy to encourage the circular economy or 'smart waste management'. These moves are most advanced in the European Union and other regions where landfill is expensive or scarce. 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 continue to require guidance and information on waste and resource management systems that are environmentally and economically sustainable. 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. Over the past year it has provided 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 Energy and Environment, 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

Task meetings and workshops

The Task's core work was undertaking structured Task meetings, each of which was accompanied with a themed workshop. The aim of these workshops was to allow Task members to present work on the nature of the issues concerned within their own country; to invite speakers to present work of relevance and to allow discussion of the issues presented. Over the 2014-15 period the Task held the following workshops, of which the topics were:

- Factors influencing the development of energy from waste (held in June 2015)
- The role of energy from waste in a Circular Economy, in association with ISWA, (held in October 2015)

The workshops held are outline in more detail below:

A workshop focussed on factors influencing the development of energy from waste, including public perception, legislation and policy changes, and health issues. *Bordeaux, June 2015*

Workshop aim:

In 2012, the World Bank estimated that there was around 1.3 billion tonnes of waste produced per annum globally and that this would grow to 2.2 billion tonnes/year by 2025. They attribute this rise in waste production to increased urbanisation in developing and emerging economies and the increase in per capita production of waste as a result of this trend. The workshop examined the impact of government policy on the development of EfW in different member countries, and the impact this had on technology, application and outputs.

Workshop outcomes:

Whilst recycling of waste continues to increase in developed economies, the demand for treatment of residual waste continues to grow. EfW has long been recognised as playing a vital role in meeting European waste targets. The EfW technologies adopted in any one place are very much linked to what is driving their development in policy terms. The outcomes of the workshop include updates from all Task 36 members on how policy, public perception, legislation and health issues were impacting on the development of EfW in member countries. Presentations made by each member country are available on the Task 36 website.

A joint workshop with the International Solid Waste Association Waste to Energy working group on the role of energy recovery in a Circular Economy, *Berlin, October 2015*

Workshop aims:

The aim of the workshop was to facilitate discussion between Task 36 and the ISWA WtE working group on the role of EfW in a Circular Economy. The workshop consisted of presentation by Task 36, ISWA, and facilitated workshops sessions.

Outcomes:

The workshop consisted of facilitated sessions which sought to examine the following questions:

- Is Energy Recovery from waste an integral part of a Circular Economy?
- What are the opportunities that a Circular Economy presents to EfW?
- What changes will EfW face as we move towards the Circular Economy?

- What are the current and future barriers that will need to be overcome to ensure EfW is part of a Circular Economy in developed and developing nations?

A summary report from the workshop is available on the Task 36 website.

Task Meetings and site visits

The Task held two meetings in 2015. The first took place on 2-4 June 2015 in Bordeaux, France. This meeting was held in association with the workshop on factors impacting on waste to energy development as outlined above. A study tour allowed the Task to visit the Sivom WtE plant at Pontenx les Forges, and the CHP Power facility at Morcenx.

The second Task meeting took place in Berlin in and around the IEA Bioenergy Conference on 27-30th October 2015. During this week, we also held a workshop in association with the International Solid Waste Management Waste to Energy working group, as described above. This meeting including the workshop on Energy from waste – the next generation described above. The task also visited the New Earth Solutions waste gasification facility at Avonmouth in Bristol. A meeting note and note on the site visit is available on the Task 36 website.

Deliverables

The deliverables for the Task in 2015 have included presentations for the two Workshops. A further deliverable was the presentation of a paper which titled *'An Evaluation Of Arisings And Markets For Waste Derived Fuels In Wales'* at the 5th International Symposium on Energy from Biomass and Waste in Venice in November. The Task also prepared two progress reports and an annual audit report for the Executive Committee. These are listed in Appendix 4.

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 2015, there were 56,776 visits to the website, with an average of 156/day. These were fairly evenly spread across the year. Where the country of origin is known, the most page views were from users in the UK, US, China, Germany and France. Other countries visiting the site included Japan, Poland, Romania, South Korea, Australia and Turkey and numerous other European countries.

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 thousands of 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, particularly at small farm-scale, in order to reduce both investment and operating costs and to increase income.

The approach of Task 37 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. In addition, there is growing interest in the use of biogas and biomethane to help stabilise power grids that are increasingly fed from variable sources of generation like wind and solar.

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 at small and large farm-scale, in waste water treatment plants and treatment of the biodegradable fraction of municipal waste (biowaste), energy crops and algae.

Only recently has the environmental performance of biogas production and utilisation been assessed in detail. Recent studies have identified key sources of emissions of greenhouse gases at various stages of the biogas production chain. In collaboration with a Swedish nationally-funded project, Task 37 has addressed emissions and is directing attention to environmental sustainability of biogas production and utilisation and is working towards defining best practices for emissions reduction.

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 drafting of standards in Member Countries.

Participating countries: Australia, 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

In 2015 the work programme consisted of the following Topics:

- Continuation of on-going work on preparation of technical reports
- Collaboration with other Tasks (main activity with Tasks 39 and 43)
- Reports to ExCo75 and ExCo76
- Extending the range of published Success Stories and Case Studies
- Consolidating contacts with the growing number of national mirror groups
- Website: updating; maintenance; proceedings, country reports, plant lists, etc.
- Planning of future Task meetings and workshops

Some of the Task members participated in the 23rd European Biomass Conference in Vienna at which biogas was a key focus. There has been close cooperation with a Swedish national project on measurement of methane emissions from biogas plants and with the European Biogas Association (EBA).

The progress made on Task Topics is summarised below.

New Technical Brochures/Reports

Four new technical reports were published in 2015. The first, on "Nutrient recovery by biogas digestate processing" was the product of an extended study at University of Natural Resources and Life Sciences (BOKU) in Austria. The report addresses the technical challenges of processing digestate for the purpose of maximising nutrient recycling. While economics play an important role in process viability, the report identifies a number of treatment options that are both effective and economically viable.

The second technical report on "A perspective on algal biogas" assesses the prospects of macroalgae (seaweed) and microalgae for large scale production of biogas. The assessment was largely based on the state of development of technologies and energy balance achievable, with economic data presented where available. The main conclusion was that while seaweed is already being used for biogas production in specific situations, microalgae is probably better targeted at higher value products. Excerpts of the Task 37 algae report were provided to Task 39 for inclusion in the algal biofuels report being prepared in collaboration with other Tasks.

The third technical report on "Sustainable biogas production in municipal wastewater treatment plants" was the first such report from the Task on wastewater treatment. The report reviews the various innovative options for exploiting the energy recovery potential during wastewater processing, while at the same time ensuring high overall performance of the process and improved environmental performance, including recycling of nutrients. Two separate Case Studies were published in association with this report, one in 2014 (from Switzerland) and one in 2015 (from Sweden).

The final technical report on "Exploring the viability of small scale anaerobic digesters in livestock farming" was prepared in response to the growing demand to reduce GHG emissions from farm animal manure. The particular challenge is that around the world most farms are quite small and that dairy herds for example have typically 100 animals. This is not enough to provide feedstock for the most common size of biogas plants even in developed countries. The challenge is therefore to find ways of achieving economic viability at small scale where unit costs are expected to be high. The report explores approaches and identifies options that should enable small farm scale AD that will provide an effective means to reduce GHG emissions and at the same time provide an additional source of local renewable energy.

One new IEA Bioenergy report was published jointly in collaboration with Task 43 on "Mobilisation of sustainable bioenergy supply chains". This was a major report on mobilisation of biomass and the supply chains for bioenergy and biofuels production to which Task 37 contributed technical information and editorial support, but no authorship of texts.

The Task published an updated Country Report Summary in January 2015. The summary contains information on the biogas sector in each of the Task member countries, including energy recovery data, biogas utilisation data, details of support schemes and key research projects.

New Case Studies

Three new Case Studies were published in 2015. The first covered a scheme established in Sweden for certification of wastewater treatment plants for the purpose of ensuring the production of high quality digestate from sewage sludge through strict controls on wastewater streams from industry and municipalities. The second Case Study uses the example of the Ringkøbing-Skjern project in Denmark to demonstrate an extended network of biogas plants

that is integrated into the energy supply to rural communities. Lastly, a project (Solrød) set up to counter odour problems caused by seaweed washed up on beaches in Denmark is described. Seaweed growth is increased by run-off of nitrate-rich water from areas of intensive agricultural. As well as the seaweed being an additional source of biomass for renewable energy, collection and processing in a biogas plant allows nutrients to be recycled and odour due to natural rotting to be avoided.

National Biogas Mirror Groups

The Task maintains close links with national mirror groups. Linked to the business meeting in March 2015, the Task contributed to the national Green Gas Research Outlook Sweden 2015 conference.

Collaboration with Other Tasks

Task 37 collaborated closely with Task 43 on the Strategic Inter-Task Study on mobilising sustainable bioenergy supply chains, which resulted in an IEA Bioenergy publication in October 2015.

Task 37 contributed chapters of macroalgae and microalgae for biogas production to the Inter-Task Study on algal biofuels led by Task 39.

Task 37 collaborated with a Swedish national project on methane emissions measurements from biogas plants. The main role of Task 37 was life cycle assessment using data generated by the project. Publication of an IEA report will follow in 2016.

Website

The website (www.iea-biogas.net) is updated with news, biogas data and publications (including national biogas reports using a new "biogasreports" tool – www.biogasreports.com). The Country Reports as well as the Task publications, proceedings of the workshops and newsletters were made available along with important publications from the participating countries.

Task Meetings and Workshops

Two Task meetings were held in 2015. The first meeting was hosted by Energiforsk on March 25th to 27th in Uppsala, Sweden. Task 37 members also contributed to the Green Gas Research Outlook Sweden (GGROS) conference on the days before the Task meeting.

The second meeting took place on October 29th and 30th in Berlin, Germany, and was hosted by ATB-Potsdam. The meeting concluded discussions on the outstanding reports

scheduled to be published by the end of the 2013-2015 work programme and agreed the basis for implementation of the new 2016-2018 work programme. This meeting followed the IEA Bioenergy 2015 conference in which the Task organised a parallel session on "Biogas integration in sustainable energy systems".

Planning of Future Task Meetings and Workshops

Task meetings in 2016 will be held in the UK (13-15 April), including a technical workshop held in cooperation with local biogas organisations, and in Australia in association with the Bioenergy Australia conference.

Deliverables

The deliverables for the Task included: publication of technical reports, case studies, minutes of the Task meetings, progress reports to ExCo75 and ExCo76, Country Reports (including a consolidated Country Report summary), one parallel session within the IEA Bioenergy Conference 2015, newsletters 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 mitigation of climate change, energy security, and rural development. Reduction in greenhouse gas (GHG) emissions has become an issue of great international importance. Mounting evidence of climate change and its impacts, together with developments in emissions trading through international, regional, national, bilateral and multilateral agreements, have stimulated abatement activities. While bioenergy has grown dramatically, particularly due to favourable policy environment in Europe and the USA, there is intensifying debate about the climate change benefits 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 improved 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 bioenergy systems and of forest carbon sequestration. Our objective is to support decision makers in government and industry, in the development of climate change mitigation strategies.

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

Task Leader: Annette Cowie, New South Wales Department of Primary Industries/ University of New England, Australia

Task Manager: Miguel Brandão, Royal Institute of Technology, Stockholm, Sweden

Operating Agent: Stephen Schuck, Bioenergy Australia, Australia

The Task Leader directs and manages the work programme, with the assistance of the Task Manager. A National Team Leader from each country is responsible for coordinating national participation in the Task by each participating country.

For further details on Task 38, please refer to 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

During 2015 Task 38 held two face-to-face meetings of national team leaders, organised one Task 38 conference, co-organised one joint workshop and presented a session at the end of triennium conference.

Task 38 Business Meeting: Växjö (Sweden) 25 May

- Five of the eight participating countries (Australia, Finland, Germany, Sweden, USA) were represented at the meeting.
- Key discussion points:
  - Progress reports on items on workplan, particularly paper in development on choosing the appropriate reference system with which to compare a bioenergy system, to determine the climate change mitigation benefits – decisions on next steps;
  - Brief input from NTLs on recent developments in each country.

Task 38 Conference, Växjö, Sweden 26-27 May 2015,

Topic: Climate Change Effects of Biomass and Bioenergy Systems

- Hosted by Linnaeus University
- Presentations on climate effects of managed forest systems, wood products and bioenergy, including presentations from four Task 38 members.
- Excursion to the Växjö Energy AB, visit CHP-plant, Limnologen Wood-frame apartment buildings and Södra Climate Arena.

Task 38 session End of Triennium conference Berlin

Task 38 presented the session: "Quantifying climate change effects of bioenergy" at the conference "Realising the world's sustainable bioenergy potential". Four members of Task 38 presented papers.

Task 38 Business Meeting: Berlin 29 October

- Six of the eight participating countries (Australia, Brazil, Finland, Germany, Sweden, USA) were represented at the meeting.
- Key discussion points:
  - reviewing progress and deciding next steps for items on workplan, particularly paper in development, on metrics for quantifying climate effects of emissions and removals associated with bioenergy systems.
  - Discussion on recent papers that present negative results for bioenergy;
  - Brief input from NTLs on recent developments in each country;

Joint Task Workshop: Berlin 30 October

- Experts from Task 38 participated in the workshop on Quantifying climate effects of forest-based bioenergy, jointly organised by Tasks 38 and 43
- Key points:
  - Presentations of studies on quantifying climate effects of forest-based bioenergy from member countries
  - Presentations on quantifying and managing iLUC
  - Policy development in GHG accounting
  - Economic and energy system modelling
  - Planning for future collaboration

Next Meeting

The next Task 38 Business Meeting will be held in the USA in April 2016.

Work Programme

In 2015 the Task:

- Organised two Task 38 face to face business meetings (see above)
- Organised a one day conference on the theme of climate effects of forest-based bioenergy (see above)
- Co-organised one expert working meeting on quantifying effects of forest-based bioenergy(see above)

- Presented a session at the end of triennium conference
- Progressed the preparation of scientific papers:
  - Metrics for quantifying the climate effects of bioenergy systems:
  - Reference Systems for evaluating climate effects of bioenergy
- Participated in one Inter-Task project ("Mobilising Sustainable Bioenergy Supply Chains")
- Participated at ExCo75 in Dublin and ExCo 76 in Berlin

Scientific Papers

The following scientific papers are under preparation:

Reference systems for evaluating climate effects of bioenergy

Stemming from the two expert meetings in 2012, this paper discusses the importance of the reference system in evaluating the climate effects of bioenergy. It develops 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. A decisions tree is presented to aid researchers and decision-makers in identifying the relevant reference system for their purpose.

Metrics for quantifying climate effects of bioenergy

Also arising from the two expert meetings in 2012 is a paper that discusses the implications of different metrics in evaluating the climate impacts of bioenergy. Climate change effects, including those of biomass and bioenergy systems, are traditionally measured with the cumulative radiative forcing of greenhouse gas emissions (using GWP_{100} to combine impacts of different gases) as the indicator, but other indicators such as global temperature potential could be used.

Updating the Standard Methodology

The standard methodology for calculation of GHG emissions for different bioenergy systems developed by Task 38 is in the process of being up-dated in order to capture the latest and best available knowledge and state-of-the art methods for modelling the climate change effects of biomass and bioenergy systems. The task is currently working on a paper which shows how the climate change effects of biomass and bioenergy systems ought to be modelled by defining sharply the research question, choosing the appropriate system boundaries, reference system and functional unit, as well as integrating new scientific topics, such as the timing of GHG flows, direct and indirect land use change impacts and non-greenhouse gas effects (e.g. albedo effect) and how to deal with e.g. harvested wood products. The completion of the paper is postponed until the metrics and reference system papers are completed, as it will refer to these.

Comparison of Major Life Cycle Assessment Models

Several papers are under preparation addressing: (1) models and practices used in policy implementation for GHG emissions in Europe, United States, and Canada; (2) other environmental impacts for commercial biofuels; and (3) prospective models used in conjunction with technology development evaluation. Topic (1) methodology was developed in 2014 and accepted for presentation at the 2015 IEA Bioenergy Conference [1], and will be used in conjunction with Task 39, to prepare a short IEA report explaining differences reported in the various IEA and IEA Bioenergy task reports.

Inter-task Projects

Joint workshop on Quantifying climate change effects of forest-based bioenergy, Berlin, October 30, 2015 (see also above)

Tasks 38 joined Task 43 in devising and presenting this workshop which brought together researchers with a range of views on the role of forest-based bioenergy in contributing to climate change mitigation. The workshop was successful in facilitating dialogue between experts from different disciplines, discussing the appropriate approaches for assessing the climate effects of bioenergy, and priorities for future collaborative research between Tasks 38 and 43.

Mobilising sustainable bioenergy supply chains

Task 38 collaborated in this large project led by Task 43, and contributed to several of the supply chain case studies. Annette Cowie was a member of the Coordination Committee for this Inter-task Project. Alison Goss Eng from the U.S. program provided input to the case study on agricultural residues to Niclas Scott, leader, through Patrick Lamers and Jacob Jacobson of the Idaho National Laboratory (INL); Helena Chum informed the study on the GBEP indicators. Regis Leal and Helena Chum provided input to the component of the project that focuses on cultivated grasslands and pastures, and converting part of the degraded pastureland to ethanol from sugar cane in Brazil. Kristen Johnson from the U.S. provided Task 38 input to lignocellulosic supply chains through Virginia Dale and Keith Kline from the Oak Ridge National Laboratory. Patrick Lamers from INL provided input to the Boreal and Temperate Forest Supply Chain. Task 38 reviewed the reports on each of the supply chains.

1 Helena Chum and Ethan Warner, "Tools for greenhouse gas (GHG) assessment for biofuels: a comparison," 2015 IEA Bioenergy Conference, Berlin, October 27-29, 2015. Presentation in Proceedings of Conference, Session 8, paper #4, available at: http://ieabioenergy2015.org/fileadmin/veranstaltungen/2015/IEA_Bioenergy_Conference/S08-4_Chum.pdf

Website/Communication

Task Website

The Task 38 website (www.task38.org) is the repository of publications and other material produced by Task 38 and predecessor Task Greenhouse Gas Balances of Biomass and Bioenergy Systems.

Information on the site includes:

- Documentation from Joint workshop on Forests, bioenergy and climate change mitigation, Copenhagen, May 19-20 2014: workshop statement, background documents, presentations, summary of discussion
- presentations from all Business Meetings and Workshops
- case studies (identified by both country and process)
- publications of Task 38
- journal publications of Task38 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

Joint workshops

Quantifying climate change effects of forest-based bioenergy, Berlin, October 30, 2015 (see above)

Intertask projects (see above).

Within the inter-Task project "Mobilising sustainable bioenergy supply chains" (a collaboration of Tasks 43, 42, 40 and 38) Task 38 has contributed and reviewed the case studies.

Task 38 is working with Task 39 to review GHG assessment tools for liquid biofuels, and contribute to a review of algae biofuels.

Joint publications:

Berndes, G., Ahlgren, S., Borjesson, P. and Cowie, A.L., 2015. Bioenergy and Land Use Change-State of the Art. Advances in Bioenergy: The Sustainability Challenge, pp.249-271.

Berndes Göran et al., 2015. CULTIVATED GRASSLANDS AND PASTURES IN BRAZIL, in Mobilizing Sustainable Bioenergy Supply Chains, Inter-task Synthesis Report, pages 137-160, IEA Bioenergy, ISBN 978-1-910154-20-5 (electronic) (with Helena Chum and Regis Leal). http://www.ieabioenergy.com/wp-content/uploads/2015/11/IEA-Bioenergy-inter-task-project-synthesis-report-mobilizing-sustainable-bioenergy-supply-chains-28ot2015.pdf

Cintas, O., Berndes, G., Cowie, A. L., Egnell, G., Holmström, H., and Ågren, G. I. (2015). The climate effect of increased forest bioenergy use in Sweden: evaluation at different spatial and temporal scales. Wiley Interdisciplinary Reviews: Energy and Environment.

Schweinle, J., Rödl A., Börjesson, P., Neary, D.G., Langeveld J.W.A., Berndes, MG., Cowie, 2015. Assessing the Environmental Performance of Biomass Supply Chains. IEA Bioenergy Task 43 Report 2015:TR01 http://www.ieabioenergytask43.org/wp-content/uploads/2015/02/IEA-BIOENERGY-TR2015-01i-.pdf

Stupak, Inge; Jamie Joudrey; C. Tattersall Smith; Luc Pelkmans; Helena Chum; Annette Cowie; Oskar Englund; Chun S Goh; Martin Junginger. "A global survey of stakeholder views and experiences for systems needed to effectively and efficiently govern sustainability of bioenergy", *Wiley Interdisciplinary Reviews: Energy and Environment* (11) DOI: 10.1002/wene.166.

IEA Bioenergy, 2015 Mobilizing Sustainable Bioenergy Supply Chains, Inter-task Synthesis Report, pages 137-160, IEA Bioenergy, ISBN 978-1-910154-20-5 (electronic)

Networking

1. Networking with bioenergy-relevant multilateral organisations' projects and publications:

Task 38 contributed expert authors and reviewed a journal paper resulting from the IPCC 5th Assessment Report Working Group 3 Report on Agriculture, Forestry and Other Land Use: Creutzig, F., Ravindranath, N. H., Berndes, G., Bolwig, S., Bright, R., Cherubini, F., Chum, H., Corbera, E., Delucchi, M., Faaij, A., Fargione, J., Haberl, H., Heath, G., Lucon, O., Plevin, R., Popp, A., Robledo-Abad, C., Rose, S., Smith, P., Strømman, A., Suh, S. and Masera, O. (2015), Bioenergy and climate change mitigation: an assessment. GCB Bioenergy, 7: 916–944. doi:10.1111/gcbb.12205. Top 15 most downloaded publication of 2015 in this journal.

IEA Bioenergy experts, including from Task 38, contributed to the development of the SCOPE (Scientific Committee on Problems of the Environment, http://www.scopenvironment.org/) Volume #72, led by the São Paulo Research Foundation (FAPESP). The electronic book publication was released in April 2015 (http://bioenfapesp.org/scopebioenergy/): Bioenergy & Sustainability: Bridging the gaps, SCOPE, (2015). Souza, G. M., Victoria, R., Joly, C., & Verdade, L. (Eds.). (2015). Bioenergy & Sustainability: Bridging the gaps (Vol. 72, p. 779). Paris: SCOPE. ISBN 978-2-9545557-0-6. The contribution of Task 38 specifically included to the multi-authored Chapters and Policy Brief:

- Chapter 1. SCOPE Bioenergy and Sustainability Technical Summary, pp. 8-26. (Chum)
- Chapter 2. Bioenergy Numbers, pp. 28-57 (Chum, Regis Leal)
- Chapter 6. Sustainable development and Innovation, pp. 184-217 (Chum, Regis Leal)
- Chapter 11. Feedstock Supply Chains, pp.348-373 (Regis Leal)
- Chapter 12. Conversion Technologies to Biofuels and Their Use, pp. 374-468 (Chum)
  Chapter 14. Case Studies, pp. 450-527 (Regis Leal)
- Chapter 17. Greenhouse Gas Emissions of Bioenergy, pp. 482-617 (Annette Cowie)*
- Chapter 18. Soils and Water, pp. 618-659 (Annette Cowie)*
  * With contribution from Task 43 (Göran Berndes)
- Bioenergy & Sustainability, Policy Brief, SCOPE, (2015) (Chum)

2. In December 2015 the Finnish team leaders of IEA Bioenergy Task 38 organised a stakeholder workshop in co-operation with the Finnish research programme BEST (Sustainable Bioenergy Solutions for Tomorrow) in Espoo, Finland. The aim was to discuss the current issues in climate impact assessment of bioenergy systems. Altogether 20 participants from Ministry of Employment and the Economy, from 5 private companies and from 3 Finnish research institutes participated, and had a lively discussion on the topic.
3. Annette Cowie presented on Task 38 activities, specifically related to the current debate on climate effects of bioenergy, to the quarterly meeting of Bioenergy Australia in September 2015, and to the Bioenergy Australia conference in December 2015.
4. Annette Cowie presented on the work of Task 38 to the Industrial Ecology group at the Royal Institute of Technology, Stockholm, Sweden

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. 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 38 members.

TASK 39: Commercialising Liquid Biofuels from Biomass

The ongoing low price of oil over the past year continues to challenge the world's biofuel industries, with investments in biofuels declining and projections for future biofuels production capacity scaled back. Against this background, 195 countries signed a historical climate agreement at the UNFCCC COP21 summit, committing to curb GHG emissions to keep global temperatures from rising more than 2ºC above 1900 levels. It was noted that transportation contributes about 14% of the world's GHG emissions and that significant reductions in carbon emissions can be achieved by replacing fossil fuels with biofuels. While the climate agreement did not specifically mention biofuels, it is clear that biofuels will have to play an increasing role if the world is to meet its needed emission reductions. Task 39 continues to play a critical role in facilitating the commercialisation of liquid biofuels from biomass.

Overview of the Task

The goal of Task 39 is to support the commercialisation of liquid biofuels from biomass, including conventional and advanced technologies, "drop-in" and algal biofuels. Through a coordinated program that includes technology, commercialisation, sustainability, policy and markets, the Task assists participants in their efforts to develop and deploy biofuels, including cellulosic ethanol, biomass-based diesel, renewable aviation fuel, etc. through various technology routes such as oleochemical, biochemical, thermochemical and hybrid technologies. 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, including the active involvement of participants from industry, government and academia. The Task continues to lead and coordinate activities in three main program areas:

- **Technology and Commercialisation:**
  - develop and commercialise improved, cost-effective bio-based processes for the generation of advanced biofuels, particularly "drop-in" biofuels from biomass;
  - 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 and challenges in 'next-generation' liquid biofuel technologies, including biomass-to-hydrogen and algae-to-biofuel processes.

- **Policy, Markets, Implementation and Sustainability** encompassing issues that address policy/legislative/regulatory and infrastructure concerns regarding expanding conventional and advanced liquid biofuels; and to 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 'next-generation' biofuels.

- A Multifaceted Communication Strategy to facilitate knowledge transfer, dissemination of information, outreach to stakeholders, and coordination 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, Antonio Bonomi, Franziska Müller-Langer, Nicolaus Dahmen, Christian Koolloos, Claus Felby and Les Edye. Sub-Task leaders for policy, markets, implementation and sustainability include Warren Mabee, Dina Bacovsky, John Neeft, Emile van Zyl, Shiro Saka, Jin-Suk Lee, Ian Suckling and Paulo Barbosa. The Task leadership is assisted by Dr Susan van Dyk (UBC), who acts as Editor of the Task Newsletter and Webmaster. Dina Bacovsky (Austria) manages the demonstration plant database. Franziska Müller-Langer 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 2015, the Task held two business meetings (Gwangju, South Korea and Berlin, Germany), as well as one informal Task meeting (San Diego, USA).

The first business meeting of the year took place on 10 March 2015 in Gwangju, Korea in conjunction with the 21st International Symposium on Alcohol Fuels (ISAF). The Task organised two sessions titled 'IEA Bioenergy Task 39' within the ISAF symposium with 7 speakers (http://www.2015isaf.org). The business meeting took place immediately before the main ISAF conference and most of the member countries attended this meeting. The full day business meeting covered country updates on the status of biofuels in the majority of Task 39 member countries. We also 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 the new triennium.

Task 39 also held a more informal buisness meeting during the Symposium on Biotechnology for Fuels and Chemicals (SBFC) in San Diego on 29 April. The group discussed 3 items: (1) Current status of outstanding deliverables (Advanced Fuels in Advanced Engines; Updated Algal report; LCA model comparisons); (2) Prolongation Proposal (3) program of the Task 39 business meeting in Berlin in conjunction with the IEA Bioenergy end-of-triennium conference. Various suggestions were discussed about where the Task should focus in the coming triennium.

The Task also convened a session on "International Commercialisation Progress" at the 37th SBFC. This included 6 invited speakers from 6 companies who are at the forefront of commercial development of advanced biofuels and sustainable bio-based chemical production. The companies were, Iogen, Novozymes, Abengoa, Borregaard, Genomatica and Katzen International. This session was very well attended (estimated attendance of 300 plus), reflecting strong on-going interest in Task 39 activities within the renewable fuels and chemicals community.

The Task held a second business meeting in Berlin, Germany in conjunction with the IEA Bioenergy Conference on 27-28 October, 2015. The first day of the meeting was focused on current and future collaboration between Task 39 and other Tasks and the Advanced Motor Fuel Implementing Agreement. The multi-Task strategic project "Mobilizing Sustainable Bioenergy Supply Chains", which included Tasks 38, 39, 40, 42 and 43 (and led by Task 43) was completed and findings presented to the meeting. For each of the 5 bioenergy supply chains investigated, the study developed recommendations for better mobilising the supply chain for the specific feedstock class being examined, e.g., the forest biomass supply chain underlying the wood pellet trade between North America and the EU (incl. Britain), highlighting the role of policy. Another multi-Task strategic project, "The potential for Algal biofuels production" update involving Tasks 34, 37, 38, 39, 42 (led by Task 39) is near completion and preliminary findings were discussed. Further collaborative projects which are currently under way are the "Comparison of life cycle assessment models" with Task 38 and 39; as well as the "Advanced Fuels for Advanced Engines" project with Task 39 and AMF IA. The last two projects will continue into the next triennium (2016-2018)

Task 39 organised a session within the IEA Bioenergy conference that profiled several leading companies active in advanced biofuels development and utilisation (Boeing, UPM Biofuels, SkyNRG, Biochemtex). Invited speakers from each of these companies presented at the IEA Bioenergy Conference 2015 in the session entitled, *Progress in the development and use of advanced liquid biofuels.*

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:

Technical Aspects of Advanced Biofuels

Advanced biofuels remain a topic of key importance, including a continued focus on cellulosic ethanol production and commercialisation, although drop-in biofuels production has become more prominent as these fuels are a direct replacement for petroleum fuels, requiring no changes to infrastructure. Several cellulosic ethanol facilities have commenced commercial production worldwide (Chemtex, DuPont, GranBio, POET-DSM), but continue to experience problems with feedstock quality and supply chains. The economics have also become more challenging at this time of low oil prices. Task 39 has facilitated several conference sessions where biofuel producers have been able to share the problems and challenges they are experiencing plus suggesting possible solutions. This forum role is a critical function of the Task and provides a crucial link between international researchers and industries, with the Task acting as both an "honest broker" and as an unbiased, but informed source of knowledge and experience that academia, governments and industries can access.

Drop-in biofuels are especially relevant to transport sectors such as aviation, long distance trucking and marine where no good alternatives exists. The Task's publication of the "drop-in biofuels report" was well-received worldwide as an excellent assessment of the potential and challenges of these advanced biofuels across the whole spectrum of technologies – oleochemical, biochemical, thermochemical and hybrid conversion technologies. As these technologies develop from research and development through to pilot, demonstration and commercialisation, Task 39 will continue to assess and monitor these developments. We will continue to disseminate information to the biofuels community, as an objective observer, giving stakeholders, including governments and policy makers the necessary tools for decision-making. A specific area that has been at the forefront internationally is renewable aviation biofuels (biojet). This need to de-carbonise air travel is being driven by voluntary aviation organisations initiatives, aircraft manufactures such as Airbus and Boeing, as well as by airlines investing in new technologies and entering into offtake agreements for biojet fuels. Task 39 plays a critical role in monitoring and reporting on developments, in addition to providing guidance on the types of policies that will be needed to facilitate biojet development and deployment.

The potential of algal biofuels as a next-generation biofuel has been under investigation by Task 39 over a number of years. This area will continue to be monitored to determine how multiproduct algal-based biorefineries can provide a means to bring algal biofuels to market, including advances in technology and commercialisation.

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. It remains difficult to obtain detailed and accurate information from many of the companies as the various processes approach commercialisation, particularly in areas such as China and India that do not form part of the IEA Bioenergy network. This reinforces the need for our ongoing efforts to recruit these countries into IEA Bioenergy Task 39.

Providing Information on Policy, Regulatory, Infrastructure and Sustainability 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. One of our annual business meetings allocates time for country representatives to present updates on developments in their respective regions. Country report presentations along with the meeting minutes and other presentations from the business meetings are posted in the 'members only' section of the Task website. An annual summary entitled "Implementation Agendas" compiles the country specific information into a single document and is revised every triennium. The purpose of this effort is to maintain the Task's role as a central source of relevant information on biofuels.

Policy has globally played a key role in advancing the development and deployment of biofuels and lack of stable policy has a clear impact on investment in the industry as seen in the USA over the past year as the US EPA delayed the release of final volume obligations for different categories of biofuels. It is also apparent that the aviation industry represents a unique situation as an international industry and requires a different policy approach for advancement of biojet fuels. As biojet is the only long-term solution for the aviation industry to meet their emission reduction targets, establishment of a commercial and stable supply of biojet volumes will remain a priority. However, strong policies will be essential to achieve the increased use of biojet as the various technology routes to biojet develop and mature.

Biofuels can play an important role in reduction of emissions from transportation to meet long-term climate goals. However, not all biofuels offer the same reduction potential. The ongoing analysis of emission reduction potential of different feedstock and technology combinations is vital to measure the carbon intensity and sustainability of biofuels. While many life cycle analysis models are available, they often give different results for the same scenario and the Task's work in comparing models and providing reliable information on emission reduction potential forms an essential component of our work.

Newsletter

The Task has published three newsletters in 2015 (featuring the country reports of Denmark, New Zealand and Germany). 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. The country reports represent a unique source of information to biofuel stakeholders worldwide and we have had regular requests for permission to republish these reports in other magazines.

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

Task 39 participated in the multi-Task collaboration project "Mobilising sustainable bioenergy supply chains" and has contributed a chapter to this report entitled "Challenges and opportunities for the conversion technologies used to make forest biomass based bioenergy/biofuels".

The report on Update on the Status of Algal Biofuels (and products) was a multi-Task project with participation from Tasks 34, 37, 38 and 43.

Other collaborations with IEA AMF and other tasks include work on two ongoing deliverables, namely the Advanced Fuels in Advanced Engines; and Comparison of GHG models for advanced biofuels. Task 39 has been and will continue to collaborate with IEA HQ in updating relevant IEA reports.

Deliverables

The deliverables for the Task in 2015 included: organisation of several meetings throughout the year; two progress reports and audited accounts (submitted to ExCo); development and maintenance of the Task 39 website; three newsletters and the update to our Advanced Biofuel Demonstration Database. 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

There is increasing need to develop biomass resources and exploit biomass production potentials in a sustainable way and to understand what this means in different settings. 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 is '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 does 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 of Sustainable Development, Utrecht University, the Netherlands

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

Secretary: Mr. Chun Sheng Goh, Copernicus Institute of Sustainable Development, Utrecht University, the Netherlands

Operating Agent: Ir Kees Kwant, RVO, the Netherlands

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 2015. The programme and presentations (and in some cases summaries) can be downloaded from the Task website: www.bioenergytrade.org.

On 20 January 2015, the 4th "Biomethane International"- Session was carried out within the conference "Fuels of the Future" in Berlin. The current event was organised in close cooperation between the DBFZ and the IEA Bioenergy Task 40. The session was chaired by prof. Dr. Daniela Thrän. The aim was to address international experts and stakeholders from economy, science and politics. In total, approximately 40 experts joined the session while presentations were held by international experts from five countries. They provided insight in the global and national status and trends for biomethane production and trade. The workshop summary and the presentations are also available on the Task 40 website.

In April, the session "Visions for bio-energy trade in the Baltic Sea region in a ten year perspective" was organised and led by IEA Bioenergy, Task 40 (Sustainable International Bioenergy Trade) at Conference Nordic Baltic Bioenergy, Riga, Latvia. The discussion focussed on the key questions – how will bioenergy trade develop in the Nordic Baltic region in the coming ten years, and what are the driving forces, taking the perspective of the North European region on the potential of biogenic raw materials, woodchips, pellets and liquid biofuels as important sources of income to producers and traders. All presentations are available on the Task 40 website.

In May, under the banner of "Biomass Trade and Supply in a Global Bio-Based Economy", IEA Bioenergy Tasks 40 and 42, together with the European Commission funded project DiaCore, hosted a workshop on May 5 in Sassari, Italy. Many governments across the globe have defined national 'bioeconomy' strategies. However, it remains unclear how the current economy will shift towards a future bioeconomy where chemicals, materials, transport fuels, and other high-value products are derived from non-food materials. Draft findings of a recent Intertask study between Tasks 34, 40, and 42 as well as results of DiaCore on the same topic were presented, and the viewpoints of policy makers and representatives from the biofuels, biopower, and logistics industry were heard and discussed. The workshop was connected to Italian research perspectives in the afternoon on May 5 and included a site-visit to the MATRICA Biorefinery (a Versalis-NOVAMONT joint venture). With the workshop, Task 40 also had an internal meeting in Sassari to discuss the progress of Task activities.

In August, a workshop was organised by The Global Bioenergy Partnership (GBEP) and IEA Bioenergy 43 and 40 on 'Examples of Positive Bioenergy and Water Relationships' in Stockholm, Sweden. GBEP Activity Group 6 ("Bioenergy and Water") aims to identify and disseminate ways of integrating bioenergy systems into agricultural and forested landscapes for improving sustainable management of water resources, including waste water. This includes sharing knowledge and experiences on landscape identification and design, best management practices as well as on policies and instruments supporting bioenergy implementation that contributes positively to the state of water. With the support of the IEA as a GBEP partner, IEA Bioenergy Task 43, assisted by Task 40, is co-chairing the Activity Group and contributing to the work defined in the workplan. In this framework, GBEP Activity Group 6 launched the Call for Examples of Positive Bioenergy and Water Relationships. This initiative aims to showcase innovative examples of how bioenergy systems (in both the feedstock production and conversion phases) can produce positive impacts on the status of water and to serve as a way to inspire and build on this knowledge and experience with other bioenergy producers. The submissions received in response to the Call for Examples were reviewed by the Activity Group and the most relevant among them were selected to be presented at this workshop organised by GBEP and IEA Bioenergy, in collaboration with the Royal Swedish Academy of Agriculture and Forestry (KSLA) and Chalmers Energy Area of Advance, in Stockholm (Sweden). The workshop was broadcast on the web and a dvd will be made available by GBEP, in addition to a web link for direct streaming if technically feasible. More details are available on the Task 43/Task 40 website.

At the IEA Bioenergy conference in October, Task 40 hosted a workshop to discuss lessons from international bioenergy trade for the development of bio-based economy and their implications. The workshop attracted about 100 attendees, not only from European countries but also from outside Europe such as Canada, US and South Korea. It offered information on bioenergy trade, particularly from the aspect of standardisation, sustainability and logistics. It covered the latest development in technical standardisation and sustainability certification of liquid biofuels, biogas and solid biomass, as well as opportunities and challenges in terms of logistics. All presentations are available on the Task 40 website. Task 40 members also met again internally in conjunction with this event to discuss the Task activities and exchange information.

Future Meetings and Workshops

After the kick-off meeting and two one-day workshops on torrefaction (jointly with IBTC and AEBIOM) in Utrecht in January 2016, the next meeting of Task 40 is scheduled in May 2016, and will be held in Stockholm, Sweden, possibly linked to the World Bioenergy Conference. The final meeting is tentatively planned to be in the US in November 2016 along with the USIPA Conference.

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 2015, the Task focused more on the organisation of workshops (in total 5 workshops were organised). In the meantime, the Task also published new country reports. Two more deliverables, were (nearly) finished and will be published in January 2016. All reports and presentations are available for free download from the Task 40 website www.bioenergytrade.org.

Report(s): Country reports

These country reports identify domestic biomass resources in each member country, and their current use, trends, and main users. In the reports, policy support and expected biomass use in 2020 (and beyond) is also described, together with biomass prices and international biomass trade for energy. Finally, discussions on drivers, barriers & opportunities are also presented. The published reports include Austria, Brazil, Denmark, Finland, Germany, Netherlands, Norway, Sweden, and US.

Report: Ongoing developments for torrefaction of biomass

Torrefaction as an industry is still in its early stages. Obviously by the nature of such early stage industries, the overall sector is very dynamic and changes are to be observed almost continuously. Task 40 has produced a report on the possible effect of torrefaction on biomass trade in the last triennium. Since then, the technology has developed further, the knowledge basis was extended, combustion experience has been gained and there are some changes within the group of active companies. This projects aims to provide an update of the technology status overview as well as a deeper analysis of the trading side by looking into transportation and the issues arising when physically moving torrefied biomass between trading partners is being implemented. Torrefaction in its earlier days was a sector focusing almost completely on coal power plants as target product consumers. Torrefied biomass will have plenty of other applications. These other applications might even be more important to the sector in the coming years when probably only small to medium production capacities will be in operation. A further look into some of the other potential consumer groups, describing their needs and expectations is intended as well.

Book: Biomass Trade and Supply System Opportunities for a Global Bio-Based Economy (cooperation of Task 40 & 42)

The future vision for global bioenergy trade is that it develops over time into a real 'commodity market'. Investigating the requirements (pre-conditions) for commoditisation of biomass and biofuels will play a central role in this report. It specifically covers (1) an in-depth historical analysis of the developments of existing key commodity markets, e.g., of the energy (e.g., coal) or food/feed sector (e.g., corn), and (2) an exploration of how conditions can be created and enhanced to achieve the same for biomass resources and biofuels. The report will assess the potential international supply, trade, and demand of biomass for energy, fuels, and chemicals applications within a competitive (energy) market, including the identification of improved and new value chains (e.g., conversion technologies and end uses). The assessment will include current state-of-the-art overviews on the markets for power, heat, and fuels/chemicals, and the identification and characterisation of emerging biomass demand regions. The ultimate aim will be to integrate the market demand assessment and specification analysis to form a larger picture of the implications of developing a bio-based economy for biomass supplies and trade at the international level. This can include the identification of new or improved value chains and integration of biomass into existing large-scale logistics infrastructure.

Workshops

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

- The workshop in Berlin (January) is linked to topic 1 and 2.
- The workshop in Riga covered topic 1, 2 and 4.
- The workshop in Sassari is related to topic 1, 2, 4 and 5.
- The workshop in Stockholm is related to topic 2 and 3.
- The workshop in Berlin (October) is related to topic 1, 2, 3 and 4.

On-going and New Topics (2015-2016)

The projects listed below are all currently ongoing and will be finalised over the course of 2016.

- ***Socio-economic assessment of two supply chains of imported biomass (pellets) to the EU:*** Brazil and the USA: Due to the EU objectives to reduce emissions under the Renewable Energy Directive (RED) (EC, 2009) and the objective of pushing forward the green economy in the EU, the biomass exports for electricity, heat and biomaterials is expected to increase in the next 20 years. Several studies have been conducted to evaluate the main supply chains regarding environmental issues such as GHG emissions, land use, and indirect land use. Nevertheless, few studies have been conducted to better understand the socio-economic implications of this production and use for specific supply chains feeding the European market and, in particular, assessing the impacts on smallholders or on communities. The Overseas Development Institute (Locke and Henley 2014) indicated that a starting point for assessing socio-economic impacts would be to use a different analytical framework to assess the balance and the distribution of different impacts on (socio-economic) issues with comparison points. It also recommended using more data from baseline surveys and longitudinal studies that allow comparison before-and-after impacts and comparison over time and across target populations. To tackle this knowledge gap, this project proposes to conduct a detailed assessment of socio-economic impacts of the biomass production and conversion supply chain with the EU biomass market target. Two case studies will be developed: one for Brazil, a potential supplier of solid biomass, and the other for the US, which is the largest exporter to the EU. A framework to conduct the study will be developed together with an assessment of the socio-economic impacts based on previous work conducted by the researchers.
- ***Biomass prices as drivers for trade:*** International trade streams of solid and liquid bioenergy commodities exhibited significant growth in the past decade. While the main drivers for their absolute increases are policy induced, drivers for particular developments of trade streams between regions have to be examined in more detail. Assuming the Pareto efficiency concept playing a major role in resource allocation between countries, in this project we will develop a model in order to explain

the role of regional biomass price differences as a driver for trade between those regions. Statistical import and export data is correlated with commodity prices within the investigated regions, taking into account interregional transport costs. The key objectives are to investigate biomass price differences as drivers for trade, taking into account interregional transport costs.

- ***Cascading effect:*** Cascading use of biomass is an issue that has become increasingly discussed in policy debates especially in the European Union as a possible tool to ensure efficient use of woody biomass resources. This study aims to inform the current debate on cascading by discussing if, and how, the cascading principle could be implemented into existing and future policy structures related not only to renewable energy, but to frameworks on bio-based and circular economies as well. Several perspectives on cascading and policies for resource allocation are discussed, from different national contexts drawn from both historical and current cases. Also parallels are drawn to two similar existing policy structures that have aimed to implement principles into policy (the Waste Hierarchy implemented in the EU Waste Framework Directive and Food vs. Fuel implemented in the so-called ILUC Directive). From these comparisons, conclusions about the lessons that can be learned for the cascading case are drawn.

Tentatively, the Task are also preparing four proposals for strategic inter-task projects:

- Wood pellet study
- Governance of sustainable biomass production & trade
- Highlight success stories
- Logistics for biorefineries

Website

The Task website is a key tool for dissemination of information. In 2015, the average number of unique visitors was maintained at 1,400 per month. Thirty four documents were downloaded more than 1,000 times (compared to 17 in 2014). In 2015, the report "Global Wood Pellet Study (2011)" has been downloaded nearly 5,000 times, still maintaining a high download rate since publication in 2011, but has dropped by half compared to 2014 (about 10,000 times). This shows that there is a need to update the report. The most downloaded report is "A Global Overview of Vegetable Oils, With Reference To Biodiesel (2009)" with almost 10,000 downloads and about 42,000 online views. One notable record is the popularity of the report "Biomethane: Status and Factors Affecting Market Development and Trade (2014)", which reached a download rate of 4,600. In 2015, one Task 40 newsletter was 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 Task 34, 42 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 2015, such as the workshops (jointly) organised by Task 40 with many other parties like GBEP in Stockholm. Task 40 will also continue this effort in 2016, collaborating with both IEA Bioenergy Tasks and external partners. One of the major inter-task projects is a joint strategic prohect on sustainability of biomass supply chains: different aspect of sustainable biomass production, trade and consumption have been scrutinised by amongst others Task 38, 40, 42 and 43. Under the lead of Task 40, this inter-task project will bring together and synthesise part of the work done by the individual tasks. Other joint work will include studies in biomass success stories and biomass pretreatment.

Deliverables

Deliverables in 2015 included 5 workshops, various types of reports, one hardcopy book, one newsletters (circulation of 1400), minutes from three Task meetings, two progress reports 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'.

Progress in R&D

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 and completed to date as follows:

Project 1: Bioenergy – Competition and Synergies

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

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

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

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

Status: Completed in May 2014.

Deliverables

The deliverables may consist of progress reports and financial accounts to the ExCo, and a final report on each project.

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

www.iea-bioenergy.task42-biorefineries.com

Overview of the Task

In a future Bio-Economy sustainable production and valorisation of biomass to both Food and Non-food 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).

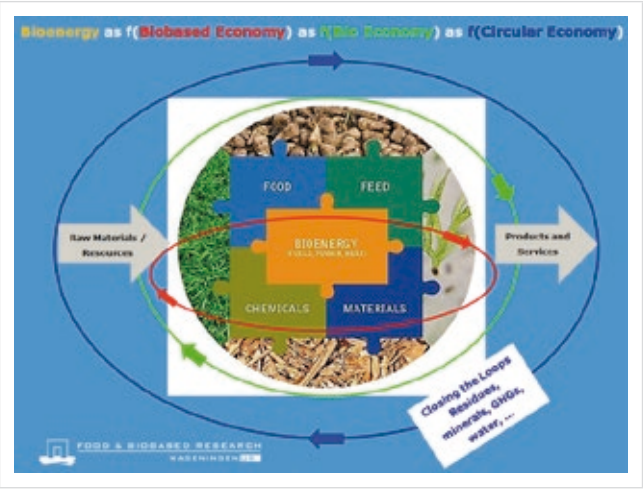


Figure: Bioenergy within the Circular Economy [Wageningen UR, IEA Bioenergy Task42]

In the **short-term** bioenergy (fuels, power, heat) is expected to play an initiating role in the transition to a Bio(based) Economy by providing biomass mobilisation and certification expertise, facilities and infrastructure, and chain covering stakeholders that potentially can be used to kick-start biorefinery deployment, with the aim to use the available biomass potential in a sustainable way to co-produce both food/feed ingredients, biobased products (chemicals, materials) and energy (fuels, power, heat).

In the **mid and longer-term** bioenergy is expected to play a central role as part of efficient bio-cascading/biorefining approaches within the Bio(based) Economy by:

- Providing sustainable biofuels – biofuels sustainably produced from non-food biomass sources – to sectors where they are the only alternative fuels to be used to reduce their GHG-emissions, i.e. aviation, shipping and heavy duty transport – **biofuel-driven biorefinery approach.**
- Valorisation of primary (agro), secondary (process) and tertiary (post-consumer) chain residues to both power/heat to be used to meet internal product-driven biorefinery-based process energy requirements or for external use, and to sustainable biofuels to meet (part of) the logistical energy requirements for biomass sourcing and product delivery purposes – **product-driven biorefinery approach.**
- Valorisation of biomass residues and non-food biomass sources to power/heat in high-efficient co-firing and stand-alone conversion facilities with upstream value-added products extraction and/or valorisation of process residues – **energy-driven biorefinery approach.**

Biorefining is the optimal way for large-scale sustainable use of biomass in the BioEconomy. By accelerating the sustainable production and use of biomass, particularly in a biorefinery approach, the socio-economic and environmental impacts will be optimised resulting in more cost-competitive production of food and feed ingredients, biobased products (chemicals, materials) and bioenergy (fuels, power, heat), reduced greenhouse gas emissions, and efficient use of available resources (raw materials, minerals, water).

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 & 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 Task42** is to facilitate the commercialisation and market deployment of environmentally sound, socially acceptable, and cost-competitive biorefinery systems and technologies, and to advise policy and industrial decision makers accordingly. Task42 provides an international platform for collaboration and information exchange between industry, SMEs, GOs, NGOs, RTOs and universities concerning biorefinery research, development, demonstration, and policy analysis. This includes the development of networks, dissemination of information, and provision of science-based technology analysis, as well as support and advice to policy makers, involvement of industry, and encouragement of membership by countries with a strong biorefinery infrastructure and appropriate policies. Gaps and barriers to deployment are addressed to successfully promote sustainable biorefinery systems market implementation.

Challenges to be tackled

- Develop industry legitimacy, including social acceptance, 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 and industrial infrastructure energy/fuel, agro/food, material and chemical manufacturing sectors
- Develop the necessary human capital by training students and other stakeholders to become the biorefinery experts of tomorrow

Task data

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: 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 Enterprise Agency, the Netherlands

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

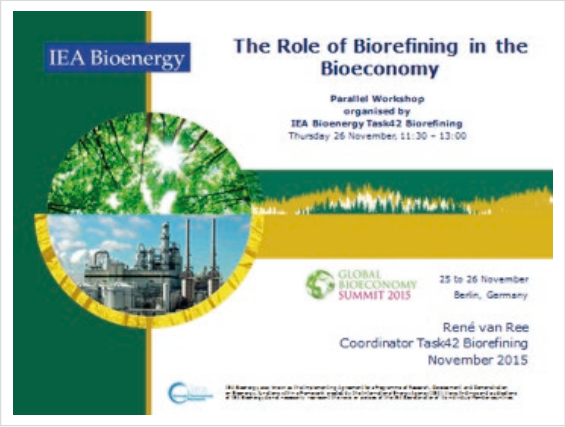
Task Meetings & Workshops

The **18th Task42 Progress Meeting,** incl.: 1) a Joint Task 40/Task 42 Workshop on "Biomass Trade and Supply in a Global Bio-Based Economy, 2) an Italian (industrial) Stakeholder Meeting and 3) an Excursion to the MATRICA (Novamont/Versalis (ENI)) Biorefinery plant in Porto Torres (Sardinia), was organised from 4 – 6 May 2015 in Sassari, Sardinia, Italy.

8th Task42 Progress Meeting, May 2015, Sassari, Sardinia (IT)

The **19th Task42 Progress Meeting** was organised on 29 and 30 October 2015 in Berlin, Germany, following the IEA Bioenergy End-of-Triennium Conference "Realising the world's sustainable bioenergy potential" (27/28 October 2015, Berlin, Germany). Task 42 contributed to this conference by organising a specific biorefining session, incl. 4 lectures.

Most recently Task 42 organised the **workshop** "The Role of Biorefining in the BioEconomy" as part of the Global BioEconomy Summit 2015, Berlin, Germany, 25-26 November 2015.
A report of this event is available for downloading at the Task42 website.



The **next (20th) Task42 Progress** Meeting will be organised on 18 and 19 April 2016 in Dublin, Ireland. This meeting will be coupled to an Irish stakeholder meeting to exchange information.

All non-confidential presentations given at the Task meetings and workshop report(s) can be downloaded from the Task website.

2013-2015 Work Programme – Selection of Major Achievements

(Country) Reports

In recent years the following countries were participants of Task 42: AT, AUS, CAN, DEN, FRA, GER, IRE, IT, JAP, NL, NZ, TUR, UK, US. All have prepared Country Reports describing: overall (bio)energy production and use; biomass use for non-energetic applications; mapping of biorefineries, incl. commercial facilities, demo and pilot plants, major R&D projects and regional initiatives; Bio(based) Economy strategies; policy goals and instruments, and major national stakeholders (industry, SMEs, GOs, NGOs, RTOs, UNIs). These Country Reports are updated every three years.

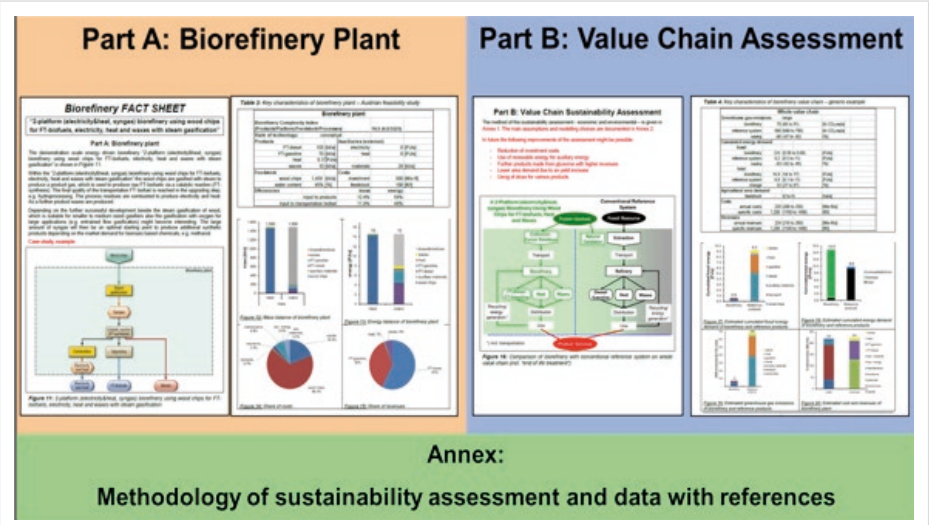
Recent reports (and papers) that have been published are:

- Assessing Biorefineries Using Wood for the BioEconomy – Current Status and Future Perspective of IEA Bioenergy Task 42 "Biorefining", G. Jungmeier (AT) et al.
- The role of industry in a transition towards the BioEconomy in relation to biorefinery, H. Jørgensen (DEN) et al.
- National BioEconomy Strategies IEA Bioenergy Implementing Agreement Countries, M. Beermann & G. Jungmeier (AT)/V. Pignatelli & M. Monni (IT)/R. van Ree (NL)
- Biorefinery Concepts in Comparison to Petrochemical Refineries, Ed de Jong (NL) & Gerfried Jungmeier (AT)
- Reducing volatility and financial risk and increasing returns by producing co-products in a lignocellulosic bio-refinery, Geoff Bell (AUS)
- Country Report Canada 2015, Maria Wellisch (CAN)

Biorefinery Fact Sheets

While biorefining is considered to be very promising for the sustainable valorisation of biomass into food and feed ingredients, industrial biobased products and bioenergy, the integrated biorefinery processes often are difficult to understand. The technologies involved can be very complicated, and data on their technical, socio-economic and ecological performance are mostly very difficult to find. To facilitate biorefinery deployment, Task 42 developed a Biorefinery Fact Sheet methodology to provide a uniform description of the key facts & figures of different biorefineries. Based on a technical description, classification scheme, mass and energy balance, and indicative investment and O&M costs, the

three dimensions of sustainability are assessed and documented in a compact form, i.e. the Biorefinery Fact Sheet (BFS). The BFS consists of three parts. In Part A "Biorefinery plant" the key characteristics of the biorefinery facility are described by giving compact information on: description of the biorefinery, classification system, mass and energy balance, costs and revenues. In Part B "Value chain assessment" the sustainability assessment is described by giving compact information on: system boundaries, reference-system, cumulated primary energy demand, greenhouse gas emissions, and costs and revenues. In the Annex the methodology of – and data used in – the sustainability assessment are documented. By the end of 2015 about 10 completed BFSs can be found for downloading at the Task 42 website. *Task 42 is always looking for candidate biorefineries to prepare new BFSs, and the website offers the opportunity to build a BFS for your own biorefinery facility/concept (data-input-form available for downloading). If you are interested to do so, please get in direct contact with the Austrian Task 42 partner (Gerfried Jungmeier: gerfried.jungmeier@joanneum.at) for further advise on how to proceed.*



Biorefinery Fact Sheet (BFS) set-up

Biorefining driving the Bio(based) Economy

Biorefining is the basis for sustainable biomass use for the synergistic production of Food and Non-food within the BioEconomy. At the request of IEA Bioenergy ExCo, Task 42 made an assessment of the National BioEconomy Strategies in IEA Bioenergy Implementing Agreement Countries. A poster based on the results of this work was presented at the 23rd European Biomass Conference and Exhibition in Vienna, Austria, and was nominated for the Poster Award within the topic Biomass Policies, Markets and Sustainability.

G. Jungmeier, V. Pignatelli, M. Monni, M. Beermann,
K. Kwant, K. Sipilä, R. Van Ree

have been nominated by the official jury for the
Poster Award
for the topic "Biomass Policies, markets and sustainability"

The Poster entitled
"BioEconomy Strategies in the Member Countries of the IEA Bioenergy Implementing Agreement - Current Status, Approaches and Opportunities "

was deemed to be a particularly valuable contribution to the

23rd European Biomass Conference and Exhibition
Vienna, Austria, 1 - 4 June 2015

Ingwald Obernberger, Conference General Chairman
David Baxter, Technical Programme Chairman
Dimitrios Sidiras, Poster Awards Coordinator
Peter Helm, Executive Committee
Angela Grassi, Executive Committee

Linked to this, Task 42 delivered a questionnaire-based assessment concerning the Role of Industry in a Transition Towards the BioEconomy in Relation to Biorefinery. *The results of both assessments, and the prize winning poster, can be found for downloading at the Task42 website.*

Workshops and Conferences

Over the last 9 years of its existence, Task 42 has organised 30-40 stakeholder meetings, excursions and workshops in the partnering countries. Task 42 also contributed to training activities for both students, policy makers, industry/SMEs, and RTOs to acquire experience with the biorefining approach.

Task Website

The Task 42 website – www.IEA-Bioenergy.Task42-Biorefineries.com – was successfully upgraded during 2015. All Task 42 deliverables and major biorefinery information in general can be found at this website.

Collaboration with Other Tasks/Networking

In this triennium co-operation was established with international activities, such as: other Tasks (Task 39 and 34 on Biorefinery Factsheet Data, Task 40 on biomass supply for the BE, and Task 43 et al. within the multi-tasks strategic project on sustainable bioenergy chains), European-based Technology Platforms (o.a. EBTP), EC Specific Support Actions, and EC FP7 Integrated Projects. This co-operation will be enhanced in 2016 – 2018 by organising joint events, e.g. workshops and meeting.

2013-2015 Work Programme (WP) – Activities, Status Deliverables*

Subject	Progress
Act.1 Assessment of the market deployment potential of integrated biorefineries	
Technical and non-technical critical success factors	Delivered (US) [Q1, 2015] – slide-deck with major results
Disruptive/game changing technologies	Delivered (NL) [Q4, 2015] – slide-deck with major results
Centralised vs. decentralised processing	None. Originally brought-in the WP by France who finally decided not to join Task42
Biorefinery-Complexity-Index (BCI)	Delivered (AT) [Q3, 2013]
Act.2 Support of industrial/SME stakeholders finding their position in a future BioEconomy	
Role involved market sectors in the transition to a BioEconomy	Delivered (DEN) [Q2, 2015] – report with results workshop i-SUP 2014 conference and questionnaire
Upgrading strategies for existing industrial infrastructures	Delivered (AT) [Q4, 2014] – slide-deck with major results
Factsheets on major biorefineries/ national case studies	Delivered (AT) [Q4, 2015] – factsheet methodology (A and B part + Annex), and more than 10 mainly biofuel-based factsheets fully filled-in
Updating of bio-chemicals report	None. It was decided to postpone the update of the 2012 Task42 report till the next triennium to be able to build on EC report ENER/C2/423-2012/S12.673791 (April, 2015) that used the Task42 2012-report as starting point
Preparation Report "Proteins for Food and Non-food Applications"	A first draft report has been prepared (NL) [Q4, 2015]. The report will be finalised and upgraded for external dissemination in the 1st half of 2016
Act.3 Analysis optimal sustainable biomass valorisation in market-pull perspective approach	
Sustainability assessment toolbox	Activity replaced by CAN LEEAFF-indicators sustainability assessment. Delivered (CAN) [Q4, 2015]
Mobilising sustainable bioenergy supply chains	Delivered (GER, CAN) [2015] – contributions to reports inter-Tasks project coordinated by Task43
Future market demand for biomass from a BioEconomy perspective	Delivered (GER et al) [2015] – contribution to workshop and report (book chapter "Biorefineries in a Global Bio-based Economy") coordinated by Task40
Optimal sustainable biomass valorisation	Replaced on ExCo-request by Assessment National BioEconomy Strategies in IEA Bioenergy countries; delivered (AT, IT, NL) [2014] – slide-deck with major results

Subject	Progress
Act.4 Preparation advice policy makers on current status, future potential and priority needs	
Biorefinery Roadmap	None. Originally suggested for the WP by IEA HQ who finally did not put it on their agenda for the 2013-2015 period
Biorefinery (related) policies in participating countries	Delivered (AT, IT, NL) [2014] as part of Assessment National BioEconomy Strategies in IEA Bioenergy countries – slide-deck with major results
Country reporting	Delivered (all, except IL) [2013-2015] – slide-decks with up-to-date national biorefinery info
Act.5 Biorefinery knowledge dissemination	
Bi-annual task and stakeholder meetings, incl. excursions	Delivered, minimally 2 a year
Annual task meetings at national level	Delivered in some (AT, IT, NL, ...) of the partnering countries
Task website (public internet and closed members area)	Delivered, will be updated for the new 2016-2018 triennium
Task newsletters	Not delivered. For the new triennium minimally 2 Task42 newsletters a year will be prepared directly after the Progress Meetings, and widely distributed by the NTLs using their own distribution channels
Glossy task brochure, poster, leaflet	Delivered (all) [Q4, 2015]
Contributions international workshops and conferences	Delivered (all), incl. contributions to EC (BBI/EBTP, ...) [2013-2015]
Act. 6. Delivery of biorefinery training activities	
Annual training school on biorefining	None in 2015.

* The deliverables can be found at the Task42 website

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. Organic consumer waste as well as biomass from many land uses (e.g. forestry residues, straw, dedicated energy crops) can become a plausible energy source if production systems are economically and environmentally attractive. Science, governance and technology must support this expansion ensuring that suitable production systems are established and can be relied on to help achieve the climate and 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 feedstock, 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 2015): Australia, Canada, Croatia, Denmark, European Commission, Finland, Germany, Ireland, the Netherlands, Norway, Sweden, and the USA

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

Associate Task Leaders: Professor Tat Smith, University of Toronto, Canada, Dr. Bill White, Kingsmere Economic Consulting, Edmonton, Canada

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

Operating Agent: Dr Åsa Forsum, 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 country and through establishing cooperation with other organisations in specific areas.

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

A number of business/planning meetings were held in 2015: (i) Dublin, Ireland, May 21-22: Task 43 business meeting and planning meeting for next triennium. Also planning meeting in inter-task project "Mobilizing sustainable bioenergy supply chains"; (ii) Berlin, Germany, Oct 29: Task 43 business meeting and end-of-triennium meeting.

The Task has organised six international workshops/conference sessions and webinars in 2015: (i) Rome, Italy, May 19: Conference *Mobilization of woody biomass for energy and industrial use: Smart logistics for forest residues, prunings and dedicated plantations,* organised with INFRES, LogistEC, EuroPrunning, FAO, USDA-FS, AEBIOM, EUBIA, ITABIA, FederUnaCome; (ii) Stockholm, Sweden, Aug 25-26: Workshop *Examples of positive bioenergy and water relationships,* organised with GBEP-AG6, Chalmers Energy Area of Advance, and The Royal Swedish Academy of Agriculture and Forestry; (iii) Berlin, Germany, Oct 27: Conference session *Biomass feedstocks for Energy markets* at IEA Bioenergy Conference 2015; (iv) Berlin, Germany, Oct 30: *Forests, bioenergy and climate change mitigation,* joint workshop with Task 38; (v) Webinar *Assessment of the Risks Associated with Certain Biomass Fuel Sourcing Scenarios – Canadian Stakeholder feedback to the DECC North American Wood Pellet Survey: An opportunity to discuss key findings tested with forestry experts,* organised with Canadian Institute of Forestry and UK Department of Energy and Climate Change (DECC); (vi) Joint Task 38-Task 43 Webinar Forest Biomass – *Climate and Wider Environmental Issues,* organised with Bioenergy Australia.

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 2015 was the report *Best Practice Guidelines for Managing Water for Bioenergy Feedstock Production* (Task 43 report TR2015:02). This report presents comprehensive information regarding the management of water in the production of feedstocks for bioenergy. It details the role of "Best Management Practices" in ensuring sustainable biomass production systems and preventing environmental disbenefits. Another highlight was the 2-day workshop *Examples of good bioenergy and water relationsships* and the subsequent outcome report published by IEA Bioenergy and GBEP.

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. One highlight in this area during 2015 was the finalisation of the report *Assessing the Environmental Performance of Biomass Supply Chains,* with contributions from 14 authors under the leadership of Jörg Schweinle, Task 43 NTL for Germany (Task 43 report TR2015:01).

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.

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. In 2015,

the Task published the report Fuel Poverty and Bioenergy Discussion paper (Task 43 report TR2015:03). An important part of the work in this area takes place within the Inter-Task project "Mobilizing sustainable bioenergy supply chains", which is coordinated by Task 43.

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 via editorship in two scientific journals: *(i) WIREs: Energy and Environment* (Associate Editor for the bioenergy area); *(ii) Biofuels, Bioproducts and Biorefining* (Consultant Editor). These and other journals offer valuable opportunities for outreach via special issue publications, occasional articles and editorials. A highlight in 2015, the book *Advances in Bioenergy: The Sustainability Challenge* edited by TL Berndes together with three other colleagues, includes 13 chapters involving authors from the Task.

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) and the web based dissemination tool – *Perennial Biomass Crops on the Map* (see: http://www.pbconthemap.org). The Task 43 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 Task 38 in the organisation of the workshop *Forests, bioenergy and climate change mitigation.* Task 43 further collaborates with several other Tasks in the inter-Task project – *Mobilizing 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, FAO, IINAS, and The Royal Swedish Academy of Agriculture and Forestry. Task 43 also collaborated with other organisations, including 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 2015 included: (i) Technical and more popular reports (see section "Library" on the Task 43 website); (ii) publications in scientific journals; (iii) conference presentations; and (iv) reporting to the ExCo (progress reports to Exco 75 and ExCo76). Also the organisation and minuting of Task meetings, and updating of the Task website. Please see Appendix 4.

TASK PARTICIPATION IN 2015

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

⊗ = Operating Agents • = Participant

BUDGET IN 2015 – SUMMARY TABLES

Budget for 2015 by Member Country (US$)

Contracting Party	ExCo funds	Task funds	Total
Australia	11,700	76,500	88,200
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	14,700	128,000	142,700
New Zealand	8,700	32,500	41,200
Norway	15,700	141,820	157,520
South Africa	8,700	30,000	38,700
Sweden	15,700	141,820	157,520
Switzerland	9,700	43,000	52,700
UK	12,700	98,820	108,520
USA	13,700	116,000	129,700
European Commission	8,700	28,000	36,700
Total	**263,100**	**1,707,420**	**1,970,520**

BUDGET IN 2015 – SUMMARY TABLES

Budget for 2015 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	10	15,000	150,000
Task 34: Pyrolysis of Biomass	7	20,000	140,000
Task 36: Integrating Energy Recovery into Solid Waste Management	6	15,320	91,920
Task 37: Energy from Biogas	15	13,000	195,000
Task 38: Climate Change Effects of Biomass and Bioenergy Systems	8	16,000	128,000
Task 39: Commercialising Conventional and Advanced 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	0	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			**1,707,420**

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 and Agriculture (Germany)

The Sustainable Energy Authority of Ireland (SEAI)

Gestore dei Servizi Energetici – GSE (Italy)

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

Ministry of Knowledge Economy, the Republic of Korea

NL Enterprise 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

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 ExCo75 meeting, Dublin, Ireland, May 2015.

Final Minutes of the ExCo76 meeting, Berlin, Germany, October 2015.

IEA Bioenergy News February 2015

IEA Bioenergy News Volume 27(1), June 2015

IEA Bioenergy News September 2015

IEA Bioenergy News Volume 27(2), December 2015

IEA Bioenergy Update. Number 57. Biomass and Bioenergy. Published, JBB 72, January 2015

IEA Bioenergy Update. Number 58. In press

IEA Bioenergy Update. Number 59. In press

Anon. IEA Bioenergy Annual Report 2014. IEA Bioenergy ExCo:2015:01.

Anon. Electricity from Biomass: from small to large scale. Summary and Conclusions from the IEA Bioenergy ExCo72 Workshop. IEA Bioenergy ExCo:2015:02

Anon. Bioenergy: Land-use and mitigating iLUC. Summary and Conclusions from the IEA Bioenergy ExCo74 Workshop. IEA Bioenergy ExCo:2015:03

Anon. IEA Bioenergy Conference 2015 Conclusions Rev 16.02.16

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

TASK 32

Minutes of the Task meeting in Drax, UK, June 2015.

Minutes of the Task meeting in Berlin, Germany, Oct 2015.

IEA Bioenergy Task 32 Newsletter, Issue 11, June, 2015.

IEA Bioenergy Task 32 Newsletter, Issue 12 Dec, 2015.

Ingwald Obernberger, Alfred Hammerschmid, Michaela Forstinger, Techno-economic Evaluation of Selected Decentralised CHP Applications Based on Biomass Combustion with steam turbine and ORC processes, IEA Bioenergy Task 32, Dec 2015

Marcel Cremers, Jaap Koppejan, Jan Middelkamp, Joop Witkamp, Shahab Sokhansanj, Staffan Melin, Sebnem Madrali, Status overview of torrefaction technologies – A review of the commercialisation status of biomass torrefaction, IEA Bioenergy Task 32, ISBN 978-1-910154-23-6

Ingwald Obernberger, Thomas Brunner, Advanced Biomass Fuel Characterisation Methods for Solid Fuels, IEA Bioenergy Task 32, June 2015

Progress report for ExCo75, Dublin, May 2015

Progress report for ExCo76, Berlin, Oct 2015

Koppejan, J. Report from the Workshop 'Highly Efficient and Clean Wood Log Stoves, 29 October 2015

Frank Kienle, HKI – Industrieverband Haus-, Heiz- und Küchentechnik e.V., Frankfurt, Germany, Market development and perspectives

Dr. Morten Seljeskog SINTEF Energy Research, Trondheim, Norway, Black carbon emissions from wood stoves

Dr. Christoph Schmidl, Bioenergy 2020+, Wieselburg, Austria, Real life stove testing for European label development – The BeReal-project

Prof. Dr. Ingwald Obernberger, BIOS Bioenergiesysteme GmbH, Austria, Guidelines and relevant issues for stove development

Prof. Dr. Laurent Georges, Norwegian University of Science and Technology, Trondheim, Norway, Wood stoves for future's energy efficient buildings

Dr. Øyvind Skreiberg, SINTEF Energy Research, Trondheim, Norway, CFD as an efficient design tool for log wood stoves

Dr. Martina Blank, BIOS Bioenergiesysteme GmbH, Graz, Austria, Transient CFD simulation of log wood stoves

Dr. Jytte Illerup, Technical University of Denmark – DTU, Copenhagen, Denmark, Advanced combustion control for a log wood stove

Dr. Ingo Hartmann, German Biomass Research Centre (DBFZ), Leizpig, Germany, Emission abatement using integrated catalysts in log wood stoves

Dr. Hans Hartmann, Technology and Support Centre of Renewable Raw Materials – TFZ, Straubing, Germany, Performance of foam ceramic elements in log wood stoves

Please visit the Task website for the reports and original presentations: www.ieabioenergytask32.com

TASK 34

Minutes of the Task meeting in Hengelo, Netherlands, May 2015.

Minutes of the Task meeting in Berlin, Germany, October 2015.

Progress report for ExCo75, Dublin, Ireland, May 2015.

Progress report for ExCo76, Berlin, Germany, October 2015.

Task 34 Newsletter No. 37, July 2015.

Task 34 Newsletter No. 38, December 2015.

Oasmaa, A.; van de Beld, B.; Saari, P.; Elliott, D.C.; Solantausta, Y. 2015 "Norms, Standards & Legislation for Fast Pyrolysis Bio-Oils." **Energy & Fuels 29**, 2471-2484, web published: March 18, 2015, DOI:10.1021/acs.energyfuels.5b00026.

Elliott, D.C. 2016. "Review of Recent Reports on Process Technology for Thermochemical Conversion of Whole Algae to Liquid Fuels." **Algal Research** 13, 255-263, web published: December 17, 2015, DOI: 10.1016/j.algal.2015.12.002

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

TASK 36

Minutes of the Task meeting in Bordeaux, France, June 2015

Minutes of the Task meeting in Berlin, Germany, October 2015

Progress report for ExCo75, Dublin, May 2015

Progress report for ExCo76, Berlin, October 2015

Proceedings of workshop on factors impacting on waste to energy, Bordeaux, June 2015

Proceedings of workshop on role of waste to energy in a Circular Economy, Berlin, October 2015

Report – Factors influencing the development of small scale EfW

Report – An Assessment of the Export of Municipal Solid Waste from the UK as Refuse Derived Fuel using a Mass Balance Technique

Presentations:

'Factors Influencing the development of Small scale EfW' – paper presented at ISWA Annual Congress, Antwerp, September 2015

'Opportunities for Solid Recovered Fuel in a Circular Economy' – presentation at the European Recovered Fuels Organisation Workshop, Brussels, April 2015

At the IEA Bioenergy Conference 2015 in Berlin

'An introduction to the needs of decision makers' – presentation by B. Kamuk, ISWA, Ramboll, Denmark

'Solid recovered fuels production and use in Europe' – presentation by G. Ciceri, RSE – Ricerca Sistema Elettrico, Italy

'Small scale energy from waste' – presentation by I. Johansson, SP Technical Research Institute of Sweden

'An investigation into the growth of advanced conversion technology for thermal treatment of municipal and commercial and industrial wastes in the UK' – presentation by K. Riley, Vismundi Limited, UK

Papers

Warren K, Johannson I: 'Factors influencing the development of Small scale EfW' – paper presented at ISWA Annual Congress, Antwerp, September 2015

TASK 37

Minutes from the Task meeting in Uppsala, Sweden, March 2015

Minutes from the Task meeting in Berlin, Germany, October 2015

Progress report for ExCo75, Malahide, Ireland, May 2015

Progress report for ExCo76, Berlin, Germany, October 2015

Drosg, B., Fuchs, W., Al Seadi, T., Madsen, M., Linke, B., "Nutrient recovery by biogas digestate processing", IEA Bioenergy, August 2015, ISBN 978-1-910154-15-1

Murphy, J.D., Drosg, B., Allen, E., Jerney, J., Xia, A., Herrmann, C., "A perspective on algal biogas", IEA Bioenergy, September 2015, ISBN 978-1-910154-17-5

Bachmann, N., "Sustainable biogas production in municipal wastewater treatment plants", IEA Bioenergy, October 2015, ISBN 978-1-910154-21-2

Lukehurst, C.T., Bywater, A., "Exploring the viability of small scale anaerobic digesters in livestock farming", December 2015, ISBN 978-1-910154-24-3

Persson, T., Baxter, D., (editors) "IEA Bioenergy Task 37 Biogas Country Reports Summary 2014" January 2015, ISBN 978-1-910154-11-3, http://www.iea-biogas.net/country-reports.html

Strategic Inter-Task Study: "Mobilising Sustainable Bioenergy Supply Chains", IEA Bioenergy, ISBN 978-1-910154-19-9

Case Study: "REVAQ Certified Wastewater Treatment Plants in Sweden for Improved Quality of Recycled Digestate Nutrients", April 2015, Sweden, April 2015

Case Study: "Ringkøbing-Skjern, Denmark – Decentralised Biogas Network Model", May 2015

Case Study: "Solrød Biogas – Towards a Circular Economy", Denmark, December 2015

Anon. Task 37 Country Report 2015 Presentations, October 2015. http://www.iea-biogas.net/country-reports.html

Anon. Presentations from members of Task 37 at the IEA Bioenergy 2015 conference, Berlin, Germany, October 27 and 28, 2015. http://www.iea-biogas.net/workshops.html

Charles Banks (UK) – Sustainable Resource Management and Energy from Organic Wastes

Jerry Murphy (IRL) & Bernard Drosg (AT) – A perspective on algal biogas

Jan Liebetrau (D) – Possibilities for biogas in electricity grid balancing

John Baldwin (Industry) & Mathieu Dumont (NL) – Biomethane production and gas grid injection – Industry experience and examples

Newsletters: 8 issues in 2015

All publications are available on the Task website: http://www.iea-biogas.net/

TASK 38

Minutes from the Task Business Meeting: Växjö (Sweden), 25 May 2015

Minutes from the Task Conference, Växjö (Sweden), 26-27 May 2015

Minutes from the Task Business Meeting: Berlin (Germany), 30 October 2015

Progress Report for ExCo75, Dublin (Ireland), May 2015 2015

Progress Report for ExCo76, Berlin (Germany), October 2015

Brandão, M., 2015. Assessing the Sustainability of Land Use: A Systems Approach. Sustainability Assessment of Renewables-Based Products: Methods and Case Studies, p.81.

Gustavsson, L., Haus, S., Ortiz, C., Sathre, R., Truong, N.L. (2015). Climate effects of bioenergy from forest residues in comparison to fossil energy. Applied Energy Vol. 138, pp. 36-5o.

Haus, S., Gustavsson, L., and Sathre, R. (2015) Climate mitigation comparison of woody biomass systems with the inclusion of land-use in the reference fossil system. Biomass and Bioenergy, Vol. 65, pp. 136-144.

Koponen, Kati; Sokka, Laura; Salminen, Olli; Sievänen, Risto; Pingoud, Kim; Ilvesniemi, Hannu; Routa, Johanna; Ikonen, Tanja; Koljonen, Tiina; Alakangas, Eija; Asikainen, Antti; Sipilä, Kai. Sustainability of forest energy in Northern Europe. VTT Technology: 237. 2015. VTT, Espoo. ISBN 978-951-38-8364-5. www.vtt.fi/inf/pdf/technology/2015/T237.pdf

Koponen K., Soimakallio S. 2015. Forgone carbon sequestration due to land occupation for agro-bioenergy – the case of Finland. International Journal of Life Cycle Assessment. DOI: 10.1007/s11367-015-0956-x

Mohammadi, A., Cowie, A., Mai, T.L.A., de la Rosa, R.A., Kristiansen, P., Brandão, M. and Joseph, S., 2015. Biochar use for climate-change mitigation in rice cropping systems. Journal of Cleaner Production.

Muñoz, I., Schmidt, J.H., Brandão, M. and Weidema, B.P., 2015. Rebuttal to 'Indirect land use change (iLUC) within life cycle assessment (LCA)–scientific robustness and consistency with international standards'. GCB Bioenergy,7(4), pp.565-566.

Pelletier, N., Ardente, F., Brandão, M., De Camillis, C. and Pennington, D., 2015. Rationales for and limitations of preferred solutions for multi-functionality problems in LCA: is increased consistency possible?. The International Journal of Life Cycle Assessment, 20(1), pp.74-86.

Pingoud, K., Ekholm, T. Soimakallio S., Helin T. 2015. Carbon balance indicator for forest bioenergy scenarios. GCB Bioenergy (2015) Article first published online: 12 May 2015

Pizzol M, Weidema B, Brandão M, Osset P (2015) Monetary valuation in Life Cycle Assessment: a review. Journal of Cleaner Production 86 (1) 170-179.

Schmidt, J.H., Weidema, B.P. and Brandão, M., 2015. A framework for modelling indirect land use changes in life cycle assessment. Journal of Cleaner Production, 99, pp.230-238.

Soimakallio, S., Cowie, A., Brandão, M., Finnveden, G., Ekvall, T., Erlandsson, M., Koponen, K. and Karlsson, P.E., 2015. Attributional life cycle assessment: is a land-use baseline necessary?. The International Journal of Life Cycle Assessment, 20(10), pp.1364-1375.

Soimakallio, S., Brandão, M., Ekvall, T., Cowie, A., Finnveden, G., Erlandsson, M., Koponen, K. & Karlsson, P.E. 2016, On the validity of natural regeneration in determination of land-use baseline. The International Journal of Life Cycle Assessment, First online: 01 February 2016, 1-3.

Sokka, Laura; Koponen, Kati; Keränen, Janne T. Cascading use of wood in Finland – with comparison to selected EU countries. Research Report: VTT-R-03979-152015. VTT, 25 p. http://www.vtt.fi/inf/julkaisut/muut/2015/VTT-R-03979-15.pdf

TASK 39

Minutes from the Task meeting in Gwangju, South Korea, March 2015

Minutes from the Task meeting in Berlin, Germany, October 2015

Progress report for ExCo75, Dublin, Ireland. May 2015

Progress report for ExCo76, Berlin, Germany. October 2015

Van Dyk, S. (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 39, May 2015

Van Dyk, S. (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 40, August 2015

Van Dyk, S. (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 41, December 2015

The publications are available on the Task website: www.task39.org

TASK 40

Task documents

Minutes from the Task meeting in Sassari, Italy, May 2015.

Minutes from the Task meeting in Berlin, Germany, October 2015.

Progress report for ExCo75, Dublin, Ireland 19 – 21 May 2015.

Progress report for ExCo76, Berlin, Germany 26 October 2015.

Goh CS, Junginger M, and Schouwenberg P-P. (Eds) Task 40 Newsletter. Issue 1, September 2015.

Reports

Country reports 2014: Austria

Country reports 2014: Brazil

Country reports 2014: Denmark

Country reports 2014: Finland

Country reports 2014: Germany

Country reports 2014: Netherlands

Country reports 2014: Norway

Country reports 2014: Sweden

Country reports 2014: US

Wild M et al. (2016) Ongoing developements for torrefaction of biomass (in the final stage)

Lamers et al. (2016) Biomass Trade and Supply System Opportunities for a Global Bio-Based Economy (cooperation of Task 40 & 42) (in the final stage)

TASK 42

- Van Ree R., co-organisation and chairing of the Biorefinery Platforms Day at the World Biofuels Markets Conference (WBM-2013) (including a short Task42 lecture), Rotterdam, the Netherlands on 12 March 2013.

- Stichnothe H., IEA Task42 Overview Lecture at 52th Tutzing Symposium "One year on: Germany's Biorefinery Roadmap in an International Context", Tutzing, Germany, 11 June 2013.

- Jungmeier G. et al., "A Biorefinery Fact Sheet for the Sustainability Assessment of Energy Driven Biorefineries – Efforts of IEA Bioenergy Task 42 "Biorefining", 21th EU BC&E, Copenhagen, Denmark, 3-7 June 2013.

- Jungmeier G., "Possible Role of a Biorefinery´s Syngas Platform in a Bio-based Economy – Assessment in IEA Bioenergy Task 42 Biorefinery", ICPS 13 – International Conference on Polygeneration Strategies, Vienna, Austria, 3-5 September 2013.

- Jungmeier G., "Facts & Figures of Producing Biofuels in Biorefineries – Current Status and Future Perspectives", 8th A3PS Conference Eco-Mobility 2013, Vienna, Austria, 3-4 October 2013.

- Jungmeier G., "The Austrian Participation in IEA Bioenergy Task42 Biorefining", Austrian Stakeholder Meeting, Graz, Austria, 24 October 2013.

- Van Ree R., "Achievements of IEA Bioenergy Task42 Biorefining", Austrian Stakeholder Meeting, Graz, Austria, 24 October 2013.

- Stichnothe H., "Update of the German Biorefinery Roadmap", Austrian Stakeholder Meeting, Graz, Austria, 24 October 2013.

- Jorgensen H., "Using Straw and MSW for Biorefineries in Denmark – Technical Developments and Demonstration Activities", Austrian Stakeholder Meeting, Graz, Austria, 24 October 2013.

- De Bari I., "Biorefineries and Green Chemistry in Italy – Overview of Applied R&D, Demo and Industrial Breakthroughs", Austrian Stakeholder Meeting, Graz, Austria, 24 October 2013.

- Wellisch M. et al, "Building Sustainable Biomass Supply Chains", International Forest Biorefinery Symposium, Montreal, QC, 3-4 February 2014.

- de Jong Ed, Task42/Avantium Lecture at Tomorrow's Biorefineries Event, Brussels, Belgium, 11-12 February 2014.

- Van Ree R., chairing of 2 Biorefinery Sessions at the World Bio Markets Conference (WBM-2014) (including a short Task42 lecture), Amsterdam, the Netherlands, 4-6 March 2014.

- Van Ree R., The role of industry in a transition towards the BioEconomy (BE) in relation to biorefinery – Overview Task42, Task42 Workshop at i-SUP Conference, 3 September, Antwerp, Belgium.

- Jungmeier G., "Approach for the Integration of Biorefineries in the Existing Industrial Infrastructures", Task42 Workshop at i-SUP Conference, 3 September, Antwerp, Belgium.

- BioEconomy Strategies in the 22 IEA Bioenergy Member Countries – Current Status, Approaches and Opportunities for Bioenergy, bmvit Bioenergie Fachgespräch, Wien 21. November 2014.

- Introduction to IEA Bioenergy and Task 42 Biorefining, Ed de Jong, Canadian Bioeconomy Conference (CRFA), Toronto/Canada, December 1 – 3, 2014.

- Maximising Revenues and Minimising waste in Fuel and Feed-based Biorefineries, Geoff Bell, Canadian BioEconomy Conference (CRFA), Toronto/Canada, December 1 – 3, 2014.

- The "Biorefinery Fact Sheet" of IEA Bioenergy Task 42 "Biorefining", Gerfried Jungmeier, Canadian BioEconomy Conference (CRFA), Toronto/Canada, December 1 – 3, 2014.

- Biorefinery Evolution in the Netherlands, Bert Annevelink, Canadian BioEconomy Conference (CRFA), Toronto/Canada, December 1 – 3, 2014.

- Biorefinery Evolution in the US, Steven R. Thomas, Canadian BioEconomy Conference (CRFA), Toronto/Canada, December 1 – 3, 2014.

- Biorefinery Evolution in Japan, Satoshi Hirata, Canadian BioEconomy Conference (CRFA), Toronto/Canada, December 1 – 3, 2014.

- Working Document „Upgrading Strategies for Industrial Infrastructures – Integration of Biorefineries in Existing Industrial Infrastructure", Gerfried Jungmeier, Martin Buchsbaum with contributions from Rene van Ree, Henning Jørgensen, Ed de Jong, Heinz Stichnothe, Maria Wellisch, Isabella di Bari, Geoff Bell, James Spaeth, auf der Task 42 webpage veröffentlicht am 22.12. 2014.

- Heinz Stichnothe, Dietrich Meier, Isabella de Bari, Martin Beermann, Gerfried Jungmeier, Steven Thomas, Biorefineries in a Global Bio-based Economy", book/report chapter, to be published.

- Ed de Jong and Gerfried Jungmeier, Biorefinery Concepts in Comparison to Petrochemical Refineries, Industrial Biorefineries and White Biotechnology, Elsevier, Amsterdam, the Netherlands, June 2015.

- Gerfried Jungmeier and Task 42, Assessing Biorefineries Using Wood for the BioEconomy – Current Status and Future Perspective of IEA Bioenergy Task 42 "Biorefining", 18th ISWFPC 2015, 9-11 September 2015, Vienna, Austria.

- Gerfried Jungmeier and Task 42, The Biorefinery fact Sheet and its Application to Wood Based Biorefining – Case Studies of IEA Bioenergy Task 42 Biorefining, Nordic Wood Biorefinery Conference (NWBC), Helsinki, Finland, 20-22 October 2015.

- René van Ree and Task 42, Contribution to Handbook of Biofuels' Production: Processes and Technologies (Second Edition), A VOLUME IN THE WOODHEAD PUBLISHING SERIES IN ENERGY) edited by Prof Rafael Luque, Prof James Clark, Prof Karen Wilson and Dr Carol Lin, Q4 2015.

- Gerfried Jungmeier and Task 42, Implementing Strategies of Biorefineries in the BioEconomy using a Life Cycle Sustainability Approach developed in IEA Bioenergy Task42 Biorefining, to be presented at the European Biomass Conference, Amsterdam, The Netherlands 2016.

These publications are available on the Task website www.IEA-Bioenergy.Task42-Biorefineries.com.

TASK 43

Progress report for ExCo75, Dublin Ireland, May 2015.

Progress report for ExCo76, Berlin, Germany, October 2015.

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

Task 43 Technical Reports

Schweinle, J., Rödl A., Börjesson, P., Neary, D.G., Langevel J.W.A.,Berndes, MG.,Cowie, A., Ahlgren, S., Margni, M., Gaudreault, C., Verschuyl, J., Wigley, T.B., Vice, K., and B. Titus. 2015. Assessing the Environmental Performance of Biomass Supply Chains. IEA Bioenergy Task 43 Report TR2015:01

Neary, D.G. (2015). Best Practices Guidelines for Managing Water in Bioenergy Feedstock Production. IEA Bioenergy Task 43 Report 2015:02.

Richards, K.M., Pearce, C., Domac, J., White, W., Elbe, S., Hohle, E.E. (2015). Fuel poverty and bioenergy – discussion paper. IEA Bioenergy Task 43 Report TR2015:03

Nordborg, M., Cederberg, C., Berndes, G. (2015). Modeling potential freshwater ecotoxicity impacts due to pesticide use in biofuel feedstock production: the cases of maize, rapeseed, Salix, soybean, sugarcane and wheat. IEA Bioenergy Task 43 Report TR2015:04

ExCo Report

Smith, C.T., Lattimore, B., Berndes, G., Bentsen, N.S., Dimitriou, I., Langeveld, J.W.A., Thiffault, E. (Eds.) 2015. Mobilizing Sustainable Bioenergy Supply Chains – Inter-Task Project Synthesis Report. IEA Bioenergy ExCo: 2015:04. ISBN ISBN 978-1-910154-19-9 (printed paper edition). ISBN ISBN 978-1-910154-20-5 (eBook electronic edition). 170 pp.

Selected other publications and dissemination (only including publications directly associated with Task 43 activities)

Cintas, O., Berndes, G., Cowie, A. L., Egnell, G., Holmström, H. and Ågren, G. I. (2015b), The climate effect of increased forest bioenergy use in Sweden: evaluation at different spatial and temporal scales. WIREs Energy Environ. doi: 10.1002/wene.178

Dale V.H., K.L. Kline, M.A. Buford, T.A. Volk, C.T. Smith, I. Stupak (2016). Incorporating bioenergy into sustainable landscape designs. Renewable & Sustainable Energy Reviews 56: 1158-1171.

Energistyrelsen (2015). Kulstofkredsløb, kulstofgæld og CO_2 neutralitet [Carbon cycles, carbon debt and CO_2 neutrality] (elaborated by Niclas Scott Bentsen, Asger Strange Olesen, Simon Laursen Bager, Sanne Lisby Eriksen). The Danish Energy Agency.

Energistyrelsen (2015). Biomassepotentialer i Danmark, EU og Globalt [Biomass potentials in Denmark, EU and globally] (elaborated by Niclas Scott Bentsen et al.). The Danish Energy Agency.

Energistyrelsen (2015). Bæredygtighed og certificering af biomasse [Sustainability and certifcation of biomass] (elaborated by Inge Stupak and Asgar Strange Olesen). The Danish Energy Agency. The Danish Energy Agency.

Englund O, Berndes G, Persson M, Sparovek G. 2015. *Oil palm for biodiesel in Brazil – risks and opportunities.* Environmental Research Letters, 10 2015 044002. doi: 10.1088/1748-9326/10/4/044002

Englund O. Berndes G, in press. The Roles of Public and Private Governance in Promoting Sustainable Bioenergy. Chapter 2. In: Le Bouthillier Y, Cowie A, Martin P, and McLeod-Kilmurray H (eds). The Law and Policy of Biofuels. Edward Elgar Publishing, UK (in Press)

GBEP-IEA Bioenergy (2016) 'Examples of Positive Bioenergy and Water Relationships', a report from the GBEP-IEA Bioenergy collaboration within the GBEP Activity Group 6 ''Bioenergy and Water

Ghaffariyan, M., Spinelli, R., Magagnotti, N., Brown, M. (2015) Integrated harvesting for conventional log and energy wood assortments: a case study in a pine plantation in Western Australia. Southern Forests: a Journal of Forest Science 77 (4), 249-254

Lund, P., Byrne, J., Berndes, G., Vasolos, I. (Eds.) *Advances in bioenergy – the sustainablity challenge.* Wiley & Sons. Ltd. The book includes 13 chapters involving authors from the Task

Mansoor M, Stupak I and Smith CT. Private regulation in the bioenergy sector. Chapter 17. In: Le Bouthillier Y, Cowie A, Martin P, and McLeod-Kilmurray H (eds). The Law and Policy of Biofuels. Edward Elgar Publishing, UK (in Press)

Meadows, J., Coote, D., Brown, M. (2014) The potential supply of biomass for energy from hardwood plantations in the Sunshine Coast Council Region of South-East Queensland, Australia. Small Scale Forestry 13 (4), 461-481

Murphy, F., Devlin, G. and McDonnell, K. 2015. Benchmarking Environmental Impacts of Peat Use for Electricity Generation in Ireland – A Life Cycle Assessment. Sustainability 2015 (7): 6376 – 6393

Murphy, F., Devlin, G. and McDonnell, K. 2015. Greenhouse Gas and Energy based Life Cycle Analysis of Products from the Irish Wood Processing Industry. Journal of Cleaner Production. 92 (2015) 134-141

McGrath, J.F., Goss, K.F., Brown, M.W., Bartle, J.R., Abadi, A. Aviation biofuel from integrated woody biomass in southern Australian. Wires – Energyand Environment, in review

Sosa, A., McDonnell, K., and Devlin, G. 2015. Analysing Performance Characteristics of Biomass Haulage in Ireland for Bioenergy Markets with GPS, GIS and Fuel Diagnostic Tools. Energies 2015 (8) – Special Issue Economics of Bioenergy 2015 (ISSN 1996-1073). 12004 – 12019

Sosa, A., Acuna, M., McDonnell, K. and Devlin, G. 2015. Managing the Moisture Content of Wood Biomass for the Optimisation of Ireland's Transport Supply Strategy to Bioenergy Markets and Competing Industries. Energy (86) 354 – 368

Sosa, A., Devlin, G., Klvac, R. and McDonnell, K. 2015. Improving Log Loading Efficiency for Sustainable Biomass Transport through Better Moisture Content Management. Sustainability, Special Issue – Transportation Sustainability. 2015, 7(3), 3017-3030

Sosa, A., Acuna, M., McDonnell, K. and Devlin, G. 2015. Controlling Moisture Content and Truck Configuration to Model and Optimise Biomass Supply Chain Logistics in Ireland. Applied Energy. 137 (2015) 338 – 351

Sparovek G., Barretto A., Berndes G. 2015. *Effects of governance on availability of land for agriculture and conservation in Brazil.* Environmental Science and Technology, doi: 10.1021/acs.est.5b01300

Stupak, I., Joudrey, J., Smith, C.T., Pelkmans, L., Chum, H., Cowie, A., Englund, O., Goh, C.S., Junginger, M. (2016) A global survey of stakeholder views and experiences for systems needed to effectively and efficiently govern sustainability of bioenergy. WIREs Energy Environ 2016, 5:89-118. doi: 10.1002/wene.166

Thiffault, E., Berndes, G., Junginger, M., Saddler, J., Smith, T. (Eds.) (2016). Mobilisation of Forest Bioenergy in the Boreal and Temperate Biomes. Elsevier. (in press)

KEY PARTICIPANTS IN EACH TASK

TASK 32 – Biomass Combustion and Co-firing

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

Task Leader: Jaap Koppejan, Procede Biomass BV, the Netherlands.
For contacts see Appendix 6.

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

Country	National Team Leader	Institution
Austria	Ingwald Obernberger	Technical University of Graz
Belgium	Mike Temmerman	Walloon Agricultural Research Centre
Denmark	Morten Tony Hansen	Force Technology
Germany	Hans Hartmann	Technologie- und Forderzentrum
Ireland	William Smith	Teagasc
Japan	Nobuyuki Tahara	New Energy and Industrial Technology Development Organization (NEDO)
The Netherlands	Jaap Koppejan	Procede Group BV
	Robert van Kessel	DNV KEMA
	Kees Kwant	NL Agency
Norway	Øyvind Skreiberg	SINTEF
South Africa	Yokesh Singh	ESKOM
Sweden	Claes Tullin	Swedish National Testing and Research Institute
Switzerland	Thomas Nussbaumer	Verenum
UK	William Livingston	Doosan Babcock Energy Limited

TASK 33 – Thermal Gasification of Biomass

Operating Agent: Jim Spaeth, US Department of Energy, USA.
For contacts see Appendix 7.

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

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

Country	National Team Leader	Institution
Austria	Reinhard Rauch	Vienna University of Technology
Denmark	Morten Tony Hansen	Force
Finland	Ilkka Hannula	VTT Energy
Germany	Thomas Kolb	KIT
Italy	Antonio Molino	ENEA
The Netherlands	Bram van der Drift	ECN

Norway	Roger Khalil	SINTEF
Sweden	Lars Waldheim	Waldheim Consulting
Switzerland	Martin Rüegsegger	ETECA
USA	Kevin Whitty	University of Utah

TASK 34 – Pyrolysis of Biomass

Operating Agent: Jim Spaeth, US Department of Energy, USA. For contacts see Appendix 7.

Task Leader: Doug Elliott, PNNL, USA. For contacts see Appendix 6.

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

Country	National Team Leader	Institution
Finland	Anja Oasmaa	VTT (Technical Research Centre of Finland Ltd.)
Germany	Dietrich Meier	Thünen Institute for Wood Research
Netherlands	Bert van de Beld	BTG (Biomass Technology Group)
Norway	Kai Toven	PFI (Paper and Fibre Institute)
Sweden	Magnus Marklund	SP ETC (Energy Technology Centre)
United Kingdom	Anthony Bridgwater	Aston University
USA	Douglas Elliott	PNNL (Pacific Northwest National Laboratory)

TASK 36 – Integrating Energy Recovery into Solid Waste Management

Operating Agent: Elizabeth McDonnell, Department of Energy and Climate Change (DECC), UK. For contacts see Appendix 7.

Task Leader: Pat Howes, Ricardo Energy & Environment.

Assistant Task Leader: Kathryn Warren, Ricardo Energy & Environment.

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

Country	National Team Leader	Team Leader Institution
France	Elisabeth Poncelet	ADEME
Germany	Helmut Seifert	KIT, Karlsruhe
Italy	Giovanni Ciceri	RSE
Norway	Michael Becidan	SINTEF
Sweden	Inge Johansson	SP Sweden
UK	Keith Riley	Drenl UK

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.
For contacts see Appendix 6.

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

Country	National Team Leader	Institution
Australia	Bernadette McCabe	University of Southern Queensland
Austria	Bernhard Drosg	BOKU University, IFA-Tulln
Brazil	Cícero Jayme Bley	Itaipu Binacional
Denmark	Teodorita Al Seadi	BIOSANTECH
European Commission	David Baxter	European Commission, JRC Petten, NL
Finland	Saija Rasi	Natural Resources Institute Finland (Luke)
France	Olivier Théobald	Ademe
Germany	Bernd Linke	Leibniz-Institute for Agricultural Technology
Ireland	Jerry Murphy	University College Cork
Korea	Ho Kang	Chungnam National University
Netherlands	Mathieu Dumont	Netherlands Enterprise Agency
Norway	Tormod Brieid	Norwegian Institute for Bioeconomy Research (NIBIO)
Sweden	Mattias Svensson	Energiforsk
Switzerland	Nathalie Bachmann	ENVI Concept
United Kingdom	Clare Lukehurst	Probiogas UK

TASK 38 – Climate Change Effects of Biomass and Bioenergy Systems

Operating Agent: Stephen Schuck, Bioenergy Australia Manager, Australia.

Task Leader: Annette Cowie, NSW Department of Primary Industries, Australia.

Task Manager: Miguel Brandão, Royal Institute of Technology, Stockholm, Sweden

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

Country	National Team Leader	Institution
Australia	Annette Cowie	NSW Department of Primary Industries
Brazil	Manoel Regis Leal	Brazilian Bioethanol Science and Technology Laboratory
Finland	Sampo Soimakallio	Finnish Environment Institute (SYKE)
	Kim Pingoud	VTT Technical Research Centre of Finland
France	Roland Gerard	Ademe Service Bioressources
	Alice Gueudet	

Germany	Sebastian Rüter	Thünen Institute of Wood Research
Norway	Anders Strømman	Norwegian University of Science and Technology
Sweden	Leif Gustavsson	Linnaeus University
	Matti Parikka (deceased)	Swedish Energy Agency
USA	Alison Goss Eng	US Department of Energy
	Helena Chum	National Renewable Energy Laboratory

TASK 39 – Commercialising Liquid Biofuels from Biomass

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

Task Leader: Jim McMillan, NREL, USA.

Associate Task Leader: Jack Saddler, University of British Columbia, Canada.
For contacts see Appendix 6.

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

Country	National Team Leader	Institution
Australia	Les Edye	Queensland University of Technology
Austria	Dina Bacovsky	Bioenergy 2020+
Brazil	Paulo Barbosa	Petrobras
	Eduardo Barcelos Platte	Petrobras
	Antonio Maria Bonomi	CTBE
Canada	Jack Saddler	University of British Columbia
	Warren Mabee	Queens University
Denmark	Michael Persson	Inbicon A/S
	Claus Felby	University of Copenhagen
	Anders Kristoffersen	Novozymes
	Henning Jørgensen	Technical University of Denmark
Germany	Franziska Mueller-Langer	DBFZ
	Nicolaus Dahmen	DBFZ
Italy	Alessandra Frattini	Chemtex Italia SRL
	David Chiaramonti	Chemtex Italia SRL
	Stefania Pescarolo	Chemtex Italia SRL
Japan	Shiro Saka	Kyoto University
	Satoshi Aramaki	NEDO
The Netherlands	Timo Gerlagh	NL Agency
	Christian Koolloos	DSM
New Zealand	Ian Suckling	Scion
Norway	Gisle Johansen	Borregaard
	Karin Øyaas	PFI
	Judit Sandquist	SINTEF
	Berta Guell	SINTEF
South Africa	Emile van Zyl	University of Stellenbosch
	Bernard Prior	University of Stellenbosch
South Korea	Jin Suk Lee	Korean Institute of Energy Research
	Kyu Young Kang	Dongguk University
	Seonghan Park	Pusan National University

Sweden	Alice Kempe	Swedish Energy Agency
	Maria Nyquist	Swedish Energy Agency
	Jonas Lindmark	Swedish Energy Agency
	Leif Jonsson	Umea University
USA	Jim McMillan	NREL

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

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

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

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

Task Assistant (Secretary): Chun Sheng Goh, Copernicus Institute of Sustainable Development, Utrecht University, the Netherlands

The Task is organised with 'National Teams' in the participating countries. The contact persons (National Team Leaders) as of December 2014 in each country are listed below:

Country	National Team Leader	Institution
Austria	Lukas Kranzl	Vienna University of Technology
	Michael Wild	Wild und Partner
Belgium	Luc Pelkmans	VITO – Flemish Institute for Technological Research
Brazil	Arnaldo Walter	University of Campinas
Denmark	Wolfgang Stelte	Danish Technological Institute
	Anders Evald	HOFOR
Finland	Tapio Ranta	Lappeenranta Technical University
	Jussi Heinimö	Miktech
Germany	Uwe Fritsche	IINAS
	Daniela Thrän	Deutsches BiomasseForschungsZentrum
	Michael Deutmeyer	Green Resources AS
Italy	Luca Benedetti	Gestore Servizi Energetici (GSE)
The Netherlands	Martin Junginger	Copernicus Institute, Utrecht University
	Peter-Paul Schouwenberg	RWE
Norway	Erik Tromborg	Norwegian University of Life Sciences
Sweden	Bo Hektor	Svebio
	Lena Dahlman	Sveaskog
UK	Rocio Diaz-Chavez	Imperial College
	Laura Cragg	Drax
USA	Richard Hess	Idaho National Laboratory

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

Operating Agent: Kees Kwant, NL Enterprise Agency, Ministry of Economic Affairs. For contacts see Appendix 7.

Task Leader: René van Ree, Wageningen UR – Food and Bio-based Research, the Netherlands. For contacts see Appendix 6.

Assistant Task Leader: Ed de Jong, Avantium Technologies B.V., the Netherlands. For contacts see Appendix 6.

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

Country	National Team Leader	Institution
Australia	Stephen Schuck	Bioenergy Australia c/o Stephen Schuck and Associates Pti Ltd
	Geoff Bell	Microbiogen Pty Ltd
Austria	Gerfried Jungmeier	Joanneum Research Forschungsgesellschaft mbH
Canada	Maria Wellisch	Agriculture and Agri-Food Canada
Denmark	Claus Felby	University of Copenhagen
	Henning Jorgensen	Technical University of Denmark
Germany	Heinz Stichnothe	Thunen-Institute of Agricultural Technology
Italy	Isabella de Bari	ENEA C.R.TRISAIA
Ireland	Matthew Clancy a.i.	Sustainable Energy Authority of Ireland
Japan	Shinya Kimura	New Energy and Industrial Technology Development Organisation (NEDO)
	Akihiko KONDO	Kobe University
Netherlands (coordinator)	Rene van Ree	Wageningen UR – Food and Biobased Research
	Ed de Jong	Avantium B.V.
	Bert Annevelink	Wageningen UR – Food and Biobased Research
New Zealand	Kirk Torr	Scion
United States of America	Steven Thomas	U.S. Department of Energy

---

TASK 43 – Biomass Feedstocks for Energy Markets

Operating Agent: Åsa Forsum, Swedish Energy Agency, Sweden. For contacts see Appendix 7.

Task Leader: Göran Berndes, Chalmers University of Technology, Sweden. For contacts see Appendix 6.

Associate Task Leaders: Tat Smith, University of Toronto, Canada. For contacts see Appendix 6.

Bill White, Kingsmere Economic Consulting, Edmonton, Canada. For contacts see Appendix 6.

Task Secretary: Sally Krigstin, University of Toronto, Canada.
For contacts see Appendix 6.

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

Country	National Team Leader	Institution
Australia	Mark Brown	Tamworth Agricultural Institute
Canada	Dana Collins	Canadian Institute of Forestry
Crotatia	Biljana Kulisic	Energy Institute Hrvoje Pozar
Denmark	Inge Stupak	University of Copenhagen
European Commission	Jean-Francois Dallemand	JRC, European Commission
Finland	Antti Asikainen	The Finnish Forest Research Institute
Germany	Jörg Schweinle	Johann Heinrich von Thünen-Institute (vTI)
Ireland	Ger Devlin	School Of Biosystems Engineering, University College Dublin
Netherlands	Jan van Esch	Ministry of Agriculture, Nature and Food Quality
Norway	Simen Gjølsjø	Norwegian Forest and Landscape Institute
Sweden	Gustaf Egnell	Swedish University of Agricultural Sciences
United States	Marilyn Buford	USDA Forest Service

OPERATING AGENTS AND TASK LEADERS

Operating Agent Task 32: The Netherlands

(duration 1 January 2013-31 December 2015)

OA: Kees Kwant

TL Jaap Koppejan
Procede Biomass BV
PO Box 328
ENSCHEDE. 7500 AH
THE NETHERLANDS

Phone: +31 53 7112 500/502
Fax: +31 53 7112 599
Email: jaapkoppejan@procede.nl

Operating Agent Task 33: USA

(till December 2013 Austria, from January 2014 USA)

OA: Jim Spaeth

TL: Kevin Whitty
The University of Utah
50 S. Central Campus Dr., Room 3290
Joseph F. Merrill Engineering Building
Salt Lake City, UT 84112
USA

Phone: 801-585-9388
Fax: 801-585-9291
Email: kevin.whitty@utah.edu

Reinhard Rauch (Associate Task Leader)
Institute of Chemical Engineering
Vienna University of Technology
Getreidemarkt 9/166
A-1060 VIENNA
AUSTRIA

Phone: +43 1 58801 15954
Fax: +43 1 58801 15999
Email: rrauch@mail.zserv.tuwien.ac.at

Jitka Hrbek (Task Secretary)
Institute of Chemical Engineering
Vienna University of Technology
Getreidemarkt 9/166
A-1060 VIENNA
AUSTRIA

Phone: +43 664 88 537 003
Fax: +43 1 58801 15999
Email: Jitka.hrbek@tuwien.ac.at

Operating Agent Task 34: USA

(duration 1 January 2013-31 December 2015)

OA: Jim Spaeth
TL: Doug Elliott
Pacific Northwest National Laboratory
902 Battelle Boulevard
PO Box 999, MSIN P8-60
Richland, WASHINGTON 99352
USA

Phone: +1 509 375 2248
Email: dougc.elliott@pnnl.gov

Operating Agent Task 36: United Kingdom

(duration 1 January 2013-31 December 2015)

OA: Elizabeth McDonnell
TL: Pat Howes
Ricardo – AEA
Gemini Building,
Fermi Avenue, Harwell
DIDCOT, OX11 0QR
UNITED KINGDOM

Phone: +44 (0) 1235 753 254
Mobile: +44 7968 707 376
Email: Pat.Howes@ricardo-aea.co.uk

Operating Agent Task 37: European Commission

(duration 1 January 2013-31 December 2015)

OA: Kyriakos Maniatis
TL: David Baxter
Sustainable Transport Unit
European Commission
Joint Research Centre
Westerduinweg 3
1755 LE PETTEN
THE NETHERLANDS

Phone: +31-22456-5227
Email: david.baxter@ec.europa.eu

Operating Agent Task 38: Australia

(duration 1 January 2013-31 December 2015)

OA: Stephen Schuck

TL: Annette Cowie
School of Environmental and Rural Science
NSW Department of Primary Industries
Beef Industry Centre, Trevenna Road
University of New England
ARMIDALE, NSW 2351
AUSTRALIA

Phone: +61 2 6770 1842
Email: annette.cowie@dpi.nsw.gov.au

Operating Agent Task 39: Canada

(duration 1 January 2013-31 December 2015)

OA: Ed Hogan

TL: Jim McMillan
NREL
1617 Cole Boulevard
Golden, CO 80401-3393
USA

Phone: +1 (303) 384-6861
Email: jim.mcmillan@nrel.gov

Jack Saddler (Associate Task Leader)
Professor of Forest Products Biotechnology/Bioenergy
Faculty of Forestry
University of British Columbia
4th Floor, Forest Sciences Center
4041-2424 Main Mall
VANCOUVER, BC V6T 1Z4
CANADA

Phone: +1 604 822 9741
Email: jack.saddler@ubc.ca

Operating Agent of Task 40: The Netherlands

(duration 1 January 2013 – 31 December 2015)

OA: Kees Kwant

TL: Martin Junginger (Scientific)
Energy & Resources,
Faculty of Geosciences,
Copernicus Institute of Sustainable Development,
Van Unnik gebouw
Heidelberglaan 2,
3584 CS Utrecht
THE NETHERLANDS
Phone: +31-30-2537613
Email: h.m.junginger@uu.nl

TL: Peter-Paul Schouwenberg (Industry)
Senior Officer Regulatory Affairs-Corporate Affairs Essent
Willemsplein 4
5211 AK 's-Hertogenbosch
THE NETHERLANDS
Phone: +31 06 1151 3528
Email: Peter-Paul.Schouwenberg@essent.nl

Chun Sheng Goh
Energy & Resources,
Faculty of Geosciences,
Copernicus Institute of Sustainable Development,
Van Unnik gebouw
Heidelberglaan 2 (K906),
3584 CS Utrecht
THE NETHERLANDS
Phone: +31 30 253 7610
Email: c.s.goh@uu.nl

Operating Agent Task 42: The Netherlands

(duration 1 January 2013-31 December 2015)

OA: Kees Kwant

TL: René van Ree
Theme Leader Bioenergy & Biofuels
Wageningen University and Research Centre (WUR)
Food and Bio-based Research
P.O. Box 17
WAGENINGEN, 6700 AA
THE NETHERLANDS

Phone: +31 317 480 710
Fax: +31 317 475 347
Email: rene.vanree@wur.nl

Ed de Jong (Assistant Task Leader)
Avantium Technologies BV
Zekeringstraat 29
AMSTERDAM, 1014 BV
THE NETHERLANDS

Phone: +31 020 586 80 80
Fax: +31 020 586 80 85
Email: ed.dejong@avantium.com

Operating Agent Task 43: Sweden

(duration 1 January 2013-31 December 2015)

OA: Åsa Forsum

TL: Göran Berndes
Department of Energy and Environment,
Division of Physical Resource Theory
Chalmers University of Technology
GÖTEBORG, SE-412 96
SWEDEN

Phone: +46 31 772 3148
Fax: +46 31 772 3150
Email: goran.berndes@chalmers.se

Tat Smith (Associate Task Leader)
University of Toronto
33 Willcocks Street
TORONTO, Ontario, M5S 3B3
CANADA

Phone: +1 416 978 4638
Fax: +1 416 978 3834
Email: tat.smith@utoronto.ca

EXCO MEMBERS AND ALTERNATES

	Member	Alternate Member
AUSTRALIA	Dr Stephen Schuck Bioenergy Australia Manager c/o Stephen Schuck and Assoc. Pty Ltd 7 Grassmere Road Killara, SYDNEY, NSW 2071 Phone: +61 2 9416 9246 Fax: +61 2 9416 9246 Email: sschuck@bigpond.net.au	Mr Brendan George Rural Climate Solutions University of New England & NSW DPI Tamworth Agricultural Institute 4 Marsden Park Rd Tamworth NSW 2340 Phone: +61 2 6763 1238 Fax: +61 2 6763 1222 Email: brendan.george@dpi.nsw.gov.au
AUSTRIA	Dr Theodor Zillner Federal Ministry for Transport, Innovation and Technology Radetzkystrasse 2 1030 WIEN Phone: +43 1 711 62 652925 Email: theodor.zillner@bmvit.gv.at	Dr Manfred Wörgetter Bioenergy2020+ GmbH Standort Wieselburg Gewerbepark Haag 3 3250 WIESELBURG Phone: +43 7416 52238 30 Email: manfred.woergetter@bioenergy2020.eu
BELGIUM	Dr Yves Schenkel CRAW Rue de Liroux, 9 GEMBLOUX, B-5030 Phone: +32 81 62 65 56 Fax: +32 81 61 57 47 Email: schenkel@cra.wallonie.be	Mr. Ruben Guisson Project manager biobased economy VITO NV Boeretang 200 MOL, BE-2400 Phone: +32 14 33 58 49 Fax: +32 14 32 11 85 Email: ruben.guisson@vito.be
BRAZIL	Mr Ricardo de Gusmão Dornelles Director, Department of Renewable Fuels Ministry of Mines and Energy Esplanada dos Ministérios, Bloco U, 9° Andar 70 065-900 – BRASILIA – DF Phone: +55 61 3319 5509 Fax: +55 61 3319 5626 Email: Rdornelles@mme.gov.br	To be announced
CANADA	Dr Alex MacLeod Senior Science & Technology Adviser Office of Energy Research & Development Natural Resources Canada 580 Booth Street, 14th Floor OTTAWA, Ontario K1A 0E4 Phone: +1 613 286 1459 Fax: +1 613 995 6146 Email: alex.macleod@canada.ca	Mr Jeff Karau Project Officer Forest Science Division Natural Resources Canada 580 Booth Street, OTTAWA, Ontario K1A 0E4 Phone: +1 613 947 8997 Fax: +1 613 947 9035 Email: jkarau@rncan.gc.ca

	Member	Alternate Member
CROATIA	Dr Branka Jelavic Head Dept for Renewable Resources Energy Institute 'Hrvoje Pozar' Savska 163 P.B. 141 ZAGREB, 10001 Phone: +385 1 632 6117 Fax: +385 1 604 0599 Email: bjelavic@eihp.hr	Ms Biljana Kulisic, MSc. Senior researcher – biomass Department for RES&EE Energy Institute 'Hrvoje Pozar' Savska 163 Zagreb 10000 Phone: +385 1 632 6169 Fax: +385 1 604 0599 Email: bkulisic@eihp.hr
DENMARK	Mr Jan Bünger – Senior Adviser Energy R&D and Joint Implementation Danish Energy Authority Amaliegade 44 COPENHAGEN, DK-1256 Phone: + 45 33 927 589 Fax: + 45 33 114 743 Email: jbu@ens.dk	Mrs Bodil Harder Programme Manager Energy R&D The Danish Energy Agency Ministry of Climate & Energy Amaliegade 44 DK-1256 Copenhagen K Phone: +45 33 92 6797 Email: bha@ens.dk
FINLAND	Professor Kai Sipilä VTT PO Box 1000 Vuorimiehentie 3 ESPOO, FIN 02044 VTT Phone: +358 20 722 5440 Fax: +358 20 722 7048 Email: kai.sipila@vtt.fi	Mrs Marjatta Aarniala Tekes, Finnish Funding Agency for Technology and Innovation Energy and Environment Industries PO Box 69 Kyllikinportti 2, Lansi-Pasila HELSINKI, FIN-00101 Phone: +358 10 605 5736 Fax: +358 10 605 5905 Email: marjatta.aarniala@tekes.fi
FRANCE	Mr Jean-Christophe Pouet Head of Bioresources Department (DBIO) ADEME 20 avenue du Grésillé BP 90406 49004 ANGERS Cedex 01 Phone: +33 02 41 20 43 27 Fax: +33 02 41 20 43 02 Email: jean-christophe.pouet@ademe.fr	Ms Elisabeth Poncelet Direction Economie Circulaire et Déchet, Service Mobilisation et Valorisation des Déchets ADEME 20 avenue du Grésillé BP 90406 F - 49004 ANGERS Cedex 01 Phone: +33 2 41 20 42 57 Email: elisabeth.poncelet@ademe.fr
GERMANY	Mr Birger Kerckow Fachagentur Nachwachsende Rohstoffe e.V. (FNR) Hofplatz 1 GÜLZOW-PRÜZEN, 18276 Phone: +49 3843 693 0125 Fax: +49 3843 693 0102 Email: B.Kerckow@fnr.de	Dr Volker Niendieker Federal Ministry of Food and Agriculture (BMEL) Wilhelmstraße 54 10117 Berlin Phone: +49 30 18 529-3140 Fax: +49 30 18 529 55-3140 Email: volker.niendieker@bmel.bund.de
IRELAND	Mr Matthew Clancy Programme Manager Bioenergy & CHP Sustainable Energy Authority of Ireland Wilton Park House Wilton Place DUBLIN 2 Phone: +353 1 808 2152 Fax: +353 1 808 2002 Email: matthew.clancy@seai.ie	Mr Shay Kavanagh Specialist: Technical Services Sustainable Energy Authority of Ireland Wilton Park House Wilton Place DUBLIN 2 Phone: +353 1 808 xxxx Fax: +353 1 808 2002 Email: shay.kavanagh@seai.ie

	Member	Alternate Member
ITALY	Mr Luca Benedetti Gestore dei Servizi Energetici – GSE S.p.A. Viale Maresciallo Pilsudski, 92 00197 ROME Phone: +39 06 8011 4572 Fax: +39 06 8011 2040 Email: luca.benedetti@gse.it	Mr Vito Pignatelli ENEA Research Centre of Casaccia Via Anguillarese, 301 – 00123 – S.M. di Galeria, ROME Phone: +39 06 3048 4506 Fax: +39 06 3048 6514 Email: vito.pignatelli@casaccia.enea.it
JAPAN	Mr Takahisa Yano Project Coordinator – Biomass Group NEDO Muza Kawasaki Central Tower 18F 1310 Ohmiyacho, Saiwai-ku, Kawasaki, KANAGAWA 212-8554 Phone: +81 44 520 5271 Fax: +81 44 520 5275 Email: yanotkh@nedo.go.jp	Dr Nobuyuki Tahara Project Coordinator – Biomass Group NEDO Muza Kawasaki Central Tower 18F 1310 Ohmiyacho, Saiwai-ku, Kawasaki, KANAGAWA 212-8554 Phone: +81 44 520 5271 Fax: +81 44 520 5275 Email: taharanby@nedo.go.jp
KOREA	Sang-keun YU (Gavin) NRE Policy Dept. New & Renewable Energy Center (NREC) Korea Energy Agency (KEA) 298, Sujidaero, Suji-gu Yongin-si Gyeonggi 448-994 Phone: +82 31 260-4814 Fax: +82 31 260-4825 Email: yusk@energy.or.kr	Professor Don-Hee Park Chonnam National University Rm5B-216 77-Yongbongro Gwangju 500-757 Phone: +82-62-530-1841 Email: dhpark@chonnam.ac.kr
NETHERLANDS	Ir Kees Kwant Ministry of Economy, Agriculture and Innovation NL Agency Division: NL Energy and Climate Change PO Box 8242, UTRECHT, 3503 RE Phone: +31 88 602 2458 Email: kees.kwant@agentschapnl.nl	Mr Patrick Todd Directie Energie en Duurzaamheid Directoraat-Generaal Energie, Telecom en Mededinging Ministerie van Economische Zaken Postbus 20401 DEN HAAG, 2500 EK Phone: + 31 6 460 66053 Email: p.g.todd@minez.nl
NEW ZEALAND	Dr Paul Bennett SCION Private Bag 3020 ROTORUA Phone: +64 7 343 5601 Fax: +64 7 348 0952 Email: paul.bennett@scionresearch.com	Dr Elspeth MacRae SCION Private Bag 3020 ROTORUA Phone: +64 7 343 5824 Fax: +64 7 343 5528 Email: elspeth.macrae@scionresearch.com
NORWAY	Mr Trond Vaernes The Research Council of Norway Department for Energy Research Postboks 564 1327 Lysaker Phone: +47 22 03 70 00 Email: trv@rcn.no	Mr Øyvind Leistad Enova SF Professor Brochsgt Gate 2 7030 TRONDHEIM Phone: + 47 73 19 04 61 Fax: + 47 99 51 80 08 Email: oyvind.leistad@enova.no

	Member	Alternate Member
SOUTH AFRICA	Dr Thembakazi Mali SANEDI (Pty) Ltd Senior Manager: Clean Energy Solutions PO Box 786141 Sandton, 2146 JOHANNESBURG Phone: +27 010 201 4782 Fax: +27 010 201 4932 Email: thembakazim@saneri.org.za	Mr Khanyiso Zihlangu Deputy Director Off-grid based Renewable Energy Department of Energy Private Bag X96 PRETORIA, 0001 Phone: +27 12 406 7651 Email: Khanyiso.zihlangu@energy.gov.za
SWEDEN	Dr Åsa Forsum Swedish Energy Agency P.O. Box 310 Eskilstuna, SE-631 04 Phone: +46 16 544 2255 Fax: + 46 16 544 2261 Email: asa.forsum@energimyndigheten.se	Dr Göran Berndes Department of Energy and Environment, Physical Resource Theory Chalmers University of Technology GÖTEBORG, SE-412 96 SWEDEN Phone: +46 31 772 3148 Fax: +46 31 772 3150 Email: goran.berndes@chalmers.se
SWITZERLAND	Dr Sandra Hermle Swiss Federal Office of Energy (SFOE) Energy Research, Biomass and Combustion BERN, CH - 3003 Phone: +41 31 325 8922 Fax: +41 31 323 2500 Email: sandra.hermle@bfe.admin.ch	Mr Matthieu Buchs Renewable energy specialist, Biomass Federal Department of the Environment Transport, Energy and Communications Swiss Federal Office of Energy SFOE Mühlestrasse 4, 3063 Ittigen, postal address: 3003 Bern Phone: +41 58 462 56 40 Fax: +41 58 462 25 00 Email: matthieu.buchs@bfe.admin.ch
UNITED KINGDOM	Dr Elizabeth McDonnell Office for Renewable Energy Deployment Department of Energy and Climate Change 3 Whitehall Place LONDON, SW1A 2AW Phone: +44 (0)300 068 6187 Email: elizabeth.mcdonnell@decc.gsi.gov.uk	To be announced
USA	Mr Jim Spaeth Bioenergy Technologies Office Demonstration & Market Transformation, Program Manager Energy Efficiency and Renewable Energy U.S. Department of Energy 15013 Denver West Parkway Golden, CO 80401 Phone: +1 720 356 1784 Email: jim.spaeth@ee.doe.gov	Ms Corinne Drennan Pacific Northwest National Lab 902 Battelle Blvd P.O. Box 999, MSIN: K2-44 Richland, WA 99352 Phone: +1 509 TBA Email: corinne.drennan@pnnl.gov

	Member	Alternate Member
EUROPEAN COMMISSION	Dr Kyriakos Maniatis DG Energy and Transport European Commission Rue de la Loi/Wetstraat 200 BRUSSELS, B-1049 BELGIUM Phone: +32 2 299 0293 Fax: +32 2 296 6261 Email: Kyriakos.Maniatis@ec.europa.eu	Dr David Baxter Sustainable Transport Unit European Commission Joint Research Centre Westerduinweg 3 1755 LE PETTEN THE NETHERLANDS Phone: +31-22456-5227 Fax: +31-22456-5626 Email: david.baxter@ec.europa.eu

SOME USEFUL ADDRESSES

ExCo Chairman 2014

Ir Kees Kwant
Senior Expert Bioenergy and Biobased Economy
Netherlands Enterprise Agency
Ministry of Economic Affairs
PO Box 8242,
UTRECHT, 3503 RE
NETHERLANDS

(Address etc., see below)
Phone: +31 88 602 2458
Email: kees.kwant@rvo.nl

ExCo Vice Chairman 2014

Dr Sandra Hermle
Swiss Federal Office of Energy (SFOE)
Energy Research, Biomass and Combustion
BERN, CH - 3003
SWITZERLAND

(Address etc., see below)
Phone: +41 31 325 8922
Email: sandra.hermle@bfe.admin.ch

IEA Liaison

Mr Yasuhiro Sakuma
Renewable Energy Division
International Energy Agency
9 Rue de la Fédération
75739 PARIS Cedex 15
FRANCE

(Address etc., see below)
Phone: +33 1 40 57 65 62
Email: Yasuhiro.SAKUMA@iea.org

Contact details for the Secretary and Technical Coordinator are provided on the back cover of this report.

IEA Bioenergy

IEA BIOENERGY SECRETARIAT

Website:
www.ieabioenergy.com

Secretary:
Pearse Buckley
ODB Technologies Ltd
P.O. Box 12249
Dublin 9
IRELAND
Phone: +353 87 737 3652
Email: pbuckley@odbtbioenergy.com

Technical Coordinator:
Arthur Wellinger
Triple E&M
Châtelstrasse 21
AADORF, CH-8355
SWITZERLAND
Phone: +41 52 365 4385
Fax: +41 52 365 4320
Email: wellinger@triple-e-und-m.ch

iea Energy Technology Network