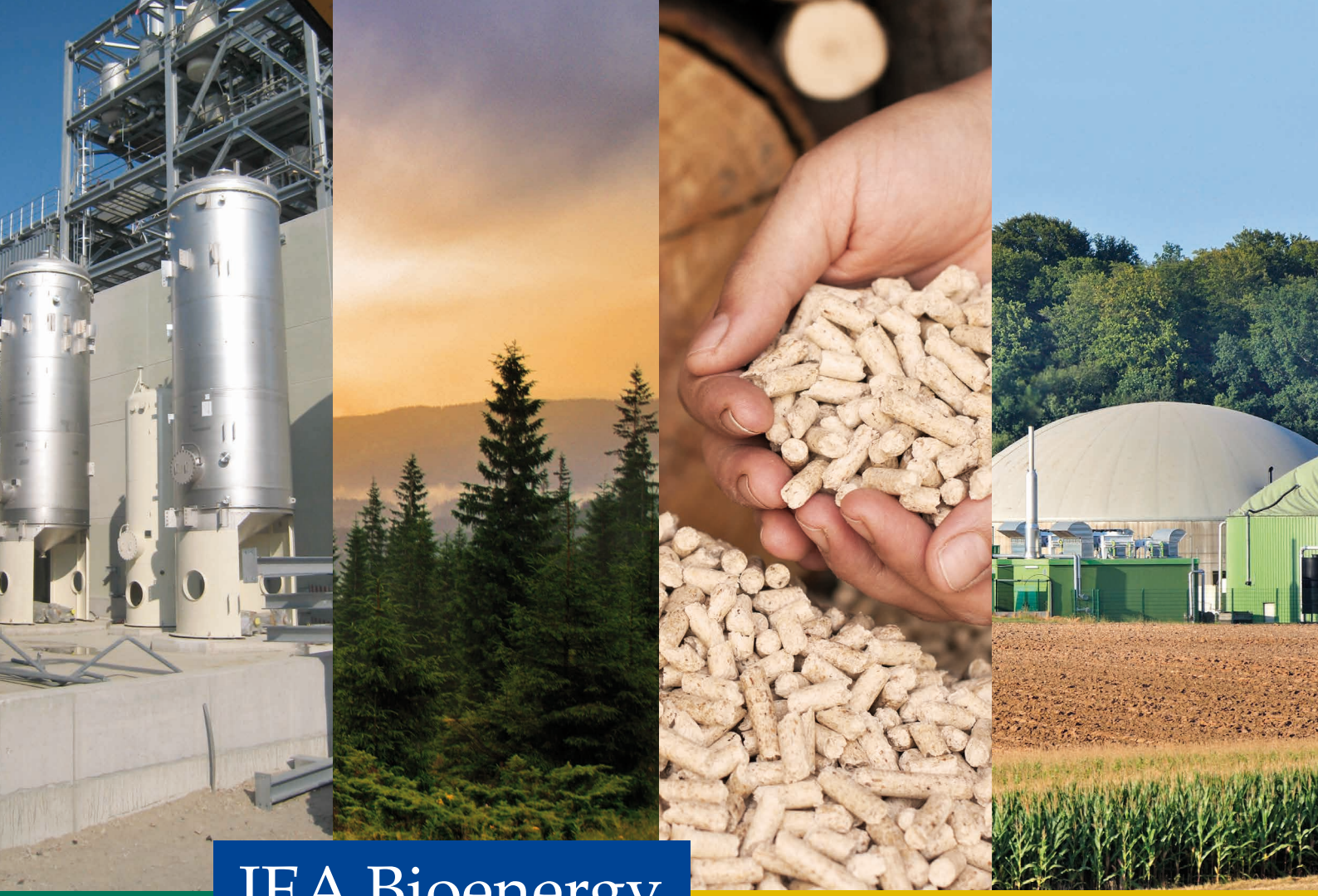

IEA Bioenergy

Report on IEA Bioenergy Tasks' Activities 2010-2012

IEA Bioenergy: ExCo:2014:02

Introduction

IEA Bioenergy (www.ieabioenergy.com), also known as the Implementing Agreement for a Programme of Research, Development and Demonstration on Bioenergy, functions within a Framework created by the International Energy Agency (IEA). The Implementing Agreement (IA) was originally established in 1978 as IEA Forestry Energy. In 1986 it broadened its remit to become IEA Bioenergy and to include non-forestry bioenergy in the scope of the work. IEA Bioenergy is governed by an Executive Committee (ExCo) made up of representatives of the contracting parties from Australia, Austria, Brazil, Belgium, Canada, Croatia, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Korea, The Netherlands, New Zealand, Norway, South Africa, Sweden, Switzerland, The United Kingdom, the USA and the European Commission.

IEA Bioenergy's vision is 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. The vision is accompanied by a mission to facilitate the commercialisation and market deployment of environmentally sound, socially acceptable, and cost competitive bioenergy systems and technologies, and to advise policy and industrial decision makers accordingly.

The IEA Bioenergy Strategic Plan (2010-2016) has the following drivers:

- The increased emphasis on security of energy supply by Member Countries and the need to reduce dependence on fossil fuels
- The increased emphasis on greenhouse gas mitigation through the use of bioenergy technologies by Member Countries
- The need to develop sustainable, non-food biomass resources to be used in bioenergy applications that are environmentally sound and socially acceptable
- The need for large-scale development and deployment of new or improved bioenergy technologies
- The need to increase the strategic role of IEA Bioenergy and to support energy policy development.

The work of IEA Bioenergy is carried out though Tasks, which cover the full value chain from biomass feedstocks to final energy product. These Tasks operate on the basis of 3 year work programmes (triennia) with budgets and deliverables approved by the Executive Committee. As increased scientific understanding of biomass technologies has been followed by plants of pilot and industrial scale, the Tasks have started to focus more on the deployment of technologies and on work to address barriers to deployment. As a result, policy oriented statements and publications have become more important and basic research papers and overviews are less dominant. Another important trend in the work of IEA Bioenergy has been a greater emphasis on collaboration among Tasks, resulting in a more comprehensive approach to issues affecting the development and deployment of bioenergy.

This Report on IEA Bioenergy Tasks' Activities 2010-2012 provides an overview of the work of the 11 Tasks that were active during the 2010-2012 triennium. For each Task the reporting format follows the general structure of background and objectives, followed by details of the activities and outputs. Where more detail is required, this can be obtained by referring to the relevant Task website at http://www.ieabioenergy.com/our-work-tasks/.

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TASK 29: Socio-Economic Drivers in Implementing Bioenergy Projects

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Introduction

Task 29 is seeking to investigate different regional and national achievements in the recognition and evaluation of the social and economic benefits of biomass use and drivers in implementing bioenergy projects. The fourth and final triennium period of the Task was focused on integrating the results and findings obtained previously and also through the international state-of-the-art socio-economic evaluation of bioenergy programmes and projects.

The events organised during the triennium included the sharing of research results, stimulation of new research directions in national, regional, and local programmes, and technology transfer from researchers to resource managers, planners, and industry.

The participation in the last triennium changed again; Germany joined the team but Ireland and Japan left. The first half of 2010 was dedicated to detailed planning of the three-year programme. The new Task member (Germany) was informed about past activities and introduced to the current programme, which was jointly reviewed with other partners.

Background

The Task has been able to clearly set out the 'state of the art' of socio-economic understanding and begun to apply new and novel methods of thinking to community-centred initiatives, based on community interaction and feedback. Such modelling work and study has shown a clear impact when deployed in participating countries and beyond. The Task has also commenced the aggregation of case-study material, which shows in stark contrast the differing approaches and results that can be gained at the local and regional level by working with different host entities.

One key area that was explored in this triennium in greater detail was the impact of national policy on regional and local activities. The aim was to provide feedback to policymakers on both the positive and negative implications of actual change and any further proposed change. In the final period, the Task sought to build on the solid foundations constructed with a core team of participants as well as to extend the work beyond its current level. The Task participants, supported by a wide range of national experts, identified the following three overarching themes, which were given maximum attention in the final three-year programme:

- Fuel poverty
- Regional benefits
- Financing bioenergy projects
- National policy impact

Task objectives and work carried out

The objectives of Task 29 are to:

- Achieve a better understanding of the social and economic drivers and impacts of establishing bioenergy fuel supply chains and markets at the local, regional, national and international level
- Synthesise and transfer to stakeholders critical knowledge and new information
- Improve the assessment of the above-mentioned impacts of biomass production and use in order to increase the uptake of bioenergy
- Provide guidance to policymakers

The first half of 2010 was dedicated to detailed planning of the three-year programme. An important deliverable completed at the beginning of 2010 was a new Task poster, important for the visibility of the project and targeted at local and regional events in partner countries. The Task also prepared detailed plans for event-based meetings (conferences/workshops), with the UK, Norway, Croatia and Germany as hosts.

Task events

The first Task 29 event in the final three years period was *International Conference – Local and Regional Influence on the National Bioenergy Strategies and Policies*, organised between 17 and 19 June 2010 in Hadeland, Norway, together with The Energy Farm – Centre for Bioenergy. The event was supported by the Norwegian University of Life Sciences, CENBIO and the Norwegian Research Council. The conference was attended by a number of Norwegian mayors and municipal leaders who presented their practical experiences in implementing local and regional-based bioenergy projects. Their detailed cases added to Task members' understanding of the genesis of such projects and the interplay with local social, economic and environmental (or a mixture of these in most cases) drivers. Linkages between local, regional and national bioenergy strategies and policies were explored in detail and the importance of clear communication was emphasised.

The second event in 2010 was *International Workshop Socio-economic Drivers in Implementing Bioenergy Projects: Actions Together*, held on 4-6 October in Ogulin, Croatia. This workshop included local authorities, international organisations, NGOs and experts from participating countries, but also guest participants from Slovenia, Austria and Macedonia (FYRM) who shared their knowledge and experiences on cooperation projects and programmes.

The year 2011 started with another interesting event – an international *Fuel Poverty Conference* at the Oculus Centre in Aylesbury, Buckinghamshire, UK on 14 June. The event targeted an audience of around seventy and included a mixture of delegates from housing associations and local councils to installers and utility businesses. Presentations were given by members of the IEA Bioenergy team (Canada, Croatia, Germany, Norway and UK) as well as local partners of TV Energy. The presentations contrasted and compared the actions from different countries on such issues.

A series of case studies were presented to explain what is currently being done in the UK to harness the potential of local, renewable energy resources to mitigate some of the impacts within our communities. A number of exhibitors, from the UK, helped to demonstrate innovative good practice and illustrate the benefits of renewable energy to tenants and/or local communities in the UK. The conference was followed by a day of technical tours and site visits to show associated IEA Bioenergy members working examples of biomass boilers and other forms of renewable energy at various sites across the Thames Valley.

The final event for 2011 was connected to the *Sustainable Energy Financing and Investment Summit Croatia 2011* held in Cavtat, Croatia, 19-22 October. The aim of the conference was to identify ways of financing energy efficiency and renewable energy projects using innovative financial instruments. The event highlighted the importance of investment and regional cooperation to promote energy efficiency, with a view to reducing energy costs, maintaining a cleaner environment and increasing security of energy supply. Apart from the central day, which featured well known speakers from the European Commission and governmental and financial institutions, several dedicated workshops and sessions were held on interesting topics.

During 2012, the Task organised an international event alongside the Task meeting and also participated in the *IEA Bioenergy Conference 2012*, held in Vienna. Presentations were given by Canada, Croatia, Germany and the UK. These contrasted and compared the actions from different countries on issues such as fuel poverty, policy consistency, the role of bioenergy networks, and rural development through a socio-economic perspective; it focused in particular on the role of bioenergy in mitigating the worst impacts.

The last event of Task 29 activities was a Task workshop, *Bioenergy – Valorizing Potentials for Regional Benefits, held on 29 November in Berlin*, alongside the *International Bioenergy Congress – Regions – First Funding Phase 2009-2012*. Birger Kerckow, chairman of IEA Bioenergy, welcomed the attendees. The workshop was aimed at exchanging and collecting experiences and results in the field of socio-economic drivers in implementing bioenergy projects at the local and regional level. Special emphasis was placed on the question of what is needed to bridge the gap between research, the public and investors. Based on these discussions, it is planned to identify factors of success and first future needs as well as possibilities for cooperation. The presentations were given by members of the Task team as well as local partners of SPRINT Consult. Short interviews with the speakers were carried out to highlight the main aspects of their presentations, including asking the audience which focus they would like to set. The presentations contrasted and compared the actions from different countries on potentials for regional benefits. The conference and workshop were followed by a meeting organised by the NTLs together with FNR. The programme featured a day of visits to various sites across the Altmark region to show working examples of biomass boilers and other forms of renewable energy, including the largest biomass power plant in Germany.

Case studies

Over the working period of Task 29, a series of case studies was produced to show the diversity of socio-economic drivers for both small and large-scale projects. The case-study material aggregated shows in stark contrast the differing approaches used by each host entity, which have triggered outstanding results at the local and regional level. It should help in the construction of additional projects which optimise bioenergy's social, economic and environmental benefits. Over the last triennium, Germany and Norway have provided best-practice examples from their national perspectives.

The *National Model Project "Bioenergy Regions"* is a German case study of a nationwide competition aimed at regions with high bioenergy awareness in search of innovative forms of energy supply realisation. Each of the 25 Bioenergy Regions independently assessed its regional demarcation in order to make use of its biomass potential, and was funded by the National Ministry for Agriculture, Food and Consumer Protection with €400,000 in the period 2009-2012. Based on the individual regional development plans and the scientific support of research institutes for each region, the expected results were to be achieved on a regional as well as national level. Growth of the bioenergy industry in Norway's Inland Region is presented in the best-practice study, *Experiences from establishment of a bioenergy cluster in Hedmark and Oppland counties in Norway*. This case study aims to deliver performance evaluation of the Arena Bioenergy Inland Project and answer some key questions such as: Is it possible to create virtual clusters? How important are local, geographic clusters given that the new challenge facing local businesses today is international?

Final Task publications

The main activity in 2012 was the preparation of the final Task publication, *IEA Bioenergy Task 29 – 12 years of People first project!* This document recreates developments from the early days of Task start-up through the 12-year evolution of project activities. It describes in detail the results obtained. Each triennium appears in a separate chapter, revealing the focus of work activities at that time, viz. modelling of socio-economic aspects, education possibilities and solutions for biomass supply systems which emphasised the importance of regional benefits and also addressed fuel poverty issues. The deliverables included studies published in a special issue of *Energy Policy* (Vol. 35, Issue 12), 'Modelling Socio-Economic Aspects of Bioenergy Use', a series of case studies developed over the years, as well as the educational website as a definitive source of information for the general public.

The impact of national policy on regional and local activities was one of the key issues inspected in the 2012 paper published in *Biomass and Bioenergy* on 'The role of governments in renewable energy: The importance of policy consistency'. The study shows that large, unexpected changes in policies increase uncertainty and may negatively affect investments.

Widened scope and increased cooperation

In the final year of the triennium, the Task dedicated significant capacity to prepare inter-Task projects that would have a wider scope, including aspects covered by other Tasks. Accordingly, the Task 29 team got involved in the inter-Task project *Mobilizing sustainable bioenergy supply chains*, which will be an important basis for many planned activities in the coming years. The inter-Task project, approved at ExCo69 in Istanbul in May 2012, contains several questions that are central for the Task. Task 43 is appointed as coordinating Task. This strategic project will be conducted during 2013-2015 and involve Task 38 (Greenhouse Gas Balances), 39 (Liquid Biofuels), 40 (Trade and Markets) and 42 (Biorefineries) to build a team of experts with extensive interdisciplinary knowledge and ability to tackle the complex problems involved in enhancing the mobilisation of sustainable bioenergy supply chains.

One outcome of ExCo69 was a successful dialogue between Task 29 and Task 43 (Biomass Feedstocks for Energy Markets) on merging their programme activities for the next working period. The T29 perspectives were thus introduced as a distinct activity in the T43 proposal; further integration will take place in the next triennium, which will be the start of engaging in cooperation to achieve agreed goals. The objective of the new Task 43 is to promote sound bioenergy development, driven by well-informed decisions by business, governments, etc. The planned programme of activities builds on the work done in the current triennium where both Task 29 and 43 have established several activities that address key questions in the area of biomass feedstock production and that are of high relevance for both forestry and agriculture as well as for society at large, given the expected contribution of bioenergy to important environmental and socioeconomic objectives.

The Task will, during the next triennium, maintain focus on such key questions and seek new opportunities for cooperating with other Tasks as well as major organisations outside of IEA Bioenergy. Julije Domac (North-West Croatia Regional Energy Agency, Croatia) will remain Associate Task Leader together with Tat Smith (University of Toronto, Canada) while Göran Berndes (Chalmers University of Technology, Sweden) will continue as Task leader.

Success story

Biomass resources are common and widespread across the globe, making it the number one renewable energy option at present. However, biomass use, bioenergy technologies, their market share as well as the interests of researchers vary considerably between different countries. Additionally, in most countries the socio-economic benefits of bioenergy use are clearly identified as a strong driving force in increasing the share of bioenergy in the total energy supply. Through commercial biomass use, a substantial, positive impact on local and regional economies is made by generating employment. Moreover, regional employment creation and economic gains are probably the two most important factors addressed when considering biomass use as compared to more conventional solutions for energy production.

The work of Task 29 over 12 years has enabled comparisons of the importance of various socioeconomic themes across a range of European countries as well as for Canada and Japan. Quality-of-life gains have been at the forefront of consideration along with employment, environmental benefit, security of fuel supply, wealth generation and retention. Opportunities have been taken to explore the importance of host organisations and the degree to which communities benefit from change arising from the greater deployment of bioenergy technologies. Scale is also an important factor. In general, larger schemes require more traditional business models to be deployed, although some novel cooperative and collaborative schemes have taken root where local people have more direct involvement and receive greater benefit as a result. The prioritisation of drivers such as 'bottom line profitability' in more conventional companies, for example, can be eclipsed by more community-based efforts where a multiplicity of other benefits are seen to have greater importance. Recognising such differences is the key to the successful introduction of the technology.

The sustainability potential of global biomass for energy is widely recognised and undeniable, but the key issue remains to find the right scale at which biomass can be used that balances energy and environmental needs. An encouraging trend is that, in many countries, policymakers are becoming more and more aware of the huge economic potential and benefits that could be unlocked by commercial biomass use e.g. employment/earnings, regional economic gain, contribution to security of energy supply, etc. This represents an important shift in social consciousness compared to the old view where biomass was defined as a non-commercial rural source, or 'poor man's fuel'. In terms of policymaking, the future lies in national strategies providing a holistic view of biomass use in setting bioenergy policy.

In the final analysis, making bioenergy both affordable and accessible to an increasing proportion of the population will be the route to creating a long and sustainable future for biofuels, resulting in greater success and wider use. For more than 12 years, our Task experts have been suggesting ways of providing quality fuels to meet the energy services required to promote the quality of life of communities. In doing so, we have confirmed that bioenergy can make an ever-increasing contribution to the socio-economic success of many of our communities. Task 29 has gone a long way in increasing our understanding of just how we might make the most of these beneficial outcomes.

Conclusions and recommendations

In practice, implementing bioenergy projects turned out to be quite a challenging task. There are many issues to consider:

- Selecting the appropriate technologies
- Ensuring a reliable supply of biomass feedstock
- Developing the bioenergy conversion plant
- Overcoming the various resource consenting requirements
- Securing the sale of the heat, electricity or biofuel products

As these seem almost like self-imposed issues, the matter of social licence is often put aside. However, field experience shows, for example, that positioning a power and heat facility in the community requires extensive public consultation in order to acquire stakeholder support. The members of the community have to be included from the beginning so they learn about the project and provide the social licence needed to move forward with construction. The perceived social impacts that a bioenergy project might be seen to bring to a community can also be a barrier. However, it is less well understood by many that social benefits can also result in rural development, organic waste disposal avoidance, improved health, employment opportunities and greater social cohesion of a community. It has been the role of Task 29 to help identify and promote the multiple benefits that can accrue from bioenergy deployment. The research work of Task 29 clearly showed that socio-economics is the key component of developing regional and local strategies.

Developing tools for the evaluation of socio-economic benefits and models proved to be valuable in providing greater status to the social pillar of sustainability (alongside the environment and technology pillars). Concrete statistics, such as the number of new jobs created, have contributed much to improved understanding that renewable energy systems are more than just technologies but that people are also involved in benefiting from the energy and other beneficial services that they can provide.

Bioenergy is a complex topic for people to grasp compared with other sources of renewable energy such as solar energy or wind power, so many of the Task efforts were focused on educational aspects. Providing easy access to information through the educational website on biomass as well as the Task 29 website has ensured greater awareness of the need for further deployment of bioenergy projects and also helped to educate representatives of businesses, local and national governments, and communities. The opportunities for improving energy supply security and increasing the mitigation of greenhouse-gas emissions by the deployment of small and large bioenergy projects is now better understood. This has encouraged schools, businesses, private householders and farmers to take greater responsibility for their local environment, to improve their quality of life, and to become environmentally aware and responsible citizens by using local supplies of sustainably produced biomass – not only in IEA Bioenergy member countries but also in emerging and developing countries.

Task 29 appendix

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TASK 32: Biomass Combustion and Cofiring

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Introduction and aims of Task 32

Task 32 aims to stimulate the expansion of the use of Biomass Combustion and Cofiring for the production of heat and power by generating and disseminating information on technical and non-technical barriers and solutions. The relevance of the various technical and non-technical issues that hinder further market introduction of biomass combustion technologies varies for different scales:

For small-scale combustion technologies applied on the domestic scale, **aerosol emissions** are the most relevant issue. Driven by the objective for lower PM10 concentrations in the ambient air, several countries are setting more stringent targets for woodstoves, and researchers are generating new expertise on how to reduce aerosol formation and emissions. By exchanging technical knowledge on the formation mechanisms, mitigation options and toxicity of combustion-originated aerosols, a contribution can be made to accelerating the achievement of such objectives.

For industrial combustion systems, most of the challenges are technical. An upcoming issue is the desire to burn uncommon and **challenging fuels** with low ash melting temperatures and high N and Cl content, such as agrifuels, reed canary grass, **Solid Recovered Fuels**, etc. The use of such fuels contradicts the aim of raising steam temperatures in superheaters to obtain higher electric efficiencies, because of anticipated ash deposition and corrosion problems. The development of new fuel pre-treatment options, boiler concepts and boiler materials may broaden the fuel flexibility of combustion systems. Another issue is the development of several **new CHP concepts** (based on Stirling engines, ORC systems, etc) that are about to find their place in the market.

Biomass cofiring with pulverised coal in existing power plants has rapidly gained popularity over the last 15 years because of the limited investment involved, the large amounts of biomass that can be used, and the high electric efficiency of the plants. Probably the most important challenge is related to establishing a sustainable and secure fuel supply. Depending on the type of biomass used and amount of coal to be substituted, technical challenges may also arise, such as **safety and fire hazards** in large-scale biomass handling and storage, superheater corrosion, ash deposition, SCR deactivation and ash use. While some power plants have invested in advanced biomass fuel pre-treatment systems that enable the use of more challenging biomass types (such as gasification or steamside integration), the main trend is that power utilities apply easily grindable and clean biomass types such as wood pellets that can be cofired without too much plant modification. The recent interest in **biomass torrefaction** as a tool to design a tailormade fuel that is very similar to coal is an example of this. Recently, other large fossil-based industrial combustion processes such as cement kilns and blast furnaces have also started to gain experience with co-use of biomass fuels. It is important that the results of recent R&D work is efficiently shared with power utilities, policymakers and technology providers.

Task 32 has contributed to further development and implementation of biomass combustion and cofiring systems in its member countries through exchanging information during semi-annual Task meetings, Task-organised workshops on particular topics (with active industry involvement and eventually organised with other tasks), and Task-initiated studies on combustion-related topics such as aerosols emissions and cofiring. To achieve its goals, Task 32 seeks industrial participation, interaction with other bioenergy Tasks, other IEA Implementing Agreements and European bioenergy industry organisations. There is a memorandum of understanding for collaboration with the industrial biomass power group VGB Powertech (the European branch organisation of power producers). Several joint workshops and studies were carried out with other such groups, as noted in this report.

Background

In the triennium 2010-2012, Task 32 addressed most of the issues listed above in specific workshops or publications. The following specific activities were undertaken:

Task meetings

Six task meetings were held to communicate progress and the results of both national R&D programmes and Task-initiated projects. Each Task meeting was combined with plant visits and/or a Task-organised workshop on a combustion-related topic.

Workshops

Nine workshops were organised, typically in combination with a Task meeting. Through the hyperlinks in the table below, detailed information can be obtained from the Task 32 website.

Task studies

Task 32 prepared a number of publications in which recent R&D developments were collated in order to address the market issues. Table 32.2 lists these publications in the triennium 2010-2012. A detailed description per activity is given below.

Table 32.1: Task 32 workshops

Nr.	Topic	Deliverable
D14	Expert meeting on combustion of challenging biomass fuels, Lyon, 4 May 2010	Individual presentations
D2	Workshop on state-of-the-art technologies for small biomass co-generation, Copenhagen, 7 Oct 2010	Individual presentations Report incl. evaluation
D8	Workshop on aerosols from small-scale biomass combustion plants, Graz, 27 Jan 2011	Individual presentations summary and conclusions
D12	Joint workshop with Task 40 on development of torrefaction technologies and possible impacts on global bioenergy use and international bioenergy trade, 28 January 2011, Graz	Individual presentations
–	Irish national workshop on local developments in small-scale biomass combustion, Dublin, 18 Oct 2011	Individual presentations
D19	Workshop on processing routes for solid recovered fuels, Dublin, 20 Oct 2011	Individual presentations
D5	Joint workshop on biomass cofiring, with IEA CCC and VGB Powertech, Copenhagen, March 2012	Individual presentations
–	Workshop on biomass torrefaction, Milan, June 2012	Individual presentations
D16	IEA Bioenergy workshop on developments in small-scale biomass combustion, Vienna, Nov 2012	Individual presentations

Table 32.2: Task 32 publications

Nr.	Deliverable
D4	Paper on options for increased ash utilisation from biomass combustion and co-firing
D7	Review of small-scale particle removal technologies
D10	Evaluation of suitability of torrefied fuels for different appliances
D11	Review on safety issues in fuel storage, handling and preparation
D17	Database on cofiring experiences

Task objectives and work carried out

This section presents the work carried out during the triennium (workshops and publications) in order to meet the initial targets of the Task.

Workshops

A summary of the results of the workshops is provided below. Reports on all the workshops can be downloaded from the Tasks website: www.ieabioenergytask32.com.

1. Challenging fuels

A workshop on this topic was organised jointly with Task 36, in conjunction with the EU biomass conference in Lyon, France. The workshop addressed the challenges faced when burning uncommon biomass types with lower fuel prices, such as (pellets from) agrifuels such as straw and press cake, reed canary grass, RDF, chicken litter, etc. These fuels typically have relatively low ash melting temperatures and high N and Cl content. If properly designed, the combustion technology may be able to deal with these fuels, with acceptable corrosion in boiler tubes, slagging and fouling and emissions of NOx and (fine) particles. The workshop presented detailed information on:

- The resource basis of alternative fuels for small-scale and industrial combustion
- The consequences of using challenging fuels for furnace design, boiler operation and emissions
- Approaches for adaptations of technical design
- The outlook for new boiler materials and limits in steam temperature

2. Small-scale CHP

Together with Task 33, Task 32 organised a workshop in Copenhagen on recent developments in small-scale power production from solid biomass, using a wide variety of gasification and combustion-based technologies. Examples are ORC technologies, Stirling engines, steam engines and steam turbines that are coupled to combustion, but also various gasification-based technologies (updraught, downdraught or indirect).

Several industries were asked to present their technologies, as well as a quantification of their operational experiences and CAPEX and OPEX costs. This led to an interesting and much-appreciated summary table that enables comparison of the various technologies Joint workshop with Task 33 – State-of-the-art technologies for small biomass co-generation.

3. Aerosols from biomass combustion

Aerosols originating from biomass combustion devices are a major health concern in many countries. For example, in countries such as Austria and Switzerland, about 50% of the ambient concentration of aerosols is attributed to combustion of biomass. This is largely due to relatively inefficient and small-scale combustion devices, while more efficient, high-quality stoves emit much less aerosols, which also have less impact on health due to the absence of carbon.

This workshop held in Graz summarised recent R&D work on the formation and health impact of aerosols from different types of biomass combustion devices and biomass fuels, as well as the opportunities to reduce aerosol emissions using either primary or secondary measures for emission reduction, such as electrostatic precipitators (ESPs).

4. Workshop on torrefaction

In 2011, Task 32 and 40 jointly organised a workshop in Graz (Austria) on progress in the development of torrefaction technologies, and the possible implications for biomass trade. The workshop showed that torrefaction can be an important technology if successfully developed, leading to reduced fuel delivery costs and better compatibility with coal. However, though many companies are involved in developing torrefaction concepts, no clear winner can yet be identified and commercial availability of torrefied material can be expected to be low in the coming years, as compared to, for example, wood pellets. With about 250 participants and speakers from Europe and North America, the workshop was highly successful.

5. Irish national workshop on local developments in small-scale biomass combustion

In October 2011, Task 32 organised a workshop in Ireland in conjunction with a Task 32 meeting, to help facilitate the growing Irish market for small-scale combustion technologies. The workshop, targeted at the commercial actors in Ireland that have recently started to sell equipment to local customers, discussed how to mitigate aerosol emissions and ensure safe installations (past incidents include dust explosions and suffocation). The workshop also helped to facilitate discussions with governmental organisations on how the local market development of the small-scale combustion technologies should be supported.

6. Workshop on options for SRF processing

Task 32, Task 36 and the European Association of Producers of Solid Recovered Fuels (ERFO) jointly organised an expert workshop in Ireland on options for solid recovered fuels (SRFs) processing. This fully booked workshop was timely as Ireland needs to develop alternatives to landfilling combustible waste. At the workshop, several processing routes for SRF were presented and discussed by representatives from industry and government. In conjunction, a field trip was organised to the first WtE plant in Ireland, and a cement kiln where SRF is cofired.

7. Workshop on high percentages cofiring and increased fuel flexibility

Together with the IEA Clean Coal Centre and the biomass industry group of VGB Powertech, Task 32 organised a workshop on biomass cofiring in Copenhagen. The workshop was fully booked and attended mainly by people from industry. It presented the state of the art in biomass cofiring, from operational experiences to fuel processing options (including torrefaction), mitigating ash-related impacts, and a discussion was held on the future of cofiring.

8. Workshop on developments in torrefaction

An additional workshop (not included in the original work plan) was co-organised in June 2012 as part of the European Biomass Conference in Milan. This was decided after a request by the European FP7 project SECTOR to co-organise the event. Task 32 helped out by, for example, providing input from North American market agents, through facilitating their visits to the event.

9. Workshop on low-emission woodstoves and boilers

As part of the IEA Bioenergy Conference held in November 2012 in Vienna, Task 32 organised a workshop on innovations in small-scale combustion technologies, with a focus on mitigating aerosol emissions. The workshop provided a better understanding of the formation principles, associated health effects and mitigation options for aerosols.

To further reduce emissions, a number of companies have recently started to develop small-scale electrostatic precipitators. These may be expected on the market within the next few years. To realise the associated social benefits, it is important that users be financially encouraged to make the additional investment.

T32 Study 1: Options for increased ash use from biomass combustion and cofiring (D4)

The increasing demand for biomass-based heat and electricity will also increase biomass ash production. Thus, there is increased interest in biomass ash use. Several options exist or are possible for use of ash. Technical feasibility is usually not an issue. However, in practice, only a limited amount of biomass ash is used and the rest is still disposed of in many countries.

Coal and cofiring bottom ash (for up to 20% (m/m) biomass/coal) has successfully been applied in road construction and as a concrete aggregate, replacing natural stone, while fly ash from cofiring, with up to 20% (m/m) biomass/coal, is used as an additive in cement or as a concrete and asphalt filler. Regarding the use of coal fly ash as cement replacement, the European technical standard for the use of fly ash for concrete, EN-450, is currently being revised to include the use of ash obtained from cofiring percentages up to 50% (m/m, fuel input) for clean wood.

A common application for bottom ash or mixtures of bottom and coarse fly ash from clean biomass fuels is direct use as fertiliser on agricultural or forest soils. These ashes are also used as additives for compost production in Austria and as a liming agent for forest soils in Austria and Germany. Fly ashes are used as raw material in the cement and brick industry in a few countries. In some countries, the ashes are used for grouting mines or as asphalt or concrete filler. In Sweden, some ashes are used as construction material for landfills. In many countries, however, most of the ash is disposed of.

There are many other options for ash use. Research is in progress to find more ways of using pure biomass ashes. Promising options include more widespread use in the building industry (e.g. cement clinker production, production of bricks), civil engineering (e.g. binding material for soil stabilisation, landscape management) as well as use as raw material to produce synthetic aggregates, fertilisers or liming agents.

This Task 32 study shows that the main reasons for the very limited use of ash relate to environment, sustainability, low market volumes and differences and variations in ash quality. In addition, there are limitations in technical and regulatory regulations as well as logistics. Finally, there is a lack of awareness, knowledge and willingness among plant operators, potential end-users and authorities alike to improve ash use.

T32 Study 2: Review of small-scale particle removal technologies (D7)

Solid biomass combustion is increasingly criticised as a major source of PM emissions. With the introduction of the EU directive 1999/30/EC, which limits PM10 concentrations in the ambient air, it had to be recognised that in many European regions these limiting values are frequently exceeded. Traffic, industry and domestic heating have been identified as the main sources of PM emissions. The contribution of residential biomass combustion to the total PM emissions of the residential heating sector exceeds 80% in some European countries.

There are significant differences in the dust emission limit values for small-scale combustion systems in the IEA Bioenergy Task32 member countries. This is of great relevance as stricter emission limits accelerate the technological development and market introduction of particle precipitation devices.

R&D of particle precipitation devices is especially intense in Austria, Germany and Switzerland as these countries have the strictest dust emission limits.

The scope of this review was to compile the current state-of-the-art of particle precipitation devices for residential biomass combustion systems (nominal boiler capacity <50 kW) in the IEA Bioenergy Task32 member countries. The work mainly focused on technologies which are already available or are close to market introduction, with an emphasis on ESP systems. The survey involved the evaluation of 13 electrostatic precipitators, two catalytic converters, two ceramic filters, three condensing heat exchangers and one additional device.

Subsidies or incentives for small-scale particle precipitation devices are only available in Germany. There are no certificates for particle precipitation devices foreseen in the IEA Bioenergy Task32 member countries at present.

The ESP technology seems to be the most promising technological approach for small-scale biomass combustion. Up to 2011, three ESPs for residential biomass combustion systems had been introduced to the market. Four ESPs for residential biomass combustion systems can be expected to enter the market soon. A considerable number of devices are under development and can be expected to be demonstrated within the next few years.

Most of the ESPs have been developed and tested under good or acceptable combustion conditions at test stands. Up to now only a few long-term field test runs have been performed. Therefore, sufficient data on the applicability and availability of the investigated devices are not available.

Moreover, the influence of condensable and sticky particles, which result from poor combustion conditions (typical for old stoves/boilers as well as start-up conditions) on the efficiency and availability of ESPs is still not sufficiently clarified.

Ongoing and future projects are focusing on these issues as they will be crucial for broad market introduction of a specific technology.

Up to now no promising results have been achieved with catalytic converters for wood boilers/stoves. Due to the required high flue gas temperatures for catalytic oxidation, these devices are not available during start-up and phases of incomplete burnout of the flue gas due to low temperatures. A specially developed high-temperature condensing heat exchanger could achieve satisfying particle precipitation efficiency, based on theoretical calculations. The technology has potential, but needs further research on practical needs. The precipitation efficiency of conventional condensing heat exchangers is rather low. The main application of these systems is to increase the thermal efficiency of the boiler rather than to reduce particulate emissions.

In general particle precipitation devices are secondary measures and therefore could be especially attractive for old systems which show the highest particulate emissions. For these conditions the filters must show robust behaviour and be equipped with an efficient and automatic cleaning system. Therefore, the applicability of filters for old systems, where there is great particle reduction potential, should be a special focus of future work. For modern biomass boilers the main focus should be on reducing particulate emissions through primary measures and filters should only be applied if also necessary.

International standards

There is no common international approach regarding PM emission measurements; a common European method to determine PM emissions is urgently needed. Also, there is no common international approach to determining filter efficiencies.

Regarding future standards for filter testing, relevant points such as the influence of the condensation of volatile organic compounds in and downstream of the filter, aspects regarding the positioning of the filter indirectly downstream of the boiler/stove outlet or on roof top, as well as the monitoring of filter parameters relevant for filter performance, must be considered.

If they are to make a serious entry into the market, new small-scale filters must be well tested and reliable. They must also operate automatically over a whole heating period and must work efficiently.

Besides the technological requirements, which still have to be proven for most applications, legal and financial incentives will be needed to ensure effective market introduction – which should, according to the present state of development, take place within the next five years in mid Europe (Germany and Austria).

T32 Study 3: Evaluation of suitability of torrefied fuels for different appliances (D10)

In the last five years, interest in torrefaction technologies as a pre-treatment technology for solid biomass has much increased. This interest has mainly been driven by the characteristics of the torrefied and densified biomass, including better transportation characteristics and compatible properties to coal such as heating value, grindability, bulk energy density and hydrophobicity.

Among the various applications being considered for the torrefied and densified biomass, the most likely ones include cofiring with coal in pulverised coal-fired power plants and cement kilns, coke and steel industry (for charred biomass), small to medium-scale dedicated biomass and pellet burners, and gasification in entrained flow gasifiers that normally operate on pulverised coal.

This review summarises the current status of the development of torrefaction technologies, including technical and economic aspects and the potential market application from the energy sector perspective. It is based on several recent public reports as well as research and market information from sources such as IEA Bioenergy workshops in 2011 and 2012, direct contacts with technology developers, and university and institutional researchers.

Torrefaction initiatives

At the time of writing, at least 40-50 torrefaction initiatives had been identified, about equally divided between Europe and North America. These installations are intended to demonstrate the technical and economic feasibility of torrefaction as a viable pre-treatment option and of the torrefied product for cofiring in existing pulverised coal-fired power plants.

Several of these installations in both Europe and North America have a name plate capacity of up to several hundred thousand tonnes. This is driven partly by the need for large commercial-scale test burning requiring several thousand tonnes of fuel. As yet, however, only a handful are actually producing; the greatest challenge is therefore related to successful technical and economic demonstration of the individual technologies. It is still early to identify the winning technologies but it is likely that several viable torrefaction technologies will capture the market over time.

Technical challenges

The most important technical challenges in the development of torrefaction technologies are related to the process gas handling and contamination, process upscaling, predictability and consistency of product quality, densification of torrefied biomass, heat integration, and flexibility in using different input materials. The goal is to produce hydrophobic material after torrefaction and convert this to durable pellets or briquettes after densification, which can be handled and stored outdoors without weather protection like coal. However, achieving a durable product able to withstand large-scale handling remains to be proven and is perhaps the main challenge to be resolved.

In addition to difficulty in compacting torrefied biomass, the dust from torrefied material is potent and can explode in high concentrations. Issues associated with outdoor storage of torrefied material and leaching have yet to be dealt with, and the environmental impact of leaching from weather-exposed storage must be better understood.

Added value

The results of the economic analysis carried out for this report highlight the added value of torrefaction when compared to conventional wood pellets. Provided that outdoor storage becomes feasible, a lower break-even delivered fuel price at the gate of a power plant for torrefaction pellets compared to wood pellets is achievable as a result of the reduced logistical cost. The potential of achieving higher cofiring ratios, which in turn will result in further reduction in CO_2 emissions, will also benefit the economic value. The market price of torrefied biomass pellets is, however, not only determined by the cost, but also the balance between demand and supply. There is still a need to improve end-user confidence about combustion properties, grindability, storage behaviour, self-heating and self-ignition of large amounts of torrefied product for safe and reliable operation.

Factors hampering market development

When combined with the limited availability of torrefied materials, these issues hamper rapid market development and highlight the need to continue efforts in carrying out fundamental and applied research and undertaking large-scale cofiring demonstration initiatives. Security of supply is a major issue as the many potential buyers of torrefied biofuels, such as power plants, are not likely to rely on supply from a single producer or even a small number of producers. There is also a reluctance to rely on supply based on a single or proprietary torrefaction technology since it may lock in the buyer.

Commercial-scale supply to power stations is not likely to become a reality until there is sufficient product available, with multiple suppliers using multiple technologies and relying on multiple feedstocks. Consolidated and more open collaboration between producers would advance the common cause but it is difficult to cultivate this in a fiercely competitive environment since the technology innovators are often also the producers at this early stage.

Since there is no commercial market fully developed for torrefied biofuels, the pricing structure and trend are uncertain. There is obviously a premium to be paid for the higher heat value compared to regular wood pellets and also for the potentially superior handling characteristics, based on the assumption that the product can be stored similar to coal. This bonus could be quite high if the initial large-scale bulk handling projects turn out to be successful. It is, however, not possible at this early stage to predict the market price for torrefied pellets. The economics of torrefaction on the producer side require a low-cost feedstock due to the significant loss of material during the torrefaction process.

Issues to resolve

At present, torrefaction processes are largely based on clean biomass resources such as clean waste wood. Due to lower prices and better availability, the interest in waste streams and residues as feedstock for torrefaction is increasing. To facilitate the use of such resources, issues related to availability, price and technical specifications need to be resolved. This particularly relates to the input density, limited throughput capacity, the regulatory framework and permitting procedures for cofiring the waste-derived materials, special scrutiny due to concerns about emissions and ash quality, boiler integrity (fouling and corrosion) and efficiency.

Research is under way to explore the potential for using lower-cost feedstock from agriculture. This is challenging due to the somewhat unfavourable chemical composition of such feedstock without pre-treatment of the feedstock. On the other hand, the agri-material feedstock is plentiful and could become a major factor in the long term.

With regard to waste-derived torrefaction fuels, regulators may discuss with energy producers how these could be used in existing facilities and to what extent these facilities would have to be operated under the EU Waste Incineration Directive. It could be argued that if a torrefied material has a similar performance to the base fuel in a power plant, there is no need to change the emission control devices. It is not yet clear if this complete compatibility can indeed be achieved.

Product quality standards and specific test methodologies for torrefied materials are under development by the ISO Technical Committee 238, expected to be published in 2014 as part of the ISO 17225 Standard, while criteria for sustainability is under development by ISO/PC 248.

T32 Study 4: Review on safety issues in fuel storage, handling and preparation (D11)

With the continuous growth in production and use of solid biofuels, an increasing number of incidents have taken place related to the handling of the biofuels, resulting in injuries, infections, intoxications, etc, leading to illness or loss of life, as well as severe material damage due to dust explosions, fires, etc. This report, written by various Task experts, gives an overview of the causes and effects of incidents, as well as mitigation measures.

The properties of a biomass material and the intended use determine how the material should be safely produced, transported, stored and used. While woody biofuels such as pellets and chips from fresh or recycled wood dominate the market in terms of volume, other solid biofuels, such as straw, biodegradable fuels used for anaerobic digestion and municipal solid waste, pose specific health and safety challenges that need to be addressed.

Self-heating and fire risks

Self-heating processes may be due to biological metabolic reactions (microbiological growth), exothermic chemical reactions (chemical oxidation) and heat-producing physical processes (e.g. moisture absorption), and may arise both with dry and wet biofuels. They may become problematic if a pile or silo is so large that the heat generated cannot be easily dissipated to the surroundings. While this is not the case for relatively small-scale installations (e.g. as used by households), attention is needed in the case of larger industrial storage. Several test methods are available for determining self-heating potential and self-ignition of materials on a small scale, which can then be extrapolated to predict self-heating potential at larger scale. Apart from self-heating, biomass stock may be set on fire through various external sources such as hot bearings, overheated electric motors, back-fire, etc.

Several conclusions can be drawn from the full-scale silo fires that have broken out. The most important prevention measure to take is temperature monitoring of the storage at several different locations in the fuel bulk. For detection of any activity in the bulk, CO concentration should be measured in the air above the pellet surface. The first sign of an ongoing self-heating process is often a sticky and irritating smell (probably from aldehydes and low-molecular-weight carboxylic acids). If this is sensed, pyrolysis is already taking place somewhere in the fuel bulk and a fire-fighting operation has to be initiated. The fire-fighting strategy needs to be determined case by case and requires specialised fire-fighting equipment and trained staff. Water should not be used in the case of wood pellets, due to rapid expansion of the pellets (hindering the extinguishing operation and subsequent unloading of the silo) and the formation of explosive H2 through water gas shift reactions. A silo fire is usually extinguished by inerting the closed silo from the bottom, after which fuel is discharged from an opening in the silo wall.

Off-gassing

Off-gassing is the process where volatile organic compounds are released in the logistical chain. One mechanism is the initial release of lipophilic compounds, yielding carbonyl compounds (aldehydes and ketones) and complex terpenes. CO, CO_2 and CH4 may also be released. The concentrations of aldehydes found in domestic sites and warehouses constitute a health hazard, and require preventative measures. Hexanal may enter the body by contact with skin or by inhalation and cause skin irritation, headaches, and discomfort on the eyes and nose. Other aldehydes such as methanal and ethanal are suspected to be carcinogenic in high doses and may also have short-term effects on human health. There are several guidelines issued by government bodies that describe the effect these aldehydes have on human health depending on exposure time and level. Monoterpenes (particularly present in fresh raw material) cause eye and respiratory system irritation. CO may be released from the auto-oxidation of lipophilic compounds. Related hazards are predominantly poisoning, but the CO may also contribute to self-heating or ignition processes. A combination of proper ventilation, gas meters and the use of self-contained breathing devices is needed in areas where the levels of CO might increase to poisonous concentrations.

Dust clouds

Dust clouds are a major cause of damage in the bioenergy sector. The combination of relatively small particle sizes and low minimum ignition energy results in high ignition sensitivity. Factory dust may stay suspended in the air, so that the Minimum Explosible Concentration is easily reached under practical conditions if cleaning and ventilation are inadequate. It is therefore important to minimise the risk of dust explosions by minimising the risk of sparks (e.g. due to electrostatic discharge, through proper grounding) and good dust housekeeping through dust prevention and dust collection. Once an explosion takes place, it needs to be properly contained, suppressed or vented. Compliance with ATEX Directives and NFPA guidelines is essential in this respect.

Dust and bioaerosol risks

The health risks posed by biomass fuels in the form of dusts and bioaerosols come from the both the physical particle and size effects. As particles become smaller they pose a greater hazard. As a result, limits on PM10 and PM2.5 (particles less than 10 μm or 2.5 μm respectively) are becoming more prevalent in national regulations. In addition, the organic nature of biomass fuels may result in additional impacts through either allergenic or pathogenic routes. The most prevalent feature will be the allergenic responses; most of the effects will be minor and short-lived, but increasing severity of impact will also be linked to falling incidence of response. In the same way, pathogenic responses will be a rare occurrence, but potentially result in severe hazards.

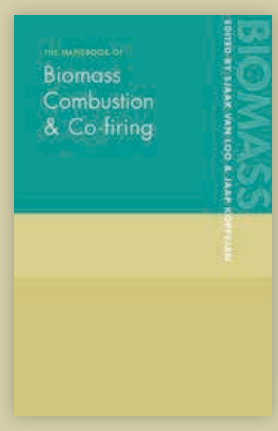
The biological materials released from biofuels are similar to the naturally occurring background levels, and the human population are equipped with bodily responses to deal with this natural environmental exposure. This natural bodily response and the variation in individual sensitivity makes the determination of dose response relationships particularly difficult. Without such understanding it is difficult to ascribe definite limits and regulations that are 'safe' for the population at large, while also protecting the population from hazards derived from the alternatives to biofuel use (e.g. climate change, fossil fuel emissions, fuel poverty). Thus this area is generally governed by guideline values and recommendations to minimise exposure rather than definitive limits derived from hard scientific data.

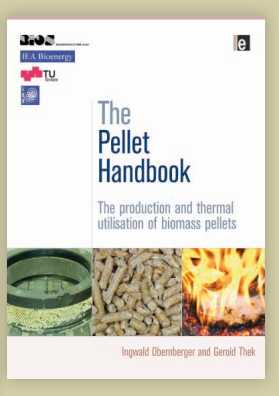
The potential health impact of bioaerosols from waste management processes is relatively low for waste collection, transfer and sorting. While it can be moderate for open microbial processes such as composting (particularly during movement and unloading of material) due to pathogenic micro-organisms and microbial constituents or metabolic products, such as organic dust and endotoxins, the risk is relatively low in the case of anaerobic digestion where processes are contained and the product is often hygienised. The risks are generally airborne, and therefore likely to occur through inhalation of bioaerosols, but there are also ingestion risks, often through hand-mouth contact or from infection of wounds.

Trauma and sharps injuries

Trauma and sharps injuries are the most common recorded cause of accidents and injury in the forestry and waste management sectors; we assume that these also affect workers in the bioenergy and energy-from-waste parts of these sectors. The serious nature of some injuries and the number of injuries means there has been much work to reduce injuries; in most countries there are established obligations and guidance. Rather than comprehensively reviewing this legislation, we have provided an introduction with references, providing an insight into the risk evaluation and mitigation methodologies available at international and national level.

T32 Study 5: Updated database on biomass co-firing with expert tool (D17)





On the T32 website, a database exhibiting experiences with biomass cofiring is operational since 2003. In 2010, the database was made interactive so that individual companies could provide data themselves after registration. This has, for example, been done by a number of VGB Biomass Industry Group members. Currently approximately 234 coal-fired power plants are identified with experience in cofiring biomass.

Handbooks

In the last few years, Task 32 has published two important handbooks related to biomass combustion.

The Pellet Handbook: The Production and Thermal Utilisation of Biomass Pellets

In 2010, Task 32 published an international pellet handbook that covers all issues of pellets, from the raw materials through production, logistics, trade and use to economic and environmental issues from an international and multidisciplinary perspective. The handbook covers this information on the international pellet markets, relevant international constraints and applications. Significant inputs were provided by Tasks 29, 31 and 40. The handbook was co-funded by IEA Bioenergy and Austrian institutions.

Handbook of Biomass Combustion and Cofiring

This handbook was first published in 2001, with a second edition in 2008. In 2008 the book was also translated into Chinese and published. It is used by both market actors and in a number of training courses.

Conclusions and recommendations

In the period 2010-2012, Task 32 has cooperated on several occasions with other IEA Bioenergy tasks (particularly for the preparation of the Health and Safety report and the organisation of several workshops as described above) and networks outside IEA Bioenergy, e.g. the IEA Clean Coal Centre as well as industry networks (e.g. VGB Powertech and ERFO). Task 32 recognises the added value of interaction with related experts. In the coming triennium the industrial collaboration will therefore be further extended, e.g. with the German Association of Catering, Heating and Cooking Equipment Manufacturers (HKI).

The work of Task 32 is greatly appreciated by the market, as indicated by interactions at the workshops organised and in the feedback on published reports. One success factor is the provision of publications with detailed insights into key technical performance figures on costs, efficiencies and emissions from various technology concepts such as torrefaction, low-emission furnaces, new particle-removal technologies, or pellet production and use. Task 32 also addressed operational issues such as the formulation of recommendations for improved ash use, and the coordination of a multitask report in which the health and safety aspects of solid biomass handling, storage and transportation are described in detail.

Finally, Task 32 has a unique role to play by providing an independent platform for hands-on information exchange among manufacturers and operators of biomass combustion plants, and in translating findings of fundamental and applied R&D work to industry and policymakers.

Task 32 appendix

Participation in major events

Task 32 contributed to the organisation of the following events:

- EU biomass conference and exhibition in Lyon, 2010 (expert workshop on challenging fuels)
- EU biomass conference and exhibition in Milan, 2012 (torrefaction workshop)
- Mid-European Biomass Conference in Graz, Jan 2011 (torrefaction workshop)
- Contribution to the IEA Roadmap on Biomass Heat and Power (several workshops in Paris)
- Co-organisation of a cofiring workshop with IEA Clean Coal Centre and VGB Powertech
- Final conference of the FP7 DEBCO project on Biomass Cofiring, Brussels, Dec 2012
- IEA Bioenergy Conference in Vienna, 2012 (workshop on small-scale combustion)

Deliverables

Nr.	Deliverable
D14	Expert meeting on Combustion of Challenging Biomass Fuels, Lyon, May 4, 2010: Individual presentations
D2	Workshop on state-of-the-art technologies for small biomass cogeneration, Copenhagen, Oct 7, 2010: Individual presentations or report incl. evaluation
D4	Paper on options for increased ash utilisation from biomass combustion and co-firing
D5	Joint workshop on biomass cofiring, with IEA CCC and VGB Powertech, Copenhagen, March 2012: Individual presentations
D7	Review of small-scale particle removal technologies
D8	Workshop on Aerosols from Small-Scale Biomass Combustion plants, Graz, 27 January, 2011: Individual presentations and summary and conclusions
D10	Evaluation of suitability of torrefied fuels for different appliances
D11	Review on safety issues in fuel storage, handling and preparation
D12	Joint workshop with Task 40 on the development of torrefaction technologies and the possible impacts on global bioenergy use and international bioenergy trade: individual presentations
D16	IEA Bioenergy workshop on developments in small-scale biomass combustion, Vienna, November 2012: Individual presentations
D17	Database on cofiring experiences
D19	Workshop on Processing routes for Solid Recovered Fuels, Dublin, 20 Oct 2011: Individual presentations
–	Irish national workshop on local developments in small-scale biomass combustion, Dublin, 18 October, 2011: Individual presentations
–	Workshop on Biomass Torrefaction, Milan, June 2012: Individual presentations

Co-ordination with other Tasks within IEA Bioenergy

Several activities on cross-cutting topics were carried out jointly with other IEA Bioenergy Tasks:

Task 33: Joint workshop on cogeneration (D2)

Task 36: Health and safety report (D11)
Expert meeting on Combustion of Challenging Biomass Fuels (D14)
Workshop on Processing routes for Solid Recovered Fuel (D19)

Task 37: Health and safety report (D11)

Task 40: Torrefaction workshop (D12)
Health and safety report (D11)

Co-ordination with other bodies outside of IEA Bioenergy

- Beyond IEA Bioenergy, Task 32 collaborated with:
- IEA Clean Coal Centre on the organisation of a biomass cofiring workshop (D5)
- The biomass working group of the European Association of Power Producers (VGB Powertech) on the organisation of a biomass cofiring workshop (D5) and the health and safety report (D11). An MoU for strategic collaboration exists with this organisation, with mutual participation in progress meetings.
- Individual industries, participating predominantly in workshops

Task 33: Thermal Gasification of Biomass

Prepared by:

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Operating Agent:

Paul Grabowski, US Department of Energy

Participating countries:

Austria, Denmark, Finland, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Sweden, Switzerland, Turkey and USA

Introduction

Task 33 is a forum for National Team Leaders (NTLs) to exchange, review and evaluate information from worldwide biomass gasification (BMG) RD&D programmes and operating commercial and pilot plants that assist in the development of national bioenergy programs and to advance the state of the art of BMG. In recognition of the potential to produce fuels and chemicals via synthesis gas, the Task expanded its role to address issues related to synthesis gas in addition to combined heat and power (CHP) and power. The Task continued its interaction with industrial and academic experts to coordinate technology and product development. These activities were useful for participating countries to refine national bioenergy plans as well as to explore cooperative RD&D projects with other NTLs.

Objectives

- Conduct sub-task studies to review and evaluate information from the current worldwide RD&D programmes and operating gasification systems to identify and resolve barriers for advancement of economical, efficient, and environmentally preferable BMG processes
- Promote commercialisation of BMG to produce fuel and synthesis gases that could be subsequently converted to substitutes for fossil-fuel-based energy products and chemicals and lay the foundation for secure and sustainable energy supply
- Enable NTLs to develop forward-looking strategies and policies to implement programmes in their respective countries, and help 'leapfrog' resource-consuming repetitive and redundant exercises

Background

The scope of work for the 2010-2012 triennium was 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 had been very effective. These remain the basic foundations for developing and implementing a programme of work that addresses the needs of the participating countries.

The Task monitored the current status of the critical unit operations and unit processes that constitute biomass gasification (BMG) processes, and identified hurdles to advancing further development and operational reliability, and to reducing the capital cost of BMG systems. The Task meetings provided a forum to discuss the technological advances and issues critical to scale-up, system integration and commercial implementation of BMG processes. Generally, these discussions led to selection of sub-task studies and/or technical workshops that focus on advancing state-of-the-art technology and identifing options to resolve barriers to technology commercialisation. The Task has continued the practice of inviting industrial experts to Task meetings 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 NTLs to evaluate refinements to existing product lines and/or processes. Academic experts are also invited when the need arises, to seek information and cooperation in order to address basic and applied research needs.

The work programme included the following elements:

- The Task planned and conducted semi-annual Task meetings including workshops on sub-task studies selected by the NTLs, and addressed matters related to the Task mission and objectives. Meeting locations, dates, and the subject of the associated workshops are given in the table below. Discussions of workshops are presented later. (Status: complete)

Task 32 workshops

Meeting	Associated Workshop	Dates and Location
1st Task meeting	WS1 'Second generation biofuels'	1-3 June 2010 Helsinki, Finland
2nd Task meeting	WS2 'State-of-the-art technologies for small biomass co-generation'; jointly with Task 32	5-7 October 2010 Skive/Copenhagen, Denmark
3rd Task meeting	WS3 'Gasification and alternative fuels development'	12-14 April 2011, Christchurch, NZ
4th Task meeting	WS4 'Biomass gasification opportunities in the forest industry'	18-20 October 2011, Piteå, Sweden
5th Task meeting	WS5: 'Bed materials in fluid bed gasifier'; jointly with EERA	17 – 19 April 2012, Istanbul, Turkey
6th Task meeting	WS6: IEA Bioenergy 2012; end of triennium conference jointly with all tasks	13 – 16 November, Vienna, Austria

- NTLs surveyed the current biomass and waste gasification RD&D programmes in member countries, commercial operations and market opportunities for BMG, and identified the technical and non-technical barriers to commercialisation of the technology. NTLs used the survey results to prepare and update Country Reports for information dissemination. Summary country report presentations and supporting reports were posted on the Task website (http://www.ieatask33.org). *(Status: complete)*
- The Technical University of Vienna maintained and updated the Task 33 website, including country reports from member countries, workshop summaries and presentations, selected gasification publications, and meeting schedules. *(Status: current)*
- The Task developed a database of gasification facilities in collaboration with Task 39. *(Status: current)*
- The Task initiated an annual Task letter in 2012. *(Status: 2012 Newsletter published)*

Task objectives and work carried out

Observations from WS1: Second-Generation Biofuels

The workshop was held in Helsinki, Finland, on 3 June 2010 and attended by Task NTLs and 30 guests representing the Finnish biomass community. The objective was to present overviews of international efforts for biofuels development to the Finnish bioenergy community.

ECN reported on Bioenergy Carbon Capture and Storage (BECCS). This research involves multidisciplinary collaboration between different units. It offers opportunities for net atmospheric CO_2 reduction from CCS combined with production of second-generation biofuels: BioSNG, FT-diesel, and bioethanol from lignocellulose. ECN also reported on biosyngas systems. Five systems were compared, looking at efficiency, syngas price, technology status, and CO_2 reduction potential.

Andritz Carbona presented its portfolio for biomass gasification: biomass preparation and handling, belt and drum dryers, atmospheric pressure CFB gasifier, low and high pressure BFB gasifier and gasifier gas clean-up and combustion. Cooperation with the Gas Technology Institute, Chicago was mentioned.

Vienna University of Technology reported on the CHP plant in Güssing, including producer gas composition and use for biofuels production. Also covered was the OptiBtL gas, ERA Net project. The aim of the project is reforming of hydrocarbons to increase overall conversion of biomass to FT products. A second interesting project on mixed alcohols was also presented. The aim of this project is to obtain fundamental know-how regarding the synthesis of mixed alcohols. A project on the conversion of mixed alcohols to hydrocarbons is planned.

Information about liquid biofuels in Finland was reported by VTT. Neste Oil produces biofuels by hydrogenation of vegetable oils and animal fats. The first plant has been in operation since 2007, the second since 2009. There are large plants under construction in Singapore and Rotterdam. The combined production capacity in Finland adds up to almost 10% of road transport fuels consumption in Finland.

NREL, a national laboratory of the US Department of Energy, made a presentation on "Techno-economics of the production of mixed alcohols from lignocellulosic biomass via high temperature entrained flow gasification". The US

Department of Energy has the target to produce cost-competitive ethanol via thermochemical conversion by 2012. The key points were:

- Pilot-scale alcohol production from lignocellulosic biomass
- Research targets primarily in the areas of syngas clean-up and alcohol synthesis
- Main cost drivers in this process: gasifier capital cost, air separation cost, feed preparation (grinding) cost
- Main advantage is getting relatively clean syngas with minimal downstream processing compared to lower-temperature gasification

The techno-economics of biofuel processes for synthetic natural gas (SNG) production was reported by PSI. The key points were:

- Energy and/or heat integration of SNG plants is much easier than for liquid biofuels value chains.
- The scale for biomass-to-SNG plants is probably determined by biomass supply chain.
- Analysis has shown that gasification technology is the most distinctive and critical choice that dominates the entire biomass-to-SNG process design.
- The developed model of EPFL suggests that pressurised, steam/oxygen gasification outperforms all other thermal gasification approaches at ambient pressure with respect to efficiency and investment cost.
- A 1 MW SNG PDU has successfully been commissioned. There is strong evidence that fluidised bed methanation technology is quite robust for bulk gas composition for SNG production.

Results of simulation studies for BTL were presented by TUBITAK. The aim was to compare the different technologies with respect to performance of a CTL/BTL process to compare the different operational parameters with respect to performance of a CTL/BTL process and to determine the mass and energy balance of the whole system, with its subsystems, for a pilot-scale CTL/BTL plant at the Marmara Research Centre.

Observations from WS2: State-of-the-art Technologies for Small Biomass Cogeneration

Tasks 32 and 33 joined forces in the organisation of an expert workshop to present an update on recent developments in relatively small-scale (up to 10 MWe) power plants based on either combustion or gasification of solid biomass fuels. The workshop was held in Copenhagen, Denmark, on 7 October 2010 and attended by NTLs of both Tasks, plus about 150 outside participants. A summary of the report was prepared and is available on the Task 32 website (www.ieabcc.nl).

The Bioenergy 2020+ group reported on "Next generation pellets combustion with thermoelectric power generation". The advantages of the process are: direct energy conversion, no moving parts, and no working fluids (maintenance-free durability and noise-free operation). The process is targeted for micro-scale CHP based on biomass. The idea is to integrate a thermo-electrical generator (TEG) into a biomass furnace. Industrially available thermoelectric generators (TEGs) from cooling technology are based on Bismuth Telluride. The efficiency is 5-6%, and they may be used up to 250°C. Still under development are materials and technologies for higher temperatures. Prototypes TEG 250 and 400 were introduced.

Weiss A/S reported on its two-stage biomass gasification pilot-plant. In the two-stage gasification process, the pyrolysis and the gasification process are separated into two different zones. In between the pyrolysis and the gasification zones, the volatiles from pyrolysis are partially oxidised, decomposing most of the tars into gas. To enable high energy efficiency, the thermal energy in the gasification gas and the exhaust gas is used for drying, air preheating and pyrolysis. The two-stage gasification process has successfully demonstrated that the process offers low tar content in gas (<5 mg/Nm3), stable unmanned operation, high cold gas efficiency (>95%) and low environmental impact (clean condensate, high carbon conversion). The process verification and documentation has been performed at small scale. To manufacture economically attractive plants the process is now being scaled up. The two-stage gasification process is being modified to separate the drying from the pyrolysis unit. The drying agent is high temperature steam. Product steam from the dryer is led to the pyrolysis-gasification reactor to reduce soot production and increase char reactivity.

Turboden SRL reported on Organic Rankine Cycle (ORC) technologies for biomass plants. There is a whole range of ORC applications, including timber drying in saw mills, sawdust drying in wood pellets factories, district heating networks, etc.

Pyroforce Technology reported on its down-draft gasification with a gas engine. It has been involved for 15 years with R&D on biomass gasification. Five gasification plants have been built and are successfully operating: Emmen, Spiez, Güssing, Stans I and Stans II.

The status of the Babcock & Wilcox Vølund gasifier facility at Harboøre, Denmark was presented. The updraft gasifier was commissioned in 1996 and processes wood chips with typical moisture content 35-55%. Thermal input is 3.5 MWth resulting in electrical output of approximately 1 MWe. Use of heat for district heating was added in 2000. At the time of the workshop, the gasifier had operated for more than 120,000 hours, the gas engine had operated for more than 80,000 hours and power production was more than 500 MWh per month.

The Andritz-Carbona gasifier CHP plant at Skive, Denmark was introduced. It is an air-blown, bubbling fluidised bed gasifier with a capacity of 20 MWth and 6 MWe. Wood pellets are used as a feedstock – 40,000 t/year. The bed material has been changed from dolomite to olivine. The construction of the plant was started in 2005. Investment was DK 248 million (€33.3m). The write-off period is about 20 years. Annual sales are 120,000 MWh of district heating and 22,000 MWh of electricity.

Vienna University of Technology reported on indirect gasifier commercialisation in Austria and Germany and Dong Energy reported on scale-up of the LTCFB gasifier. Siemens presented an overview of Siemens steam turbines, and IDA reported on perspectives for data collected through the Danish follow-up programme for biomass CHP.

Observations from WS3: Gasification and alternative fuels development

The workshop was held in Christchurch, New Zealand on 14 April 2011 and attended by NTLs and about 40 outside participants. The workshop included presentations by NTLs on the status of gasification-based biofuels processes, and also presentations from New Zealand and Australia on local gasification and other renewable energy developments.

NREL reported on biomass gasification in North America. R&D activities, Biopower and biofuels status, resources potential and gasifiers in the USA and Canada were presented.

Earth Systems reported on biomass gasification in Australia. No commercial biomass gasification plant was operating in Australia but projects are in preparation that may yield commercial biomass gasification installations in the near future. Biomass gasification research in Australia is limited at present. There is no funding specific to the bioenergy sector, but the activity fits within a number of sectors for which funding schemes exist. It is likely that a combination of avoided waste costs plus income from energy production will be the key drivers for bioenergy processes such as gasification in the near to medium term.

VUT reported on the current status of work concerning the conversion of biomass by steam gasification to biofuels and chemicals. Fluidyne, NZ reported on charcoal gasification on a small scale. The University of Canterbury reported on R&D activities and on the BTSL programme, of which the objectives are:

- Optimisation of biomass gasification and co-gasification for clean and H2 rich syngas
- Gasification of energy-densified biomass slurry (pyrolysis and gasification)
- Fischer-Tropsch (F-T) synthesis for biodiesel
- New biomass resources and feasibility studies for an integrated F-T plant

There was also a report on gasification of biomass for clean and hydrogen-rich syngas. The University of Canterbury has constructed and commissioned a 100 kW Dual Fluidised Bed gasifier using steam as gasification agent. The impact of different bed materials and gasification temperatures on gas quality was investigated. Also tests with different fuels and biomass-coal blends were carried out. A gas cleaning system operating at the University of Canterbury was also presented.

CRL Energy Ltd, Coal Association of NZ, reported on gasification of coal and biomass for purified hydrogen production. The amount of available coal per capita in New Zealand is 10 times the world average. A four year program on biomass gasification and hydrogen production was presented. The main points of the program are:

- Bench-scale gasification tests on coal-biomass blends
- Modelling char reactivity and product streams
- Proof of concept O_2 blown gasifier

Solid Energy NZ reported on underground coal gasification. In their view the underground coal reserve should not be mined, but gasified to produce the gasification gas. In the underground gasification process the gasifying agent (air, steam, oxygen) is injected into the coal seam and the product gas is pumped out. This new and courageous idea can save the environment and reduce the costs of the gasifier.

Observations from WS4: Biomass gasification opportunities in the forest industry

The workshop was held at ETC in Piteå, Sweden, on 20 October 2011 and attended by Task NTLs and about 30 outside participants representing the Swedish bioenergy industry and academia. The objective was to present updates on the status of international and Swedish developments in gasification-based bioenergy.

NREL reported on climate change and the pulp and paper industry, and on BMG in North America. The current status of biofuels and biopower in the USA was also presented. Gasification technologies projects in the USA (e.g., Nexterra, Enerkem) were mentioned.

ETC reported on black liquor gasification and on the project "Transportation Fuels from Forest Residues via PEBG". In Sweden, black liquor production is concentrated in about 20 pulp mills. Estimates have shown that about 25% of Sweden's use of gasoline and diesel can be replaced with synthetic fuels from black liquor.

Chemrec reported on the DP-1 gasifier. It is an oxygen-blown, pressurised entrained flow gasifier using black liquor as feedstock to produce clean, cool synthesis gas. Chemrec also reported on the BioDME plant that uses Haldor Topsøe technology to produce demethyl ether for use as a diesel fuel in Sweden.

Sveaskog, the leading forest owner in Europe, with its base in the Swedish boreal forests, presented a forest owner´s perspective on bioenergy. Sweden has shown that a transition from fossil to renewable energy is possible. Today, bioenergy in Sweden is the largest energy source, so forests can play a key role.

VTT reported on biomass-to-syngas projects at VTT in 2011, an advanced analysis technique for gasification gas, and woody biomass-based gasification process development for H2 or SNG production (Vetaani project).

Metso, a global supplier of sustainable technology and services that employs about 28,500 people in over 50 countries, presented details of its CFB gasifier and of the Lahti Energia project (solid waste gasification).

VUT reported on economic conditions in Austria, R&D and projects concerning the behaviour of specific elements during biomass gasification and production of mixed alcohols.

Andritz/Carbona reported on different gasification areas where it is active, including equipment for biomass preparation and handling, belt and drum dryers, CFB gasifiers (atmospheric, air-blown for boilers and kilns in the range 10-150 MWth) and BFB gasifiers (low pressure, air blown in the range 10-50 MWth).

NSE Biofuels Oy, which is owned by Oil Oy and Stora Enso Oy, reported that its current business is to produce syngas from woody biomasses to be used as fuel in Stora Enso Varkaus pulp mill's lime kiln.

Observations from WS5: Bed materials in fluid bed gasifiers

The workshop was held in Istanbul, Turkey on 19 April 2012, and attended by Task NTLs and about 10 outside visitors. The objective was to provide information to Task NTLs on R&D activities to evaluate and understand catalytic properties of bed materials in fluid bed gasification.

The synthesis gas from the thermal biomass gasification process is an outstanding energy carrier. It can be used as a standalone fuel (heat and power applications) or can be further treated and transformed into another energy source. At present, product gas is used not just for heat and power generation as in recent decades, but also for transportation fuels production. That is why much more R&D work is performed and planned in this area.

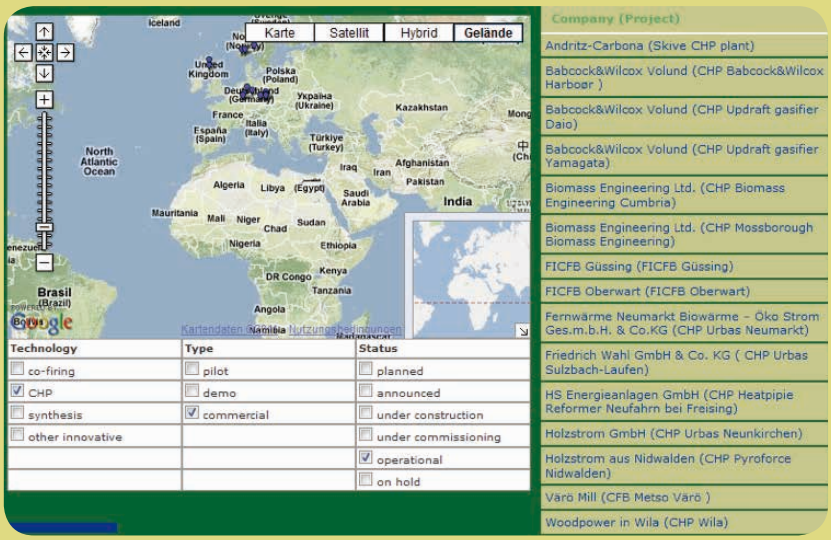
The quality of the product gas from the biomass gasification process plays an important role in synthesis gas applications and is influenced by many factors, including the type and quality of bed material. The most common bed materials used in commercial thermal biomass gasification facilities are silica sand, olivine and dolomite. Their influence on the quality of the product gas (especially tar content) was discussed during the workshop.

The workshop was organised with the cooperation of the European Energy Research Alliance (EERA), an initiative by several leading European R&D institutes. The aims are to accelerate development of new energy technologies, to expand and optimise research capabilities and to harmonise national and EC programmes.

Task website

The Task website (www.ieatask33.org) is the most important tool for disseminating information, updates, studies and meeting reports. It includes descriptions of the gasification process and of the Task, including the contact data of national experts. Within two weeks of each Task meeting, all presentations (country reports, workshop presentations) are put up on the Task website. The minutes are posted on the website as soon as all Task members provide their feedback. Summaries of the workshops can be found on the website in the form of reports. The website also includes a database of biomass gasification facilities worldwide (see next section for details).

Success story



Biomass gasification database

A Google-map-based interactive database of implementations of gasification plants was incorporated on the Task website. Currently, 87 gasification facilities are registered in the database, 54 of which are located in Task member countries, as shown in the following table:

Austria	9	NZ	1
Denmark	7	Norway	0
Italy	0	Sweden	4
Finland	4	Switzerland	4
Germany	7	Turkey	2
Japan	2	USA	8
Netherlands	6	**Total**	**54**

The database is interactive; the technology, type and status of the gasifiers can be chosen to filter all the gasification facilities registered in the database. The database is updated regularly and provides a good overview on gasifiers throughout the world.

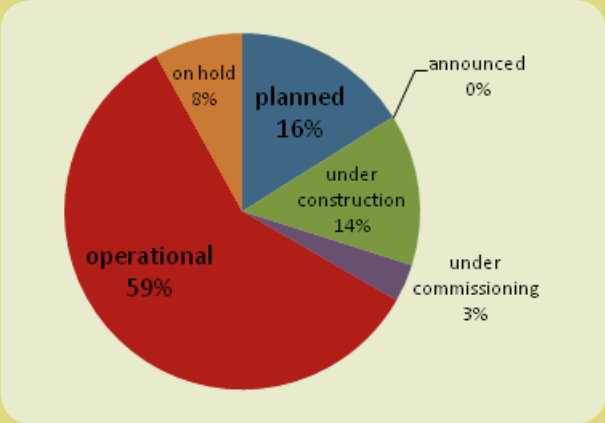
The database includes four types of gasification implementations:

- Co-firing (4 gasification facilities)
- CHP (37 gasification facilities)
- Synthesis (34 gasification facilities)
- Other innovative (12 gasification facilities)

The database displays three scales of gasifiers: pilot, demo and commercial. Nearly half of all gasification facilities (47%) are commercial, with 27% pilot plants and 26% demo plants.

All gasification facilities can also be divided by status, as shown in the figure below:

Status of gasification facilities



As the figure shows, the majority of the 87 gasification facilities are now in operation (59%), a further 14% are under construction, 3% are under commission and 16% planned. Only 8% are on hold.

Once technology, type or status has been selected, a table is displayed, as shown below:

In this example, the FICFB gasifier in Oberwart in Austria was chosen. As shown in the table, all the important information – including location, technology, raw material used, input and output data, products, facility type, partners, total investment, status and start-up – is displayed. For many plants a short technology brief or flowsheet is also included. If more information is required, the contact person displayed in the table is ready to answer questions concerning the gasification facility.

Conclusions and recommendations

Task 33 has been primarily a technical task whose objective is 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. The Task monitored the current status of the critical unit operations and unit processes that constitute biomass gasification (BMG) processes, and identified hurdles in the advancement of further development, operational reliability, and reducing the capital cost of BMG systems. These remain the basic foundations for developing and implementing a programme of work that addresses the needs of the participating countries.

To move beyond the information exchange between NTLs and industry, which has been a successful feature of the Task, special projects need to be more directly aligned with the RD&D interests of NTLS. As a practical matter, funding available for special projects is insufficient to cover NTL participation unless adequate funding comes from NTL funding outside of IEA Bioenergy. If the desire is to move more into the policy arena, then policy representatives need to be added. At present, the task NTLs are individuals involved in technology development.

Task 33 website

The new version of the Task 33 website was activated in July 2011 (www.ieatask33.org). The aim was to create a new, clear and informative webpage on thermal gasification of biomass, not just for Task members but also for all specialists in the gasification area and involved public.

A schematic figure of thermal biomass gasification, with input and output of the process, can be found on the home page. Cellulosic biomass (mostly forest and agricultural residues) is converted by thermal gasification into heat and/or power and steam and/or synthesis gas, which can be used for production of liquid fuels (e.g. Fischer Tropsch liquids, mixed alcohols, or gasoline), hydrogen, methane, and other chemicals.

The website has nine main sections:

- Thermal Gasification of Biomass
- Task Description
- Participants
- Publications
- Country Reports
- Meeting Minutes & Presentations
- Future Task Meetings
- Thermal Gasification Facilities – Database
- Newsletter

The new section 'Thermal Gasification of Biomass' provides short, clear descriptions of the gasification process, products and product gas usage. It is possible to download a table 'Main gasification reaction', which provides important information on thermal biomass gasification processes.

The section 'Participants', created from the former 'Member countries' and 'National representatives' sections, gives contact information about Task 33 members. In the triennium 2010-2012, there were 21 Task 33 members from 13 countries.

National Task Leaders provide an update on their country reports regularly. The status of biomass gasification in all member countries can be found in the section 'Country Reports'.

Within two weeks after Task 33 get-togethers, meeting minutes (after approval by all Task 33 members) and workshop presentations are posted in the section 'Meeting Minutes & Presentations'. 'Future Task Meetings' gives information about the meetings and workshop topics for the triennium 2013-2015.

A key part of the website is the section 'Thermal Gasification Facilities', which consists of a worldwide gasifier database.

TASK 34: Pyrolysis of Biomass

Prepared by:

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Operating Agent:

Paul Grabowski, US Department of Energy

Participating countries:

Canada, Finland, Germany, Netherlands, UK and USA

Introduction

This is the final report of Task 34: Pyrolysis of Biomass of the IEA Implementing Agreement on Bioenergy. This task was reorganised in 2009; this report covers the transition period of 2009 as well as the triennium of 2010-2012.

The overall objective of the continuing Task was to improve the rate of implementation and success of fast pyrolysis for fuels and chemicals (where this complements the energy considerations) by contributing to the resolution of critical technical areas and disseminating relevant information, particularly to industry and policymakers. Fast pyrolysis as practised by the participating countries maximises production of a single-phase liquid product from solid biomass.

The scope of the Task was to monitor, review and contribute to the resolution of issues that would permit more successful and more rapid implementation of pyrolysis technology, including identification of opportunities to provide a substantial contribution to bioenergy. This was achieved through the activities in the following topic areas:

Priority topics for Task 34

Norms and standards
Analysis – methods, comparison, new developments, protocols
Country reports updates/Review of state of the art
Fuels and chemicals from pyrolysis

Background

The work programme was similar to that of the previous Task 34, but with more emphasis on overcoming barriers to commercialisation of fast pyrolysis of biomass for liquid fuel production. During 2009 the Task was reorganised with the smaller membership of Finland, Germany, Australia and the US. The plan for new activities was discussed and revised during 2009 in order to prepare for the new triennium. At the start of the new triennium in 2010, Australia withdrew from the Task but Canada and the UK joined.

The process of fast 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 byproduct. The technology review focused on the thermal conversion and applications steps, but implementation requires the complete process to be considered. Process components as well as the total process were therefore included in the scope of the Task, which covered optimisation, alternatives, economics, and market assessment.

The work of the Task addressed the concerns and expectations of the following:

- Pyrolysis technology developers
- Bio-oil applications developers
- Equipment manufacturers
- Bio-oil users
- Chemical producers
- Utilities providers
- Policymakers
- Decision-makers
- Investors
- Planners
- Researchers

Industry was actively encouraged to be involved as Task participants, as contributors to workshops and working meetings, as consultants, or as technical reviewers of Task outputs to ensure that the Task orientation and activities matched or met their requirements. This involvement was a key factor in the value of the Task outputs as industrial involvement was high, including regular meeting participation by two of the leading industrial developers for fast pyrolysis of biomass, while a third attended one of the meetings.

Operating agent/task leader

The operating agent for the Task was the US Department of Energy, represented by Paul Grabowski. The contractor for leading Task 34 was Battelle-Pacific Northwest Division, with Doug Elliott as task leader.

Participating countries

Through the reporting period (2009-2012), the Task participants included Finland, Germany and the United States. During 2009, Australia was also a participant. Canada and the United Kingdom joined in 2010 for the complete triennium. The Netherlands joined for 2012.

Task activities

1. Norms and standards

In 2009 the Task members were already playing a role in establishing the ASTM standard for use of fast pyrolysis bio-oil as a burner fuel. During 2009 the method for solids determination in bio-oil was validated and included in the issuance of D7544-09, Standard Specification for Pyrolysis Liquid Biofuel. The efforts continued through 2010 with the issuing of the first bio-oil analysis standard method, D7579-09, Standard Test Method for Pyrolysis Solids Content in Pyrolysis Liquids by Filtration of Solids in Methanol. Even as the first standard was issued, the Task members were discussing subsequent standards to cover bio-oil in additional applications. In 2011 a draft mandate was developed to be presented to the European Committee for Standardisation (CEN; *Comité Européen de Normalisation*) for standards development, specifying a number of grades of bio-oil for a range of uses. The basis of the draft mandate that went to CEN was also used to develop a revised version of D7544-12 to include a second grade of bio-oil. Further efforts will continue in the coming triennium.

In Europe a new chemicals classification system REACH is being adopted. The Task members also recognised the confusion as a result of several material data safety sheets (MSDS) being issued by different organisations with different data and descriptions for bio-oil. To alleviate some of the confusion, a definition was developed by the Task as the basis for a new CAS number, which was approved and issued in 2010. Efforts to bring consistency to the MSDSs were an ongoing point of discussion at Task meetings.

As part of one Task meeting, a seminar was presented on the transportation standards and definitions relevant to bio-oil. An important element of this presentation was the recognition of sustained combustion as an alternative to flashpoint determination. The testing for sustained combustion is relevant to bio-oil as flashpoint is difficult to measure and is reported with widely varying numbers. An effort to remove flashpoint measurement from bio-oil standards is now under way, led by Task members. The EU-funded BIOTOX project had provided data on the toxicity of biomass-derived pyrolysis liquids. Unfortunately, the data combined both fast and slow pyrolysis oils. In IEA Bioenergy Task 34, this data was forwarded to toxicity experts and conclusions relevant to fast pyrolysis bio-oils were presented in a paper dealing with guidelines for transportation of fast pyrolysis bio-oils, which was published in *Energy & Fuels*. A continuing effort in the new triennium will be the issuance of a new MSDS for bio-oil which will address the several points of confusion.

2. Analysis – methods, comparison, new developments, protocols

During 2009 the output from the round robin on lignin fast pyrolysis held during the preceding triennium was condensed into an article published in 2010 *Journal of Analytical and Applied Pyrolysis* **88**, pp.53-72; web published 6 March 2010.

The subject and organisation of another round robin were discussed, and it was agreed to compare viscosity results and its measurement as involved in the accelerated ageing test developed at VTT. Participants in the round robin were solicited from interested laboratories in the five participating countries in the Task; 15 laboratories agreed to receive the two bio-oil samples and to perform and report the results from the prescribed accelerated ageing test using the viscosity measurement of their choice. The bio-oil samples were distributed in 2011 and the results received and documented by the end of the year. The write-up of the results was published in *Energy & Fuels* **26**, pp. 3769-3776; web published May 21, 2012.

An extension of the round robin was undertaken at three of the participating laboratories to further evaluate bio-oil viscosity changes. The repeatability of the accelerated ageing test was assessed by a 10-day test at two of the labs. This type of repeatability testing is a requirement for validating a method to include in a standard such as for bio-oil. The two bio-oil samples also were stored at three of the labs for a year's time at three temperatures to evaluate the effect of temperature on the ageing of the bio-oil and the resulting viscosity increase. The results of these tests were also published in a second article, *Energy & Fuels*, **26**, pp. 7362-7366; web published November 6, 2012.

Additional discussions were held on other important components in bio-oil and the relevant analytical methods. The components of interest, the trace contaminants for the most part, are potential problems for bio-oil utilisation and their quantitation is key to understanding impacts of bio-oil utilisation. Sulphur analysis was considered in detail with the range of sulphur analytical methods reviewed. Other trace components such chlorine and phosphorus were also discussed. As an outcome of these discussions, these trace element analyses will likely be the topic for a round robin in the coming triennium.

3. Country reports updates/Review of state of the art

Presentation of country reports by participants was a routine part of the agenda for each Task meeting. These country reports are also the basis for the country reports posted on the Task website. During this triennium the decision was made to publish a 'state of the art' of fast pyrolysis in the participating countries. Journals were considered for the publication and a receptive editor found. The country reports from the participants were updated and drafted into a common format for the journal publication. The manuscript was published in *Renewable and Sustainable Energy Reviews*, **20**, 2013, pp. 619-641.

It was recognised by Task members that the state of the art presented in the technology areas of the Task website could do with updating so that interested parties would receive the most current and correct information. Initial efforts in this direction were begun in 2012. Further work will continue in the next triennium.

4. Fuels and chemicals from pyrolysis

The key activity under this topic was performed as a collaboration with IEA Bioenergy Task 42 on Biorefineries. As an outgrowth of the previous triennium the interest in fast pyrolysis of lignin continued. Research on the subject was ongoing at ECN in the Netherlands; however, the Netherlands was not a participant in Task 34, so the direct participation of Paul de Wild, the principle investigator at ECN, was no longer possible as it had been in the previous triennium. As the collaboration with Task 42, Paul continued his interaction with Task 34 by providing reports on his research in lignin pyrolysis and his investigations into biorefineries based on fast pyrolysis. This work was published as his PhD thesis from Groningen University in 2011.

Conclusions and recommendations

Task 34 has continued to play an active role in supporting the market penetration of fast pyrolysis of biomass to produce bio-oil. The support has included major roles in standards development, organisation of round robins to validate important bio-oil analytical methods; and providing a source of useful information to interested parties who might want to get involved in biomass pyrolysis.

The Task has successfully disseminated the results of its work in technical journals and on the Task website. It has also played a role in informing the technical community through the organisation of a symposium of the leading industrial participants in the field, as a session of the IEA Bioenergy 2012 international conference in Vienna.

Success story

The bio-oil product produced in fast pyrolysis is a relatively new type of fuel oil whose properties are not well known or understood. Since the product is only recently coming out of the laboratory into demonstration-scale operations, the literature is full of analytical information about a range of bio-oils produced in small laboratory systems and there is little about commercial products. In addition, there is confusion about the product quality related to differences between the well-known technology of conventional wood pyrolysis for the production of solid char product and the newer fast pyrolysis of biomass, which produces primarily a liquid product.

The condensates from conventional (slow) pyrolysis of wood are typically not recovered but burned (or vented) as a vapour, without condensation. When condensed, they consist of a heavy tar and a highly acidic liquor (pyroligneous acid). The bio-oil from fast pyrolysis is a single-phase liquid, combining the characteristics of the two phases produced in slow pyrolysis. Clarifying the differences is a key goal of Task 34 as part of its mission to develop standards for bio-oil to facilitate commercialisation. One initial step taken by Task 34 was to define the properties of fast pyrolysis bio-oil as a CAS chemical entity. The CAS number for fast pyrolysis bio-oil (1207435-39-9) has been issued based on the description drafted by Task 34.

Task 34 participants have also played a leading role in the establishment of an ASTM standard for bio-oil for use as a burner fuel (D7544-09). As part of the establishment of the standard, a new analytical method for solids determination in the bio-oil was evaluated by Task participants in laboratory repeatability tests. This method has now been accepted as an ASTM method as well (D7579-09). The Task members have also worked to re-establish the standard development within CEN in Europe. A multi-grade standard was proposed as part of the draft mandate and is now under deliberation. The multi-grade concept has also been incorporated into the revised bio-oil burner standard (D7544-12). Finally, bio-oil is now a subject for REACH registration through support by Task members. Technical input to the registration team (SIEF) has included the recent transfer of the toxicology data developed with the BIOTOX project undertaken with the participation of some Task members in earlier trienniums of Task 34. As bio-oil is moved into the marketplace in Europe and North America, standards development is a key issue and Task 34 is playing a leading role.

Task 34 appendix

Participation in major events

tcbiomass 2009

The Task 34 meeting was held in conjunction with this conference in Chicago, US, September 2009. Task members made presentations at the conference:

> "Catalytic Hydroprocessing of Biomass Fast Pyrolysis Bio-oil to Produce Hydrocarbon Products." presented by DC Elliott at International Conference on Thermochemical Biomass Conversion Science, Chicago, September 18, 2009; and published as Elliott, D.C.; Hart, T.R.; Neuenschwander, G.G.; Rotness, L.J.; Zacher, A.H.; 2009. "Catalytic Hydroprocessing of Biomass Fast Pyrolysis Bio-oil to Produce Hydrocarbon Products." Environmental Progress & Sustainable Energy 28(3), 441-449; web published 5 August 2009.

> "Quality Control in Fast Pyrolysis Bio-Oil Production and Use." presented by A Oasmaa at International Conference on Thermochemical Biomass Conversion Science, Chicago, September 18, 2009; and published as Oasmaa, A.; Elliott, D.C.; Müller, S. 2009. "Quality Control in Fast Pyrolysis Bio-Oil Production and Use." Environmental Progress & Sustainable Energy 28(3), 404-409; web published 12 August 2009.

Bioenergy Australia 2011 Conference

Task 34 was represented by the German NTL, Dietrich Meier, at this conference at Sunshine Coast, Australia.

IEA Bioenergy Conference 2012

The Task 34 meeting was held in conjunction with this conference in Vienna, Austria, November 2012. Task members made presentations at the conference:

> "Bio-oil ≠ Bio-oil – Major differences in properties and use of fast pyrolysis bio-oil compared to fossil fuels and other bio-oils." Oasmaa A, Elliott DC, Meier D, Bridgwater AV, Preto F, and van de Beld B

> "Progress in the IEA Bioenergy Task 34 on Pyrolysis." Elliott DC, Oasmaa A, Meier D, Bridgwater AV, Preto F, and van de Beld B.

NIST Biofuels Standards Conference

Task 34 was represented by the Canadian NTL, Fernando Preto, at this conference at Washington, DC, USA. He made this presentation:

> "Standards Development Related to Fuel Use of Fast Pyrolysis Bio-Oil" Fernando Preto, Douglas C. Elliott, Anja Oasmaa, Dietrich Meier, Anthony V. Bridgwater, Bert van de Beld, Stefan Muller.

Deliverables for 2010-2012

Deliverables for the triennium 2010-2012 for Task 34 were:

- Continuation and updating of Task internet site
- Organisation and minuting of two Task meetings per year for a total of 6 Task meetings
- Two issues per year of the newsletter prepared and posted to the website for a total of 6 issues
- Reporting to the ExCo
  - Annual reports prepared and presented each year to ExCo at the October-November meeting
  - Progress reports prepared and presented each year at April-May meetings
  - Input provided to ExCo secretary each year for ExCo annual report and triennium report
  - Budget audit performed and reported each year

Further accomplishments:

- The state of the art of pyrolysis technology was presented for the participating countries at each Task meeting; it was drafted into a report that was published in *Renewable and Sustainable Energy Reviews*, **2013**, 20 619-641.
- In the standards topic area, the burner fuel standard for fast pyrolysis bio-oil was issued by ASTM in September 2010 with direct input from Task participants. A successful effort was led by the Task leader to have a unique CAS number assigned to 'fast pyrolysis bio-oil' based on a definition generated by the Task participants.
- The EU-funded BIOTOX project data on the toxicity of biomass-derived pyrolysis liquids was reviewed by toxicity experts and conclusions regarding fast pyrolysis bio-oils were outlined in 'Guidelines for Transportation, Handling, and Use of Fast Pyrolysis Bio-oils. 1. Flammability and Toxicity', published in *Energy & Fuels* **2012**, *26*, 3864-3873.
- After further revision, the final report on the lignin fast pyrolysis round robin (undertaken in the past triennium) was published in the *Journal of Analytical and Applied Pyrolysis*, **2010**, 88, 53-72.
- The results of the round robin undertaken during the current triennium were published in two parts. The first – Elliott, D.C.; Oasmaa, A.; Preto, F.; Meier, D.; Bridgwater, A.V. 'Results of the IEA Round Robin on Viscosity and Stability of Fast Pyrolysis Bio-oils', *Energy & Fuel* **2012** 26, 3769-3776 – described the collaboration of 15 labs in the participating countries to evaluate viscosity measurement and the accelerated ageing test. The second – Elliott, D.C.; Oasmaa, A.; Meier, D.; Preto, F.; Bridgwater, A.V. 'Results of the IEA Round Robin on Viscosity and Aging of Fast Pyrolysis Bio-oils: Long-Term Tests and Repeatability', *Energy & Fuels* **2012** 26, 7362-7366 – described work at three of the labs to test the repeatability of the accelerated ageing test and perform long-term storage tests of viscosity change.

Coordination with other Tasks within IEA Bioenergy

Efforts were made to collaborate with Task 42 (Biorefineries). Paul de Wild of ECN from the Netherlands represented Task 42 at the Task 34 meetings. The topic of collaboration was development of a pyrolysis-based biorefinery. Progress was made in defining pyrolysis-based biorefineries to produce chemicals and fuels particularly based on lignin as the biomass feedstock. The results are reported in the PhD thesis of Dr de Wild, Groningen University (Biomass Pyrolysis for Chemicals, 2011).

Plans were developed with Tasks 32, 33, 38, 39, and 42 for the coming triennium.

Industrial participation

Task 34 maintains strong connections with industrial leaders in biomass fast pyrolysis for bio-oil production. A representative of Ensyn, Stefan Muller, attended and participated in all Task meetings. Ensyn is the leader in commercial development of biomass fast pyrolysis for bio-oil production, with four new plants in development and an operating demonstration plant, along with several smaller plants for chemical food-flavouring products in operation since the 1990s. A second key connection is Anja Oasmaa from VTT in Finland who provides the direct connection to the consortium in Finland including Metso, UPM, Fortum, and VTT that is building a commercial biomass fast pyrolysis plant while operating a scaled-up demonstration plant. The third industrial connection joined Task 34 in 2012, when the Netherlands joined the Task. Bert Van de Beld from BTG represents the commercialisation effort in the Netherlands, which plans to build a fast pyrolysis plant in partnership with Akzo and others. Bert played a strong role in just his first year in the Task.

The Task works with and through these participants to address the commercialisation barriers. It supported the development in America of the ASTM standards for bio-oil, both the initial version of 2010 and the revised version of 2012. The Task members, including the industrial members, helped to develop the mandate that was presented to CEN to initiate the standards writing process in Europe. The Task is providing continuing input to the REACH registration process for bio-oil, which is currently under way in Europe. Task members wrote the description of bio-oil which provided the basis for the CAS number which was issued in 2010 and now applies to that chemical composition.

Task 36: Integrating Energy Recovery into Solid Waste Management

Prepared by:

Pat Howes, Task Leader, Ricardo AEA

Operating Agent:

Elizabeth McDonnell, Department of Energy and Climate Change, United Kingdom

Participating countries:

Canada, France, Germany, Italy, Norway, Sweden and United Kingdom

Introduction

This is the final report for the IEA Bioenergy Agreement Task 36 on integrating energy recovery into solid waste management systems for the period 2009-2012.

In this period the Task aimed to examine issues that are important to policy development and implementation of energy recovery systems for solid wastes. In undertaking this work we considered crosscutting issues such as lifecycle assessment and collaborated with other Tasks.

The key objectives of the Task were to:

- Review and exchange information on energy-from-waste options in participating countries in order to share potential solutions to overcoming barriers to implementation – this included examining the impact of management and design of facilities on environmental impacts, such as the production of residues
- Develop an understanding of the appropriate application of energy recovery, including integration with recycling and recovery facilities (i.e. within 'eco refineries'), and an understanding of the options available at small scale for rural areas and developing countries
- Increase understanding of the impact of changing policies on the uptake of energy from waste in participating countries – relevant policies include renewable energy, heat use and waste policy
- Work with other key Tasks where relevant work is being undertaken, e.g. on the increasing use of refined waste fuels or on anaerobic digestion

This report summarises the work and results of the Task over the 2010-2012 triennium, evaluating the work carried out and the significance of the findings.

Background

The proposal presented to ExCo 64 outlined the work programme for the Triennium. This included the production of five topic reports and collaborative work with Tasks 32 and 37. The five topic reports were:

- A review of the impact of policy on renewable energy on the inclusion of energy recovery from waste in renewable energy policy; this was to include a review of methods being developed to examine the renewable or 'biogenic' content of waste, which are required as proof of renewable energy generation.
- Examination of the options for integration of energy recovery from waste into recycling and recovery waste management facilities in order to explore the practical aspects of an eco-refinery concept.
- Lifecycle assessment of the eco-refinery concepts outlined in item (2) above.
- A review of small-scale options for energy-from-waste recovery that are particularly suited to rural areas and developing nations.
- A review of the management of the residues from energy recovery, particularly with respect to the impact of design of the front end.

In addition to this we proposed to collaborate with Task 32 to hold a workshop on refined waste fuels; to collaborate with Task 37 on topics of mutual interest; and to deliver links with international policy and dissemination bodies such as the International Solid Waste Association (ISWA).

The objectives also included organisation of twice-yearly meetings, reporting to the ExCo as required and attendance at ExCo meetings as required.

The proposed deliverables were:

- Topic reports
- Country reports (providing a summary of conditions and policies)
- Publication of proceedings on the workshop on refined waste fuels
- Website for dissemination of the work of the Task
- Contributions to annual reports and reports to the Executive Committee
- Inputs into national discussion of the topics of the Task

Task objectives and work carried out

To report on the Task's objectives and whether or not they have been achieved, the following section is divided into a series of sub-sections dedicated to each part of the Task programme of work (as described above). The initial sub-sections deal with the topic reports and the collaboration with other IEA Bioenergy Tasks. The final sub-section examines the routine work of the Task such as dissemination, reporting to the ExCo, etc.

Topic reports

Topic report 1: **Policy issues relevant to energy from waste**	
Task	**Review policy in the EU on inclusion of energy recovery from waste in renewable energy targets**
Relevance	The definition of energy from waste as a renewable energy is complicated by the mixed and variable composition of waste. For energy recovery to be included in national figures and in incentive schemes that reward renewable energy as part of national policies to achieve renewable targets, there must be an agreed method of defining the renewable content of waste. This work was designed to examine the various methods used to define the renewable content of waste.
Initial target	To provide a comprehensive review of the methods currently used and in development to measure the biogenic or renewable content of waste
Outcome, including significance	Report completed and published on Task 36 website. Presented at 2 conferences: in UK and at end of triennium conference in Vienna. Work discussed at workshop in Vienna. Presentations from workshop published on website. Work disseminated to regulator in UK and to interested power companies in UK.

Topic report 2: **Integrated Advanced Waste Refineries (IAWARE)**	
Task	**Integration of energy recovery into advanced waste management options, so that materials and energy recovery are balanced**
Relevance	Waste management is currently orientated in a waste hierarchy, where reduction, reuse and recycling take precedence over energy recovery. This work examined the impact of integrating energy recovery into a hypothetical waste management facility in terms of the overall energy balance. Three scenarios were examined, including a reference case based on current technologies (mechanical and biological treatment – anaerobic digestion – and conventional heat recovery) and two scenarios using advanced energy conversion technologies.
Initial target	To provide an analysis of the impact on the energy balance of integrated site
Outcome, including significance	The work showed that the energy balance for advanced conversion options was improved compared to conventional combustion of waste. However, this is based on assumptions about these technologies, as existing performance data is not available. Draft report published on Task 36 website. Work presented at the end of triennium conference.

Topic report 3: **Lifecycle of IAWARE concepts**	
Task	**Lifecycle analysis of the concepts developed in Topic 2, using the UK Environment Agency WRATE lifecycle assessment tool**
Relevance	This work provided an additional perspective on the systems developed in Topic 2 by analysing lifecycle greenhouse-gas emissions.
Initial target	To provide an indication of greenhouse-gas emissions for the scenarios developed in Topic 2
Outcome, including significance	The work showed that the greenhouse-gas balance improved when using advanced conversion options. However, this is based on assumptions about these technologies, as existing performance data is not available. Both this and Topic 2 showed that there is a need for improved performance data for advanced combustion options such as gasification of waste if policymakers are to be able to make the right decisions about investment based on evidence. Report completed and published on Task 36 website with the Topic 2 report. Work presented at the end of triennium conference.

Topic report 4: Small-scale energy from waste systems

Task	**Produce a report reviewing the options for small-scale energy-from-waste systems, updating the report produced by the Task in 2004**
Relevance	Small-scale energy-from-waste systems are becoming more important as part of the strategy of diversion of waste from landfill and integrating energy recovery with solid-waste management. They are particularly important in areas where there are low populations or where the population is spread, as in rural and remote locations.
Initial target	To produce an updated report, detailing what the major issues are for such plants and strategies that have been used to improve their economics
Outcome, including significance	This work was to have been done by the Canadian participant. The work was not started and Canada withdrew from the Task. This work has been carried over into the new triennium.

Topic report 5: Management of residues from energy recovery by thermal waste to energy systems

Task	**Produce a report reviewing the management of residues from energy-from-waste plants**
Relevance	Energy recovery plants provide a means to treat wastes using thermal combustion. However, these plants reduce the volume of waste for final disposal; they do not result in zero residues. The residues left include bottom ash from the combustion process and residues from the air emissions pollution control equipment. These residues are managed differently according to national policy and their composition. The main objectives of the management of these residues are: production of inert bottom ashes; reduction in quantity of the fly ashes; management and safe disposal of the residues from air pollution control; and material recovery, e.g. metals from bottom ash and filter ashes.
Initial target	This report was intended to provide a comprehensive review in one report of all of the options for management of energy from waste residues and the associated policy and regulation.
Outcome, including significance	The report showed developing practice and policy. The recent increase in commodity prices has made it worthwhile to recover metals from bottom ash, and the methodologies in use and being developed were reviewed. The review also examined the reuse of bottom ashes and the evidence that shows that these residues are inert and will not leach harmful chemicals into the environment. The report also discusses the treatment and disposal of air pollution control ash for different waste-to-energy options. This report is of value to decisionmakers who wish to understand the full impact of energy from waste. The report has been published on the Task 36 website. The work was presented at the end of the triennium conference. In addition results were partly presented at: ■ 2nd Synergia Forum, Athens, Greece, 10 June 2010 (Management of Waste Incineration Residues) ■ WTERT 2010 Bi-Annual Meeting at Columbia University, New York, NY, 7/8 October 2010 (Trends in utilising WTE residues in Europe) ■ KIT – Workshop on Gasification, Combustion, Residues and Deposits in MSW and Biomass Plants, Karlsruhe, Germany, 22 March 2011 (Management of Waste Incineration Residues) ■ 7th i-CIPEC, Seoul/Ilsan, Korea, 5-7 September 2012 (Metal Recovery from WtE Residues – Practice and Options) ■ WTERT 2012 Bi-Annual Meeting at Columbia University, New York, NY, 18/19 October 2012 (Trends in waste incineration and residue management) ■ IEA Bioenergy Conference 2012, ´Vienna, Austria, 13-14 November 2012 (Management of Residues from Waste-to-Energy Processes)

Collaboration with other Tasks

Collaboration with other Tasks involved:

1. Organisation of a workshop on solid recovered fuels in Dublin, Ireland – October 2011

This workshop, which attracted over 100 attendees, was associated with a site visit to two key plants near Dublin, Ireland. Both Tasks 32 and 36 were actively involved in organising the workshop, providing contacts for advertising the workshop and for speakers. The workshop attracted additional sponsorship from the Sustainable Energy Authority of Ireland and the Chartered Institute of Waste Management in Ireland.

Outcome and significance: The meeting was highly successful. The presentations were of a high standard and are presented on the Task 36 website. Not only was attendance good, but it stimulated additional interest in the Task website. The workshop also allowed development of additional contacts for Task 36.

2. Joint work with Task 37 on source separation of municipal solid waste

The separation of municipal solid waste has important impacts for both the combustion and the anaerobic digestion of waste. This work was part of a decision process on whether or not this is a suitable topic of interest to both Tasks and it involved commenting on a report that Task 37 had produced.

Outcome and significance: The work is ongoing.

3. Report on the health and safety of solid biomass storage, transportation and feeding

This report was produced as a result of a multi-Task collaboration. Task 36 contributed to two chapters.

Outcome and significance: This is a much-needed report, which provides details of health and safety effects that are often not appreciated. It is published on the Task 32 website (http://www.ieabcc.nl/).

Dissemination

Dissemination activities include:

- Presentations at conferences
- Workshops associated with Task meetings
- Website

Presentations at conferences

The Task's work was presented at the following conferences:

- NextGen Biowaste conference 2012 (on the work of Topic 1)
- Bioenergy 2011, Australia 2011
- FO Lichts NexGen Biofuels 2013 (on the use of waste for advanced conversion to biofuels)
- Presentation of work at BIOM2E conference in Amsterdam, 2012 (on energy from waste in Europe)
- Presentations listed under Topic 5

Workshops held in association with meetings

- Trondheim: Advances in waste management in Norway – presentations on website
- Rome: Biogenic content of waste by the team investigating the different techniques at RSE – presentations on website
- Mannheim: KIT workshop on advanced conversion of waste and biomass, including a tour of the facilities for testing these technologies and the Bioliq pilot plant – presentations on website
- Vienna: workshop on the biogenic content of waste – presentations on website

Workshop at Sintef, Trondheim

Workshop at KIT, Karlsruhe

Success story

One of the key issues for energy recovery from waste is its inclusion in renewable energy targets. Most Government regulators have 'deemed' a renewable content for waste and use this as a proxy for measurement. However, these deemed values only apply to municipal waste, not any other form of waste (such as refuse-derived fuels, solid recovered fuels and industrial wastes). Additionally, when there are incentives available to energy-from-waste plants, the plant operators frequently dispute the deemed value. In these cases the operators can claim a higher value, providing it is backed by scientific evidence. This has proved a stumbling block for the waste sector, as regulators require them to provide a methodology for measurement of biogenic content, but no cheap and easy method is available. The traditional methodologies available are expensive and require large amounts of sampling of waste streams into the energy-from-waste plant. Furthermore the results are not available until sometime after electricity has been generated. The importance of developing new methods can be demonstrated by the fact that the UK government supported a programme of research on novel techniques in 2010, and that a number of trials have been established in Europe to compare traditional and emerging methods.

One of the Task 36 participants (RSE, Italy) began a project to investigate and compare the methodologies at the start of 2010. This project was evaluating new methodologies, comparing them to results from traditional methods. The proposed methods, involving carbon isotope measurement and mathematical modelling, promised to be faster and easier than traditional methods. The Italians offered to share their results with the Task as part of a contribution to the Task. This came at an opportune time, as it is a key issue for many of the participating countries and across the EU.

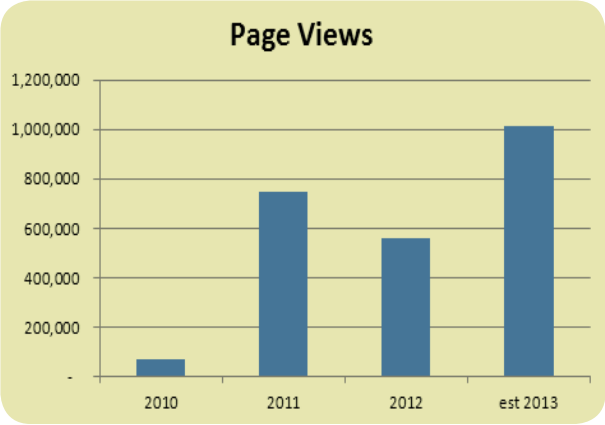
The final report provides the findings of the Italian study, translated into English so that all participants can share the work. In addition, this work was presented at an international conference in London and has been shared with industry and regulators in the UK.

The final report and presentations on the work are on the website. The work was presented at a workshop in Vienna, held in association with Professor Rechberger's research group at the Technical University of Vienna. This research group had developed a computer model to provide a means of estimating biogenic content for waste biomass using routine plant operating data. The workshop resulted in a lively debate. The model developed by Rechberger and his team would provide an even cheaper and more rapid method to monitor biogenic content of waste, providing it can be demonstrated to be representative. Currently, results from different energy-from-waste plant across the EU show promising but variable results.

This work shows how the Task is working at the forefront of technical development on waste, helping to distribute information internationally and stimulate international debate.

Website

The figure below shows the number of page views for the website. These have increased due to interest in publications on the website and the Irish solid recovered fuel website.



The site attracts most interest when there is publicity on a new publication or a seminar. This shows the importance of continuous publicity for the work of the Task.

Conclusions and recommendations

This is a small but vibrant Task. The participants are knowledgeable and enthusiastic and all have actively participated, providing additional value in organising Task meetings in association with workshops and site visits. They have provided interesting and informative reports as part of the topic report series. These reports have been used to contribute to scientific reports and conference presentations, as listed throughout this report. The aim of the topic reports is to provide information for key decisionmakers in policy and industry in participating countries. Building on the work of the previous three years in which a summary of energy from waste was produced for decisionmakers, the Task has examined key issues in this triennium. The major outcomes are:

- A series of reports on key topics for energy recovery from waste, such as the state of the art of residue management at energy-from-waste plants; a review of methodologies for measuring the biogenic content of waste; and examination of potential configurations of waste refineries and their relative environmental impacts
- Examination of key issues with local groups at each of the Task meetings
- Participation in international conferences to report on the work of the Task
- Contribution to key debates regarding the deployment of energy from waste in Europe

As the Task shrinks, the opportunities for doing specific reports on the Task also shrink, as does the budget for dissemination. A number of strategies are being examined to combat this, such as working with other international groups. Unfortunately we have not managed to leverage funding in this manner, although our contacts have allowed interesting exchange of ideas and information.

One of the strengths of the Task is the contacts and wide experience of the participants. This has been demonstrated through the organisation of small workshops associated with each Task meeting, in which a useful and educative exchange of information was achieved. We propose to support a series of such workshops over the next three years and to publicise the outcomes of these workshops through the website and through presentation at international events.

Task 36 appendix

Additional information

- Participation in major events (as outlined above). *The presentations at events are published on the website.*
- Deliverables (conference papers, seminar proceedings, technical notes, newsletters, industry days, scientific publications, books, etc), including website address or reference of the publication. *These publications are on the Task 36 website.*
- Co-ordination with other bodies outside of IEA Bioenergy, e.g. other Implementing Agreements and other organisations – *see Task 36 appendix.*
- Industry participation: How was industry involved in the Task activities? How did it influence the work carried out by the Task? Which industries participated and what activities did they participate in? *See Task 36 appendix.*
- Budget for the triennium as at 2010 and expenditure on different items by end of 2012. *See Task 36 appendix.*

Photos from seminars and site tours 2010-12

Bioliq pyrolysis plant at Karlsruhe Institute of technology

Grate incineration at MVV energy-from-waste plant, Mannheim, Germany

Bioliq pyrolysis pilot plant at KIT

Lasse incineration plant (100,000t/y) near Angers, France

District cooling plant at **Spittelau Incineration Plant**, Vienna

Trondheim incinerator, Norway, an important part of the city's district heating system

Co-ordination with other bodies outside IEA Bioenergy

The participants in Task 36 are all linked into organisations (academic and industrial) outside of IEA Bioenergy through their work. They used these links to provide interesting workshops at Task meetings and site tours in association with Task meetings. This is the main way in which the Task co-ordinates with organisations outside IEA Bioenergy.

Recently the Task made a concerted effort to contact other international organisations in the waste area. The aim was twofold: to see if organisations in other countries were interested in joining Task 36; or to see if there were areas where we can collaborate to mutual benefit. Examples include the Air and Waste Management Association (AWMA) and the US Energy Recovery Council (the trade association for EfW in USA), Zero Waste Australia and the European Recovered Fuels Organisation (ERFO). The discussions centred on areas of common interest or potential membership of the Task. It is unlikely that any of these organisations would join the Task, but there is interest in collaboration (such as presentations at events).

Our German participant is an active member of the International Conference on Combustion, Incineration, Pyrolysis, Emission and Climate Change (I –CIPEC). He has reported interest in the work of the Task from Malaysia, Indonesia and Korea within this group and the participant has presented work at the conference. We are currently negotiating an official presence at this event in the future.

The work of the Task was also presented at international conferences in the UK and Denmark. These presentations are on the website.

TASK 37: Energy from Biogas

Prepared by:

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Operating Agent:

Kyriakos Maniatis, European Commission

Participating countries:

Austria, Brazil, Canada, Denmark, Finland, France, Germany, Ireland, Netherlands, Norway, Sweden, Switzerland, Turkey, United Kingdom and European Commission

Introduction

Task 37 addresses both the technological aspects of anaerobic digestion (AD) and, based on the technical knowledge and expertise of its members, provides support to policymakers in the member countries. The period from 2010-2012 featured intensive planning and indeed rapid growth in the biogas sector in most member countries as national policies for renewable energy expansion were implemented. Policymakers widely acknowledge that AD can play an important role in the future of sustainable agriculture, rural development, waste management and renewable energy/biofuel production. AD technology is often chosen as a means to provide solutions to more than one of these challenges. For example, it is applied in agriculture to reduce eutrophication of water in areas of intense animal rearing by facilitating the capture of plant nutrients, while at the same time providing a source of energy and an alternative source of income to the farm. However, in terms of economic performance, biogas and biomethane production technologies usually struggle to compete with the fossil energy and fuels sectors. Task 37 dedicated a substantial part of its effort in the 2010-2012 work programme to defining ways to improve the technical and economic performance of biogas plants.

Before the 2010-2012 work programme, relatively little work had been carried out on the environmental performance of biogas plants. However, after the adoption of new renewable fuels and energy legislation in Europe in 2009, the frequency of questions concerning the environmental impact of biogas production and its use increased considerably. Task 37 saw a role for its international biogas experts to address the need for information and data that would allow realistic determination of the impact of biogas production on the environment. The work in 2010-2012 started with a study of methane emissions from all steps of the biogas production and utilisation process chain. The Task worked closely with organisations involved in lifecycle assessment (LCA) of biogas process chains.

In general, the Task planned to disseminate information through technical reports and case studies to people involved in the deployment of economic and environmentally sustainable biogas installations. While aiming at a high technical level, the intention of most publications was to enable easy understanding by both technical and non-technical people and indeed the general public, using a combination of website and dissemination forums. Publication of a new all-encompassing biogas handbook was included in the work plan.

Background

The main objectives of the 2010-2012 work programme of Task 37 were to support sustainable development and exploitation of technologies used in the biogas production and utilisation process chain. There are three main objectives of the work programme:

- Assessment of existing and emerging cost-effective technologies for biogas production, focusing on pre-treatment of lignocellulosic biomass and green/biowaste feedstocks, AD process monitoring and the economics of small-scale biogas systems
- Efficient use of the products of the biogas process, including efficient energy conversion, technologies for upgrading to biomethane, injection of biomethane into natural gas grids and the production and use of digestate as a biofertiliser
- Assessment of emissions from biogas production facilities and the mitigation of methane emissions

In all cases the aim of Task 37 has been to identify best practices applied or to be applied in the widespread exploitation of biogas technologies. The two main challenges of the biogas sector are the costs of investment and of operation and maintenance while maintaining high levels of environmental sustainability.

There is potential for reducing both investment and operation and maintenance costs by fine-tuning a number of processes. One of the starting points is feedstock selection and pre-treatment in which a number of national projects were engaged at the beginning of the work programme. One of the next steps is process control, either for AD of existing feedstocks or of new/modified feedstocks. Task 37 aimed to cover these topics in three technical reports – on energy crops, feedstock pre-treatment and techniques for process monitoring – with one additional report on the economics of small-scale biogas production.

Task 37 has in the past not directly addressed the environmental aspects of the biogas sector. Indeed, in 2010 there was little published information on emissions from biogas plants. Therefore, the Task started to pull together information with the aim of producing a clear view of what is known and what needs to be addressed. The work in the 2010-2012 work programme led to two reports on methane emissions. This work will be extended in future work programmes as more quantitative emissions and other environmental impact data become available.

Task objectives and work carried out

A. Biogas production

Feedstock Pre-treatments: Over the last two to three decades anaerobic digestion (AD) has expanded rapidly in the agricultural and wastewater treatment sectors. In more recent times, AD has started to expand in the waste treatment sector and there has been a move to use many types of biomass that can be difficult to digest.

Concerning feedstocks, two properties attract most attention: the methane production potential and the limitations that may be placed on the use of the digestate after biogas production. The study on pre-treatments for feedstocks was designed specifically to address methane yield, since any significant increase in the yield and/or the rate at which methane is produced would improve the efficiency of the AD process and thus have a positive impact on costs. In most countries, large-scale biogas production facilities rely upon subsidies to survive.

Completion of the final report was delayed until 2013. The report addresses a wide range of feedstocks that need pre-treatment, or would benefit from pre-treatment to improve their performance in AD. Pre-treatment technologies already available have been reviewed and an attempt has been made to judge their respective performances with respect to the level of improvement in methane recovery, their energy consumption and maintenance needs. Where possible, costs have been addressed but these are generally approached in a qualitative manner. Experience is growing on the use of mechanical, chemical and biological pre-treatment of agricultural residues containing significant amounts of lignocellulose. In practice, pre-treatment is becoming more common as plant operators become more confident in the ability of technologies to provide positive results.

Energy crops to biogas: Expansion of the biogas sector in some countries has been achieved in part by using crops grown specifically for AD. This has particularly been the case in Germany and Austria. While the most common crop used as a feedstock for AD is maize, many other crops have good methane potentials and can also be grown as part of necessary crop rotations and on degraded soils. Some of the crops are non-food and therefore conflicts surrounding the food versus fuel debate can in principle be avoided.

An earlier study on 'Biogas from Energy Crops Digestion' published in January 2010 [1] was extended to encompass a larger number of crops, including those with low water demand and needing low nutrient input. Data are provided for ranges of crop yield, measured methane yield and calculated methane yield per hectare. Data have also been added to account for energy input and for fertilisers. Comparisons of the net energy yields of the most commonly used crops are provided. The study 'Biogas from Crop Digestion' was published in September 2011 [2].

Process monitoring: Given that the economics of biogas production usually means there is some reliance on tariffs or other means of financial support to ensure viability, each step of the process needs to be operated under optimum conditions. The feedstock has been addressed in other studies (see above) and co-digestion was the topic of a much earlier study (2003). A study on process monitoring was carried out to provide better understanding of the possible techniques that would enable optimisation of process control by individual plant operators. The study reviewed process monitoring techniques that can be applied at various stages of the biogas production and utilisation process. The study was still to be completed at the end of 2012, but the final report was scheduled for publication publication before the end of 2013.

Economics of small-scale biogas plants: This topic was added after the start of the work programme on the request of Task participants. The aim was to understand how reducing the scale of biogas plants on farms affects the economics of investment and operation. Whereas in the period from roughly the 1990s to fairly recently, most plants built were typically 250 kW or greater (equivalent electrical output), however there has recently been increased interest in smaller systems suitable for either small farms or small communities. Not surprisingly, specific investment costs increase steadily with reduction in plant size. The report will provide potential new biogas owners and/or operators with examples of different approaches to plant design and the components used for new projects and consequent demands in terms of operation and maintenance. The final report was scheduled for publication by the end of 2013.

B. Biogas product utilisation

Biogas upgrading: The Task produced a detailed report on biogas upgrading to biomethane in 2007 and updated the report in 2009 [3]. During the last triennium the upgrading sector was monitored as the established technologies covered in the two earlier reports were implemented and extensive operating experience became available. The progress of newer technologies in the sector has been followed and in the case of membrane separation a Success Story was prepared for publication early in 2013. The plant list has been kept up to date on the Task website.

Biomethane pipeline injection: Use of the natural gas grid for transportation of biomethane to customers has dramatically increased in recent years as both the volume of biomethane produced has rapidly increased and specifications for grid injection have been agreed between producers and grid operators. In Europe, for example, new legislation was introduced in 2009 that has encouraged and facilitated grid injection of biomethane. Through its members, Task 37 has provided technical input to standards preparation work in Europe.

Digestate quality assurance: At the beginning of the triennium the Task published its first main report on digestate, 'Utilisation of digestate from biogas plants as biofertiliser' [4]. This report addressed the possibilities for production of a biofertiliser from digestate and the methods for application on land. The report was used as a key independent document in the United Kingdom for establishing a national specification (BSI PAS 110) for digestate from biogas plants. This work was followed by a dedicated report, 'Quality management of digestate from biogas plants used as fertiliser'; published in 2012 [5]. It contains extensive information on sources of contamination and methods for treating contaminants in digestate. While many organic contaminants can be removed during the AD process or in a separate pasteurisation process, many inorganic contaminants are either difficult or practically impossible to remove in a normal biogas plant. The report highlights the essential steps of rigorous selection and strict quality control of all feedstocks used by biogas plants. In some countries so-called positive lists of permitted feedstocks have been compiled to ease the task of the biogas plant operators. The two digestate reports were requested and have been used in European work to develop specific criteria for the definition of 'end-of-waste' of digestate within the scope of the European Waste Framework directive.

C. Emissions from biogas installations

Emissions review from biogas plants: Methane emissions are possible at all stages of the biogas production and utilisation process. The magnitude of the emissions depends on a combination of measures put in place to minimise or manage leaks, and the effectiveness of maintenance procedures. Since methane is a valuable product of a biogas plant in economic terms and has a 25 times higher global warming potential than carbon dioxide (IPCC, 2005), there is a strong incentive to minimise fugitive emissions. Only recently has detailed work been carried out on emissions from biogas plants. Studies have been initiated in a number of countries, most notably in Germany, Austria and Sweden. The results have been collated and assessed by Task 37 and a report produced in the form of a chapter (11) in the new *Biogas Handbook* published in February 2013 [6]. The report addresses the biogas production and utilisation processes step by step and describes levels of emissions depending on specific technology applied. The results are starting to be used to refine the assumptions in life cycle assessment (LCA) studies. Emissions data from Task 37 are being used to calculate the impacts of emissions from various biogas production pathways on overall environmental sustainability as part of the implementation of renewable energy technologies in the European Union. The methane emissions work will continue in 2013-2015 with closer links to Task 38.

In addition to the *Biogas Handbook* chapter, a report 'The Swedish voluntary system for control of methane emissions' was published in May 2012 [7]. It was derived from a Swedish-language text of a report introduced as a national measure to address methane emissions. The Swedish voluntary scheme is a good example of the primary steps involved in managing methane emissions from biogas plants.

D. Topics supporting dissemination and collaboration

Biogas Handbook: The Task started planning the production of a book on biogas towards the end of the previous work programme. In 2011 the Task received an invitation from Woodhead Publishing to produce a new book in its energy series, with the title *The Biogas Handbook: Science, Production and Applications*. The book, edited by former and current Task leaders (Arthur Wellinger and David Baxter) and one existing Task member (Jerry Murphy), has 19 chapters (>460 pages) covering all steps in the biogas production and utilisation process, both fundamental and applied, as well as market development of the sector. Of the 19 chapters, 13 were authored by present or recent members of the Task. The book is primarily aimed at degree and master's level students, project planners, policymakers and regulators. As a handbook, it contains a breadth

and depth of knowledge on biogas processes but can be considered as a starting point in a detailed study or project planning and is also a point of access to a wide range of further expert sources of information. The book was published in February 2013 [6].

Demonstration of new developments and lessons learned: The Task has produced a range of Success Stories based on the successful application of biogas technologies. During 2010-2012, four new Success Stories were published:

- Pioneering biogas farming in Central Finland: Farm-scale biogas plant produces vehicle fuel, heat, electricity and bio-fertiliser, Kalmari biogas farm in Finland (Annimari Lehtomäki) – published February 2012 [8]
- Nutrient recovery from digestate and biogas utilisation by upgrading and grid injection, Digestate treatment from collective of 30 farms in Switzerland (Nathalie Bachmann) – published March 2012 [9]
- Biogas pipeline for local heat and power production in a residential area, Zeewolde in the Netherlands (Mathieu Dumont) – published October 2011 [10]
- Economic sustainability of manure-based centralised co-digestion, Ribe Biogas, Denmark (Teodorita Al Seadi) – published May 2012 [11]

The main criterion for a Task 37 Success Story is that it describes a biogas plant, or a process directly connected to biogas production or utilisation, that has been in full-scale operation for long enough to prove a sustained high level of performance. Projects/plants described in Task 37 Success Stories agree to allow people to visit their facilities.

National workshops held in conjunction with Task meetings: Workshops were held in conjunction with each of the first five Task meetings. The subject of each workshop was chosen by the meeting host to address local and/or national needs.

- 'Digestate and biogas utilization – practices and perspectives', Copenhagen, Denmark, May 2010
- 'Sustainable biogas', Den Bosch, Netherlands, November 2010
- 'Biogas production and utilization', Gebze, Turkey, April 2011
- 'The role of biogas in agriculture and energy', Cork, Ireland, September 2011
- 'Biogas in the loop of recycling', Moss, Norway, April 2012

In the case of the workshops in the Netherlands and Ireland, the content of the programme was aimed mainly at local and national policymakers. The other three workshops were aimed mainly at technical organisations and the industrial sector. Workshop presentations are published on the Task website [12].

Country reports: Reports on the status of development and implementation of biogas technologies in each member country were made and updated at least annually. The country reports have been summarised in the form of PowerPoint presentations and published on the Task website [13]. A written summary of all country reports was made in the extended minutes of each Task meeting.

Meetings and minutes: It has become standard practice to provide a short version of Task meeting minutes with action points soon after each meeting. Extended meeting minutes are provided at a later date. The extended minutes contain country reports and reports on workshops. All meeting minutes are circulated only within the IEA Bioenergy membership.

Contacts with industry and research projects: Wherever possible, close contacts are maintained with R&D organisations and industry. Collaboration with international networks and projects has been maintained (e.g. European Biogas Association, BiogasMax, Valorgas, Biofuel Cities, etc.).

Newsletter: In cooperation with the European Biogas Association, Task 37 publishes a quarterly newsletter on biogas production and utilisation. The newsletter is distributed to more than 800 organisations worldwide. It is published on the Task website.

Success story

This success story concerns biogas digestate management and quality. Over the period of previous work programmes many different approaches to the treatment of digestate from anaerobic digestion (AD) were adopted across the biogas sector. In some countries poor-quality digestate was used as a fertiliser in food production, while in other countries digestate of similar quality was banned for use on agricultural land. In some cases, what is now considered high-quality digestate was also not allowed to be used on agricultural land because of the fear of what it might contain.

In the previous work programme Task 37 started a study on digestate use as a biofertiliser. The final report, published in June 2010 [4], addressed the fundamental properties of digestate, its value as a fertiliser and methods for applying it to land as a biofertiliser in place of fertiliser produced using fossil fuel. The report was authored by Task members from the United Kingdom and Denmark. Subsequently, the UK adopted the report as an independent reference when compiling a dedicated public standard (BSI PAS 110) that "aims to remove the major barrier to the development of AD and its markets for digestion process outputs by creating an industry specification against which producers can verify that they are of consistent quality and fit for purpose".

The next step in the digestate story was to compile guidelines for the quality management of digestate [5]. The report from the study, published in May 2012, contained information from member countries on the allowed levels of contaminants in digestate and methods for ensuring minimum quality requirements. The importance of local conditions was addressed in the study and how those conditions could affect the limits set for contaminants. In recent years there has been growing use of so-called 'positive lists' that define feedstocks permitted for use in biogas plants from which the digestate may be used in agriculture. These positive lists also have a local character that depends on a number of factors. The Task 37 digestate quality report stresses the importance of positive lists and their role in addressing local needs.

Requests for both digestate reports were received by the European working group on the end-of-waste for compost and digestate. The end-of-waste work is part of the process for implementation of waste legislation in Europe. The IEA work has been used to propose product quality criteria in the European legislation.

Conclusions and recommendations

Task 37 provided substantial input, in particular to policymakers, during the 2010-2012 work programme. The most concrete example is the support provided to member countries in the use of biogas digestate as a bio-fertiliser for application on agricultural land. Information from the Task has been used directly in the European Union (in particular the UK) for standards and the implementation of legislation.

Through dedicated technical workshops, the Task has been able to reach policymakers, industry and the academic communities in member countries. For example, in Ireland the workshop in Cork was attended by the chief science adviser to the government. The workshop in Den Bosch in the Netherlands was attended by leaders from the province of Noord Brabant who were keen to use IEA to promote best practices in biogas in their region.

Task members were invited to make presentations at key conferences and project events. The Task was also invited to produce a new handbook for use by a range of readers including technicians, scientists, policymakers and indeed the general public. These invitations collectively show general recognition and acknowledgement of the high level of expertise of the Task's members.

It is suggested that ExCo continue to play an active coordinating role that facilitates the widest possible dissemination of the Task's output so that the maximum benefit may be gained.

Task 37 appendix

Participation and co-ordination with other bodies

- The Task participated in the end-of-triennium conference held in Vienna in November 2012 by organising one parallel session in addition to 5 national workshops.
- Co-ordination with other Tasks within IEA Bioenergy: Task 37 started worked with Task 36 on waste feedstocks for anaerobic digestion; this work will continue in the 2013-2015 work programme. The Task also contributed to the health and safety report led by Task 32.
- Co-ordination with other bodies outside of IEA Bioenergy: the Task Leader was part of the working group for the production of the 'Technology Roadmap, Bioenergy for Heat and Power' by IEA headquarters.
- Industry participation: Industrial organisations participated mainly in workshops organisation jointly with Task 37 and organisations hosting Task meetings. At five of the six Task meetings in the triennium, visits were made to biogas facilities for the purpose of data collection and dissemination of the Task's output. Biogas plant operators provided all the information needed for the four Success Stories published.

Deliverables and publications

Task 37 website: http://www.iea-biogas.net/

1. 'Biogas from Energy Crop Digestion', Rudolf Braun, Peter Weiland and Arthur Wellinger, January 2010, http://www.iea-biogas.net/technical-brochures.html
2. 'Biogas from Crop Digestion', Jerry Murphy, Rudolf Braun, Peter Weiland and Arthur Wellinger, October 2011, http://www.iea-biogas.net/technical-brochures.html
3. 'Biogas upgrading technologies – developments and innovations', Anneli Petersson and Arthur Wellinger, October 2009, http://www.iea-biogas.net/technical-brochures.html
4. 'Utilisation of digestate from biogas plants as biofertiliser', Clare Lukehurst, Peter Frost and Teodorita Al Seadi, June 2010, http://www.iea-biogas.net/technical-brochures.html
5. 'Quality management of digestate from biogas plants used as fertiliser', Teodorita Al Seadi and Clare Lukehurst, May 2012, http://www.iea-biogas.net/technical-brochures.html
6. 'The Biogas Handbook: Science, Production and Applications', edited by A. Wellinger, J. Murphy and D.Baxter, Woodhead Publishing, 2013 (ISBN 978-0-85709-498-8 (print); ISBN 978-0-85709-741-5 (online)
7. 'The Swedish voluntary system for control of methane emissions', Anneli Petersson, May 2012, http://www.iea-biogas.net/case-studies.html
8. 'Pioneering biogas farming in Central Finland: Farm scale biogas plant produces vehicle fuel, heat, electricity and bio-fertilizer', Annimari Lehtomäki, February 2012, http://www.iea-biogas.net/success-stories.html
9. 'Nutrient recovery from digestate and biogas utilisation by up-grading and grid injection', Nathalie Bachmann, March 2012, http://www.iea-biogas.net/success-stories.html
10. 'Biogas pipeline for local heat and power production in a residential area', Mathieu Dumont, October 2011, http://www.iea-biogas.net/success-stories.html
11. 'Economic Sustainability of manure based centralised co-digestion, Ribe Biogas, Denmark', Teodorita Al Seadi, May 2012, http://www.iea-biogas.net/success-stories.html
12. Task 37 National Workshops, http://www.iea-biogas.net/workshops.html
13. Country Reports, http://www.iea-biogas.net/country-reports.html

TASK 38: Greenhouse Gas Balances of Biomass and Bioenergy Systems

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Introduction

IEA Bioenergy Task 38 brings together the research work of national programmes in all participating countries on greenhouse-gas (GHG) balances of a wide range of biomass systems, bioenergy technologies and terrestrial carbon sequestration. Emphasis is placed on the development of state-of-the-art methodologies for assessing GHG balances that demonstrate the application of established methods and support decision makers in implementing effective GHG mitigation strategies.

For the 2010-2012 triennium, Task 38 continued to work on the GHG impacts of biomass and bioenergy systems. The goals were to:

1. Focus on impacts on soil organic carbon and emissions of other GHGs (e.g. N_2O from fertiliser use)
2. Emphasise the use of waste streams (e.g. forest residuals) and improving biomass use efficiency, thus minimising the competition for biomass with other uses
3. Include emerging issues such as post-Kyoto climate-change negotiations, albedo and other climate forcing, and timing of emissions and removals
4. Incorporate the discussion of non-GHG sustainability impacts

The objectives of Task 38 are to:

1. Promote the sustainable use of biomass and bioenergy through increased understanding of the GHG and other impacts
2. Improve and modify the 'standard methodology' for calculating GHG balances by incorporating new issues, technologies and topics as they appear
3. Work in cooperation with other IEA Bioenergy Tasks to assess GHG balances of new technologies
4. Assess and report on best practices in participating countries for reducing GHG emissions using biomass and bioenergy
5. Aid decision makers in selecting mitigation strategies that optimise GHG benefits by disseminating the results of the above-mentioned activities

The report summarises the activities, deliverables, progress on objectives, and successes and difficulties during the past triennium (2010-2012).

Background

During the past triennium, bioenergy came under intense scrutiny for its environmental impacts. In 2010, international discussion on the magnitude of indirect land-use change (iLUC) remained intense, and a second topic, implications of the timing of GHG emissions from bioenergy, came to the fore. As a result most of the emphasis of Task 38 during the past triennium was on discussing and addressing these topics.

Carbon dioxide (CO_2) emissions from bioenergy are often considered zero since it is assumed that the biomass is produced sustainably, and that the amount consumed is regrown and over a lifecycle there are no net CO_2 emissions from biomass. In addition the accounting practice is to ignore CO_2 emissions from burning biomass in the energy sector. However, both these accounting conventions have led to a misrepresentation of the GHG impacts of bioenergy.

First, even though the biomass may be produced sustainably, an increase in the amount of biomass consumed may cause a decrease in carbon stocks since it takes time to regrow the biomass, and a decrease in carbon stocks is equivalent to a CO_2 emission. If the bioenergy practice is continued without further increase in consumption, after a period of time the land sector comes to a new dynamic equilibrium without further loss of carbon stocks. The emphasis is on the *increase of biomass consumed*. Secondly,

the accounting practice is only valid because CO_2 emissions from carbon stock losses are *required* to be accounted for in the land-use sector. Accounting for emissions in both the energy and land-use sectors would amount to double counting. Furthermore, bioenergy produces less energy per carbon atom than fossil energy, bioenergy systems tend to be less energy-efficient that fossil energy systems, and bioenergy systems may have more supply-chain emissions than do fossil energy systems. A combination of all of these factors leads to a situation where bioenergy produces more emissions than the fossil energy it replaces in the short term (0-50 years), but produces less emissions in the long term, as the carbon stocks on the land reach a new dynamic equilibrium. This, in a nutshell, is the essence of the timing issue. It stems from the fact that, for the atmosphere, it is immaterial from where the CO_2 comes when energy is produced. A CO_2 molecule from burning biomass is the same as a CO_2 molecule from burning coal. However, using bioenergy stimulates the biosphere to remove CO_2 from the atmosphere (regrowth of biomass), while the CO_2 flux from a fossil energy system is essentially one-direction only, from geological reserves to atmosphere.

Task objectives and work carried out

To report work carried out during the triennium in meeting the Task goals and objectives, we list below the major deliverables and activities, and discuss their relevance and progress.

List of publications

In this list, contributions from Task 38 participants have been highlighted. For example, the second citation would normally be listed as Bird et al, but other Task 38 participants have also been listed (e.g. Cowie, Cherubini and Jungmeier).

Item	Description	Relevance/Status
EXCO – Strategic Paper Bioenergy, Land Use Change and Climate Change Mitigation *(Berndes, Bird and Cowie, 2010[1])*	The report addresses a much-debated issue – bioenergy and associated land-use change, and how climate-change mitigation from use of bioenergy can be influenced by GHG emissions arising from land-use change.	Completed The purpose of the report is to produce an unbiased, authoritative statement on this topic, aimed especially at policy advisors and policymakers.
EXCO – Special Report: Comparing Greenhouse Gas Emissions and Energy Balances of Bioenergy and Other Energy Systems using a Life Cycle Assessment Approach *(Bird, Cowie, Cherubini and Jungmeier 2011[2])*	The report addresses the key methodological aspects of lifecycle assessment (LCA) with respect to GHG balances of bioenergy systems. It includes results via case studies, for some important bioenergy supply chains in comparison to fossil energy systems.	Completed. The purpose of the report is to produce an unbiased, authoritative statement on LCA methodology, aimed especially at practitioners, policy advisors, and policymakers.
EXCO – Background Technical Report Bioenergy, Land Use Change and Climate Change Mitigation *(Berndes, Bird and Cowie, 2011[3])*	The report addresses bioenergy and associated land-use change, and how climate-change mitigation from use of bioenergy can be influenced by GHG emissions arising from land-use change.	Completed
Case study: Alternatives to Use Sugarcane Residues to Reduce GHG Emissions *(Leal et al, 2013[4])*	Study of alternative uses of sugarcane residues, bagasse and straw, aiming at maximum GHG reduction. Alternative uses to be evaluated are: surplus power generation, second-generation biochemical ethanol and F-T biofuels, biochar as a way to fix carbon in the soil and to improve soil fertility.	In progress

1 Berndes G, Bird N, and Cowie A. 2010. Bioenergy, Land Use Change and Climate Change Mitigation. IEA Bioenergy Strategic Paper. IEA Bioenergy:ExCo:2010:03. Available at: http://www.ieabioenergy.com/publications/bioenergy-land-use-change-and-climate-change-mitigation/

2 Bird, N, Cowie, A, Cherubini, F, Jungmeier, G. 2011. Using a Life Cycle Assessment Approach to Estimate the Net Greenhouse Gas Emissions of Bioenergy. IEA Bioenergy: ExCo:2011:03. Available at: http://www.ieabioenergy.com/publications/using-a-lca-approach-to-estimate-the-net-ghg-emissions-of-bioenergy/

3 Berndes G, Bird D and Cowie A. 2011. Bioenergy, Land Use Change and Climate Change Mitigation Background Technical Report. IEA Bioenergy: ExCo:2011:04. Available at http://www.ieabioenergy.com/publications/bioenergy-land-use-change-and-climate-change-mitigation-background-technical-report/

4 Leal, MRLV, Walter AS, Seabra JA. 2013 Alternatives to Use Sugarcane Residues to Reduce GHG Emissions. IEA Bioenergy Task-38 Case Study. In preparation.

Item	Description	Relevance/Status
Case study: Environmental Assessment of Liquid Biofuel from Woody Biomass in Germany *(Roedl, 2012[5])*	This study examines lifecycle GHG emissions and other selected environmental impacts. Five types of woody biomass materials and two processing routes are assessed.	Completed. Optimisation of environmental benefits from multiple biomass sources and pathways.
Case study: Wood-based biodiesel in Finland. Market-mediated impacts on emissions and costs *(Forsström, Pingoud et al 2011[6])*	A market-oriented approach is applied to estimate the potential impacts on GHG emissions of achieving a national transport biofuel target under the current climate and energy policy obligations. The demand for wood in biorefineries raises the wood price, thereby weakening its competitive position against fossil fuels. Wood is thus replaced by fossil fuels in the ETS sector, and fossil-fuel CO_2 emissions in the ETS sector within Finnish borders would increase.	Completed. Demonstrates the importance of including market leakage.
Case study: Greenhouse Gas (GHG) and energy analysis of a bioethanol oriented biorefinery concept in Austria *(Cherubini, Jungmeier and Bird, 2013[7])*	This case study deals with an LCA of a conceptual biorefinery system which produces ethanol, other energy carriers (electricity, heat, biomethane) and chemicals (phenols) from softwood forest residues.	Completed. Demonstrates the timing of emissions from new bioenergy systems.
Case study: Greenhouse gas and oil use impacts of Fischer-Tropsch diesel and DME production integrated with pulp and paper mills *(Joelsson and Gustavsson, 2012[8])*	This study analyses the resource efficiency and reductions in CO_2 emissions and oil use when motor biofuels are produced in an integrated pulp and paper mill, under Swedish conditions, and used to replace fossil motor fuels. Integration of motor biofuel production with a pulp mill is more efficient than stand-alone motor biofuel production, but larger reductions in CO_2 emissions or oil use can be achieved if biomass replaces coal or oil directly in stationary energy applications.	Completed. Optimisation of resource use and importance of displaced fossil energy in assessing the CO_2 emissions saved.
Case study: Greenhouse Gas Benefits of a Biogas Plant in Austria *(Woess-Gallasch, Bird et al 2012[9])*	The goal of this study was to quantify the GHG and energy impacts of a biogas plant with closed storage of digested materials in comparison to one with open storage.	Completed. Importance of efficient systems and use of heat energy produced, and covering the storage tank to avoid methane emissions.
Case study: Life cycle assessment of greenhouse gas mitigation benefits of biochar in Australia *(Cowie and Cowie, 2013[10])*	This study evaluates the GHG impacts of a range of biochar systems, made from different biomass feedstocks, at different pyrolysis conditions, and applied to different crops.	Completed

5 Roedl A. 2012. Environmental Assessment of Liquid Biofuel from Woody Biomass in Germany. IEA Bioenergy Task-38 Case Study. Available at http://www.task38.org/

6 Forsström J, Pingoud K, Pohjola J, Vilén T. 2012. Wood-based biodiesel in Finland. Market-mediated impacts on emissions and costs. IEA Bioenergy Task-38 Case Study. Available at http://www.task38.org/

7 Cherubini F, Jungmeier G, Bird N. 2013. Greenhouse Gas (GHG) and energy analysis of an ethanol-oriented biorefinery in Austria based on wood. IEA Bioenergy Task-38 Case Study. Available at http://www.task38.org/

8 Joelsson J, Gustavsson L. 2013. Reductions in greenhouse gas emissions and oil use through di-methyl ether and Fischer-Tropsch diesel production in Swedish chemical pulp mills. IEA Bioenergy Task-38 Case Study. Available at http://www.task38.org/

9 Woess-Gallasch S, Bird N, Enzinger P, Jungmeier G, Padinger R, Pena N, Zanchi G. 2012. Greenhouse Gas Benefits of a Biogas Plant in Austria. IEA Bioenergy Task-38 Case Study. Available at http://www.task38.org/

10 Cowie AL and Cowie AJ. 2013. Life cycle assessment of greenhouse gas mitigation benefits of biochar in Australia. IEA Bioenergy Task-38 Case Study. Available at http://www.task38.org/

Item	Description	Relevance/Status
Policy brief: Time dependency of emissions related to bioenergy and their implications for policy *(Roos and Pena, 2011[11])*	Discusses the policy implications of timing of emissions from bioenergy	Draft, pending resolution by ExCo on acceptable language for inclusion in IEA Bioenergy publications to describe this topic. To be revised and released once ExCo approves the position statement (see below).
Position Statement: Reduction of carbon emissions through forest-derived bioenergy substituting for fossil energy *(Spitzer, Bird, Cowie, Soimakallio, and Woess-Gallasch, 2010[12])*	One of the initial position statements concerning the timing of emissions from bioenergy	Completed. Presented to ExCo.
Position Statement: Timing of GHG Emissions Information for ExCo68 *(Spitzer, Cowie and Bird, 2011[13])*	A second position statement concerning the timing of emissions from bioenergy	Completed. Presented to ExCo 68.
Position Statement: On the timing of mitigation benefits of Forest-Based Bioenergy *(Cowie, Bird, Bright, Cherubini and Pingoud, 2012[14])*	In response to a request from ExCo (ExCo 68) in Australia, a third position statement was prepared as part of a Task 38 expert meeting.	Completed. Presented to ExCo in Istanbul (ExCo70).
Position Statement: On the timing of mitigation benefits of Forest-Based Bioenergy *(Cowie, Bird, Berndes, and Junginger, 2012[15])*	IEA Bioenergy position statement redrafted in collaboration between Tasks 38 and 43.	Draft
Report: The influence of Emissions Trading Schemes on bioenergy use *(Tuerk, Cowie et al, 2011[16])*	Discusses the interaction between various emission trading schemes and their impacts on the bioenergy market.	Completed. Published, Tuerk et al, 2011. Presented to ExCo as an appendix to the 2011 Annual Report.
Scientific paper: Accounting for Algae *(Pena, Bird et al, 2012[17])*	A paper that discusses the implications of the current system for accounting for GHG emissions with a focus on carbon stocks in algae products, including bioenergy.	Published
Scientific paper: Special issue: Land use impacts of bioenergy. Selected papers from the IEA Bioenergy Task 38 meetings in Helsinki, 2009 and Brussels, 2010 *(Woess-Gallasch et al 2011[18])*	A special issue of Biomass and Bioenergy that discusses the timing of emissions from bioenergy and quantification of indirect land-use change.	Published

11 Roos J and Pena N. 2011. Time dependency of emissions related to bioenergy and their implications for policy – internal task 38 working paper.

12 Spitzer J, Bird N, Cowie A, Soimakallio S, Woess-Gallasch S. 2010. Position Statement on Reduction of carbon emissions through forest-derived bioenergy substituting for fossil energy.

13 Spitzer J, Cowie A, Bird DN. 2011. Timing of GHG Emissions. Information for ExCo68.

14 Cowie A, Bird DN, Bright R, Cherubini F, Pingoud K. 2012. On the timing of mitigation benefits of Forest-Based Bioenergy. Position Statement prepared for ExCo-69.

15 Cowie A, Bird DN, Berndes G, Junginger HM. 2012. On the timing of mitigation benefits of Forest-Based Bioenergy. Position Statement being prepared for ExCo-71.

16 Tuerk A, Cowie A, Leopold A. 2011. The influence of Emissions Trading Schemes on bioenergy use. Task 38 Report. Available at http://www.ieabioenergy-task38.org/

17 Pena N, Frieden D and Bird DN. 2012. Accounting for Algae. GCB Bioenergy. doi: 10.1111/j.1757-1707.2012.01194.x. Accepted 24 July 2012.

18 Woess-Gallasch S, Bird N, Cowie A. 2011. Special issue: Land use impacts of bioenergy. Selected papers from the IEA Bioenergy Task 38 meetings in Helsinki, 2009 and Brussels, 2010. Biomass and Bioenergy, 35, 4751-4752. DOI: 10.1016/j.biombioe.2010.12.053.

Item	Description	Relevance/Status
Scientific paper: The timing of greenhouse gas emissions from bioenergy systems using financial type indicators and terminology to discuss emission profiles from bioenergy *(Bird, Cowie, Strømman et al, 2011*[19]*)*	Discusses the timing of emissions from bioenergy and suggests the use of financial indicators as a method for incorporating the timing.	Published
Scientific paper: Emissions From Bioenergy: Improved Accounting Options and New Policy Needs *(Bird, Cowie, Gustavsson, Pingoud, Rueter, Soimakallio, Woess-Gallasch et al., 2010*[20]*)*	Discusses the problem with accounting for emissions from bioenergy under the Kyoto Protocol; also presents methods for rectifying the problem.	Published
Scientific paper: Bioenergy: Counting on Incentives *(Pingoud et al, 2010*[21]*)*	A response to Searchinger's paper on the accounting error for the emissions from bioenergy.	Published
Scientific paper: A comment to 'Large-scale bioenergy from additional harvest of forest biomass is neither sustainable nor greenhouse gas neutral': Important insights beyond greenhouse gas accounting. *(Bright, Cherubini, Bird, Cowie, Pingoud, Strømman et al 2013*[22]*)*	Discusses emissions from bioenergy and the importance of including changes in surface albedo.	Published
Scientific paper: Bioenergy and land use change – state of the art *(Berndes, Cowie et al 2012*[23]*)*	Discusses emissions from direct and indirect land-use change (LUC); complexity of quantification of LUC; and policy measures to minimise negative impacts of LUC.	Published
Scientific paper: Reconciling area-based supply and emission intensity-focused demand-based accounting frameworks in bioenergy *(Bird, Cowie et al 2013*[24]*)*	Investigates the possibility of using intensity-based accounting as a system for estimating and sharing the responsibility for emissions from bioenergy.	Draft paper. Undergoing internal review before submission to peer-reviewed journal.
Working Paper: Updating the Standard Methodology for Comparing the Greenhouse Gas Balances of Bioenergy Systems and Fossil Energy Systems *(Bird et al, 2013*[25]*)*	The 'standard methodology' requires a facelift so that it is more in the public eye. As well, a consistent method for displaying and quantifying the timing of emissions from bioenergy needs to be developed.	Draft

19 Bird DN, Cowie A, Strømman AH, and Frieden D. 2011. The timing of greenhouse gas emissions from bioenergy systems using financial type indicators and terminology to discuss emission profiles from bioenergy. In Proceedings of the 19th European Biomass Conference and Exhibition, Berlin.

20 Bird N, Cowie A, Frieden D, Gustavsson L, Pena N, Pingoud K, Rueter S, Sathre R, Soimakallio S, Tuerk A, Woess-Gallasch S, Zanchi G. 2010. Emissions From Bioenergy: Improved Accounting Options and New Policy Needs. In Proceedings of the 18th European Biomass Conference and Exhibition, Lyon.

21 Pingoud K, Cowie A, Bird N, Gustavsson L, Rüter S, Sathre R, Soimakallio S, Türk A, Woess-Gallasch S. 2010. Bioenergy: Counting on Incentives. Letters to Science. 327, 5 March 2010.

22 Bright RM, Cherubini F, Astrup R, Bird DN, Cowie A, Ducey MJ, Marland G, Pingoud K, Savolainen I and Strømman AH. 2012. A comment on 'Large-scale bioenergy from additional harvest of forest biomass is neither sustainable nor greenhouse gas neutral': Important insights beyond greenhouse gas accounting. GCB Bioenergy, 4, 617–619.

23 Berndes G., Ahlgren S., Börjesson P. and Cowie AL. 2012. Bioenergy and land use change – state of the art. WIREs Energy Environ. doi: 10.1002/wene.41

24 Bird N, Zanchi G, van Noordwijk M, Cowie A, Kryzanowski L, Pena N, Smith P, Tennigkeit T. 2013. Reconciling area-dependent emissions and the timing of emissions in intensity-focused, demand-based accounting frameworks for bioenergy. Draft text prepared for Global Change Biology Bioenergy.

25 Bird N, Cowie A, Soimakallio S. 2013. Updating the Standard Methodology for Comparing the Greenhouse Gas Balances of Bioenergy Systems and Fossil Energy Systems. Task 38 Working Paper.

Item	Description	Relevance/Status
Working Paper: Timing of emissions from bioenergy in LCA and GHG accounting: Metrics, associated uncertainties, and discounting *(Bird, Cowie et al, 2013[26])*	Started during the two expert meetings in 2012; discusses the importance of including other environmental impacts (e.g. changes in surface albedo) and how to handle the time component of environmental impacts of bioenergy systems.	Ongoing
Working Paper: Reference Systems for evaluating climate effects of bioenergy *(Cherubini et al 2013[27])*	Started during the two expert meetings in 2012; recognises that one of the most important factors for evaluating the climate effects of bioenergy is understanding and properly assessing what would have occurred in absence of bioenergy (the reference system).	Ongoing

Meetings and conferences organised

Item	Date	Description	Relevance
Business meeting	2010-03	Annual task business meeting, March 11th & 12th 2010, Brussels	
Business meeting	2011-03	Annual task business meeting, March 28th & 29th 2011, Graz	
Business meeting	2011-09	Additional task business meeting, September 22nd & 23rd 2011, Campinas	To discuss final year of triennium and prolongation proposal
Business meeting	2012-04	Annual task business meeting, April 10th &11th 2012, Chicago	
Business meeting	2012-11	Additional task business meeting, November 15th 2012, Vienna	To formulate transfer of responsibilities from Austria to Australia
Expert meeting (international): Greenhouse gas emissions from bioenergy systems: impacts of timing, issues of responsibility	2010-03	An open international meeting to discuss: - indirect land use change (ILUC) - impact of timing of GHG emissions bioenergy systems - responsibility for GHG emissions from bioenergy systems - policy mechanisms to limit iLUC, timing and share responsibility	At this meeting in Brussels, ILUC was still a point of discussion and timing of emissions was just beginning to appear as the next problem facing bioenergy.
Expert meeting (international): Timing of emissions from wood-based bioenergy	2010-10	First of three expert meetings to present and discuss implications of timing of emissions from wood-base bioenergy	At this meeting in Graz, Task 38 began discussion on timing of emissions from wood-based energy and started looking at solutions.
Expert meeting (international): How to present the timing of emissions from bioenergy in LCA and GHG accounting	2012-04	Organised by Task 38 to coincide with its business meeting, this expert meeting continued discussion on implications of timing of emissions from bioenergy	This meeting was held at Argonne National Laboratory (Chicago) to allow North American researchers and experts to participate. Two papers begun at this meeting and statement from Task 38 was drafted for ExCo 69.

26 Bird N, Cowie A et al, 2013. Timing of emissions from bioenergy in LCA and GHG accounting: Metrics, associated uncertainties, and discounting. Working Paper.

27 Bright R, Cherubini F et al. 2013. Reference Systems for evaluating climate effects of bioenergy. Working Paper.

Item	Date	Description	Relevance
Expert meeting (international): Impact of timing of GHG emissions	2012-11	Organised by Task 38 to occur after Vienna all task meeting, this expert meeting continued discussion on implications of timings of emissions from bioenergy	Meeting held in Vienna to allow European researchers and experts to participate. The two papers from previous expert meeting were continued.
Expert meeting (national): Austrian Roundtable #1 'Energetische Nutzung der forstlichen Biomasse und zeitliche Betrachtung der Kohlenstoffneutralität' (Utilisation of forest biomass for energy and the timing of carbon neutrality)	2010-10	First of three national meetings held in Vienna to come to grips with problem of timing of emissions from woody bioenergy	Problem put forward for discussion
Expert meeting (national): Austrian Roundtable #2 'Energetische Nutzung der forstlichen Biomasse und zeitliche Betrachtung der Kohlenstoffneutralität'	2011-01	Second of three national meetings to come to grips with problem of timing of emissions from woody bioenergy	Discussion of problem continued
Expert meeting (national): Austrian Roundtable #3 'Energetische Nutzung der forstlichen Biomasse und zeitliche Betrachtung der Kohlenstoffneutralität'	2011-04	Final national meeting to come to grips with the problem of timing of emissions from woody bioenergy	Agreement on a statement on the use of woody biomass for bioenergy
International conference: Joint Task 38/40/43 Workshop in Campinas, Brazil –Quantifying and managing land use effects of bioenergy	2011-09	A joint workshop with plenary session followed by two concurrent sessions to look at a) Quantifying land-use effects of bioenergy and b) Managing land-use effects of bioenergy	
International conference: Session at IEA Bioenergy Conference2012, Vienna 13-15 Nov 2012	2012-11	End of triennium conference of IEA Bioenergy	

Collaboration with other Tasks

Item	Description	Relevance
Technical Report: Bioenergy and Land Use Change	Project led by Göran Berndes, Task43. Annette Cowie and Neil Bird (Task 38) provided input.	
Joint Task 38/40/43 Workshop Campinas, Brazil – Quantifying and managing land use effects of bioenergy (September 2011)	Major international workshop held in Campinas, Brazil	
Collaborative project 'Monitoring Sustainability Certification of Bioenergy'	Project led by Task 40. Members of Task 38 (Helena Chum) provided significant inputs to collaborative project.	Project ongoing
Inter-task strategic project: 'Mobilising Sustainable Bioenergy Supply Chains'	Project led by Task 43. Task 38 will demonstrate utility of updated standard methodology by assessing case studies from participating countries.	Project ongoing
Strategic project proposal: the benefits of using pyrolysis oil in the shipping industry	Task 38 (Neil Bird) worked with Task 40 (Doug Bradley) on proposal to investigate potential of pyrolysis oil in shipping industry.	Proposal not accepted by ExCo

Networking and contributions outside IEA Bioenergy

Item	Description	Relevance
JRC Technical Report: Carbon accounting of forest bioenergy *(Agostini et al, 2012)*[28]	Summarises the issues in the accounting of emission from forest bioenergy. Members of Task 38 (Neil Bird, Francesco Cherubini, Annette Cowie, Kim Pingoud, Sampo Soimakallio) provided commentary and acted as reviewers.	
Poster paper: The timing of GHG emissions from bioenergy systems using financial type indicators and terminology to discuss emission profiles from bioenergy *(Bird, Cowie, Strømman et al, 2011*[19]*)*	A poster paper for the 19th European Biomass Conference and Exhibition, Berlin	
Presentation: Emissions From Bioenergy: Improved Accounting Options And New Policy Needs. *(Bird, Cowie, Gustavsson, Pingoud, Rueter, Soimakallio, Woess-Gallasch et al., 2010*[20]*)*	A presentation at the 18th European Biomass Conference and Exhibition, Lyon	
Presentation: Boreal forests in the work of IEA Bioenergy Task 38 *(Bird 2011*[29]*)*	A presentation to the Norwegian Ministry of Environment in Oslo, October 20th 2011	Ministry of Environment discussing whether Norwegian forests should be used for industrial bioenergy

28 Agostini A, Giuntoli J, and Boulamanti A. 2012. Carbon accounting of forest bioenergy. Joint Research Centre, Institute for Energy and Transport. Report EUR 25354 EN.

29 Bird DN. 2011. Boreal forests in the work of IEA Bioenergy Task 38. Presented at Internet seminar "om skog og klima" (on forests and climate) Oslo, October 20th 2011.

Item	Description	Relevance
Presentation: CO_2 Bilanz der Bioenergie *(Schwaiger and Bird, 2012[30])*	Presented at Austropapier/ÖZEPA-Vorstandsseminar, Haus der Papierindustrie, March 26th 2012, Vienna	The paper industry has competition for biomass resources from the bioenergy industry. They are looking for items that can help reduce the competition.
Presentation: LCA approach to estimate GHG emissions of bioenergy. Presented at Sustainable Biomass for Electricity Conference *(Bird 2012[31])*	Presentation at UNIDO conference held in Güssing, Austria. May 2nd-4th, 2012	
Presentation: Issues relating to the timing of emissions from bioenergy systems *(Bird 2012[32])*	Presented at Enlargement and Integration Workshop: Scientific Basis of Biomass Sustainability in EU Energy Policy, Istanbul, May 11th 2012	
Presentation: Emissions from bioenergy: the effects of timing *(Bird 2012[33])*	Presented at Carbon Emissions From Bioenergy: How it impacts our climate. Brussels, March 29th 2012	
Presentation: Issues relating to the timing of emissions from bioenergy systems *(Bird, 2012[34])*	Presented at IEA Bioenergy Conference2012, Vienna Nov. 13th – 15th 2012	
Presentation: Indirekte Landnutzungsänderung: Methoden und Modelle zur Implementierung *(Woess, Bird and Schwaiger, 2012[35])*	Presented at Wirtschaftskammer Österreich, Vienna, May 23rd 2012	Federal Chamber of Commerce in Austria and its biofuel producers members invited Task38 to present issues related to iLUC.

Participation in major events

Meetings and conferences organised, co-ordination with other Tasks within IEA Bioenergy, collaboration with other Tasks, co-ordination with other bodies outside IEA Bioenergy, and networking and contributions outside IEA Bioenergy have been outlined above.

30 Schwaiger HP and Bird DN. 2012. CO_2 Bilanz der Bioenergie. Presented at Austropapier/ÖZEPA-Vorstandsseminar, Haus der Papierindustrie, March 26th 2012, Vienna.

31 Bird DN. 2012. LCA approach to estimate GHG emissions of bioenergy. Presented at Sustainable Biomass For Electricity Conference, Güssing, Austria, May 2-4 2012.

32 Bird DN. 2012. Issues relating to the timing of emissions from bioenergy systems. Presented at Enlargement and Integration Workshop: Scientific Basis of Biomass Sustainability in EU Energy Policy, Istanbul, May 11th 2012.

33 Bird DN. 2012. Emissions from Bioenergy: the effects of timing. Presented at Carbon Emissions from Bioenergy: How it impacts our climate. Brussels, March 29th 2012.

34 Bird DN. 2012. Issues relating to the timing of emissions from bioenergy. Presented at IEA Bioenergy Conference2012, Nov. 13-15 2012, Vienna.

35 Woess S, Bird DN and Schwaiger H. 2012. Indirekte Landnutzungsänderung: Methoden und Modelle zur Implementierung. Presented at Wirtschaftskammer Österreich, Vienna, May 23rd 2012.

Success stories

During the last triennium 2010-2012, bioenergy faced much criticism from many sides. Rather than shying away from this criticism, Task 38 stimulated discussion on the critical topics and attempted to find solutions that would allow the appropriate development of bioenergy as an energy source.

This applied particularly to the issue of timing of emissions from bioenergy. The debate began with a paper by Searchinger that pointed out the problem with the accounting practice used in the Kyoto Protocol (though the focus of the paper was more on the problem of indirect land-use change). Task 38 has been aware of the issue from earlier studies by Schlamadinger, Marland and Spitzer, and in the Task's case studies, the timing of emissions was often reported (for example Cowie, 2006[33]). In response to scientific papers and attention in the media, the Task organised a series of workshops and expert meetings during 2010 to 2012 to discuss the issue and formulate potential solutions. In 2010, Task 38 produced a 'statement' to raise awareness of the issue at ExCo. ExCo requested a second statement on the topic in 2012. The statement was subsequently revised in conjuction with Tasks 43 and 40, and published by ExCo in 2013 – *On the Timing of Greenhouse Gas Mitigation Benefits of Forest-Based Bioenergy* (www.ieabioenergy.com).

The issue was noted, discussed (both within the Task and with internationally recognised experts), and both methodological and practical solutions have been recommended. For methodological solutions, Task 38 will incorporate into its updated standard methodology the explicit recommendation that GHG emissions due to C stock changes and climate-change effects due to change in albedo, should be incorporated in lifecycle assessments and case studies. As well, the case studies should provide temporal assessment of emissions and removals. As for practical solutions to optimise the outcomes, the Task recommends supporting bioenergy systems that:

- Use quickly decaying or regrowing biomass
- Convert biomass to usable energy efficiently
- Have low process-chain emissions, and
- Displace high carbon intense fossil energy systems

Greatest short-term benefits will be derived from bioenergy systems that use harvest or processing residues, or newly planted energy crops and forests with low risk of leakage due to indirect land-use change. In addition, a country may choose to develop a bioenergy system that delivers net GHG benefits only in the longer term, for political, social or other reasons, such as to establish a low-carbon energy system for th future; the short –term GHG cost of such an approach should be recognised, and allowances made within climate change policy.

Conclusions

During the 2010-2012 period, Task 38 took on challenges to bioenergy's environmental credentials, organised meetings to discuss these challenges, and produced numerous outputs (see deliverables listed above). Task National Team Leaders finalised and produced seven case studies, four policy briefs/policy statements, one report, seven scientific papers and three working papers. In addition, Task 38 held five business meetings and organised five international meetings.

36 Cowie A. 2006. Greenhouse Gas Balance of bioenergy systems based on integrated plantation forestry in North East New South Wales, Australia. IEA Bioenergy Task 38 Case Study. Available at http://www.task38.org/

TASK 39: Commercialising Liquid Biofuels from Biomass

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Introduction

Subject

Task 39's work focused on the commercialisation of liquid biofuels from renewable biomass, with a primary focus on conventional ('first-generation' sugar- and starch-based) and advanced (sometimes called 'second-generation' lignocellulose-based or 'third-generation' algae-based) biofuels production technologies. Through coordinated policy and technical activities, Task 39 assists participants in their efforts to develop and deploy biofuels such as alcohols and Fischer-Tropsch fuels from lignocellulosic biomass (biomass-to-liquid; BTL) by biochemical, thermochemical and hybrid production routes. It also continues to identify and promote opportunities for comparative technical and policy assessment and development.

The success of the Task has been, in large part, a direct result of providing an international forum for integrated discussions of these issues, in combination with the excellent participation of network members from industry, government and academia.

Objectives

The Task's objectives are to:

- Catalyse cooperative research, development and demonstration projects to help participants:
  - commercialise improved, cost-effective bio-based processes for producing conventional and advanced biofuels such as ethanol or drop-in hydrocarbons from sugar, starch, or cellulosic feedstocks, and biodiesel or renewable diesel from oil seed crops or aquatic feedstocks
  - while working with other Tasks, help develop and commercialise improved, cost-effective thermochemical-based processes, such as the Fischer-Tropsch process, for converting biomass-derived syngas to synthetic diesel and other advanced biofuel
  - assist in the development of other advanced liquid biofuel technologies, including biomass-to-hydrogen, algae-to-biofuel processes and the development of so-called 'drop-in' biofuels
- Provide information and analyses on policy, markets, and implementation issues (including regulatory and infrastructure development) that will help in the commercialisation of liquid biofuels as a replacement for current fossil fuels, by continuing the deployment of conventional biofuels production technologies, and the development and deployment of advanced technologies
- Provide information dissemination, outreach to stakeholders and coordination with related groups both within IEA Bioenergy and externally

This report provides an overview of the achievements of Task 39 over the past triennium, summarising the results and recommendations arising from the work of the Task 39 members. A background to the Task is provided, followed by a summary of the Task's recently completed work.

Background

Liquid biofuels have several advantageous attributes, including that they are: a) derived from renewable, non-fossil feedstocks; b) easily pumped and transported over long distances; and c) combustible in existing internal combustion (IC), diesel or jet engines. There are a variety of liquid biofuels such as ethanol, biodiesel or renewable (or green) diesel, and 'petroleum-like' biohydrocarbons containing little or no oxygen. Whether used as fuel additives or blendstocks (typically in 5-15% v/v blends in gasoline or diesel) or as fully fungible fuels (at blending levels of 50-100% v/v), biofuels are able to complement various petroleum-based fuels in global markets such as diesel (light duty, heavy duty and marine), gasoline and jet fuel.

The biomass feedstocks used to make biofuels are varied and are generally classified as: a) lipid feedstocks (vegetable/algae oils and animal greases); b) sugar feedstocks (sugarbeets, sugarcane, and small and large-grain starchy crops); and c) lignocellulosic feedstocks (fibrous plant matter and the cellulosic portion of municipal waste). Numerous processes can be used to convert biomass feedstocks to biofuels, spanning biochemical, thermochemical and hybrid routes.

The biofuels that have so far made significant inroads into the global fuels markets are sugar- and starch-derived ethanol (via fermentation) and lipid-derived biodiesel fatty acid alkyl esters (via esterification).

Despite technology commercialisation progress, three reservations about biofuels are sometimes raised that are common to both conventional ethanol and biodiesel commercial biofuels:

1. These biofuels are derived from food crops (i.e., sugar or starch crops for ethanol and palm/rapeseed or other oil seed crops for biodiesel).
2. These biofuels are inefficient to distribute and use because they are not fully fungible in the existing liquid fuels infrastructure. This contributes to them typically only being blended up to a few percent in petroleum fuels (5-10% v/v).
3. The GHG emissions savings achieved using these conventional biofuels are questionable due to GHG emission-intensive agronomic inputs (fertiliser requirements, feedstock collection-related emissions) as well as fuel production process emissions and any potential emissions associated with land-use change).

A growing activity within the Task has been assessing these issues. These points motivated the focus of several of the group's meetings during the triennium and were the topic of some of the Task's commissioned reports (referenced below).

Advanced biofuels made from lignocellulosic biomass (via pyrolysis, gasification or cellulosic sugars) or lipids made from aquatic algae are not yet fully commercialised. One of the Task's roles has been to help with the development and deployment of these advanced biofuels technologies. The progress in commercialisation, development and demonstration of advanced biofuels production processes is closely monitored by Task 39 members. Activities that the Task undertakes to help our network assess and monitor advanced biofuel developments around the world include biannual Task meetings, 3-4 newsletters per year, plus variously scoped and scheduled commissioned reports. The Task also maintains an online database of the world's cellulosic biofuels pilot, demonstration and commercial-scale facilities, and approximately annually issues reports documenting this database.

'Drop-in' biofuels

As well as contributing to cellulosic and algal biofuels development and deployment progress, Task 39 also has begun assessing the potential of 'drop-in' biofuels. These types of biofuels are also described as 'infrastructure-ready' biomass derived pure hydrocarbons (no oxygenated content) that are indistinguishable from petroleum-derived gasoline, diesel and jet fuels. These types of drop-in fuels can be produced from thermochemical processes (gasification and pyrolysis), by hydrotreating lipids, by direct microbial conversion of sugars (and perhaps other solubilised carbonaceous species) to hydrocarbons, or by indirect microbial conversion of sugars (and perhaps other species) to lipids for subsequent upgrading to hydrocarbon fuel product(s). Although not yet commercialised, advanced biomass-derived drop-in biofuels have been shown to be fully fungible with our existing petroleum infrastructure. Task members have been involved in various workshops that have tried to identify ways in which the development and commercialisation of these advanced, drop-in-type biofuels can be accelerated, including by improving process economy and environmental lifecycle. Two of the reports commissioned by the Task in the last three years (the 'algae biofuels, status and potential' and 'the potential and progress of "drop-in" biofuels' reports) looked at these issues. These reports have been either published or drafts have been circuited among network members.

The overall sustainability of biofuels and the extent to which their production enables GHG emission reductions relative to the fossil-fuel (business-as-usual) alternative, continue to be contentious issues. In the US, GHG emissions are now being used as a legally binding criterion for biofuel mandates (RFS2). Thus, one aspect that the Task is examining is, 'What is the net GHG reduction benefit of producing a renewable biofuel compared to its petroleum counterpart?' This question is important because, under the US RFS, net GHG reduction is the major criterion used to distinguish between biofuels that are considered 'conventional' (biofuels achieving 20% or less GHG savings) and 'advanced' (biofuels achieving 50% or greater GHG savings). Members of the Task have been assessing GHG biofuel emission issues; this is reflected in the programme of the various workshops and meetings that the Task has sponsored as well as in some of Task 39's recent published reports. However, GHG emissions are not the only environmental indicator that should be considered; as the Task recommended in a report issued early in the triennium, other criteria such as net water and energy usage (fossil or renewable) must be considered when evaluating the overall sustainability of a specific biofuels production pathway.

It is apparent that a combination of policy/regulatory issues and technological/process parameters affect the economics and commercialisation potential of both conventional and advanced biofuels. Task 39 continues to be fortunate to be able to benefit from the active participation of individuals from within industry, government and academia who have combined expertise spanning the many technology, market and policy areas that influence the economic and environmental viability and social acceptance of biofuels.

Specific Task 39 contributions are described in the following section.

Task objectives and work carried out

The various activities undertaken by the Task members are summarised below:

Objective 1: Catalyse cooperative research, development and demonstration projects to help participants develop and commercialise advanced biofuels, identify where progress in 'next-generation' biofuels (algae-to-biofuel processes) is likely to occur and, work with other IEA Bioenergy Tasks and other groups such as IEA HQ, the US DoE, etc to identify improved, cost-effective processes.

Cellulosic biofuels and especially cellulosic ethanol were the main focus of the Task during the last triennium. Task members greatly benefited from the active participation of knowledgeable industry representatives from companies such as Inbicon, Chemtex, Lignol, Abengoa, etc in helping the Task remain aware of current developments. Examples include: a) Abengoa in later 2013 is expected to start up a 25 million gallons per year (MGPY) commercial-scale plant in Kansas; b) POET-DSM is on track in later 2013 to begin operating a 25 MGPY commercial-scale facility in Iowa; c) DuPont is scheduled to start up a 30 MGPY facility in 2014; and d) Beta Renewables will soon open a 20 MGPY facility in Italy. In addition, Beta Renewables has secured a $99 million loan guarantee from the US DoE to build a commercial-scale plant in North Carolina and sealed a deal to build at least one large-scale plant in Brazil with GraalBio.

Another example of the benefits of inter-country collaboration and making use of the expertise and experience in the Task's membership are the review and publication of high-quality technical reports. A few of these reports are summarised below. A full list of reports can be accessed through the Task's website (www.Task39.org).

GHG emissions of biodiesel

The Task commissioned, reviewed and published a Biodiesel GHG/LCA report. This report assessed the many components of the biodiesel supply chain that play a role in influencing the type and amount of emissions released during the field-to-engine production and use of biodiesel. These include: no till management practices (reducing fuel use and increasing soil carbon); the use of controlled release nitrogen fertiliser to reduce N_2O emissions; increased seed oil content and lower energy consumption in oilseed crushers and biodiesel processors. Most of these types of improvements are currently being practised in some parts of the world. However, this is not the case for all participating countries and these improvements have not been integrated into all parts of the supply chain. Feedstock production is the area with the greatest potential for GHG improvement while the potential to reduce GHG emissions associated with oilseed crushing and biodiesel production is relatively small.

The likely changes in emissions during biodiesel manufacturing were modelled over several years (showing improvements due to improved efficiencies and agricultural practices) and across different regions such as Germany, UK and Canada. This comparison showed that Germany benefits from high yields and good nitrogen fertiliser use and, as a result, German biodiesel production has the lowest geographical GHG emissions when all other factors are held constant. These comparisons are useful when policymakers are deciding to what extent biodiesel use can be considered as a GHG reduction strategy. Our ability to accurately assess GHG emissions for various biofuels will become increasingly important as both the US RFS and the EU RED require minimum GHG savings for a biodiesel type to qualify as a sustainable biofuel. The full report is available on the Task 39 website.

Report and executive summary published on current status and potential of algal biofuels

The Task's Algal Biofuels report and associated joint executive summary with the AMF IA discuss the current status and potential technology risks and opportunities for development of a large-scale algal biofuels industry. These reports describe how algae possess a number of potentially attractive characteristics such as direct photosynthetic conversion of CO_2 to lipids, the ability to reach high yields of fuel produced per unit area and to use low-grade land (e.g., for siting cultivation ponds). However, despite almost 200 companies working in the area of algal biofuels, with investments of roughly USD 270 million, the estimated cost to produce algal biofuels remains high ($ or USD 5 – 30/gal, or $1.2 – 7.9/litre) and considerably higher than the cost of producing an equivalent petroleum fuel.

However, algal fuels production costs are projected to diminish over the next decade through ongoing RD&D. It is projected that about 100 million gallons of algal fuel could be available by 2020 at a cost equivalent to USD 60/bbl of crude oil, assuming continuing technology development progress. Overall, to reach economic viability, significant improvements need to be achieved in algal biofuels productivity, production cost and process robustness, e.g., through the development of improved algae strains, better reactor designs and more efficient and cost-effective lipid/oil extraction processes. Ultimately, the successful algal

biofuels companies will be those that optimise the whole production system and not necessarily those with the highest lipid/oil producing strain or the best lipid/oil extraction and recovery process.

Whole-process optimisation will be challenging as numerous trade-offs must be considered before selecting or modifying each system component. For example, regarding the choice of reactor, photobioreactors (PBRs) provide a more controlled cultivation environment but incur higher capital cost and unknown maintenance requirements, whereas open pond reactors are much cheaper but also much more susceptible to exogenous factors such as diurnal cycles, weather conditions and predation by insects and other contaminants. Similarly, algal strains capable of high lipid/oil yields tend to be less hardy than those achieving higher yields of proteins and carbohydrates (rather than lipids/oils) and therefore may not thrive in less controlled open pond systems. Another salient trade-off is between autotrophic (CO_2-fed) and heterotrophic (sugar-fed) production systems, where the former is limited by productivity (by the rate of gas-liquid mass transfer) while the latter lacks the ability to directly sequester (fix) CO_2. Very little is known about the sustainability and LCA performance of would-be commercial-scale algal biofuels facilities; this will remain a limitation until the first demonstration facilities come in line and begin providing data to enable more rigorous environmental impact investigations. These reports are available on the Task 39 website.

Collaborations form part of the success story of Task 39

The Task has ongoing interactions with the other Tasks, IEA HQ and external groups such as FAO, the US DoE, the Global Bioenergy Partnership (GBEP), etc. The Task continued to interact well with Task 42 (biorefining); both Tasks co-organised a successful joint-Task meeting in Copenhagen, Denmark, in February 2012.

Task 39 members also contributed to the highly cited IEA HQ Biofuels Roadmap and were involved in all stages of the conceptualisation, structuring and review of the various drafts of the roadmap report. Anselm Eisentraut and his colleagues at IEA HQ should be congratulated for coordinating this mutually beneficial endeavour.

The Task continued to liaise with other Implementing Agreements, particularly with the Advanced Motor Fuels (AMF) Implementing Agreement. Axel Munack acted as the liaison person and attended AMF meetings as an observer on behalf of Task 39. More recently, Dina Bacovsky took on the overall coordinator role within the AMF Implementing Agreement, providing another point of effective linkage between the IEA Bioenergy and AMF Implementing Agreements.

Objective 2: Provide information and analyses on policy, markets, and implementation issues (including regulatory and infrastructure development)

During the last three years, a variety of biofuels-related policies and strategies have been used by Task 39 participating countries. However, many of these policies have been adversely affected by the global economic downturn that started in 2008 (scarcity of capital, etc). Thus, the biofuel sector is still trying to regain traction in its efforts to both demonstrate and commercialise new technologies. During this time, the Task published two reports on policy aspects of biofuels while maintaining and updating an interactive website. The first report described the location, type and size of advanced biofuel pilot plants and demonstration facilities (with accompanying online demo plants database website). The second report discussed the various criteria being used to assess the sustainability of different biofuels production routes.

'Status of advanced biofuel demonstration facilities' (T39-P1b)

While only a very few production facilities are operational, several projects are under construction or planned. The report summarises: 1) which companies are involved; 2) the location and the process of facilities under construction; 3) which technologies, feedstocks, etc will be applied. The data/descriptions were generally supplied by the facilities owners/technology developers and the Task members sought to ensure the accuracy of the reported information. Although the reported information is regularly updated, as the plants move closer to commercialisation, understandably more proprietary information is developed that cannot be released or posted. Facilities such as the Inbicon demonstration plant in Denmark are running regularly while in the coming year plants run by Chemtex, KiOR, INEOS Bio, POET-DSM, Abengoa and Fiberight are expected to become fully operational.

'Major environmental criteria of biofuel sustainability' (T39-P4)

The report, which constitutes the first phase of a two-phase process, suggests a framework for analysis based on four primary sustainability metrics or indicators. Using these four indicators, Phase II will assess the sustainability of bioethanol and biodiesel (and other biofuels) in various geographies using regional feedstocks. Phase I of the report included the following key sections:

a) Introduction: defining sustainability issues and summarising current criteria and issues under active 'debate'
b) Trends in biofuel sustainability criteria: examining how sustainability is assessed in various Task 39 member countries (e.g. net energy balance, process-related GHG emissions, water quality and quantity, land-use change and related GHG emissions)

c) Policy recommendations: summarising the key policy issues associated with each criterion as well as proposals for developing a sustainability framework that builds on international efforts

Objective 3: Provide information dissemination and outreach to stakeholders, and coordinate with related groups both within IEA Bioenergy and externally

One of the major roles of the Task has been to promote open and active communication and information exchange between member countries. The Task 'secretariat' also responds to frequent enquiries forwarded by both Task members and other organisations and individuals. The Task is regarded as a "well-informed, independent broker of biofuels information of a technical, policy or market nature".

Task 39 has various communication deliverables that are described in this report and on the Task 39 website (www.task39.org).

The Task 39 secretariat tries to better link the 'Task 39 biofuels community' and the greater global biofuels sector by using tools such as a redesigned website, a "three-times-a-year" newsletter and frequent workshops and symposia. In 2010, Task 39 undertook a rebranding effort to update the look and feel of the Task 39 portal and to facilitate easier communication and information dissemination. The new IEA Bioenergy Task 39 site was launched in September, 2010 (www.Task39.org). The site is heavily used and has generated many enquiries that are regularly handled by the Task coordinator and webmaster. New information is added regularly. This website can be considered one of the major successes of the Task.

Business meetings, workshops and symposia meetings are typically held 2-3 times a year. Conference sessions are frequently used by Task 39 to facilitate face-to-face interaction among our country representatives. The three-times-a-year Task 39 Newsletter typically has a lead article profiling one of the Task 39 member countries and its biofuel developments. Other articles are used to inform the readership (more than 2,500 registered readers) of recent Task activities as well as to provide updates on the latest developments in the global biofuels sector.

Typically one of the 2-3 business meetings held each year is used to update Task 39 members on recent biofuels-related developments (R&D programmes, company strategies, national programmes, policy decisions, new conferences, etc) that have taken place in each of the participating countries. These presentations are circulated among the participating members and also posted on the member-only section of the Task 39 website. Other business meetings have more of a focus on idea exchanges, planning for network initiatives and reviewing Task communication tools. Together, these are used to facilitate continuous improvement in communications among the Task membership as well as to try to ensure, wherever possible, that research, development and commercialisation efforts are complementary.

The Task 39 business meetings are typically organised in conjunction with a major biofuels conference in one of the member countries. One of the primary reasons is to try to make better use of the time and travel costs of Task 39 member participation. Usually the Task organises a dedicated Task 39 session within these conferences where Task representatives from across industry, government and academia describe their work. During the last three years, the Task 39 sessions within international conferences the Task has participated in have proved very popular.

Success story

As mentioned above, the Task has been very active in working with other IEA Bioenergy Tasks, other IEA implementation agreements, IEA Headquarters and with other organisations such as FAO, US DoE, etc. One of the most successful collaborations was the joint executive summary on Algal Biofuels, 'T39-T3 – Algal Biofuel Joint Executive Summary with the AMF'. This joint executive summary built on Task 39's original 'Current Status and Potential of Algal Biofuels' report (2010) and a similarly themed Algal Biofuel report that had been subcontracted out by the IEA AMF IA (2011). With the encouragement of the ExCos from both implementing agreements, Task 39 and the AMF-IA developed a joint Executive Summary which pooled the findings documented in these two separate IEA Algal Biofuels reports. This first-of-its-kind joint IA executive summary was reviewed and revised by members of both Task 39 and the AMF and is now published, featuring the logos of both IEA expert groups.

The IEA Bioenergy IA Task 39 and IEA AMF IA joint Executive Summary provides a concise description of the current and future commercialisation potential of algae-derived biofuels. As previously discussed, algae possess a number of conceptually attractive characteristics such as direct conversion of CO_2 to lipids, high yields and no use of agricultural land. However, algae fuels are not currently commercially viable.

Another area of concern is the lack of information on the sustainability and LCA profile of commercial algal biofuels. This will remain a limitation until the first demonstration facilities are built and operated, thus providing the data for more rigorous environmental impact investigations. As indicated in the more detailed reports it appears that algae biofuels are still at the early stages of development and full commercialisation is still some way off in the future.

Conclusions and Recommendations

Biofuels continue to play an important role in global transportation markets in places such as Brazil, Europe and the US, despite the economic downturn and the projected future availability of unconventional petroleum and natural gas in areas such as North America. Conventional biofuel production as represented by ethanol and biodiesel has grown by 90 billion annual gallons from 2000 to 2010 (IEA biofuel Roadmap). The US and Brazil represent about 50% (predominantly ethanol) of global biofuel production and both countries continue to grow their capacity (albeit, at a slower rate). The US in particular is close to reaching its 15 billion gallon target for corn-grain ethanol and during 2013 several advanced biofuel plants using cellulosic feedstocks will become operational. Cellulosic biofuels are also being rapidly developed in the EU, Brazil, China and India. Despite challenges such as the recent US drought, high corn prices and policy issues such as the US blend wall and uncertainty about future GHG emission regulations, various cellulosic biofuel plants are moving towards commercialisation. Facilities such as the Inbicon demonstration plant in Denmark are operated regularly while demonstration plants built by Chemtex, KiOR, INEOS Bio, POET/DSM, Abengoa and Fiberight are expected to be fully operational this year. Major energy and chemical companies such as BP, Petrobras, DuPont and DONG energy continue to make significant RD&D investments in advanced biofuels.

Task 39 continues to play a role in facilitating communication and commissioning reports on conventional and advanced biofuels, tackling salient issues from both policy and technology perspectives. The Task has: a) helped facilitate collaborative biofuel R&D, and its network members have contributed to demonstrating emerging biofuel technologies; b) provided information and analyses on policy, markets and implementation issues; and c) facilitated information dissemination among members and the broader biofuels community (e.g., through business meetings, newsletters and a routinely updated website).

The 2-3 business meetings and 2-3 conferences/workshops that have been held each year have provided an opportunity for leading biofuel experts to interact and address the technical, social and economic issues related to commercialising biofuels. Inter-Task collaboration has facilitated the goals of the different Tasks (e.g. the Task 39-Task 42 joint meeting in Copenhagen, 2012). The three-times-a-year Task 39 newsletter has more than 2,500 registered readers who are regularly updated on the latest biofuels-related developments in member countries. This past triennium nine member countries and their biofuel developments were profiled (one each in the nine Task 39 newsletters issued during this time). Task 39 reports are typically authored by Task members or external consultants who are experts in their fields. Drafts of these reports are first reviewed by Task 39 country representatives and, after their corrections/suggestions have been incorporated, Task 39 members have sole access to the final report for several months before it is released for public access. Although these reports are highly cited there has been a request to try to get IEA Bioenergy reports into the more 'accessible' literature so that they have even more of an impact. Although IEA HQ was approached about this possibility as were some of the technical journals (e.g. Elsevier), this need for enhanced visibility of IEA Bioenergy reports has not yet been resolved.

As is apparent in the summaries of the Task 39 reports, various critical issues such as algal biofuels, GHG emissions of biodiesel systems, advanced biofuel demonstration facilities and other topical issues have been addressed by the Task. For example, although the algae biofuel report primarily focuses on the various technical challenges related to yields, product harvest and separation, it also addresses other challenges such as careful selection of location, climate and supply-chain conditions. Other topics that are currently being assessed by the Task are GHG emissions of emerging advanced biofuel systems and the potential of infrastructure-ready, drop-in biofuels.

The Task will continue to facilitate communication and provide high-quality information based on the excellent participation of its industry, government and academic members. As has been described in recent projections by credible groups such as the IEA, EIA and Bloomberg, despite the challenges precipitated by issues such as the ongoing global economic weakness, improved access to relatively cheap unconventional oil/gas in regions such as North America, etc, biofuels continue to hold considerable potential for reducing transport-related GHG emissions. In some cases, such as aviation, maritime and other long-distance transportation services, biofuels represent the only viable alternative that can make use of the current infrastructure while reducing dependency on fossil fuels.

Task 39 projects planned for the new triennium include reports on 'the progress and potential of biofuels in emerging non-OECD economies', 'a review of GHG emission tools', 'advanced biofuel integration and co-product generation opportunities', and 'a review of type, availability and likely cost of biofuel feedstock reserves'. Several of these studies will be joint Task activities while results of a recently completed task member questionnaire will be used to assemble 'teams of country member representatives' to work on each of Task 39's objectives for the new triennium. An example is the Task 42-39-40 team currently working on the mobilisation of bioenergy feedstock supply chains IEA Bioenergy special project.

The Task 39 communication tools (website, newsletter, meetings) as well as the technical and policy reports will continue to be the main vehicles used to describe the Task's activities and influence. However, as mentioned earlier, it is recommended that a more formal method of publishing IEA Bioenergy's activities be developed to increase citation of obviously highly regarded work and to increase the IEA Bioenergy Implementation Agreement's contribution to the ever-developing global bioeconomy.

Task 39 appendix

Newsletters

Karatzos, S. (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 32, December 2012.

Karatzos, S. (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 31, Sept 2012.

Hanova, J. and Karatzos, S. (Eds.) IEA Bioenergy Task 39 Newsletter Vol. 30, April 2012.

Hanova, J. (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 29, December 2011.

Hanova, J. (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 28, October 2011.

Hanova, J. (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 27, April 2011.

Hanova J (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 26, December 2010.

Hanova J (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 25, August 2010.

Hanova J (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 24, April 2010.

Meetings

Minutes from the Task meeting in Vienna, Austria, November 2012.

Minutes from the Task meeting (joint with Task 42) in Copenhagen, Denmark, February 2012.

Minutes from the Task meeting in Rio de Janeiro, Brazil, August 2011.

Minutes from the Task meeting in Verona, Italy, October 2011.

Minutes from the Task meeting in Seattle, USA, May 2011.

Minutes from the Task meeting in Sydney, Australia, Dec 2010

Minutes from the Task meeting in Clearwater, Florida, USA, April 2010

Minutes from the Task meeting in Cambridge, UK, January 2010

ExCo

Progress report for ExCo70, Vienna, Austria, November 2012.

Progress report for ExCo69, Istanbul, Turkey, May 2012.

Progress report for ExCo68, Sunshine Coast, Australia, October 2011.

Progress report for ExCo67, Helsinki, Finland, May 2011.

Progress Report for ExCo66, York, UK, October 2010.

Progress Report for ExCo65, Nara, Japan, May, 2010.

Workshops

Bioconversion Network Pre-treatment Workshop, June 2012 http://www.biotechnologyforbiofuels.com/content/6/1/17

Collaboration/Co-ordination with other Tasks/agencies

Joint inter-Task meeting with Task 42 (Biorefineries) in Copenhagen, Denmark.

Joint executive summary of the two Algal Biofuel reports from Task 39 and from AMF IA.

Publications

Ackom E, Mabee W, Saddler J, Industrial Sustainability of Competing Wood Energy Options in Canada. *Applied Biochemistry and Biotechnology* 162 (8), pp. 2259-2272. DOI: 10.1007/s12010-010-9000-6

Proceedings

Saddler J.J.N. and Karatzos S., 2012, The Biorefining Story: Progress in the commercialization of biomass-to-fuels and chemicals (The influence of the biomass feedstock on the process and products). 2012 IUFRO (International Union of Forest Research Organizations) Conference, Division 5: Forest Products. Lisbon, Portugal.

Reports

Bacovsky D, Dallos M, Wörgetter M, 2010. Status of 2nd Gen Biofuel Demonstration Facilities. A report to the IEA Bioenergy Task 39, Report T39-P1b.

Darzins A, Pienkos P, Edye L, 2010. Current status and potential of Algal Biofuels Production. A report to the IEA Bioenergy Task 39, Report T39-T2.

Ackom E, Mabee W, Saddler J, 2010. Backgrounder: Major Environmental Criteria of Biofuel Sustainability. A report to the IEA Bioenergy Task 39, Report T39-PR4

O'Connor, D. 2011. T39-T3 – Algal Biofuel Joint Executive Summary with the AMF. Task 39, Report T39-T3.

O'Connor, D. 2011. Biodiesel GHG emissions, past, present, and future. Task 39, Report T39-T1a.

Contributions

Contribution to the technology outlook of the AMF IA-VTT report titled 'Fuel and Technology Alternatives for Buses': http://www.vtt.fi/inf/pdf/technology/2012/T46.pdf

Contribution (20%) to IEA HQ Report – Biofuels Roadmap

IEA Bioenergy Update 47th Contribution for biomass and bioenergy: Progress towards 2nd and 3rd gen liquid biofuels

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

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

Prepared by:

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Participating countries:

Austria, Belgium, Brazil, Canada, Denmark, Finland, Germany, Italy, Japan, Netherlands, Norway, Sweden, UK and USA

Introduction

Throughout the first decade of the 21st century, a strong increase in the trade of both solid and liquid biofuels has been observed. Imports of biodiesel into the EU rose to 96 PJ in 2011, compared to 68 PJ in 2009. For bio-ethanol, the US has become the primary destination for competitively priced exports, importing about 21 PJ of bio-ethanol in 2011. In the EU, the year 2011 is considered a transition year for the certification of liquid biofuels. In principle, starting from 2012, all liquid biofuels consumed in the EU have to be certified with sustainability schemes recognised by the EU-RED. For solid biofuels, the EU remains the largest market, while North America remains the largest exporter of industrial pellets (about 2.1MT in 2011), followed by Russia and the Baltic States. The trade volumes of wood pellets between EU and non-EU countries has increased to about 57 PJ in 2011 (about 45 PJ in 2010). In 2011, more than 80% of North American pellets exported to EU were either verified or certified with voluntary schemes, but there is still no EU-wide sustainability requirement for solid biofuels. See the Task 40 Appendix for an overview of global bioenergy trade flows.

While the recent economic crisis may have slowed down growth rates, it is likely that global bioenergy trade will further increase strongly, until 2020. This will be driven by the renewable energy targets in the EU (as defined in the NREAPs), and subsequent demand for both solid and liquid biomass, as well as increasing demand from East Asian countries – especially South Korea and Japan – driven by current renewable energy policies. More speculative additional drivers may be a search for alternatives to nuclear energy (after Fukushima), the upcoming development of the bio-based economy, and further increases in oil prices. Thus, there is increasing need to develop biomass resources and exploit biomass production potentials in a sustainable way and to understand what this means in different settings. In some markets, prices of biomass resources and fuels are already rising, causing indirect effects on raw material prices, for example in the forest and food industries (e.g. sugar). Biomass markets are still immature and vulnerable, and this is particularly true for the demand side of the market. Many biomass markets, e.g. solid biofuels, rely on policy support and incentives.

It is important to develop both supply and demand for biomass, and energy carriers derived from biomass, in a balanced way and to avoid distortions and instability that can threaten investments in biomass production, infrastructure and conversion capacity. Understanding how this is best organised and managed needs further investigation. In the past triennium, the core objective of Task 40 was: "to support the development of a sustainable, international, bioenergy market, recognising the diversity in resources and biomass applications". The Task aims to provide a vital contribution to such (policymaking) decisions in the coming years for market players, policymakers, international bodies and NGOs. It aims to do so by providing high-quality information and analyses, providing overviews of developments, linking different arenas involved in the debate, being a clearing-house for information and engaging in dissemination activities.

Background

During the triennium 2010-2012, Task 40 was led by Prof Dr André Faaij (Scientific Task Leader), Utrecht University, the Netherlands, and Peter-Paul Schouwenberg (Industry and Business Task Leader), RWE Essent, the Netherlands. Dr Martin Junginger and Chun Sheng Goh (starting in August 2011) from Utrecht University, the Netherlands were the Task Assistants, and Ir Kees Kwant from NL Agency, the Netherlands was the Operating Agent. 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 included Austria, Belgium, Brazil, Canada, Denmark, Finland, Germany, Italy, Japan, the Netherlands, Norway, Sweden, United Kingdom, and USA.

In the 2010-2012 period, membership remained constant, maintaining Task 40 as one of the largest tasks under the IEA Bioenergy Implementing Agreement. Task 40 is currently recognised as a strong and unique international platform in this field, because of its content orientation, neutral position, and strong involvement of market players. The Task was considered a relevant partner for governments, market players, NGOs and international bodies interested in the field of sustainable international bioenergy trade and development of bioenergy markets (solids, liquid as well as gaseous).

Overall, Task 40 has succeeded in carrying out a broad work programme, produced significant outputs, and attracted considerable interest internationally. The main issues and barriers the Task worked on were:

- Mapping and understanding the development of international markets (both demand and supply side)
- The optimisation of supply chains
- Contributing to the sustainability debate (e.g. the possibilities and drawbacks of certification)
- Addressing the need for additional investments not related to bioenergy trade projects by exploring investment opportunities (for e.g. the World Bio-trade Equity Fund)
- Delivering unique insights into the evaluation of barriers and policies for bioenergy trade in many countries

The events organised to date resulted in considerable exposure, evident from many invitations for presentations and written contributions to journals and newsletters, and the use of the Task 40 website (www.bioenergytrade.org) and its structural inclusion in a wide variety of relevant policy and research arenas. These will be further elaborated on below.

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

Task objectives and work carried out

The Tasks under IEA Bioenergy consist first of all of a network in which activities and knowledge from its members are brought together. For this reason, up-to-date country reports remained a stable component of the Task, and serve a variety of objectives of the work programme. In addition, the Task funds have facilitated additional analysis in dedicated Task projects, but these are relatively small compared to larger national research and market activities.

The objectives of Task 40 in 2010-2012 were:

Objective 1: Biomass supplies: To deliver refined insights into the availability, potential production and supply of biomass resources at regional, national and global levels. This explicitly includes a range of biomass residue streams, land use and competition for land in various markets worldwide, including developing regions.

Objective 2: Sustainability and certification: To determine how the sustainability of biomass supplies, use and trade can be secured optimally and efficiently, especially from a market perspective, with specific attention to the impacts of certification on international biomass and biofuels trade.

Objective 3: Trade, market and demand dynamics: To map and provide an integral overview of biomass markets and trade at a global level, as well as for specific regions. Identify and map new markets and products, improve understanding of how biomass trade and markets respond to fluctuating fossil energy prices, developments in global markets for food and forestry products, emission trading, and the policies of different countries.

Objective 4: Transport, Logistics, and trade: To provide insights of international biomass supply lines and logistic requirements (including new producing regions, i.e. developing countries and Eastern Europe) and how these can be optimised over time. This includes increasing the understanding of how costs of biomass production, pre-treatment and transport can be reduced. Such work includes advanced forecasting exercises on the required logistic capacity to facilitate increased biomass use and trade.

Objective 5: Outreach and dissemination: High-quality dissemination; the Task is to provide a key international platform (with a diverse range of stakeholders) for bioenergy trade and markets (covering supply and demand, sustainability, financial products, etc).

In addition to 14 country reports, 10 other reports were published, and many of them were presented to the public in workshops or conferences. Many events were organised jointly with other tasks and organisations. 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 2012, such as the workshops (jointly) organised by Task 40 with many other parties in Berlin, Milan, Quebec, Vancouver, etc. The publications and activities of Task 40 in 2010-2012 are listed in the Overview table below. These may not be exactly the same as the proposed activities listed in the work programme, as some preferences and priorities changed during the triennium.

Also, a number of papers were published in high-quality scientific journals, mainly or partly based on the work of Task 40:

- Opportunities and barriers for international bioenergy trade. *Energy Policy* 2011. M. Junginger, J. van Dam, S. Zarrilli, F.A. Mohamed, D. Marchal, A. Faaij.
- From the global efforts on certification of bioenergy towards an integrated approach based on sustainable land use planning. *Renewable and Sustainable Energy Reviews* 2010. J. van Dam, M. Junginger, A.P.C. Faaij.
- Wood pellet market and trade: a global perspective. *Biofuels, Bioproducts and Biorefining* 2013. C.S. Goh, M. Junginger, M. Cocchi, D. Marchal, D. Thrän, C. Hennig, J. Heinimö, L. Nikolaisen, P. Schouwenberg, D. Bradley, R. Hess, J. Jacobson, L. Ovard, M. Deutmeyer.
- An assessment of international trade related to bioenergy use in Austria –Methodological aspects, recent developments and the relevance of indirect trade. Kalt, G., Kranzl, L. *Energy Policy*, 46(2012) 537-549.

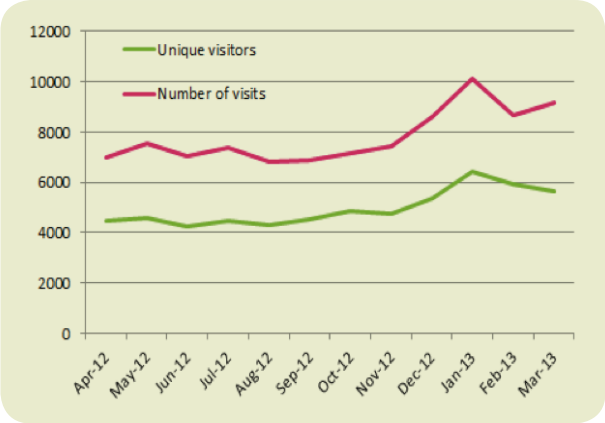
In addition, another scientific publication on the development of an international logistic trade model by Utrecht University and Idaho National Laboratories (Dutch and US Task 40 members) was submitted to peer-review journal.

Some unfinished and ongoing work was carried over to 2013:

- IEA Bioenergy Strategic Inter-task study (Task 40/43/38): Monitoring Sustainability Certification of Bioenergy. Published in March 2013.
- Book *Health and Safety Aspects of Solid Biomass Storage, Transportation and Feeding* co-produced by IEA Bioenergy Tasks 32, 36, 37 and 40. Published in May 2013.
- Book on bioenergy trade edited and written by Task 40 members. Published in November 2013.

The Task website is a key tool for dissemination of information. In 2012, the number of visits varied between 6,800 and 8,000 per month (figures for March to December), on average higher than in 2011. The number of visits increased dramatically in Jan 2013 to 10,000, and remained high at 9,000 in March 2013. In the period 2007-2012, visitor numbers have been relatively stable, with a five-year average of 6,200 visits per month. However, the amount of monthly downloaded data has increased continuously over the past nine years, reaching 19 GB of data on average since April 2012. As in previous years, each month, at least 10 documents are downloaded over 1,000 times, with one of the reports (Global wood pellet study) attracting more than 25,000 views since December 2011 (which still recorded 3,000 views in February 2013). Annually 2-3 Task 40 newsletters were circulated to about 1,400 subscribers. All Task deliverables (for e.g. country reports, market studies, etc) and presentations given at the Task workshops are available for downloading.

The figure below shows the number of unique visitors and visits since April 2012 (average of 6,000 visits per month in 2007-2011):



Website – no. of unique visitors and visits since April 2012

Overview of Task 40 reports and events in the 2010-2012 triennium

	Reports	Date	Description	Objectives			
				1	2	3	4
1	World Bio-trade Equity Fund Study	Apr 2010	The objective of this study was to explore the possibility for the creation of a Bio-trade Equity Fund.			x	
2	Updated overview of bioenergy	Apr 2010	The report includes an extensive overview and update on relevant certification initiatives and systems for biomass and bioenergy certification, based on the year 2009.				
3	Opportunities and barriers for international bioenergy trade	May 2010	The aim of this report is to provide an up-to-date overview of what market actors currently perceive as major opportunities and barriers for the current and future development of international bioenergy trade.			x	
4	Summary, synthesis and conclusions from IEA Bioenergy Task 40 country reports on international bioenergy trade	Apr 2011	Based on the experiences in the Task 40 member countries, this report shows how bioenergy trade has developed during the past 6 years in the member countries, and how it has contributed to increasing bioenergy production and use.	x	x	x	x
5	Development of a Tool to Model European Biomass Trade	Nov 2011	This report presents the results of an effort to develop a modelling tool for international biomass trade. The main aim is to illustrate the approach to include logistic cost of biomass in an energy model and implications to supply and demand of biomass for bioenergy.	x		x	x
6	Global Wood Pellet Industry Market and Trade Study	Dec 2011	This report presents the wood pellet industry and market in Europe and North America. It also includes perspectives of domestic use and trade of wood pellets in emerging markets (Asia and Latin America) and the challenges to ensure a sustainable pellet trade.	x		x	x
7	Prospective study: Implementation of sustainability requirements for biofuels and bioenergy and related issues for markets and trade	Feb 2012	This report focuses on the implementation of mandatory sustainability requirements for biomass (liquid, solid and gaseous), and evaluates and summarises the experiences and issues seen or expected both for commercial and administrative actors on the basis of public information, partly provided by T40 members through a questionnaire.		x	x	
8	Global Wood Chip Trade for Energy	Jun 2012	This report was commissioned to identify and present global data on wood chip trade, to analyse the underlying trade patterns, and to conclude on their interactions with bioenergy policies.	x		x	x
9	The Potential Role of Biofuels in Commercial Air Transport – Biojetfuel	Aug 2012	This report is an overview, not a detailed analysis, of the use of biofuels in commercial aviation. The use of biofuels in commercial aviation has received considerable attention in recent years, as it is currently one of the best short to medium-term alternatives.	x		x	
10	Possible effect of torrefaction on biomass trade	Nov 2012	The focus of this study is to examine briefly the status of the development of torrefaction technology, and more importantly assess the likely biomass sources and what impact the development of torrefied wood will have on global trade, in particular between now and 2020.	x		x	
11	Country Reports (14 reports)	2012	These reports describe ongoing market and trade developments, and cover the types and volumes of biomass traded, prices, and current drivers and barriers.	x	x	x	x

Overview of Task 40 reports and events in the 2010-2012 triennium

	Events	Date	Description	Objectives			
				1	2	3	4
1	Conference "Biomass power and trade"	11-12 Mar 2010, Rotterdam, Netherlands	The conference jointly organised with CMT aimed to provide opportunities for future and existing biofuels and biomass industry stakeholders to network with other industry suppliers and technology providers, as well as utility executives, researchers, policymakers, investors and project developers.	x	x	x	
2	Workshop "International trade of bioenergy commodities: Experiences with certification and setting up sustainable supply chains"	21 Oct 2010, Rome, Italy	The aims of this workshop jointly organised by EUBIONETIII and Task 40 were to provide an overview of experiences regarding sustainability certification, to show concrete case studies of ongoing sustainable international supply chains, and to identify and discuss both opportunities to develop sustainable international bioenergy supply chains and identify (policy) barriers to be overcome.		x		x
3	Workshop "Development of torrefaction technologies and impacts on global bioenergy use and international bioenergy trade"	28 Jan 2011, Graz, Austria	It was a joint workshop of Task 32 and 40, as a side-event of the Central European Biomass Conference (CEBC). The workshop gave a comprehensive overview of the main advantages of and the challenges in producing torrefied biomass. Ongoing R&D activities were shown, demonstration plants were presented and the latest state-of-science in torrefaction was discussed.			x	x
4	Conference "Biomass Trade & Power, Americas"	Feb 2011, Atlanta, USA	Task 40 supported the conference organised by CMT, which aimed to promote both domestic biomass use and international trade, and which covered a large number of topics.	x		x	x
5	Workshop "Biotrade Equity Fund"	30 Jun 2011, Brussels, Belgium	The Task commissioned a report highlighting the possibilities of such a fund, and then decided to organise two workshops, which aimed to inform possible investors about the ongoing bioenergy trade developments, and raise interest in the creation of such a Biotrade Equity Fund. The first workshop was organised jointly with the World Biomass Association (WBA) as a side event at the 2nd AEBIOM Bioenergy Conference.			x	
6	Workshop "Increasing Biomass Trade at Lowest Cost"	8 Nov 2011, London, UK	A second workshop for Biotrade Equity Fund was held, again in combination with WBA, and also supported by CanBio.			x	
7	Workshop "Quantifying and managing land use effects of bioenergy"	19 Sep 2011, Campinas, Brazil	With over 35 presentations and a dozen poster presentations, the programme was very comprehensive, providing insights into the developments of the top-down computable general equilibrium and partial equilibrium models for assessing iLUC and how ongoing local and regional case studies are addressing the impacts of land-use change caused by bioenergy.		x		
8	Workshop "Biomethane Trade"	24 Jan 2012, Berlin, Germany	This workshop at BBE Conference "Fuels of the future" was jointly organised by Task 40, the funding programme of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety "Biomass Energy Use" and the Fachagentur Nachwachsende Rohstoffe (FNR), and the German Bioenergy Association (BBE). Important stakeholders and experts from industry as well as from academia gathered at this workshop to present and discuss the latest developments in this rapidly growing market.	x			x

Overview of Task 40 reports and events in the 2010-2012 triennium

	Events	Date	Description	Objectives			
				1	2	3	4
9	Workshop "Biomass and Bioenergy – an Investor's Perspective – Challenges and Opportunities for the Financial Community"	20 Jun 2012, Milan, Italy	This event at the European Biomass Conference and Exhibition provided the financial community with information on latest trends in the biomass and bioenergy industry, market perspectives for biomass, biofuels and bio-based chemicals, trade opportunities, options to mitigate risks, ensuring sustainability, and where to find profit.			x	
10	Workshop "Sustainability for forest bioenergy"	Oct 2012, Quebec city, Canada	Tasks 40 and 43, along with the Faculty of Forestry, Geomatics and Geography of Laval University and Natural Resources Canada, and in cooperation with the Global Bioenergy Partnership, organised a workshop (+ field visit) involving key European, Canadian and American academics, industry representatives, policymakers and NGOs. The workshop addressed the sustainability of forest bioenergy through field visits, scientific presentations and moderated discussions.		x		
11	Conference CanBio Annual National Conference & Tour – "The Bioeconomy – Advantage Canada!	Nov 2012, Vancouver, Canada	Task 40 provided several presentations to the annual Canbio conference in Vancouver to showcase growth in bioenergy in Canada and Asian markets, and partnership opportunities with Australia, New Zealand, China, Korea, Singapore, and others. This event provided an opportunity to network with key industry, non-profit, and public sector stakeholders from North America, Europe and Asia.	x			x

Conclusions and recommendations

Throughout the triennium, bioenergy trade has been getting increasingly important, as reflected by the increasing trade volumes each year. With the objective of supporting the development of a sustainable international bioenergy market, Task 40 has made important contributions towards connecting people and knowledge from different capacities in several major discussions in trade aspects. In the 2010-2012 period, membership remained constant, at 14 countries, maintaining Task 40 as one of the largest tasks under the IEA Bioenergy Implementing Agreement.

In this triennium, Task 40 has achieved its objectives via numerous studies and activities, by bringing knowledge from all members together in combination with collaborative efforts with industry, public institutions and other organisations. These joint efforts make a significant contribution to the development of sustainable bioenergy trade, ensuring the most relevant and up-to-date discussions. Overall, Task 40 has carried out a broad work programme, produced substantial outputs, and attracted considerable interest internationally. In total, 24 reports on the most current issues in bioenergy trade were published, and 11 workshops were organised. 'Global Wood Pellet Industry Market and Trade Study' has been the most downloaded report (25,000 downloads since publication in December 2011). Many country reports recorded more than 1,000 downloads in 2012.

In line with the Task objectives, the work of Task 40 covers a wide range of topics, and many of them were presented at workshops or conferences. The workshops have attracted much interest from industry. One of the main aims of Task 40 is to provide a global communicating platform for bioenergy participants. The event in Vancouver brought together key market actors from the Pacific Rim and Europe to network with each other. Another remarkable event was the Quebec workshop, which involved participants in discussions that will be essential for formulation of rational policy to ensure sustainable forest biomass production and trade. Task 40 also stretched its coverage to the financial community, resulting in workshops in Milan, London and Brussels that looked at investments to promote bioenergy and biomass trade from the point of view of the investor and project proponents, and show examples of successful ventures. Furthermore, Task 40 not only focused on conventional liquid and solid biofuels, but also – recognising the diversity in resources and biomass applications – organised events on the trade of emerging bioenergy carriers such as biomethane and torrefied wood pellets.

The scientific papers and the contribution to the IPCC SRREN report, as well as workshops specifically or partially aimed at policymakers (such as the events in Campinas and Quebec) demonstrate the wider scientific and policy impact of Task 40. The Task 40 book on global bioenergy trade will further contribute to the dissemination of knowledge. Other evidence of the policy impact of Task 40 is the frequent consultation of EC policy officers with Task 40 members, and the citation of Task 40 documents by national and EU policy documents.

In the coming years, supporting the development of global, sustainable bioenergy trade will be more important than ever. Trade flows are increasing rapidly, giving rise to new barriers and challenges. In particular, the scientific and public debate on sustainable production and trade of both solid and liquid biomass requires accurate, timely information that can be (and is being) provided by the Task. At the same time, it is becoming increasingly clear that, despite high growth in trade flows, major further steps are needed to realise the bioenergy utilisation scenarios for 2030 and 2050 sketched by many integrated assessment models. This makes rapid investments and supportive policies even more crucial. New demand regions (like east Asia) and also anticipated producing regions (such as Latin America, sub-Saharan Africa and Russia) will need to become more actively involved in this debate.

Success stories

One of the most successful products of Task 40 was (and remains) the report 'Global Wood Pellet Industry Market and Trade Study'. Since its publication in December 2011, it has attracted more than 25,000 views, which still recorded 3,000 views per month in February 2013. The report was also translated into a scientific paper, 'Wood pellet market and trade: a global perspective', which was published in a high-impact journal, *Biofuels, Bioproducts and Biorefining* in 2013 to attract readers from different capacities. The report has also attracted the attention of the *International Herald Tribune (IHT)/New York Times*. The article 'Wood Makes Comeback as a Fuel', published in *IHT/New York Times* on 1 May 2012 made extensive use of the Task 40 report, and IEA Bioenergy Task 40 was explicitly mentioned in the article. This article by Kate Galbraith also interviewed experts, including the Task Leader of Task 40, Dr Martin Junginger. The report is an example of collating knowledge from Task members. It was largely built upon work done by the members, particularly the country reports. Country reports have been the core of Task activities, and have always been regarded as valuable products of Task 40 by industry, policymakers and scientists. These reports serve as a database that could be used as inputs for various studies.

Another achievement was the inclusion of bioenergy trade as a topic in the bioenergy chapter of the IPCC special report on renewable energy sources, published in 2012. This chapter was convened by Task leader Andre Faaij, and included contributions from Martin Junginger, resulting in seven pages on, among other issues, global bioenergy trade and the main opportunities and barriers for the market penetration and international trade of bioenergy, citing a large number of Task 40 studies.

Another successful product for demonstration is the strategic inter-Task project 'Monitoring Sustainability Certification of Bioenergy'.[37] It pulls together knowledge from three different Tasks: knowledge on bioenergy trade from Task 40, on biomass supply from Task 43, and on emission balance from Task 38. Throughout the project, the views and experiences of stakeholders on the basis of a worldwide survey were collected. The survey has received 194 responses from bioenergy experts, market actors, regulators, NGOs, etc. In-depth interviews with selected key industrial people were also carried out. In March 2013, the project published four comprehensive reports, and organised a workshop session with 60-70 attendees, including power companies, NGOs like Greenpeace and WWF, policymakers and scientists.

Among the most successful events, the workshops in Graz, Austria and Campinas, Brazil should be mentioned. The former was jointly organised with Task 32 on the topic of biomass torrefaction and impacts of trade. The large number of high-quality speakers from the torrefaction industry attracted an audience of over 250; it was one of the best attended Task 40 events so far. Due to this success, currently a follow-up workshop in January 2014 is planned, again in Graz, with Task 32 and several other partners. The workshop in Campinas on quantifying and managing land-use effects was the largest and probably also the most successful scientific event in the history of Task 40 so far. With over 100 participants from four continents, peer-reviewed, high-quality presentations, lively discussions and a wealth of papers and posters, it provided a platform for debate and knowledge exchange in a very inspiring setting.

37 This project is not included in the deliverables table because it was finalised in March 2013. The latest news can be found on the task website http://bioenergytrade.org

Task 40 appendix

Deliverables

Conference papers, seminar proceedings, technical notes, newsletters, industry days, scientific publications, books, etc, including website address or reference of the publication

Publications	Website address
Website – IEA Bioenergy – Task 40	http://bioenergytrade.org
Newsletters	
Newsletters 2009	http://www.bioenergytrade.org/downloads/iea-task-40-newsletter-2009.pdf
Newsletters 2010-1	http://bioenergytrade.org/downloads/iea-task-40-newsletter-2010-issue-1.pdf
Newsletters 2010-2	http://bioenergytrade.org/downloads/iea-task-40-newsletter-2010-issue-2.pdf
Newsletters 2011	http://bioenergytrade.org/downloads/iea-task-40-newsletter-2011.pdf
Newsletters 2012-1	http://bioenergytrade.org/downloads/iea-task-40-newsletter-2012-issue-1.pdf
2012-2	http://bioenergytrade.org/downloads/iea-task-40-newsletter-2012-issue-2.pdf
2012-3	http://bioenergytrade.org/downloads/iea-task-40-newsletter-2012-issue-3.pdf
Country Reports	
Austria	http://bioenergytrade.org/downloads/iea-task-40-country-report-2011-austria.pdf
Belgium	http://bioenergytrade.org/downloads/iea-task-40-country-report-2011-belgium.pdf
Brazil	http://bioenergytrade.org/downloads/iea-task-40-country-report-2011-brazil.pdf
Canada	http://bioenergytrade.org/downloads/iea-task-40-country-report-2011-canada.pdf
Denmark	http://bioenergytrade.org/downloads/iea-task-40-country-report-2011-denmark.pdf
Finland	http://bioenergytrade.org/downloads/iea-task-40-country-report-2011-finland.pdf
Germany	http://bioenergytrade.org/downloads/iea-task-40-country-report-2011-germany.pdf
Italy	http://bioenergytrade.org/downloads/iea-task-40-country-report-2011-italy.pdf
Japan	http://bioenergytrade.org/downloads/iea-task-40-country-report-2011-japan.pdf
Netherlands	http://bioenergytrade.org/downloads/iea-task-40-country-report-2011-the-netherlands.pdf
Norway	http://bioenergytrade.org/downloads/iea-task-40-country-report-2011-norway.pdf
Sweden	http://bioenergytrade.org/downloads/iea-task-40-country-report-2011-sweden.pdf
UK	http://bioenergytrade.org/downloads/iea-task-40-country-report-2011-uk.pdf
US	http://bioenergytrade.org/downloads/iea-task-40-country-report-2010-us.pdf
World Bio-trade Equity Fund Study	http://bioenergytrade.org/downloads/biotradeequityfundfinalreport.pdf
Updated overview of bioenergy sustainability certification initiatives published	http://bioenergytrade.org/downloads/overviewcertificationsystemsfinalapril2010.pdf
Opportunities and barriers for international bioenergy trade	http://bioenergytrade.org/downloads/opportunitiesandbarriersforinternationalbioene.pdf
Summary, synthesis and conclusions from IEA Bioenergy Task 40 country reports on international bioenergy trade	http://bioenergytrade.org/downloads/summary-synthesis-and-conclusions-from-iea-bio.pdf
Development of a Tool to Model European Biomass Trade	http://bioenergytrade.org/downloads/development-of-a-tool-to-model-european-biomas.pdf

Publications	Website address
Global Wood Pellet Industry Market and Trade Study	http://bioenergytrade.org/downloads/t40-global-wood-pellet-market-study_final.pdf
Prospective study: Implementation of sustainability requirements for biofuels and bioenergy and related issues for markets and trade	http://bioenergytrade.org/downloads/t40_implsustcert_final-report_march-2012.pdf
Global Wood Chip Trade for Energy	http://bioenergytrade.org/downloads/t40-global-wood-chips-study_final.pdf
The Potential Role of Biofuels in Commercial Air Transport – Biojetfuel	http://bioenergytrade.org/downloads/T40-Biojetfuel-Report-Sept2012.pdf
Possible effect of torrefaction on biomass trade	http://bioenergytrade.org/downloads/t40-torrefaction-2012.pdf
Scientific Publications (not included in attachment)	
Opportunities and barriers for international bioenergy trade. Energy Policy 2011	http://www.sciencedirect.com/science/article/pii/S0301421511000504
From the global efforts on certification of bioenergy towards an integrated approach based on sustainable land use planning. Renewable and Sustainable Energy Reviews 2010	http://www.sciencedirect.com/science/article/pii/S1364032110001905
Wood pellet market and trade: a global perspective. Biofuels, Bioproducts and Biorefining 2013	http://onlinelibrary.wiley.com/doi/10.1002/bbb.1366/abstract
Presentations and Event Summaries (not included in attachment)	
Presentations for events in 2012	http://bioenergytrade.org/events2012.html
Presentations for events in 2011	http://bioenergytrade.org/events2011.html
Presentations for events in 2010	http://bioenergytrade.org/events2010.html

Co-ordination with other Tasks within IEA Bioenergy

- Joint workshops with Task 32, 38, 40 and 43 in Graz and Campinas
- Task 40, 43 and 38 carried out a strategic inter-Task study which began in Jan 2012 and was completed by March 2013, complemented by a workshop in Rotterdam, the Netherlands.
- Task 40 contributed to the book *Health and Safety Aspects of Solid Biomass Storage, Transportation and Feeding* co-produced by IEA Bioenergy Tasks 32, 36, 37 and 40, compiled as a joint effort by experts active in four different Tasks, with their own specific fields of expertise.
- In Oct 2012, Task 40 and 43 jointly organised the Quebec workshop 'Sustainability for forest bioenergy'.

Co-ordination with other bodies outside IEA Bioenergy

Most of the events were organised in collaboration with other bodies, such as AEBIOM, BBE, CMT, Canbio, CEBC, CTBE, Eubionet III, FNR, GSE, NRCan and WBA (see table in main report for more details).

Industry participation

The Task 40 strategy is to stimulate dual NTLs with one representative from academia/research and another from industry, involving them in work discussion, workshops, conferences and other Task activities. Prominent examples of industry Task 40 members and observers were large utilities such as Api Nova Energia (Italy), RWE Essent (NL), nPower (UK), Drax (UK), and bioenergy industry associations like CanBio (Canada). Other industries that were Task 40 members/observers and involved in Task 40 activities included CHOREN and Mitsubishi. Furthermore, a number of Task 40 activities focused partially or fully on industry, such as the torrefaction workshop in Graz, the industry conferences co-organised with CMT in Rotterdam and Atlanta, and the workshop in Quebec. At these events, we were able to engage a large number of speakers from industry (e.g. 5 torrefaction technology producers in Graz, several dozens of speakers from industry at the events in Rotterdam and Atlanta, industry participants in the workshops in Quebec and the equity trade fund workshops, etc).

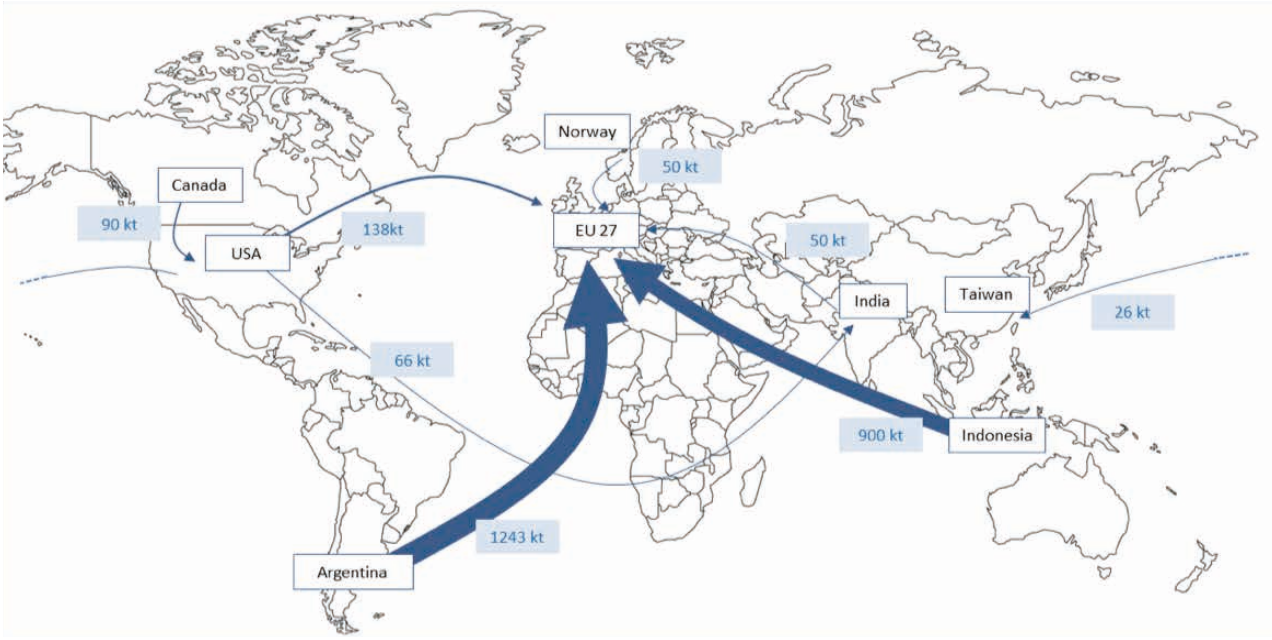


Figure 1 Global biodiesel trade in 2011 (net flow in ktonnes)

(assuming energy content = 37.8 GJ/tonnes) (Source: Lamers, 2012) (Taken from the Intertask Project: Report Task 3)

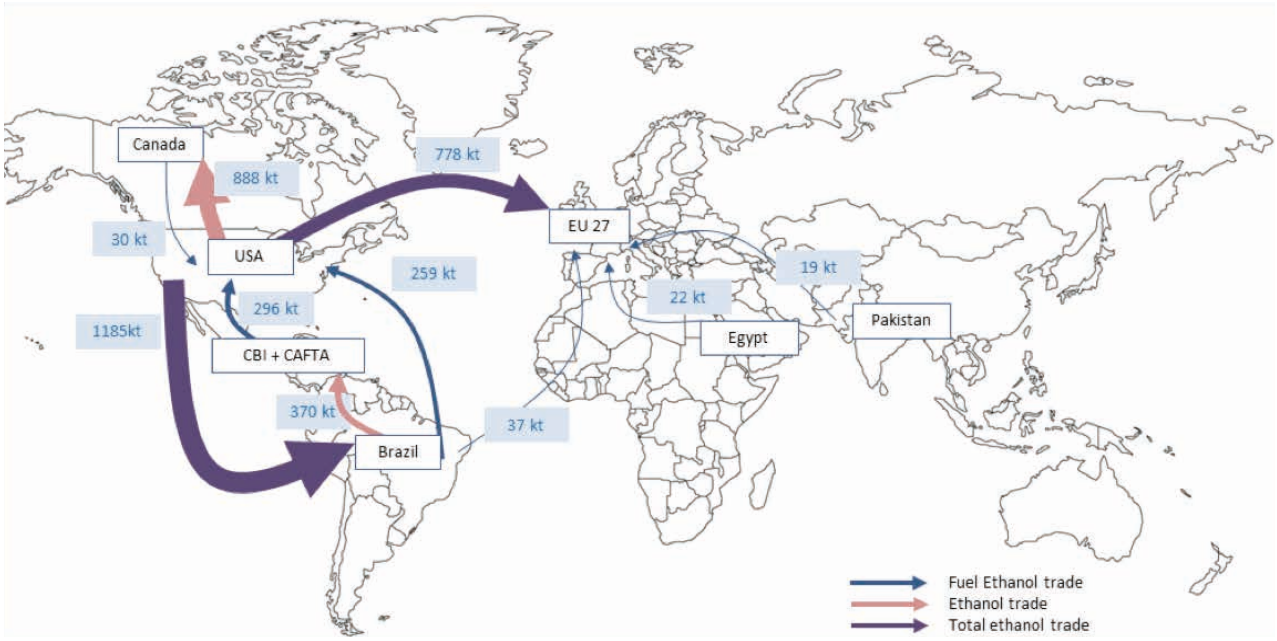


Figure 2 Global fuel ethanol trade in 2011 (net flow in ktonnes)

(Assuming energy content = 27 GJ/tonnes) (For Brazilian ethanol trade flows: Source: USDA, 2012; SECEX, 2012; CAMEX, 2013; for the other trade flows: Source: Lamers, 2012) (Taken from the Intertask Project: Report Task 3)

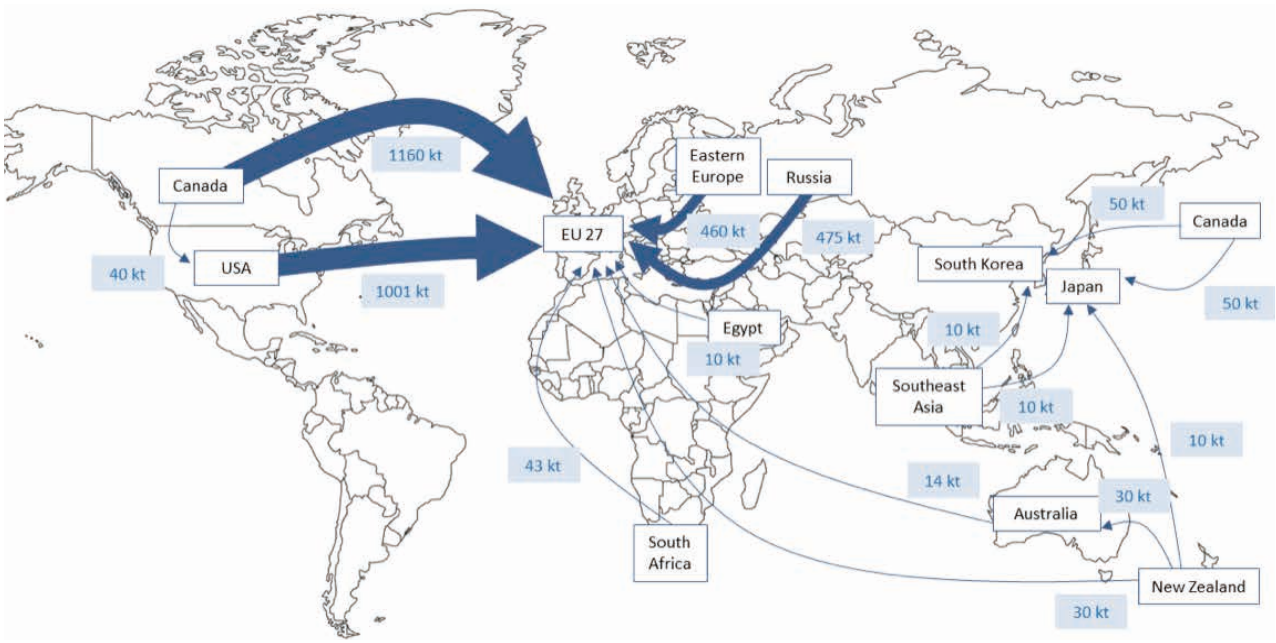


Figure 3 Global wood pellets trade flows in 2011 (ktonnes)

(Source: EUROSTAT, COMTRADE, Lamers 2012) (Taken from the Intertask Project: Report Task 3)

TASK 42: Biorefineries: Co-production of Fuels, Chemicals, Power and Materials from Biomass

Prepared by:

Drs.ing. René van Ree, Task Leader, Wageningen University

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Operating Agent:

Ir. Kees Kwant, NL Agency, The Netherlands

Participating countries:

Australia, Austria, Canada, Denmark, France, Germany, Ireland, Italy, Netherlands, Turkey and USA

Introduction

Currently, biomass is mainly used for human food, animal feed and the production of bioenergy (fuels, power and/or heat). In the future bio-economy, however, biomass will be used for the sustainable and synergetic production of food, feed, bioenergy (power, heat, CHP and biofuels for transport) and bio-based products (chemicals, materials). The relative scarcity of raw material requires the development and implementation of highly-efficient biomass conversion technologies to maximise valorisation and the overall environmental benefits of the full biomass supply chains.

It is expected that current biomass supply-chain expertise and facilities available in the energy sector will be used as the starting point for developing more sustainable multi-product and multi-stakeholder-based biomass implementation strategies. In the short term this approach could improve the overall economics of business cases in the energy sector by valorisation of currently available agriculture and process residues for added-value bio-based products (i.e. biofuels for transport could be produced in a market-competitive way if residues are optimally valorised); in the longer term the energy sector will become an integral part of full biomass refining strategies, using a variety of primary, secondary and tertiary organic residues as raw materials for their processes.

Biorefining – i.e. the sustainable processing of biomass into a spectrum of marketable bio-based products (food, feed, chemicals, and/or materials) and bioenergy (biofuels, power and/or heat) (IEA Bioenergy Task 42) is the main driver for large-scale implementation of biomass within the different market sectors of the global economy.

To realise the biorefinery application potential, technology and full chain development of multi-stakeholder consortia is still a necessity. Joint international priorities and RD&D-programmes between industry, research institutes, universities, governmental bodies and NGOs are required, while identification of market introduction strategies together with industry will be needed to create a proper RD&D framework.

The major objective of IEA Bioenergy Task 42 for 2010-2012 was to assess the worldwide position and potential of the biorefinery field, and to gather new insights that would indicate the possibilities for 'breakthrough', competitive, sustainable, safe and eco-efficient processing routes for the simultaneous manufacture of transportation fuels, combined heat and power (CHP), food, feed, and added-value bio-based products (chemicals, materials).

The information provided can be used by national and international governmental organisations to develop bioenergy-related policies; by industrial stakeholders for focusing their RTD and deployment strategies on the most promising (i.e. sustainable) biomass value chains; by NGOs to include in their renewable energy scenarios, and by research institutes and universities to focus their applied and strategic research programmes.

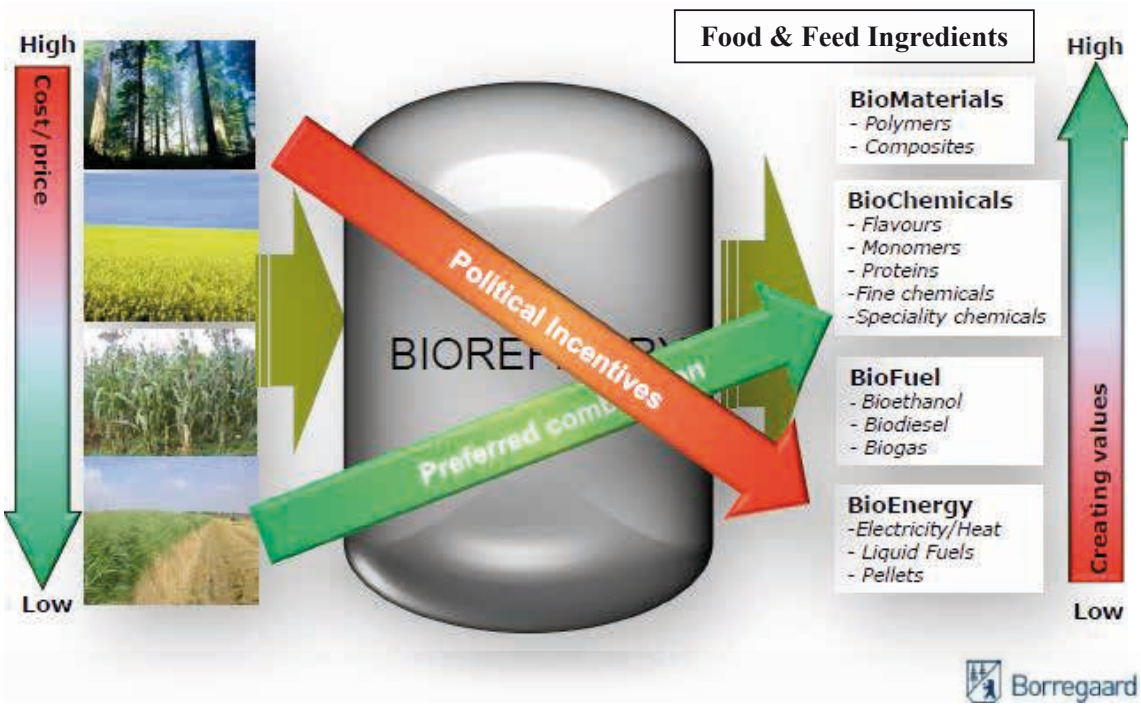


Figure T42.1: Biorefinery options – the incentive paradox in Europe

Background

In a future bio-economy, sustainable production and valorisation of biomass for both food and non-food applications will provide the operating framework. Sustainably produced biomass (crops, algae, residues) must be used as efficiently as possible – using bio-cascading and biorefining approaches – to meet future demands for food, feed, bio-based products (chemicals, materials) and bioenergy (fuels, power, heat). Biorefineries have already been operating for many years in, for example, the food industry. Large-scale implementation of biorefineries for non-food (incl. bioenergy) applications, however, is still lacking. The major reasons are:

- Some of the key technologies (fractionation and product separation), which are part of integrated biorefinery plants, are still not mature enough for commercial market implementation.
- There is still no level playing-field for sustainable biomass use for food and non-food applications.
- Market sectors that should co-operate (food, feed, agriculture, chemistry, energy, fuels, logistics, etc) for the development and commercialisation of full sustainable biomass value chains, including Food & Feed Ingredients high-efficient biorefinery processes, are often still not working together.
- There is still a lack of knowledge/expertise on the advantages of biorefinery processes for optimal sustainable biomass use at industrial, SME and (regional) governmental levels.

Work programme

1) Further developing the Biorefinery Classification System (BCS), and related Biorefinery Complexity Index (BCI)
2) Identifying the most promising bio-based products – i.e. food, feed, added-value materials and chemicals – to be co-produced with bioenergy
3) Assessing the current status and development potential of both energy-driven biorefineries (incl. biofuels) and product-driven biorefineries based on a Full Value Chain approach
4) Providing a review of approaches and developing a guidance document for sustainability assessment, including economic, environmental and social acceptance aspects of biorefineries
5) Preparing a Biorefinery Summarising Paper to be used by national/international governmental organisations for their policy developments
6) Organising bi-annual Task meetings, workshops with invited national stakeholders, and visits to running pilot/demonstration and commercial facilities. External knowledge dissemination in general will be carried out by: i) set-up and management of the Task website, including links to many other national/international websites, and ii) preparation and distribution of a Task newsletter. Internal knowledge dissemination will be carried out by means of an intranet-site coupled to the Task website.

7) Updating of the Country Reports on Biorefinery Mapping and Biorefinery-related RD&D Programmes to help national governments to define their national biorefinery policy goals and related programmes
8) Developing and delivering a broad Biorefinery Training Course to enable students, policymakers and industrial stakeholders to become familiar with the integral concept-thinking of biorefineries

Task objectives and work carried out

Biorefinery classification system and complexity index

Task 42 developed a Biorefinery Classification System (see figure T42.2), based on raw materials used, platforms (intermediate biomass-derived products), and final products and secondary energy carriers produced. The main goal is to make the often complex biorefinery processes more understandable for interested stakeholders (industry, SMEs, policymakers, NGOs, etc).

Classification system for naming biorefineries

A *[names platforms]* platform biorefinery for the production of *[names products and energy carriers]* from *[names raw materials]*

A start was made with the development of a Biorefinery Complexity Index (BCI), relating to the time-to-market, the number of stakeholders involved, the initial investment, final operational costs, etc. A high BCI has the disadvantage that the initial investment costs will be high and that a variety of stakeholders will be involved, potentially increasing the time-to-market. However, its advantage is that, when an implementation decision is taken, it will be clearly possible to co-produce significant amounts of bio-based products and bioenergy in a profitable way. The BCI will be further developed in 2013 and beyond at a low-profile level, with a few countries involved. For the time being there is no consensus in the Task on the added-value or potential disadvantages of this BCI methodology on iorefinery market deployment.

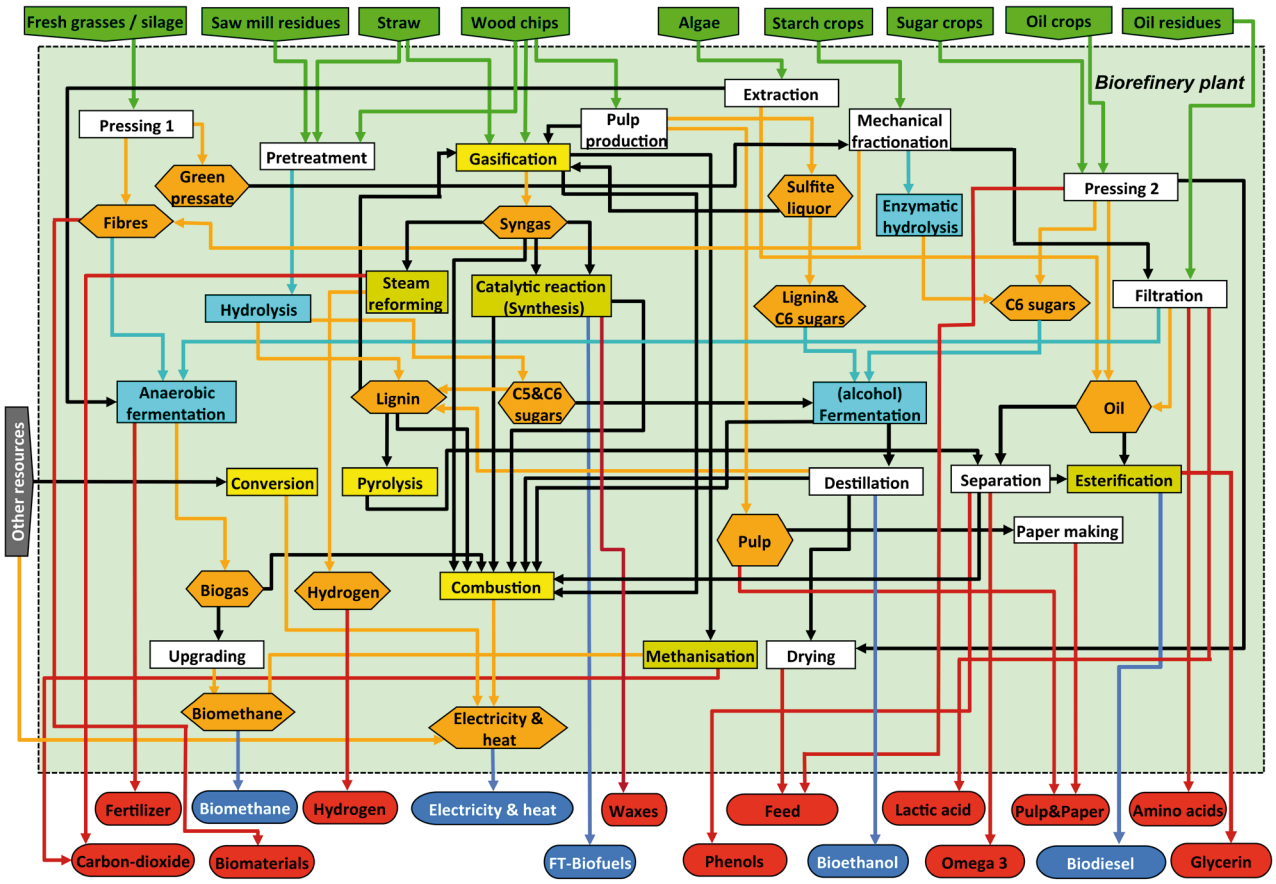


Figure T42.2: Biorefinery Classification Scheme (IEA Bioenergy Task 42)

Bio-based products to be co-produced with bioenergy

A report was published in February 2012, *'Value Added Products from Biorefineries – Bio-based Chemicals'* (see Success Stories below), and is available for downloading at the Task 42 website (www.iea-bioenergy.task42-biorefineries.com). This report will be expanded and updated in the 2013-2015 triennium. The word cloud below shows the main products discussed.

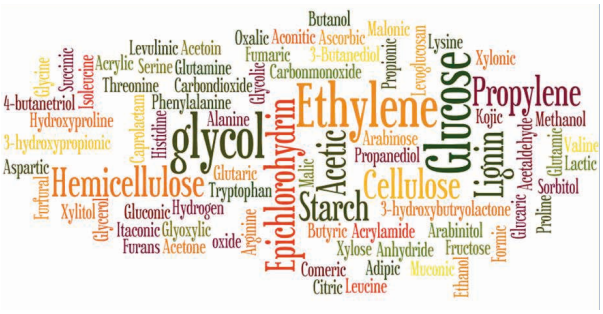


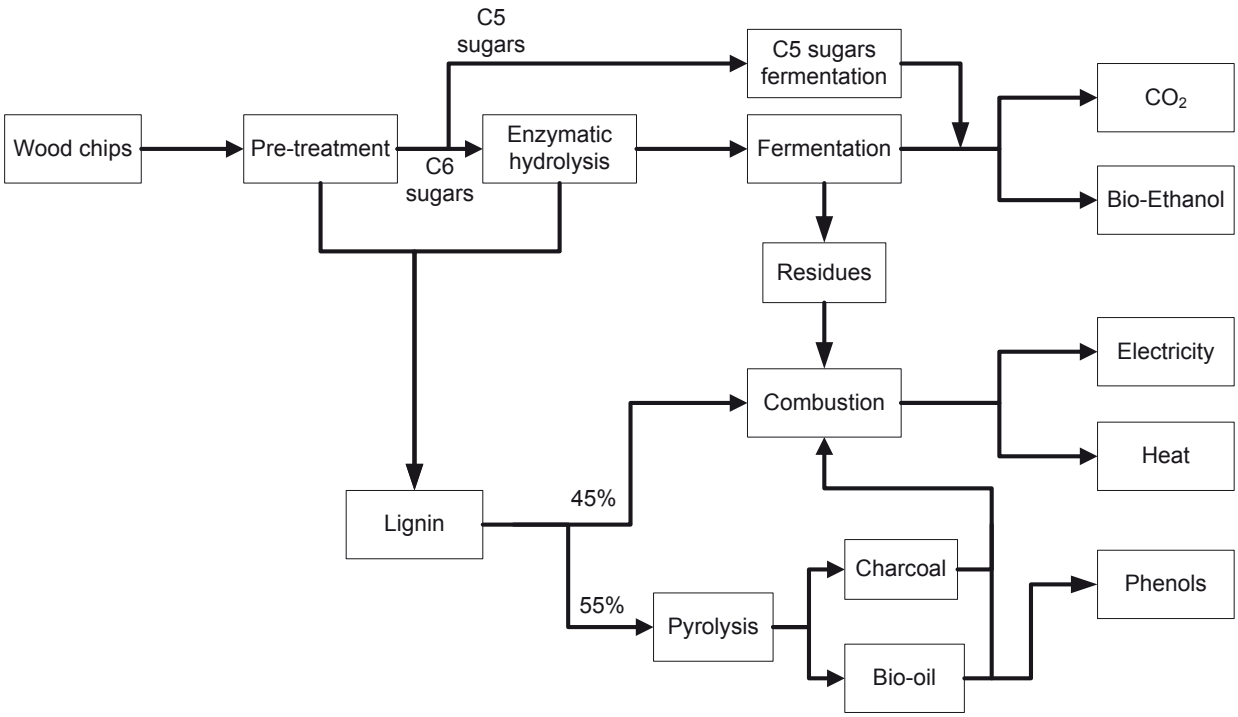
Figure T42.3: Word cloud showing bio-based products from a biorefinery

During the triennium the Task partners decided to prepare a second report, 'Value Added Products from Biorefineries – Proteins for Food and Non-food Applications', instead of a report on product-driven biorefineries since this is more directly applicable for the energy/fuel sector, the main sector dealt with within IEA Bioenergy. This report will be published and available on the Task 42 website by the end of Q2 2013.

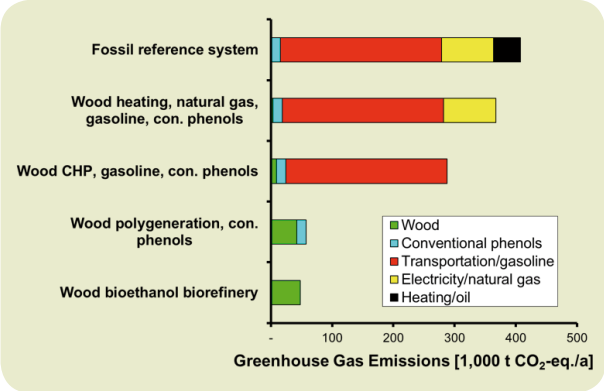
Current status and development potential of energy-driven biorefineries

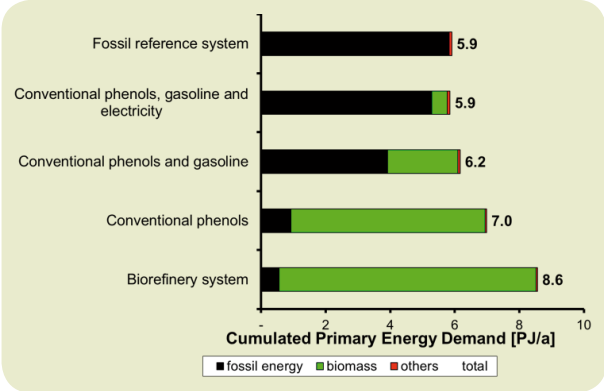
A report published in February 2013, 'Biofuel-driven Biorefineries – A selection of the most promising biorefinery concepts to produce large volumes of road transportation biofuels by 2025', gives an overview of commercial-scale, demonstration-scale and more conceptual biofuel-driven biorefineries in the participating countries, with a link to the Task 42 classification system, to make the description of the biorefineries more understandable for the public.

The report also contains the results of the environmental assessment of a C6, C5, lignin platform biorefinery for the production of bioethanol, phenols, power, heat and CO_2 from wood (see Figure 42.4a). The environmental assessment showed that the wood-based biorefinery system had the lowest annual greenhouse gas emissions (t CO_2-eq/year) (see Figure 42.4b). However, it had the highest cumulated primary energy demand (PJ/year) (Figure 42.4c), compared to other system alternatives to produce the same amount of end-products. The economics were not assessed in this report.



Figures 2a: C6, C5, lignin platform biorefinery for the production of bioethanol, phenols, power, heat and CO_2 from wood





Figures T42.4b: Greenhouse gas emissions, and 42.4c; Cumulated energy demand wood biorefinery vs alternative production systems

The full report is available for downloading at the Task 42 website (www.iea-bioenergy.task42-biorefineries.com).

Sustainability assessment on biorefineries

A draft set-up of a guidance document for biorefinery-related sustainability assessments was made in 2012. This document was finalised in Q1 2013, and is available on the Task 42 website. The biorefinery-related sustainability activities will be continued in the 2013-2015 period with both specific Task 42 activities (i.e. PROSUITE sustainability toolbox testing for some selected biofuel-driven biorefineries) and some joint Task activities (i.e. mobilising sustainable biomass supply chains, future demand for sustainable biomass from the broad bio-economy perspective).

National and international policy development support

Two types of activities have been performed within this framework: 1) the preparation of a new glossy Task 42 Brochure, covering all Task results so far, and 2) the preparation of separate National Country Reports on biorefinery mapping and RD&D programmes, and an Integrated Report for all Task 42 partnering countries, summarising the major efforts in all countries.

Concerning the new glossy Task 42 brochure, a draft 60-page version is available covering the following issues: biorefining – global status, future challenges, and country-specific challenges; vision and contribution of IEA Bioenergy Task 42; biorefineries – definition and classification; sustainability issues concerning biofuel-driven biorefineries; value-added products from biorefineries: food & feed ingredients – pharmaceuticals, chemicals and materials – fuels, power and heat; training activities, website, biorefinery status in participating countries (A4-page examples of commercial facilities, demonstrations and pilots; for examples see Figure 42.5); activity plan 2013-2015. This draft brochure will be finalised in Q2 2013, including data and examples of new partner countries, and will be disseminated both in hard copies and electronically via the Task website before 30 June 2013.

Figure T42.5: Example of biorefineries in operation in the participating counties (IEA Bioenergy Task42 Brochure, June 2013)

A pulp, off-gas, electricity & heat for the production of pulp, biomethanol, electricity from wood chips Forest Products Inc., Canada]

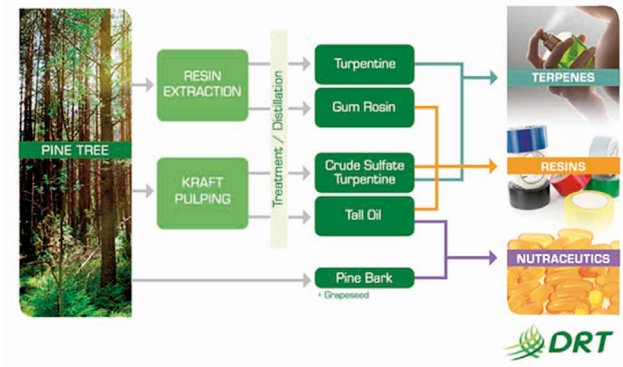
A bioliqSynCrude and syngas biorefinery pilot-plant for the production of Kraft customised fuels and chemicals and heat from lignocellulosic residues [Alpac [Bioliq, Germany]

A C6 sugars, C5 sugars, lignin and electricity & heat biorefinery for bioethanol, feed, electricity and heat from straw [Inbicon, Denmark]

A whey biorefinery for ethanol and protein-based food products from milk [Edgecumbe Milk Processing Plant, Fonterra Cooperative Group, New Zealand]

A sugar residue biorefinery sugar, bioethanol and animal feed from sugar beets [Konya Seker San, Turkey]

A sugars, lignin and syngas biorefinery for bioethanol, power and heat from renewable biomass and MSW [INEOS New Planet Bioenergy, USA]



A turpentine, gum rosin, crude sulphate turpentine and tall oil biorefinery for terpenes, resins and neutraceutics from co-products paper industry and pine trees [Dérivés Résiniques et Terpéniques (DRT) France]

An oil production and refinery pilot-plant for Omega-3, fuels, chemicals from microalgae [Wageningen UR, the Netherlands]

A biogas, bio-methane, green pressate, fibres, electricity & heat biorefinery for bio-methane, lactic acid, biomaterials and fertiliser from grass and manure [Utzenaich, Austria]

The Mackay Renewable Biocommodities Pilot Plant for bioethanol, lignin, various chemicals from sugarcane bagasse, corn stover, etc [Queensland University of Technology, Australia]

Country Reports

The Country Reports on biorefinery mapping and RD&D programmes in partnering countries include the following information per partnering country: current biomass use for both energy (power, heat, CHP, fuels) and non-energy (food, feed, materials, chemicals) applications; biorefinery-related policy goals and funding programmes; overview of running commercial biorefineries, demonstration and pilot plants; major R&D-projects, and stakeholders involved (industry, SMEs, institutes, universities, GOs, NGOs). Neither Canada nor Ireland were able to provide a country report because the data asked for could not be provided without significant efforts (Canada) and because no biorefineries were in operation (Ireland). An Integrated Countries Report was prepared by the Danish team. Both the separate country reports and the Integrated Countries Report are available on the Task website.

Knowledge dissemination

External dissemination of Task 42 results was carried out through the setting-up and management of a Task 42 website: www.iea-bioenergy.task42-biorefineries.com, the preparation of several conference papers and reports, lectures at several national/international conferences, seminars and workshops, organising biannual industrial stakeholder events (for further details, see Task 42 appendix: 'Participation in major events' and 'Deliverables'. Internal knowledge dissemination was carried out by means of a password-protected intranet-site (document sharing) and by organising biannual Task 42 meetings. During this triennium, the Task 42 meetings organised were:

- 7th Task 42 meeting, main organiser ADEME, Lille, France, 4 March 2010, including a Thermochemical Biorefinery Session organised by the Austrian team. This meeting was coupled with a French industrial stakeholder meeting and an excursion to Roquette on 3 March 2010.
- 8th Task 42 meeting, main organiser DOE, Chicago, Illinois, 4-6 October 2010. This event included a US stakeholder event on 4 October, a Task 42 progress meeting on 5 October, and excursions to both UOP and GTI/Haldor Topsoe on 6 October 2010.
- 9th Task 42 meeting, main organisers ENEA/CHEMTEX (part of M&G), Tortona, Italy, 4-6 April 2011. This meeting consisted of an Italian stakeholder meeting on 4 April, an excursion to the Polibre and other demo-plants on 5 April, and a Task 42 progress meeting on 5/6 April 2011.
- 10th Task 42 meeting, main organiser Bioenergy Australia, Twin Waters Resort, Queensland, Australia, 22-25 November 2011. This event included: a Task 42 progress meeting on 22 November, a technical tour on 23 November, and a Task 42-contribution to the Bioenergy Australia Conference on 24/25 November 2011.
- 11th Task 42 meeting, main organiser University of Copenhagen, Copenhagen, Denmark, 27 February 2012. This meeting included: a Task progress meeting on 27 February, a Task 42 contribution to the Conference Advanced Biofuels in a Biorefinery Approach on 28/29 February 2012, and an excursion on 1 March 2012.
- 12th Task 42 meeting, main organiser Joanneum Research, Vienna, Austria, 16 November 2012. This meeting was coupled with the end-of-triennium IEA Bioenergy Conference in Vienna, Austria, 12-15 November 2012.
- 13th Task 42 progress meeting, organised by Wageningen UR in Wageningen, the Netherlands on 11 April 2013, coupled with the International Biomass for Food, Fuels & Materials Symposium (BFF-2013).

Training

Task 42 developed and implemented an MSc-level Biorefinery Training (Summer) Course to familiarise students with the concept of biorefineries and the underpinning logic.

- A first half-day course was organised as part of the 5th International Conference on Renewable Resources & Biorefineries RRB5, Ghent, Belgium, 12 June 2009.
- A second, full-day course was organised as part of an International Biomass Valorisation Congress in Amsterdam, the Netherlands on 13 September 2010. With about 70 participants, this event was very successful.
- A four-day Training Course, 1st European Training Course on Biorefining Principles and Technologies, was developed together with INRA (F), and successfully (about 120 participants) given in Paris, France, 28 August – 1 September 2011.
- The 2nd European Training Course on Biorefining Principles and Technologies was developed together with INRA (F), and successfully (about 75 participants) given in Wageningen, the Netherlands, 3-6 June 2012.
- The 3rd European Training Course on Biorefining Principles and Technologies is planned to be given in Galway, Ireland, in August 2013.

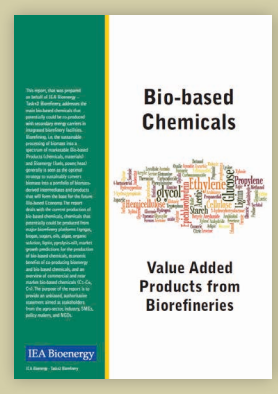
Success stories

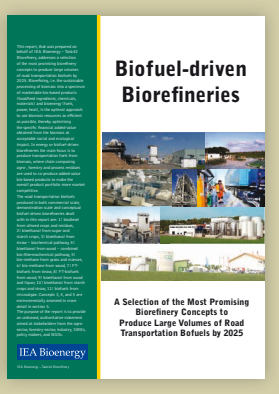
Biorefinery Classification System

The Biorefinery Classification System developed by Task 42, clarifying what is happening in often complicated biorefinery processes, has been adopted by several countries and the EC in the preparation of their policy-related documents, vision documents and Strategic Research Agendas. Recent examples can be found in the European Biorefinery Joint Strategic Research Roadmap for 2020 (Star-COLIBRI, 2011) and the German Biorefineries Roadmap – part of the German federal government's action plans for the material and energy use of renewable raw materials (2012).

Reports on Bio-based Chemicals & Biofuel-driven Biorefineries

The report 'Bio-based Chemicals: Value Added Products from Biorefineries' was a first-of-a-kind report, giving an overview of: the current production of bio-based chemicals (including global stakeholders involved), the potential production from bio-based intermediates, market growth predictions, economic benefits from co-production, commercial and near-market bio-based chemicals (C1-C6, Cn). More than 1,000 hard copies of this report have been disseminated all over the world, and many more were downloaded from the Task website. Much positive response has been received from the market. This report will be updated and expanded in the next (2013-2015) triennium.





The Biofuel-driven Biorefineries report, published in Q1 2013, gives an overview of commercial-scale, demonstration-scale and more conceptual biofuel-driven biorefineries in the participating countries, with a link to the Task 42 classification system, and makes biorefineries more understandable for the public. The report also contains the results of the environmental assessment of a C6, C5, lignin platform biorefinery for the production of bioethanol, phenols, power, heat and CO_2 from wood. This report will be distributed in hard copy all over the world, and can be downloaded from the Task website from Q1 2013.

European Training School on Biorefining

The Biorefining Training School, that began with a half-day event in Amsterdam in 2009, has been expanded into a major four-day Biorefining Training Event in Europe. The extended course was successfully organised in both Paris, France (2011) and Wageningen, the Netherlands (2012), and will be the major annual biorefining training event in Europe in the next triennium (Galway, Ireland, August 2013).

Conclusions and recommendations

Conclusion

The information (reports, Task and stakeholder meetings) that became available in this triennium in the participating countries showed that biorefining is becoming more and more the standard for the sustainable use of biomass for the production of bioenergy and bio-based products. Market implementation is progressing, specifically in the bio-transportation fuel sector, where chain and process residues are upgraded increasingly to added-value bio-based products (both chemicals and feed ingredients), improving the overall production process economics. However, some technical and non-technical critical success factors have to be solved before large-scale and optimal biomass use as a base for the bio-based economy can be guaranteed.

Recommendations

- The circular bio-economy (zero-waste: re-use of water, minerals, etc) – synergetically co-producing human food, animal feed, bio-based products (chemicals, materials) and bioenergy (fuels, power, heat) – should be the framework for the sustainable worldwide production and use of biomass. Bioenergy will be a relatively low-value but essential link in the full biomass valorisation strategy, being the implementation driver in the short term and the linchpin in the longer term. Optimal sustainable biomass valorisation approaches for food and non-food (incl. energy/fuels) applications within a market pull approach should be assessed.
- Contractibility and supply of sustainable biomass resources, including: the use of agriculture residues, process residues, post-consumer residues, and new crops (incl. aquatic biomass) needs additional attention to ensure that enough biomass of the right quality will become available at the right locations to feed both current and future biorefinery facilities.
- New, potentially disruptive and game-changing technologies will be developed over time. Identification of these new technologies and dissemination of knowledge about them may shorten the time-to-market of efficient and sustainable biomass valorisation chains including these technologies.
- The advantages and disadvantages of decentralised (regional) (pre) processing (relatively low initial investment, regional stakeholder support and development, social acceptability) vs central processing making use of economy-of-scale should be further assessed.
- Support is needed for industrial/SME stakeholders finding their position in a future bio-economy.

Task 42 appendix

Participation in major events

- Co-organisation together with EC FP7 projects StarColibri, Biocore, Suprabio and Eurobioref a Biorefinery Network Event in the Renewable Energy House, Brussels, Belgium, 7 February 2011.
- Chairing the Biorefinery Platform Day, incl. 2 presentations of IEA Bioenergy Task 42 at World Biofuels Markets 2012, Rotterdam, the Netherlands, 22-24 March 2012.
- Presentation IEA Bioenergy Task 42 at the European Expert Forum on Biorefineries, Budapest, Hungary, 12/13 April 2011.
- Towards a Common Approach for Comparing Biorefinery Systems to Conventional Systems – Findings of IEA Bioenergy Task 42 'Biorefineries', G. Jungmeier, Joanneum Research, Graz, Austria, N. S. Bentsen, H. Jørgensen, I. Skiadas (Denmark); M. Mandl, F. Cherubini (Austria); R. Van Ree, E. de Jong (The Netherlands); M. Dohy (France); P. Walsh (Ireland); M. Wellisch (Canada); T. Wilke, (Germany), 18th European Biomass Conference, Lyon/France, May 3-7, 2010.
- Classification and Assessment of Biorefinery Concepts in IEA Bioenergy Task 42 'Biorefineries', G. Jungmeier and the colleagues of IEA Bioenergy Task 42 'Biorefineries', ICPS International Conference on Polygeneration Strategies with Special Focus on Integrated Biorefineries, Leipzig/Germany September 7-9, 2010.
- The Future of Biorefinery Evolution – How will Biorefinery Platforms Fit in the Industry Sector?, World Biofuel Markets – Biorefinery Platforms, G. Jungmeier, Rotterdam, March 22-24 2011.
- Identification and Assessment of Most Promising Biorefineries up to 2020 in IEA Bioenergy Task 42 'Biorefinery', G. Jungmeier, 19th European Biomass Conference and Exhibition, Berlin, June 6-10, 2011.
- Bioenergy Driven Biorefinery Systems – Classification, Biorefinery Index and Sustainability Assessment, G. Jungmeier, Bioenergy Australia 2011, November 23-25, Queensland, Australia.
- Innovative Biofuel-driven Biorefinery Concepts and their Assessment – An Outlook until 2025 in IEA Bioenergy Task 42 'Biorefinery', G. Jungmeier, Biorefinery Conference 2012, 'Advanced Biofuels in a Biorefinery Approach', February 28 – March 1, 2012, Copenhagen, Denmark.
- Whole Chain Assessment of Bioenergy-Driven Biorefineries – Experiences of IEA Bioenergy Task 42 'Biorefineries', G. Jungmeier, World Bioenergy 2012, May 29-31, 2012, Jönköping, Sweden.

- Do We Need a Biorefinery Complexity Index? – A Critical Review in IEA Bioenergy Task 42 'Biorefinery', G. Jungmeier, 20th European Biomass Conference, June 18-22, 2012, Milan, Italy.
- Activities of IEA Bioenergy Task 42 'Biorefinery' on Wood-Based Bioenergy-Driven Biorefineries – Classification – Sustainability Assessment, Complexity Index and International Perspectives up to 2025, G. Jungmeier, Northern Wood Biorefinery Conference, October 23-25, 2012, Helsinki, Finland.
- Sustainability Assessment, Classification and Perspectives of Bioenergy-driven Biorefineries – Activities of IEA Bioenergy Task 42 'Biorefineries', G. Jungmeier, III Latin American Conference 'Biorefineries – Ideas for a Sustainable World'; November 19-21, 2012, Pucon, Chile.
- Classification of Biorefineries – Examples for Bioenergy – Driven Biorefineries, M. Hingsamer, G. Jungmeier, Finish Biorefinery Training School, 26 November 2012, Joennsuu, Finland.

Deliverables

- A printed version of glossy IEA Bioenergy Task 42 Biorefinery Brochure – including biorefinery definition, biorefinery classification system, biorefinery mapping data, and examples of both running biorefineries and biorefineries – was made available both in hard copy and electronically via the Task website at the start of 2010.
- Cherubini, F., Jungmeier, G., Wellisch, M., Willke, T., Skiadas, I., van Ree, R. and de Jong, E. (2009). Toward a common classification approach for biorefinery systems. *Biofuels, Bioproducts & Biorefining* (Biofpr) 3(5):534-546.
- Bio-based Chemicals: Value Added Products from Biorefineries, Task 42 report, February 2012.
- National Country Reports were prepared by Australia, Austria, Denmark, France, Germany, Italy, the Netherlands, Turkey, the UK and the US.
- A Summarising Countries Report was prepared by the University of Copenhagen: Biofuel-driven Biorefineries: A selection of the most promising biorefinery concepts to produce large volumes of road transportation biofuels by 2025, Task 42 report, February 2013.

All deliverables can be found for downloading at the Task 42 website: www.iea-bioenergy.task42-biorefineries.com

A deliverable that is still in progress is the preparation of the glossy information brochure 'Adding Value to the Sustainable Utilisation of Biomass at a Global Scale – BIOEFINING'. This paper will include all relevant Task 42 results of the last six years (2007-2012) showing the economic, ecological and social advantages of coproduction of Bioenergy and Bio-based Products for sustainable biomass use in a future bioeconomy.

Co-ordination with other Tasks within IEA Bioenergy

- Conference Advanced Biofuels – Sustainable Production using the Biorefinery Approach, Copenhagen, Denmark, 27-29 February 2012; co-operation University of Copenhagen, Task 39 and Task42.
- Contribution to set up strategic fund joint Tasks project 'Sustainable bioenergy supply chains'. Coordination: Task43; participation Tasks: 42, 40, 39, 38, and 29. This project will be executed in 2013 and 2014.
- Contribution to the set-up of a joint Task activity with Task 40 on 'Future market demand for biomass from the broader BioEconomy perspective'. Coordination: Task 40; Task 42 will bring in specific expertise on (types of) biorefineries.

Co-ordination with other bodies outside IEA Bioenergy

Mr Shoji Yamaguchi (Mitsubishi Chemical Corporation), as co-leader of the International Council of Chemical Association (ICCA), participated in the Task 42 meeting in Tortona, Italy, 4-6 April 2011.

Industry participation

The industry was involved in Task 42 through participation in the biannual industrial stakeholder meetings and by providing data on running commercial, demo and pilot biorefinery plants for the assessment work and reports delivered.

TASK 43: Biomass Feedstocks for Energy Markets

Task Leaders:

Göran Berndes, Task Leader, Chalmers University of Technology

Tat Smith, Assoc. Task Leader, University of Toronto

Operating Agent:

Åsa Karlsson, Swedish Energy Agency

Participating countries:

Australia, Canada, Denmark, Finland, Germany, Ireland, Netherlands, New Zealand, Norway, Sweden, UK, USA and EC

Introduction

The role of IEA Bioenergy Task 43 is to envisage and contribute to the development of competitive bioenergy supply chains that use sustainably produced feedstocks. This is accomplished by linking promising feedstocks with energy markets, addressing logistical and technical challenges, and identifying the socioeconomic and environmental consequences of feedstock production. The Task takes a global approach in investigating sustainable supply chains and considers commercial, near-commercial and promising agricultural and forestry production systems coupled with conversion technologies.

Work in the 2010-2012 triennium was based on the premise that in many countries biomass demand for energy will enter a period of expansion as a way to ensure sustainable and secure energy sources. Feedstocks from many land uses and cropping systems (e.g. agriculture, forestry, dedicated energy crops) can become a plausible energy source if production systems are economically and environmentally attractive. New science, tools and technology must be developed to support this period of rapid expansion to ensure that suitable production systems are established and can be relied on to help achieve energy and climate policy targets in many countries – and also contribute to other objectives such as job creation.

Throughout the triennium, there has been much concern about the possible negative impacts associated with bioenergy; the view that bioenergy represents an attractive alternative to conventional (primarily fossil) energy options has been challenged. Much attention has been directed to the possible consequences of land-use change (LUC), referring to the well-documented effects of forest conversion and cropland expansion into previously uncultivated areas, possibly resulting in biodiversity losses, GHG emissions and degradation of soils and water bodies. Sustainability concerns relating to the feedstock supply systems also include direct and indirect social and economic issues, including land-use conflicts, human rights violations and food security impacts.

The work in the Task has progressed in response to the need for science-based information informing the evolving public debate about bioenergy sustainability and also to provide guidance for policymaking and strategic planning in industry. This science-policy interaction has become more intensive during the 2010-2012 triennium. Through National Team Leaders (NTLs) and other associated colleagues, the Task has also contributed to the development of governance systems including legislation, sustainability standards and certification schemes. Through its members, the Task has contributed to important publications such as the IEA Technology Roadmaps 'Biofuels for transport' and 'Bioenergy for heat and power', and the IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation.

Background

Task 43 was established in 2010 from the merger of Tasks 30 (Short Rotation Crops for Bioenergy Systems) and 31 (Biomass Production for Energy from Sustainable Forestry). The objective of Task 43 is to promote sound bioenergy development that is driven by well-informed decisions in business, governments and elsewhere, and by providing 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 in the Task requires addressing complex, interdisciplinary issues, which necessitates the involvement of colleagues from many disciplines using a variety of approaches.

The work programme for the 2010-2012 triennium was developed based on a number of lead questions that were considered relevant across the full feedstock scope resulting from merging the former Task 30 and Task 31 into one broad feedstock Task:

1) How can the Task further develop and implement feedstock production systems to provide attractive solutions for energy security, climate change and sustainable development?
2) How can policy- and market-based instruments effectively promote sustainable development, and how can science-based sustainability criteria and standards be formulated to take into account the vast regional variation in conditions for production of different feedstocks?
3) What are the costs and gains associated with productivity, competitiveness and environmental performance of feedstock supply systems and how do they affect deployment and market penetration of the systems?
4) What are the motivations, opportunities and capabilities for producers in agriculture and forestry to change from conventional production systems and deploy or integrate sustainable bioenergy production systems in response to new demands? What are the necessary and sufficient conditions for financial investment in developing feedstock production systems?

Starting out from these lead questions, Task leaders and NTLs formulated five focus topic areas within which specific Task activities were established:

1) Bioenergy and land-use change, including water implications of bioenergy
2) Integration of food and fibre production with cost-effective biomass supply for energy
3) Sustainability of bioenergy feedstock supply systems
4) Bioenergy and environmental services
5) Certification systems to ensure sustainable bioenergy systems

Through specific Task projects, workshops and collaboration with other Tasks and organisations outside IEA Bioenergy, experts have been brought together to evaluate alternatives across sectors and to identify trade-offs and synergies between food, fibre and energy production systems. One central aim for the Task in the 2010-2012 triennium was to achieve strong outreach and impacts as a result of Task activities, both within the scientific community and in the rest of society. To achieve this, the Task seeks to achieve impact through multiple avenues (as further described below).

Task objectives and work carried out

As outlined above, Task 43 in the 2010-2012 triennium addressed several urgent and complex issues, which necessitated involvement of colleagues from many countries and disciplines. This was achieved through arrangement of seminars and workshops and interaction with other Tasks and organisations. Compared to earlier triennium periods, collaboration was more extensive in the 2010-2012 triennium and several Task NTLs have also worked in other networks and in this way brought collaboration opportunities to the Task.

The five focus topic areas listed above were the basis for formulation of more elaborated objectives and for the planning of associated Task activities and publications. However, while several Task activities and events were defined early in the triennium based on this list of focus topic areas, the Task maintained flexibility in its planning so that it could respond to developments taking place over time. Several events and collaboration activities thus took place that were not defined in the initial planning phase of the 2010-2012 triennium.

As stated in the introduction, compared to earlier triennium periods, science-policy interaction has become more intensive, requiring new approaches to balance the objective of providing science-based advice with that to maintain an attractive and inclusive culture where scientists interact and exchange data, modelling results, experiences and research ideas. One example of this is that the Task has arranged several dissemination events where only those Task colleagues with direct involvement participated. The Task at the same time maintained the same meeting frequency as in earlier periods, as regards regular Task meetings and workshops primarily serving the purposes of scientific interaction and planning of Task activities. One consequence of this is that the Task leaders engaged in more meetings per year than in earlier triennium periods.

It is difficult to assign different Task activities and publications to one specific focus topic area since these in many ways overlap and are inter-linked. However, the tables below presenting Task project activities, as well as workshops and seminars organised by Task 43 during the 2010-2012 triennium, indicate how the various activities and events addressed the focus topic areas. The events served the purpose of gathering international expertise but several events also served as dissemination events, and provided opportunities for meeting and planning further work with representatives from the collaborating organisations. Several of the events also served the purpose of starting-up or coordinating report writing processes aiming at joint publications as well as scientific publications.

Task project activities

Task project activity	When	Focus topic area	Collaborators/Deliverables*
Bioenergy and water	2010-2012	1, 3, 4, 5	UNEP, FAO, UN-WIDER, UN-CCD (Secretariat), Roundtable for Sustainable Biofuels, Stockholm Environment Institute, Stockholm International Water Institute, Oeko Institute, Focali. 1 report, 1 summary report, 2 briefs, 2 editorials, 1 special issue in scientific journal containing 9 articles
Bioenergy alongside other land use	2010-2011	1, 2,3	ERANET Network "Rating SRC" 2 scientific publications
Economic sustainability of supply chains	2010-2012	2, 3	COST Action FP0902 "Development and Harmonisation of New Operational Research and Assessment Procedures for Sustainable Forest Biomass Supply" 1 Task 43 report
Environmental performance of supply chains	2010-2012	1, 3, 4	1 Task 43 report (to be published Q1-2014)
Market demand vs physical supply of forest and agriculture biomass	2010-2011	2, 3	1 Task 43 report
Sustainability certification of bioenergy	2010-2012	3, 5	Focali, Task 40 Policy Brief, IEA Bioenergy reports produced within the inter-Task project "Monitoring sustainability certification of bioenergy", chapter in forthcoming Task 40 book on international bioenergy trade
Promising resources and systems for producing bioenergy feedstocks – An International Compendium of biomass feedstock supply systems	2010-2012	2, 3, 4	8 Task 43 reports, 1 additional report to be published Q1-2014
Web-based GIS system for data and knowledge dissemination	2011-2012	3	Wageningen University, Dutch Ministry of Economic Affairs, Agriculture and Innovation Website: www.pbconthemap.org
Forest Energy Portal and Journal of Forest Energy	2010-2012	n/a	Website: www.forestenergy.org/ After the initial start-up period it was decided to merge *Journal of Forest Energy with International Journal of Forest Engineering*. The publication name is now the latter, since it is a more established journal name. It is the aim to cooperate with a large publisher such as Elsevier or Springer.
Monitoring Sustainability Certification of Bioenergy	2011-2012	3, 5	Inter-Task project involving T38, 40, 43 4 project reports
Bioenergy and land use – the use of multipliers	2011-2012	1, 2, 3	Decision support framework, 1 scientific article
Quantifying environmental effects of SRC on soil, water and biodiversity	2011-2012	1, 2, 3, 4	ERANET research network "Rating SRC" 1 Task 43 report
Mobilising sustainable bioenergy supply chains	2012	1, 2, 3, 4, 5	Inter-Task project involving Task 38, 39, 40, 42, 43. The project is planned to extend into 2015. 2nd half of 2012 was dedicated to the development of work plans with specification of contributions form Tasks.

* Conference presentations are not included. Workshops and other events are listed in table below.

Task workshops and seminars

Workshops and seminars organised by Task 43*	When	Focus topic area	Collaborating organisers
Workshop – "Sustainability across the supply chain of land-based biomass"	Kamloops, Canada, June, 1-4, 2010	1, 3, 4, 5	Long-Term Soil Productivity network
Workshop – "Spotlight: bioenergy and water"	Paris, France, July 5-6, 2010	1, 3, 4, 5	UNEP, Oeko Institute
Workshop – "Sustainability Criteria for Bioenergy – Status, Visions and Challenges"	Gothenburg, Sweden, Mar 28, 2011	3, 5	Focali
Workshop – "Quantifying and managing land use effects of bioenergy"	Campinas, Brazil, Sept 19-21, 2011	1, 2, 3, 4	Task 38, Task 40
Hot topic session – "The bioenergy, food and water nexus" at the Bonn2011 Conference: "The Water, Energy and Food Security Nexus – Solutions for the Green Economy"	Bonn, Germany, Nov 18, 2011	1, 2, 3	FAO, UN-WIDER
Workshop – "Bioenergy and Water" at the Bioenergy Australia 2011 Conference	Sunshine Coast, Australia, Nov 25 2011	1, 2, 3, 4	
Workshop – "Mobilising Sustainable Supply Chains for Forest Bioenergy"	Charleston, USA, Feb 27, 2012	2, 3	
Seminar – "Biofuels and water" arranged as part of the 6th World Water Forum	Marseille, France, Mar 15, 2012	1, 3, 5	Roundtable for Sustainable Biofuels, UNEP
Seminar – "Water for Bioenergy: Assessments and Policies to Support Improved Governance" at the World Water Week 2012 conference	Stockholm, Sweden, Aug 30, 2012	1, 3, 5	Stockholm Environment Institute, FAO, UN-CCD (Secretariat)
Workshop – "Economic Sustainability of Forest Fuel Supply Chains"	Lisbon, Portugal, Sept 19-20, 2012	2, 3	COST Action FP0902
Workshop – "Science-policy interface on issues of environmental sustainability of forest bioenergy"	Quebec, Canada, Oct 3-5, 2012	3, 4, 5	IEA Bioenergy TC, Task 40, Laval University, Natural Resources Canada, International Institute for Sustainability Analysis and Strategy, Global Bioenergy Partnership
Session – "Biomass feedstocks for energy markets" at the IEA BIoenergy conference 2012	Vienna, Austria, Nov 13, 2012	1, 2, 3, 4, 5	IEA Bioenergy ExCo

* The included events are those where Task 43 was involved as the major organiser and where Task funds were used. Besides these, the Task has contributed key input to planning and/or presentations at several other events, some of which are included in the Task 43 appendix (Deliverables).

As stated, the Task has used many dissemination channels and forms of collaboration to achieve its objective of wide outreach – including timely and policy-relevant reports as well as technical reports, workshops, seminars and special sessions at conferences, involvement in international bioenergy conferences, and collaborative efforts with other Tasks as well as with other research networks and organisations outside the IEA Bioenergy sphere, such as FAO and UNEP. This collaborative work is further described in the Success Story section below.

A detailed account of Task publications is provided in the Task 43 appendix. To summarise, the Task manages two ongoing publication series, 'Promising Resources' and 'Technical Reports', providing insights into developing biomass feedstock supply chains. For example, the recently released Technical Report 'Economic Sustainability of Biomass Feedstock Supply', was the result of collaboration among researchers at the Finnish Forest Research Institute (METLA) and colleagues from the University of Toronto and the University of Copenhagen. The goal was to identify the elements necessary for a successful bioenergy business case, such as increased operational efficiencies and integration into traditional supply chains. The report was produced in response to a perceived need to include economic considerations in the global discussion on bioenergy sustainability.

The website managed by the Task serves both the objective to achieve strong outreach and that to maintain an attractive and inclusive culture facilitating interaction between researchers and exchange of data, modelling results, experiences, and research ideas. Especially serving this latter objective, the interactive online mapping tool 'Perennial Biomass Crops on the Map' has information on perennial biomass research projects around the world. Researchers can submit data, learn about similar projects, and make connections with other researchers. The goal is to increase access to data that is often not readily available, thus increasing the impact and effectiveness of the many biomass research trials occurring all over the world. The Forest Energy Portal, spearheaded by the Finnish NTLs, serves both the outreach and the research interaction objectives by providing a networking and knowledge platform for stakeholders interested in the field of forest biomass for energy.

The Task has also contributed to ExCo publications, with economic support from the strategic fund managed by ExCo. One of the most complex issues – direct and indirect land-use change from bioenergy – was addressed in the 2011 'Bioenergy, Land Use Change and Climate Change Mitigation – Background Technical Report' (see also the 2010 summary report). Combining the knowledge of experts from Tasks 43 and 38, this report delivered insightful, conceptually robust recommendations on ways to mitigate land-use change impacts potentially associated with bioenergy development. Aimed at policymakers around the globe, it was intended to discuss without bias this much-debated issue. Task 43 NTLs also contributed to ExCo workshops with associated publications and provided support for the ExCo report 'Using a Life Cycle Assessment Approach to Estimate the Net Greenhouse Gas Emissions of Bioenergy' produced by Task 38.

The Task is engaged with several scientific journals: (i) *Journal of Forest Energy* (managed by the Finnish T43 team), which has merged with the *International Journal of Forest Engineering*; (ii) *WIREs: Energy and Environment* (associate editor for the bioenergy area); (iii) *Biofuels, Bioproducts and Biorefining* (consultant editor). These and other journals offer valuable opportunities for outreach via special-issue publications, occasional articles and editorials.

Activities extending into the new triennium

The Task 43 programme for 2013-2015 includes several planned activities that build further on the work in the 2010-2012 triennium. Many aspects covered by Task 43 will remain debated, and science-based information will continuously be needed as guidance for strategic planning in industry as well as for the development of governance systems. Thus, issues such as iLUC, water impacts and sustainability certification will remain as focal points for the Task.

The work accomplished by Task 43 and its collaborators in the past has shown a need to clearly identify the elements of a self-sustained, economically viable and environmentally responsible supply chain. The newly initiated 'Mobilising Sustainable Bioenergy Supply Chains' project attempts to develop such supply chains, using lessons learned from successful and profitable supply chains around the world. This will involve a collaborative effort of five IEA Bioenergy Tasks (Tasks 43, 40, 42, 39 and 38) and will take three years to complete. The intention is to focus on the elements necessary for 'mobilising' and scaling up those supply chains to meet future demand, and to create a successful and sustainable bioenergy industry contributing substantively to mitigation of anthropogenic climate change.

It is anticipated that the results of this project will be disseminated through workshops and publications, including the anticipated end-of-triennium IEA Bioenergy Conference in 2015. The timing of this project is critical as regulations and incentive schemes are evolving in response to unsettled issues, such as iLUC. This is affecting global bioenergy markets and slowing industry development. The results will be valuable to many stakeholders, including investors, policymakers and biomass producers. It will provide the necessary elements to identify and build successful supply chains for feedstocks in different regions all over the world.

Success story

A selection of the collaboration activities that took place during the 2010-2012 triennium is presented below. Collaboration with other Tasks and organisations has been important for achieving the objectives set out for the Task; the collaboration activities have also been very positive experiences and now provide working models for the Task that will be followed in the new triennium.

The workshop organised by Task 38, 40 and 43 in Campinas on quantifying and managing land-use effects is a good example of a very successful inter-Task collaboration. The workshop had more than 100 participants from four continents and offered high-quality presentations and posters, and a forum for debate and knowledge exchange. The very constructive collaboration with Task 38 and 40 and the excellent hosting of CTBE (Brazilian Bioethanol Science and Technology Laboratory) helped to make this workshop a memorable event.

The Task collaborated with other research networks, such as the project Rating SRC, funded by ERA-NET bioenergy, which involved partners from Sweden and Germany. This cooperation resulted in two Task 43 reports and the Rating SRC project also published two special issues in scientific journals. A large number of conference presentations have also been provided. Following the completion of the Rating SRC project in 2012, a new ERANET proposal was developed that involved also Task 43 members from Ireland. While this project did not receive funding, the work plan defined in this project proposal is now developed further in the context of the inter-Task project 'Mobilising Sustainable Bioenergy Supply Chains'. Another positive experience, collaboration with colleagues involved in the COST Action FP0902 enabled the build-up of the Forest Energy Portal and the Journal of Forest Energy. Two workshops were organised where Task 43 and COST colleagues jointly developed perspectives and conclusions on sustainable bioenergy supply chains, which formed one important basis for the previously mentioned technical report 'Economic Sustainability of Biomass Feedstock Supply' and for the inter-Task project 'Mobilising Sustainable Bioenergy Supply Chains'.

Another example of collaboration, a two-day event, was organised in early October 2012 in Quebec, Canada by Tasks 40 and 43, IEA Bioenergy Technical Coordinator, Natural Resources Canada, and Laval University. The event was organised based on a proposal by Evelyne Thiffault at NRCan (who is associated with both Tasks 40 and 43) addressing the ongoing dialogue between the North American bioenergy industry and EU energy producers on the development of a sustainable, well-functioning supply chain. North America has very high capacity to produce bioenergy to meet European demand, but uncertainty over the intent and meaning behind sustainability regulations in the European Renewable Energy Directive give rise to ambiguity and potential negative impacts on otherwise sustainable trade when applied to forestry in North America. Participants from 11 countries attended the event, and included a mix of European policymakers and North American industry and academic bioenergy experts. This event was critical in facilitating dialogue for the formation of rational policy for sustainable forest bioenergy and emphasised the need for increased understanding of the localised differences in sustainable forest management systems around the world. A report from the event has been published as a strategic discussion paper.

Starting with a workshop in Paris in 2010 organised in collaboration with UNEP and Oeko Institute, the Task collaborated with many organisations to address water-related effects of bioenergy. As shown in the tables above, this collaborative work generated substantial output and placed the Task in a central position in relation to important international processes that influence how politicians and industry will respond to water-related challenges. Besides providing guidance to decisionmakers, the Task sees the work as an important opportunity for pro-actively framing the issue and in this way contributing to shaping a constructive dialogue about challenges and solutions.

As a final example, Task 43 collaborated with Task 38 and 40 in the inter-Task project 'Monitoring Sustainability Certification of Bioenergy', addressing the impact of multiple and potentially redundant layers of sustainability governance on developing bioenergy markets, which has been a source of concern in recent years. The project had three parts: 1) a comparison of different certification schemes, 2) a questionnaire for bioenergy actors to determine their views and experiences, and 3) an analysis of the impacts of certification on trade flows and markets. Findings indicated that while there is a need for increased harmonisation among certification schemes, especially with regard to terminology and methodology, there is also a benefit to some diversification due to regional or technical differences in bioenergy streams. The project also highlighted the different roles that certification and regulation play, and found that a mix of both may be the best strategy for developing sustainable bioenergy systems.

This project was finalised in January 2013, and reports are now available on the web at http://www.bioenergytrade.org/. In March 2013, IEA Bioenergy members from Task 38, 40 and 43 hosted a workshop based on the findings of this project at the World Biofuels Markets Conference in Rotterdam. The workshop was attended by around 60 participants, including from IWPB, Drax Power, WWF, Control Union, PEFC and Argos. It brought together voices from the energy sector, environmental NGOs, and certification and auditing organisations. The discussion came to a number of conclusions on the proliferation of schemes, the importance of convergence and mutual recognition, the complementarity to legislation, and the importance of a common language among sectors. It is anticipated that this discussion will help further the ongoing developments towards harmonisation and a common language for certification, reflecting both the need for certification and the need to decrease the burden facing bioenergy producers due to complex governance measures.

Conclusions and recommendations

The 2010-2012 triennium was the first triennium for Task 43. The objectives and work plan established in the approved Task proposal for the 2010-2012 triennium were broadly defined since there was a need to include the new NTLs in shaping the objectives and work plan. The five focus topic areas and the formulation of more elaborated objectives and associated Task activities and publication plans served the crucial purpose of engaging NTLs and other Task 43 associates, and also provided a basis for the interaction with other Tasks and organisations outside IEA Bioenergy. The substantial output in terms of publications and organised events (see Task 43 appendix) confirms that the Task successfully managed the initial consolidation phase, establishing an inclusive and collaborative culture where NTLs and other Task 43 associates contribute to many activities in collaboration with other Tasks as well as organisations and research networks outside the IEA Bioenergy sphere.

Issues dealt with by Task 43 in the 2010-2012 triennium are still hotly debated and can be expected to remain so in the coming years. But the fact that issues have not been 'solved' should not be considered a failure for the Task; many aspects associated with bioenergy feedstock production are very complex, and diverging views and conclusions can be explained by differences in how various aspects are assessed (e.g. methodology to quantify iLUC emissions) and also by differences in various parties' views on the relative importance of different objectives (e.g. risks of biodiversity impacts vs benefits of new income generation). The fact that Task 43 has provided science-based information for important processes addressing debated issues, and has become recognised and acknowledged in this role, may be considered a good outcome and very valuable for continued work in the 2013-2015 triennium.

Recognising the importance of understanding the socio-economic drivers associated with successful supply chains, Task 43 collaborated with Task 29 (Socio-economic Drivers in Implementing Bioenergy Projects) in writing a prolongation proposal to ExCo70 that merges Task 29 and 43 into a 'new' Task 43 for the triennium 2013-2015, which has a further broadened scope, including aspects earlier covered by Task 29. Thus, Task 43 is again entering a consolidation phase, which this time takes place in the context of increasing collaboration with other Tasks and organisations; not least, the inter-Task project 'Mobilising sustainable bioenergy supply chains' will require much attention since Task 43 has the coordinating role in this project. Given this, it can be expected that Task leaders, NTLs and other Task associates will have to work even harder in the 2013-2015 triennium to reach the goals set out for the Task, both concerning Task collaboration and outreach supporting policy and strategic planning, and concerning the ambition to be an attractive arena for researchers engaged in the development and assessment of bioenergy feedstock systems.

ExCo might consider ways to support the Task in meeting its goals, not least when it comes to outreach where ExCo could help with information dissemination and also help the Task to work proactively by providing 'early warning information' about policy processes and 'hot issues'. The recent IEA Bioenergy Conference in Vienna is a good example of how ExCo can help the Tasks in their dissemination work and at the same time making the IEA Bioenergy brand stronger. Possible further steps in building on the IEA Bioenergy brand include a gradual harmonisation of Task websites so that they have a standardised format. One possibility is that the IEA Bioenergy Secretariat manage both the IEA Bioenergy website and the Task websites. Tasks can provide material via an interactive system for uploading Task reports, workshop announcements, and other standard Task material. Tasks that manage 'specialty' websites, such as the website for dissemination and sharing of field trial data managed by Task 43, can place links to these websites on the HQ-managed main website. Going one step further, language editing and final layout of Task reports could be managed by HQ based on Tasks sending photos, diagrams, etc and draft text for language editing and layout.

Implementing the above would require that HQ increase its capacity for website management and report publication, so there would be an additional cost to consider. But there would be strong benefits. First, a centrally managed IEA Bioenergy website containing the Task websites and all publications (with standardised layout) would likely make the IEA Bioenergy brand stronger. Secondly, 'internal dissemination' could function very smoothly; the IEA Bioenergy secretary would have full control of all new Task publications and upcoming events, and could easily update ExCo. With ExCo being continuously updated in this way, Task-ExCo interactions at ExCo meetings can spend less time on controlling what Tasks have been doing and spend more time on proactive discussions about plans for the future. This might also make it easier for ExCo members to plan their participation in Task workshops and dissemination events. All in all, this plan would make the various processes more cost-effective and thus compensate for any additional cost involved in implementing the plan.

Task 43 appendix

Participation in major events

(The list includes only events organised by Task 43)

- Sustainability Across the Supply Chain of Land-Based Biomass, Kamloops, Canada (June 1-4, 2010) – 4-day workshop and field tours. Jointly with Long-Term Soil Productivity Study (LTSP).
- Spotlight on Bioenergy and Water, Paris, France (July 5-6, 2010) – 2-day workshop. Jointly with UNEP and Oeko Institute.
- Sustainability Criteria of Bioenergy – status visions and challenges. Chalmers, Gothenburg, Sweden (March 28, 2011) – 1-day workshop. Jointly with Swedish research network Focali and the Swedish Standards Institute.
- Quantifying and managing land use effects of bioenergy, Campinas Brazil (September 19-21,2011) – 3-day workshop and field tours. Jointly with Tasks 38, 40 and 43.
- The bioenergy, food and water nexus, Bonn, Germany (November 18, 2011) – Hot topic session organised within the Bonn2011 Conference: 'The Water, Energy and Food Security Nexus – Solutions for the Green Economy'. Jointly with FAO, UN-WIDER.
- Bioenergy and Water, Sunshine Coast, Queensland (November 24-25, 2011) – 1-day workshop arranged within Bioenergy Australia 2011 Conference.
- Mobilising Sustainable Supply Chains for Forest Bioenergy, Charleston, USA (February 27, 2012) – 1-day workshop.
- Biofuels and water, Marseille, France (March 12, 2012) – 1-day workshop arranged as part of the 6th World Water Forum. Jointly with Roundtable for Sustainable Biofuels, UNEP.
- Water for bioenergy: Assessments and policies to support improved governance, Stockholm, Sweden (August 30, 2012) – 1-day workshop arranged within the 2012 World Water Week. Jointly with Stockholm Environment Institute, FAO, UN-CCD (Secretariat).
- Economic Sustainability of Forest Fuel Supply Chains, Lisbon, Portugal (September 19-20, 2012). Jointly with COST Action FP0902.
- Science-policy interface on issues of environmental sustainability of forest bioenergy, Quebec, Canada (October 3-5, 2012) – 3-day workshop and field tours. Jointly with IEA Bioenergy TC, Task 40, Laval University, Natural Resources Canada, International Institute for Sustainability Analysis and Strategy, Global Bioenergy Partnership.
- Biomass feedstocks for energy markets, Vienna, Austria (November 12, 2012) – Session V within IEA Bioenergy Conference 2012.

Deliverables

- **Task Website:** www.ieabioenergytask43.org
  - Website tool: Perennial Biomass Crops on the Map. www.pbconthemap.org
  - Website tool: Forestry Energy Portal. www.forestenergy.org.
- **Task Brochure:** http://www.ieabioenergytask43.org/wp-content/uploads/2013/09/Brochure_T43_final_-april-27_2011.pdf
- **Task 43 Promising Resource Series**
  - Report PR2011:01 Eucalypts New Zealand. Nicolas & Hall.
  - Report PR2011:02 Short Rotation Eucalypt Plantations for Energy in Brazil. Couto, Nicholas and Wright.
  - Report PR2011:03 Switchgrass Production in the U.S.A. Wright, Perlack, Turhollow.
  - Report PR2011:04 Recycling of sludge and wastewater to Short Rotation Coppice in Europe – biological and economic potential. Dimitrious, Rosenqvist, Aronsson.
  - Report PR2012:01 Bioenergy, Bioproducts, Agroforestry and Phytoremediation in the Northeastern United States. Abrahamson, Volk, Smart, White.
  - Report PR2012:02 Developing Options for Integrated Food-Energy Systems – Volume 1 – Rationale for industry development, species criteria and selection of woody species in agricultural production areas for bioenergy in Australia. George, Nicholas.
  - Report PR2012:03 Developing Options for Integrated Food-Energy Systems – Volume 2. Supply chain logistics and economic considerations for short-rotation woody crops in southern Australia. George, Nicholas.
  - Report PR2012:04 Energy from Exotic Plantation Forests in New Zealand. Hall.
  - Report PR2013:01 Short Rotation Coppice with Willow in New Zealand. Snowdon, McIvor, Nicholas.
- **Task 43 Technical Reports**
  - Technical Report 2011:01 Quantifying environmental effects of Short Rotation Coppice (SRC) on biodiversity, soil and water.
  - Technical Report 2012:01 Screening Life Cycle Analysis of a Willow Bioenergy Plantation in Southern Ontario. 2012.
  - Technical Report 2012:02 Theoretical versus market available supply of biomass for energy from long-rotation forestry and agriculture – Swedish experiences.

- Technical Report 2012:03 Short Rotation Coppice Willow Best Practice Guidelines.
- Technical Report 2013:01 Economic Sustainability of Biomass Feedstock Supply.

Other publications

- Bioenergy, Land Use Change and Climate Change Mitigation. Report for Policy Advisors and Policy Makers. IEA Bioenergy:ExCo:2010:03. Berndes, Bird, Cowie (2010).
- Bioenergy, Land Use Change and Climate Change Mitigation. Background Technical Report. IEA Bioenergy:ExCo:2011:04. Berndes, Bird, Cowie (2011)
- The Bioenergy and water nexus. Main Report, United Nations Environment programme, Oeko-Institut and IEA Bioenergy Task 43. ISBN 978-92-807-3157-6. Otto, M., Metzler, J., Fritzle, U., Berndes, G. (eds.) (2011).
- The Bioenergy and water nexus. Summary Report, United Nations Environment programme, Oeko-Institut and IEA Bioenergy Task 43. Otto, M., Metzler, J., Fritzle, U., Berndes, G. (2011).
- Bioenergy and food production for local development in Brazil: inputs for policy-making. Sparovek, Berndes, Barretto, Martins, Maule, Burgi, Smorigo (2010).
- Good Practice Guidelines for Biomass Production Studies. COST Action FP-0902. Magagnotti, Spinelli (2012).
- Criteria and indicators for sustainable woodfuels. FAO Forestry Paper 160. Task 31 (2010).
- Criteria and indicators for sustainable woodfuels. Focali Brief 2011:02. Focali and IEA Bioenergy Task 43 (2011).
- The Bioenergy and water nexus – a complex relationship. Focali Brief 2013:03. Focali, IEA Bioenergy Task 43, UNEP, SIWI, IINAS. Ölund, M. and Berndes, G. (2013).
- Effects of considering greenhouse gas consequences on fertilizer use in loblolly pine plantations. *Journal of Environmental Management*. 113:383-9. doi: 10.1016/j.jenvman.2012.09.015. Gan, Smith, Langeveld (2012)
- Bioenergy and water: risks and opportunities. *Biofuels, Bioproducts and Biorefining* 4: 473-474. Berndes, G. (2010).
- The bioenergy and water nexus. *Biofuels, Bioproducts and Biorefining* 5: 343-346. Otto, M., Berndes, G., Fritsche, U. (2011).
- Bioenergy's contribution to climate change mitigation – a matter of perspectives. *Biofuels, Bioproducts and Biorefining* 6:233–235. Berndes, G. (2012).
- Water quality assessment of Bioenergy production. *Biofuels, Bioproducts and Biorefining* 5: 445-463. Diaz-Chavez R., Berndes G., Neary D., Neto A., Fall, M. (2011).
- Meeting Sustainability Requirements for SRC bioenergy: Usefulness of existing tools, responsibilities of involved stakeholders, and recommendations for further developments. *Biomass Research* 5(3): 606-620, DOI: 10.1007/s12155-012-9217-z. Englund, O., Berndes, G., Fredrikson, F., Dimitriou, I., (2012).
- Impact assessment at the bioenergy-water nexus. *Biofuels, Bioproducts and Biorefining* 5: 375-386. Fingerman, K., Berndes, G., Orr, S., Richter, B., Vugteveen, P. (2011)
- Biofuel production on wastelands in India: opportunities and trade-offs for soil and water management at the watershed scale. *Biofuels, Bioproducts and Biorefining* 5: 410-430. Garg, K., Karlberg, L., Wani, S., Berndes, G. (2011).
- The bioenergy and water nexus. *Biofuels, Bioproducts and Biorefining* 5: 353-360. Gheewala, S., Berndes, G., Jewitt, G. (2011).
- Bioenergy alongside other land use: sustainability assessment of alternative bioenergy development scenarios. *International Journal of Forest Engineering*, In press. Langeveld, H., Berndes, G., Quist Wessel, F., van Esch, J. (2012).
- Assessing environmental impacts of Short Rotation Coppice (SRC) expansion: model definition and preliminary results. *Bioenergy Research* 5(3): 621-635, 10.1007/s12155-012-9235-x. Langeveld, H., Quist-Wessel, F., Dimitriou, I., Aronsson, P., Baum, C., Schultz, U., Bolte, A., Baum, S., Köhn, J., Weih, M., Gruss, H., Leinweber, P., Lamersdorf, N., Schmidt-Walter, P., Berndes, G. (2012).
- Evaluation of water use for bioenergy at different scales. *Biofuels, Bioproducts and Biorefining* 5: 361-374. Yeh, S., Berndes, G., Mishra, G., Wani, S., Neto, A., Suh, S., Karlberg, L., Heinke, J., Garg, K. (2011).
- The role of sustainability requirements in international bioenergy markets. In: Junginger M, Goh CS, Faaij A (Eds.), *International Bioenergy Trade: History, status & outlook on securing sustainable bioenergy supply, demand and markets*. Springer, Dordrecht. Pelkmans L, Goovaerts L, Goh CS, Junginger M, van Dam J, Stupak I, Smith CT, Chum H, Englund O, Berndes G, Cowie A, Thiffault E, Fritsche U, Thrän D (2013).

- Task 1: Examining Sustainability Certification of Bioenergy. Strategic Inter-task Study: Monitoring Sustainability Certification of Bioenergy. A cooperation between IEA Bioenergy Task 40, Task 43 and Task 38. Goovaerts, L., L. Pelkmans, C.S. Goh, M. Junginger, J. Joudrey, H. Chum, T. Smith, I. Stupak, A. Cowie, L. Dahlman, O. Englund, and A. Goss Eng. (2012).
- Task 2: Survey on governance and certification of sustainable biomass and bioenergy. Strategic Inter-task Study: Monitoring Sustainability Certification of Bioenergy. A cooperation between IEA Bioenergy Task 40, Task 43 and Task 38. Stupak, I., J. Joudrey, C.T. Smith, L. Pelkmans, H. Chum, A. Cowie, L. Dahlman, O. Englund, C.S. Goh, A. Goss Eng, M. Junginger and L. Goovaerts. (2012).
- Task 3: Impacts of sustainability certification on bioenergy markets and trade. Strategic Inter-task Study: Monitoring Sustainability Certification of Bioenergy. A cooperation between IEA Bioenergy Task 40, Task 43 and Task 38. Goh, C.S., M. Junginger, J. Joudrey, H. Chum, L. Pelkmans, C.T. Smith, I. Stupak, A. Cowie, L. Dahlman, O. Englund, A. Goss Eng, and L. Goovaerts. (2012).
- Task 4: Recommendations for improvement of sustainability certified markets. Strategic Inter-task Study: Monitoring Sustainability Certification of Bioenergy. A cooperation between IEA Bioenergy Task 40, Task 43 and Task 38. Pelkmans, P., L. Goovaerts, T. Smith, J. Joudrey, I. Stupak, O. Englund, M. Junginger, C.S. Goh, H. Chum, A. Cowie. (2012).
- Biomass feedstocks for energy markets. Feature article in IEA Bioenergy Annual Report 2012. IEA Bioenergy ExCo2013:01. Berndes, G. and Smith, T (2013).

Conference papers/presentations

by Task 43 members and other participants at events organised by Task 43 and its collaborators

- **Sustainability Across the Supply Chain of Land-Based Biomass**, Kamloops, Canada. June 1-4, 2010.
  - Conference Proceedings including over 50 presentations and 10 posters were distributed on CD to meeting participants.
- **Spotlight on Bioenergy and Water**, Paris, France (July 5-6, 2010)
  - Presentations and output from focus sessions provided basis for the report "The bioenergy and water nexus", published 2011 by The United Nations Environment Programme (UNEP) together with the Oeko-Institut and IEA Bioenergy Task 43, involving about 40 authors and reviewers. A special issue in the journal of *Biofuels, Bioproducts and Biorefining* was also published.
- **Quantifying and managing land use effects of bioenergy**, Campinas, Brazil. September 19-21, 2011.
  - Practical application: Case study results, demonstration of methods. Sparovek, Berndes, Giaroli de Oliveira Pereira, Frolich.
  - The climate benefit of Swedish ethanol – present and prospective performance. Borjesson, Ahlgren, Berndes
  - Synthesis of findings. Bird, Faaij, Berndes
  - Establishing ecologically sustainable forest biomass supply chains: A case study in the boreal forest of Canada. Thiffault, Pare, Volpe, Cormier, Anttila
- **Bioenergy-Water Workshop at Bioenergy Australia**, QLD, Australia. November 23-25, 2011.
  - Conference Report in Biofuels (2012) 3(2),115-118.
  - Bioenergy and Water – Challenges and Opportunities: Introduction to the Session. Goran Berndes, Chalmers University of Technology, Sweden
  - Conceptual and Analytical Frameworks for Evaluation and Reporting of the Bioenergy Impacts: The Challenge of Applying LCA for Water. Brendan George, University of New England
  - Best Management Practices: A Tool for Responsible Water Management. Dan Neary, Southwest Watershed Team, USDA Forest Service
  - Economics of SRC and Impact of Competition for Water Resources. Amir Abadi, Future Farm Industries CRC, Australia
  - Biofuels: Addressing Major Policy Risks. Paul Martin, University of New England.
  - Hydrologic Consequences of Jatropha Production on Wastelands in Developing Countries. Suhas P. Wani, International Crops Research Institute for the Semi-Arid Tropics
  - Bioenergy in Water Scarce Countries: Experiences from South Africa. Richard Kunz, University of KwaZulu-Natal
  - Biofuels and Water: Lessons from California. Kevin Fingerman, UC Berkeley Energy & Resources Group
  - Optimising Water Use and Minimising Drought Risks in Biomass Production. John McGrath, Murdoch University FFI CRC

- **Mobilizing Sustainable Supply Chains for Forest Biomass for Energy.** Charleston, South Carolina, USA. February 21, 2012.
  - Estimates of sustainable feedstocks in the US – the Billion Ton 2 report. Marilyn Buford, US Forest Service
  - Forest biomass in the EU how much is available and how to mobilize the potential? Antti Asikainen, Finnish Forest Research Institute, METLA
  - Feedstocks for energy production in Ireland – challenges in developing economically sustainable supply chains. Ger Devlin, School of Agriculture, Food Science & Veterinary Medicine, University College Dublin
  - Research efforts to improve the harvesting of forest biomass from the mountainous areas in Italy. Raffaele Spinelli, CNR-IVALSA
  - Mobilizing sustainable supply chains – opportunities and challenges. Tat Smith, University of Toronto
  - Forest biomass supply chains from natural forests in Canada: Integrating ecological and local constraints. Evelyne Thiffault, Canadian Forest Service, Natural Resources Canada
  - Constraints to mobilizing sustainable biomass supply chains – the ecological perspective. Inge Stupak, Copenhagen University
  - Challenges of sustainable supply chains in the Southeast US. Moderator: Brian Kittler, Pinchot Institute
  - Wood procurement in a highly heterogeneous landscape. Pellet Export Perspective: Steven Meyers, FRAM Renewable Fuels
  - Sustainability Criteria and Practices in the Southeast U.S. Environmental Perspective: Will McDow, Environmental Defense Fund
  - IEA Bioenergy Task 43 efforts in 'Mobilizing economically sustainable supply chains'. Tanja Ikonen, Finnish Forest Research Institute, METLA
- **Economic Sustainability of Forest Fuel Supply Chains**, Lisbon, Portugal September 19-20, 2012.
  - COST Action FP0902 Report on Economic Sustainability of Forest Fuel Supply Chain Conference. September 2012. Rogerio.
  - Forest biomass in Central Europe: How much is available and what are the challenges to economic sustainability? Schweinle
  - Selecting between wood fuel supply chains on the basis of economic performance and robustness – evaluation and decision criterions. Belbo, Talbot
  - Biomass for co-firing and electricity production in Ireland – challenges in developing economical transport supply chains. Devlin
  - Integrating forest and biomass supply chains for sustainable forest residue bioenergy in Australia. Brown
  - IEA Bioenergy Task 43 efforts in 'Mobilizing economically sustainable supply chains'. Ikonen
- **Water for Bioenergy: Assessments and policies to support improved governance**, Seminar, World Water Week in Stockholm, August 30, 2012.
  - Governance challenges and institutional responses at the water/biofuel nexus: lessons from ongoing work at FAO. Fingerman, K.
  - Addressing water related aspects in certification systems and standards. Jungueira, V.
  - Best Management Practices for managing water in bioenergy feedstock production. Neary, D.
  - Options for rehabilitation of degraded lands and food security. Zelaya-Bonilla, S.A.
  - Quantitative assessment of global bioenergy-water linkages. Beringer, T.
  - Jatropha for rehabilitation of wastelands, improving livelihoods and downstream consequences. Wani, S.P.
  - Competing water claims in biofuel feedstock operations in Central Kalimantan: community grievances and pathways to improved governance of oil palm concessions. Klocker Larsen, R
- **IEA Bioenergy Conference 2012.** Vienna, Australia. November 13, 2012.
  - Bioenergy and water: assessments and policies to support improved governance. Goran Berndes, Chalmers University of Technology, Sweden
  - Biomass and producer decision making: direct and indirect transfers in different spheres of interaction. J. Gan, Texas A&M University, U.S.A., J.W.A. Langeveld, Biomass Research, The Netherlands, C.T. Smith, University of Toronto, Canada
  - Are multiple layers of governance systems a barrier for sustainable forest bioenergy production? C.T. Smith, University of Toronto, Canada, Stupak, I., University of Copenhagen, Denmark.
  - Assessing the Environmental Performance of Biomass Supply Chains – An Effort under Construction. J. Schweinle, S. Ahlgren, G. Berndes, P. Borjesson, C. Gaudreault, H. Langeveld, M. Margni, D. Neary, A. Rodl

- **Various conferences**
  - Smith, T. and I. Stupak. 'Forests for energy – Advancing sustainability in the bioenergy sector'. Invited paper presented at the SFI Inc. Annual General Meeting. 13 September 2012. Milwaukee, Wisconsin.
  - Smith, T. and I. Stupak. 'How certification can help meet society's sustainability goals'. Invited paper presented at the 2012 PEFC Stakeholder Dialogue titled 'Strengthening the link: Sustainable biomass & forest certification'. 14 November 2012. Vienna, Austria.
  - Stupak, I. and T. Smith. 'Sustainability certification for bioenergy – Considerations for the forest sector'. Invited paper presented at the PEFC-Netherlands Annual General Meeting. 22 November 2012. Almere, The Netherlands.
- **WIREs Journal – Energy and Environment** (restricted to contributions from Task 43 associates)
  - The climate benefit of Swedish ethanol: present and prospective performance. P. Borjesson, S. Ahlgren, G. Berndes
  - Principles of nutrient management for sustainable forest bioenergy production. D. Mead, C. Smith.
  - Bioenergy and land use changing-state of the art. G. Berndes, S. Ahlgren, P. Borjesson, A.L. Cowie
  - Forest bioenergy feedstock harvesting effects on water supply. D.G. Neary, K.A. Koestner
  - Forest energy procurement: state of the art in Finland and Sweden. J. Routa, A. Asikainen, R. Bjorheden, J. Laitila, D. Roser
  - Options for increasing biomass output from long-rotation forestry. G. Egnell, R. Bjorheden
  - Bioenergy options for New Zealand: key findings from five studies. P. Hall
  - Best management practices for forest bioenergy programs. D.G. Neary

Co-ordination with other Tasks within IEA Bioenergy

- IEA Bioenergy Strategic Report: 'Bioenergy Land Use Change and Climate Change Mitigation'. Collaboration with Task 38.
- Participation in Task 38 Workshop in Graz, France (October 4-5, 2010)
- Task 38, 40 and 43 jointly organised the workshop 'Quantifying and managing land-use effects of bioenergy' in Campinas, Brazil.
- Inter-Task Project – Monitoring Sustainability Certification of Bioenergy. Task 38, 40 and 43.
- Task 40 and 43 jointly organised the workshop and field tour 'Sustainability for forest bioenergy' in Quebec, Canada Oct 3-5, 2012.
- Inter-Task Project – Mobilising Supply Chains. Task 38, 39, 40, 42 and 43

Co-ordination with other bodies outside IEA Bioenergy

- CTBE – Brazilian Bioethanol Science and Technology Laboratory
  - Workshop
- COST Action FP0902
  - Website development and management, *Journal of Forest Energy*, workshop, publication
- Bioenergy Australia
  - Workshop
- Focali
  - Seminar and publications
- FAO
  - Publication
- UNEP
  - Workshop and publications
- Oeko Institute
  - Workshop and publications
- Stockholm Environment Institute
  - Seminar
- Long-Term Soil Productivity Study (LTSP)
  - Workshop
- Roundtable for Sustainable Biofuels.
  - Workshop, seminar, publication, formation of Target and Solutions Group (TSG) on bioenergy and water
- ERA-NET bioenergy. Consortium involved in the project 'Rating SRC
  - Publications

Industry participation

Industry involvement takes place indirectly via NTLs engaging with industry in their normal work capacity. Many Task 43 NTLs and associates, for example, are involved in the development of sustainability certification and standards; this provides plenty of opportunities for interaction with industry where one can inform about Task reports and events and bring industry views and perspectives for consideration in the planning of Task work.

Industry is also involved in Task events, such as the recent dissemination event within the inter-Task project 'Monitoring sustainability certification of bioenergy' at the World Biofuel Markets conference in Rotterdam. Another example is the workshop and field tour organised in Quebec in October 2012.

IEA Bioenergy

Further Information

IEA Bioenergy Website
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