Annual Report 2016

IEA Bioenergy

IEA BIOENERGY : EXCO : 2017 : 03

IEA Bioenergy is an international collaborative agreement set up in 1978 by the International Energy Agency (IEA) to improve international co-operation and information exchange between national bioenergy RD&D programmes. IEA Bioenergy aims to achieve a substantial bioenergy contribution to future global energy demands by accelerating the production and use of environmentally sound, socially accepted and cost-competitive bioenergy on a sustainable basis, thus providing increased security of supply whilst reducing greenhouse gas emissions from energy use.

Front Cover: Mechanical sugarcane harvesting
Photo credit Bruno Karklis

Chair Kees Kwant and Vice-chair Jim Spaeth.

To: IEA Headquarters, Paris

IEA BIOENERGY ANNUAL REPORT 2016

Under the IEA Framework for International Energy Technology Cooperation the Executive Committee of each Technology Collaboration Programme (TCP) must produce an Annual Report for IEA Headquarters.

This document contains the report of the IEA Bioenergy Executive Committee for 2016. This year, we have presented a special feature 'Integrated bioenergy hybrids – Flexible renewable energy solutions' prepared by Task 41 Project 7.

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

Kees Kwant
Chairman

Pearse Buckley
Secretary

Contents

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

IEA Bioenergy – Selected Highlights From 2016

1. Workshop On 'Mobilising Sustainable Bioenergy Supply Chains: Opportunities For Agriculture' In Conjunction With GSE, FAO And IRENA

In Rome in May 2016 a very successful workshop was held on the topic of 'Mobilising sustainable bioenergy supply chains: opportunities for agriculture'. The workshop was organised in collaboration with GSE, FAO and IRENA. It sought to examine the significant opportunies for agriculture in the deployment of sustainable bioenergy and biobased product supply chains. The main feedstocks from agriculture are crop residues, farm residues, but also energy crops. It was important to find synergies with the basic function of agriculture to provide nourishment for people. There are cases where agroforestry approaches involving a mix of food and energy crops have allowed rural communities to boost both food and fuel production. There are also a variety of situations where biogas from agricultural residues such as residues from food crops, food processing, and manure has provided a sound economic basis for combined heat and power or biomethane production to energise rural communities and industries. These were highlighted and discussed in detail. The workshop exemplified the benefit of collaboration between the organisations concerned in order to develop consistent and science based messages to inform decision makers and other stakeholders.

Opening session of ExCo77 workshop

2. IEA Bioenergy Countries' Report

This first IEA Bioenergy Countries' Report presents a summary of the total primary energy supply (TPES) by resources and the contribution of bioenergy in the member countries of the IEA Bioenergy Technology Collaboration Programme (TCP). The information presented is based on International Energy Agency (IEA) statistical data, supported by input from the Executive Committee of the IEA Bioenergy TCP, the IEA Bioenergy Tasks' countries' reports and the International Renewable Energy Agency (IRENA). The data refers to the year 2014, except where specific information was not available for that year, in which case data from 2013 was used. The report also includes information on research focus related to bioenergy, relevant funding programmes, major research institutes and recent important bioenergy developments in the member countries. It is the only collation of R&D, funding programmes, etc. for bioenergy and allows one to compare and contrast across the globe. The report can be downloaded from http://www.ieabioenergy.com/wp-content/uploads/2016/09/iea-bioenergy-countries-report-13-01-2017.pdf

3. IEA Bioenergy Webinar Series

Following a decision at ExCo76 in Berlin, IEA Bioenergy began production of webinars to present important outputs from the Tasks. The production of the webinars has been facilitated by the Canadian Institute of Forestry/Institut forestier du Canada who have provided the technical support and marketing material. By the end of 2016, five webinars had been presented covering:

- Mobilising Sustainable Bioenergy Supply Chains
- Bioenergy - is it good for the climate
- Green gas
- Cascading of woody biomass definitions, policies, and effects on international trade
- Biomass Torrefaction: Technology Status and Commercialisation, Applications for Torrefied Biomass and its Role in Logistics and Trade.

All of the webinar recordings and PowerPoint presentations are available at http://www.ieabioenergy.com/iea-publications/webinars/.

Integrated bioenergy hybrids – Flexible renewable energy solutions

Authors: Ilkka Hannula, Elina Hakkarainen. VTT Technical Research Centre of Finland

Background

The global energy supply system is currently in transition from one that relies on polluting and depleting inputs to a system that relies on non-polluting and non-depleting inputs that are predominantly renewable and variable. The cost of variable renewable energy (VRE), although initially high, has experienced significant reductions during the last decade driven by capacity expansion and R&D. According to recent data, the generation costs of VRE have already reached or are approaching those of conventional power and heat generation options.[1] This trend is likely to continue, leading eventually to elevated shares of VRE in the energy sector.[2]

As the share of variable energy supply continues to increase, it raises the important question of how best to ensure its stability and reliability. Technically and economically viable solutions to the problem, such as fast-response natural gas boilers and combined cycles, already exist in the market place. However, the ambitious long-term carbon mitigation goals agreed by the world governments in Paris, are not likely to be met with a fossil-based backup strategy. So there exists a clear need for technologies that are simultaneously low-GHG, flexible and cost-effective.

Bioenergy is a renewable energy source that is ideally suited to mediating temporal imbalances between energy supply and demand. A large number of bioenergy technologies are already commercially available and widely applied at various size ranges and locations. However, sustainable biomass is also a limited resource, and in the face of increasing demand for transportation biofuels and other value-added bio-products, the supply of biomass is likely to be constrained. Therefore, it is important to increase the efficiency of biomass use in all its applications in order to maximise its impact on climate change mitigation.

Integration of bioenergy with other renewable energy sources (RES) provides an attractive way to improve the reliability and flexibility of a VRE dominated energy system while simultaneously increasing the resource efficiency of biomass use. In this work we summarise the findings of a recent IEA Bioenergy project on such *integrated bioenergy hybrids*.[3]

1 IEA, 2016. Medium-Term Renewable Energy Market Report, OECD/IEA, Paris.

2 EU PV Technology Platform, 2015. PV LCOE in Europe 2014-30. Final report.

3 Task 41 project 7: Bioenergy RES hybrids. See http://task41project7.ieabioenergy.com/.

Flexible bioenergy

In energy systems, flexibility can be provided through four different approaches: system infrastructure, flexible generation, storage, and demand-side integration. In the context of integrated bioenergy hybrids, the most relevant aspects of flexibility are generation and storage. In terms of flexible generation, different bioenergy processes can be assessed based on the following criteria:

- The ability to select the generation level,
- The ability to select the speed at which output levels are changed, and
- The start-up and shut-down time of the plant.

In general bioenergy technologies allow fairly wide operational windows and steep ramping gradients, which establishes good starting conditions for integration with variable energy sources. In heat generation the role of bioenergy can be divided roughly into two categories: 1) bioenergy as base load RES, and 2) bioenergy as complementary RES. In a base load operation regime, integration with other heat sources can be used to reduce the annual consumption of biomass, to reduce operation time under partial loads, and to increase boiler life time (in years). On the other hand, when bioenergy is used as a complementary RES, it can be used to supply heat during peak demand and avoids over dimensioning of other heat generation equipment. In addition to the benefits, some additional costs can also be expected as a result of hybridisation. For example, thermal and pressure stresses due to part-load operation and cycling of bioenergy equipment are likely to cause premature component failures, and possibly increased emissions and reduced fuel efficiency.

As in the case of generation, energy storage solutions also encompass a diverse set of technologies. In the context of bioenergy hybrids two main options have been identified: 1) biomass drying with VRE and 2) chemical storage of electrical energy through electrolytic hydrogen and biogenic carbon. These technologies have significant technical potential due to their applicability at large scale and the high energy density of storage. The most obvious use for bioenergy based energy storage applications is to complement VRE variability by creating demand during periods of abundance and thus reducing the amount of energy lost in curtailment.

Chemical storage of VRE in biofuels is one of the few large-scale options (pumped hydro storage with large reservoirs is another) for mediating seasonal imbalances. It also has the unique feature among storage technologies that it is not constrained by its system stage, i.e. it never fills up. However, for chemical storage technologies the main value might not come from the discharge of stored electric energy back to electricity due to low round-trip efficiency, but from making surplus electricity available in chemical form for distribution in the natural gas grids, or for use in the transport sector. In addition, the possibility of increasing resource efficiency of biomass use through integration with VRE is a potentially important dimension of energy storage that is not often discussed in the literature.

State-of-the-art

The status of integrated bioenergy hybrids in Finland, Austria and Germany was assessed during the project.[4] To structure our findings and discussion we have created five categories for bioenergy hybrids depending on their application and scale, namely:

- Domestic applications,
- Utility-scale applications and district heating and cooling networks,
- Industrial applications,
- Farm-scale applications,
- Energy storage applications.

Domestic applications

RES hybrids in domestic applications are mainly found in the heating sector. Normally detached houses, especially outside the district heating network, have a hybrid heating system based on multiple energy sources, such as oil, biomass, an electric resistance heater or a heat pump. In Finland, hybrids covered almost 8% of the heating market in small-scale buildings in 2015.[5] Many companies providing stand-alone renewable heating systems have already included flexible heating solutions in their offerings, e.g. solar thermal collectors can be integrated with a wood pellet burner, a biomass burner or a heat pump. Some companies also already offer entire hybrid heating systems as a product. Such systems enable the use of multiple heat sources for domestic hot water and/or space heating. They typically include heat storage and a flexible connection for several heat sources such as bioenergy (stove or wood pellet burner), solar heat, heat pump or waste heat recovery (Figure 1).

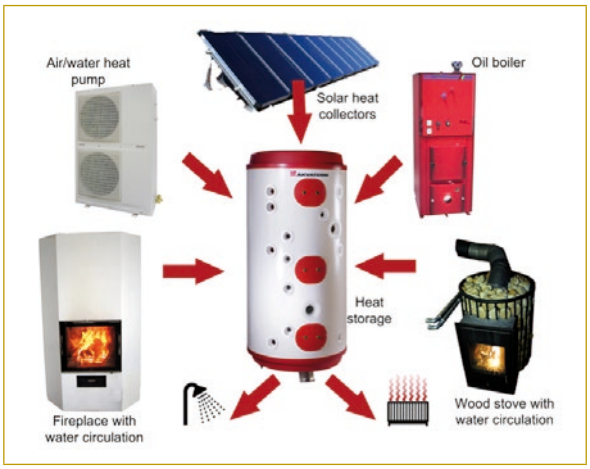


Figure 1. Flexible hybrid solution for domestic hot water and space heating by Finnish company Ekolämmöx.[6]

4 To access the reports, visit: http://task41project7.ieabioenergy.com/iea-publications/

5 Energia Uutiset, (15.4.2016), Kaukolämmön suosio jatkaa kasvua, [accessed 18.4.2016], available at: http://www.energiauutiset.fi/uutiset/kaukolammon-suosio-jatkaa-kasvua.html#commenting

6 Ekolämmöx, Hybridilämmitys – tietopaketti, [accessed 10.3.2016], available at: http://www.ekolammox.fi/hybridilammitys/

Domestic hybrid heating systems are based on proven components and the main challenges are related to the selection of technologies and their proper dimensioning. Today biomass is seldom the only heat source in a Finnish detached house due to the increasing share of electric heating, heat pumps and district heating, but its role as an additional heat source is emphasised.[7,8]

Solar heat collectors are able to complement base load heat sources through thermal storage integration (Figure 2). A hybrid system integrating bioenergy and solar thermal is not yet a "standard" in Finland, whereas in Germany and Austria the combination of biomass and solar thermal is an established concept. Currently, 60% of all pellet boilers and stoves in Germany are combined with solar heat.[9] The benefit of integrating solar heat with biomass based heating systems is the reduced need for biomass, especially during the summer period, and the increased lifetime of the boiler if properly controlled. The economic benefit can be rather limited in small installations. In the case of integration with a ground-source heat pump, the life time of the pump can be enhanced. Other reasons for solar thermal installations in households include cost savings in fuel or electricity, scalability to customer needs, effortless use, low operation and maintenance costs, long life time and the desire to contribute to CO_2 reductions in an easy way.[10]

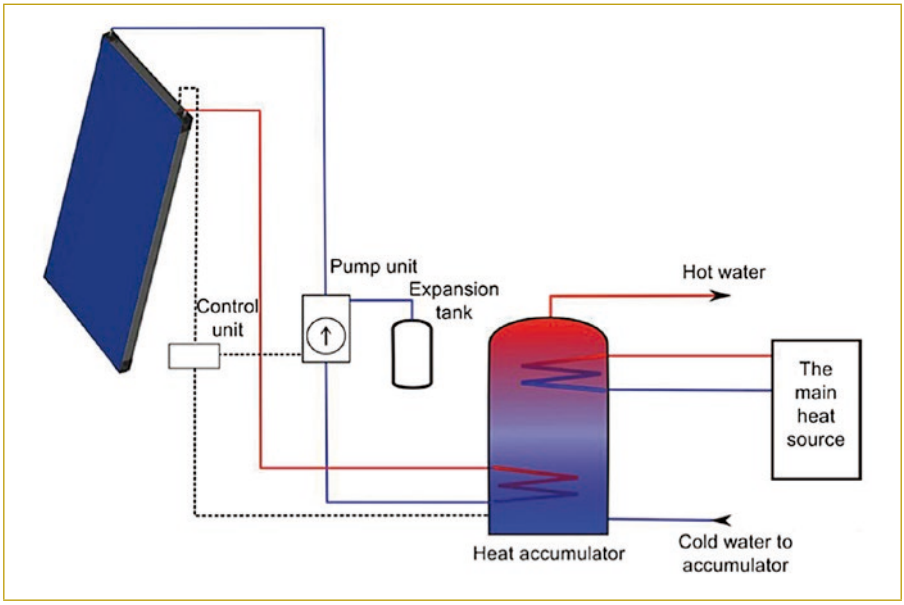


Figure 2. Integration of solar heat collectors to the heating system through thermal storage.[10]

7 Finnish Energy, Metsäenergia, [accessed 11.5.2016], available at: http://188.117.57.25/energia-ja-ymparisto/energialahteet/metsaenergia

8 Alakangas, E.; Erkkilä, A.; Oravainen, H., (2008), Tehokas ja ympäristöä säästävä tulisijalämmitys – Polttopuun tuotanto ja käyttö, [accessed 3.6.2016], available at: http://www.vtt.fi/inf/julkaisut/muut/2008/VTT-R-10553-08.pdf

9 Buderus, Pellets-Solar-Heizung, [accessed 31.10.2016], available at: http://www.baunetzwissen.de/standardartikel/Heizung-Pellet-Solar-Heizung_962265.htm

10 Savosolar, (4/2016), Solar thermal technology taken to the next level, presentation by Savosolar.

In Germany, the combination of solar thermal heat generation with bioenergy is common. There are several manufacturers offering combined systems, as well as additional research projects. For example, in a reference house with an area of 380 m² in Hutthurm near Passau, Buderus installed a combined system with a wood gasification boiler, solar panels, an oil-fired condensing boiler and a combined water tank.[11] Another example is the system offered by Brunner GmbH, which includes a pellet, woodchip or wood log boiler with a buffer tank combined with solar panels and/or heat pumps.

Utility-scale application and district heating and cooling networks

Utility-scale bioenergy RES hybrid applications cover the range from single buildings to large district heating and cooling networks. In many countries solar heat integration with district heating networks is of high interest as a means of reducing emissions from the heating sector, while simultaneously ensuring reliable supply of renewable energy at an affordable price. In Denmark, integration of solar thermal in a district heating plant, typically using also biomass, is rapidly becoming common. In these instances, solar thermal typically represents 20–30% of the annual heat demand with a storage size of around 4,000–10,000 m³. Figure 3 shows a hybrid district heating plant in Løgumkloster in Denmark.[12] The plant generates annually 108–115.2 TJ (30–32 GWh) of energy, using wood pellets as the main source of RE (3 MW). Solar collectors (15,300 m²) produce approximately a quarter of the total production (28.8 TJ i.e. 8,000 MWh). The peak solar field power is 13.5 MW, and 7,400 m³ heat storage is able to dispatch 400-500 MWh. Other heat sources include natural gas, an absorption heat pump and an electric heat pump.[12,13]

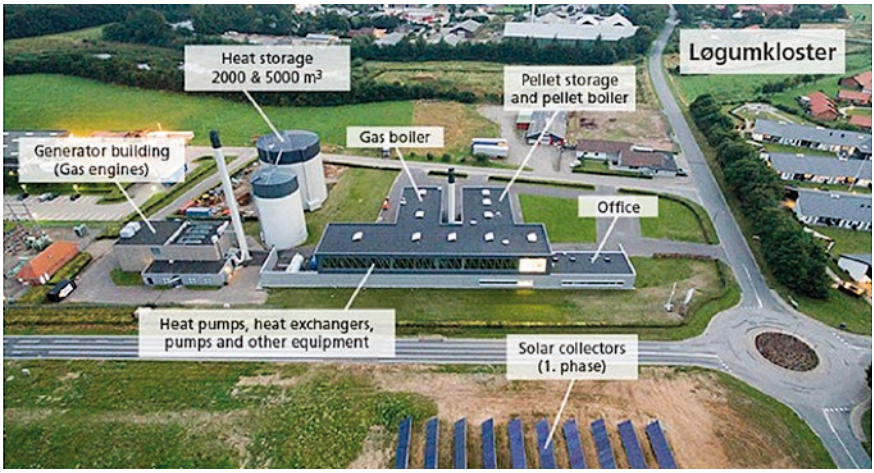


Figure 3. Hybrid district heating plant (CHP) combining wood pellets, solar thermal energy and natural gas in Løgumkloster in Denmark.

11 Buderus, Biomasse Wohnhaus Hutthurm, [accessed 16.11.2016], available at: https://www.buderus.de/de/wohnhaus-hutthurm

12 Lampila, J., (25.4.2016), Everything is different in the state of Denmark, [accessed 26.4.2016], available at: https://www.linkedin.com/pulse/everything-different-state-denmark-jouko-lampila

13 Savosolar, (2016), Savosolar Løgumkloster District heating Denmark, [accessed 6.5.2016], available at: http://www.lahienergia.org/app/uploads/Savosolar-Logumkloster-District-Heating.pdf

The first step towards solar thermal utilisation in district heating has been taken in Finland by Savon Voima (energy utility) who replaced one of its heavy fuel oil based district heating units with a pilot system in 2015. The pilot system consists of a wood pellet burner, electric heater and solar heat collectors. Solar collectors are used to preheat the return district heating water before it is raised to the target temperature in the pellet boiler or electric heater. Solar heat is available from the beginning of February until October, but during the remaining period, other heat sources are needed to cover the heat demand. During the summer period, heat is produced with collectors and an electric boiler, since electricity prices are low. The installation does not include any storage system, which reduces the investment cost, but limits the achievable solar share. The main goal of the pilot is to investigate the use of solar heat in parallel with other heat sources in district heat production and the technical and economic feasibility of scaling up the system.[14,15]

In Germany, several demonstration projects are ongoing at the residential scale. For example, Hamburg city district "Jenfelder Au" has been part of an innovative project funded by the research initiative EnEffStadt.[16] Here, city drainage has been combined with several renewable energy sources, including a biogas plant, solar thermal and geothermal systems. For the village of Wüstenrot, a roadmap for energy use and new building settlement "Vordere Viehweide" (according to the "plus energy" standard) is currently been implemented within the project EnVisaGe.[17] Here, geothermal heat supply in a low temperature local heating grid is combined with biomass heat and solar thermal systems. Vaillant installed a district heating grid for "Quartier Dortmund-Brackel" with six pellet boilers, each of 90 kW, six condensing boilers, and 232 solar collectors with 550 m² collecting area.[18]

Conventional heating grids are characterised by central heat production and consumers along the network (Figure 4, top). In more complex grids there can be several distributed producers, but still, in classical setups there is a clear distinction between heat producers and consumers. Buildings, which are not part of the network, usually have their own heat supply, and have an overcapacity in most cases. Examples of this overcapacity in Austria include solar thermal energy during sunny days in summer time and heat produced by biomass boilers in warmer winter periods and during transition times. Small- and medium-scale industry often hesitates to participate in heating grids.

14 Anttonen, K., Savon Voima, (24.8.2016), Kaukolämpöpäivät 2016, Aurinkolämpö osana uusiutuvaa kaukolämmön tuotantoa – Case Savon Voima, [accessed 22.9.2016], available at: http://energia.fi/files/796/Lu_Anttonen_Kaukolampopaivat.pdf

15 Energia Uutiset, (1/2016), Savon Voiman omintakeinen ratkaisu: Kaukolämpöä pelletillä ja auringolla.

16 KREIS, Motivation des Projekts: Wandel als Chance, [accessed 16.11.2016], available at: http://www.kreis-jenfeld.de/projekt.html

17 Envisage Wüstenrot, Projektbeschreibung, [accessed 16.11.2016], available at: http://www.envisage-wuestenrot.de/projekt-envisage/projektdetails

18 Vaillant, Quartier Dortmund-Brackel, [accessed 16.11.2016], available at: http://www.vaillant.de/heizung/heizung-finden/referenzen/mehrfamilienhauser/modernisierung-quartier-dortmund/index.de_de.html

A bi-directional heating grid (Figure 4, bottom) could be the solution to integrating such heat sources into the grid.[19] Prosumers (Producer and Consumer) would generate additional heat for the grid. As a result, there is potential to replace peak load boilers and cover the summer period demand by the production of prosumers instead of through an inefficient main boiler. The technical and economic evaluation of such a system is under development in the project BiNe2+, which is funded by the Austrian climate and energy funds (KLIEN) and the Austrian funding agency (FFG). The implementation of new decentralised heat producers into an existing heating grid is being demonstrated in Großschönau, where a heat pump, a biomass boiler for chipped wood and an existing solar collector field will be connected to the grid.

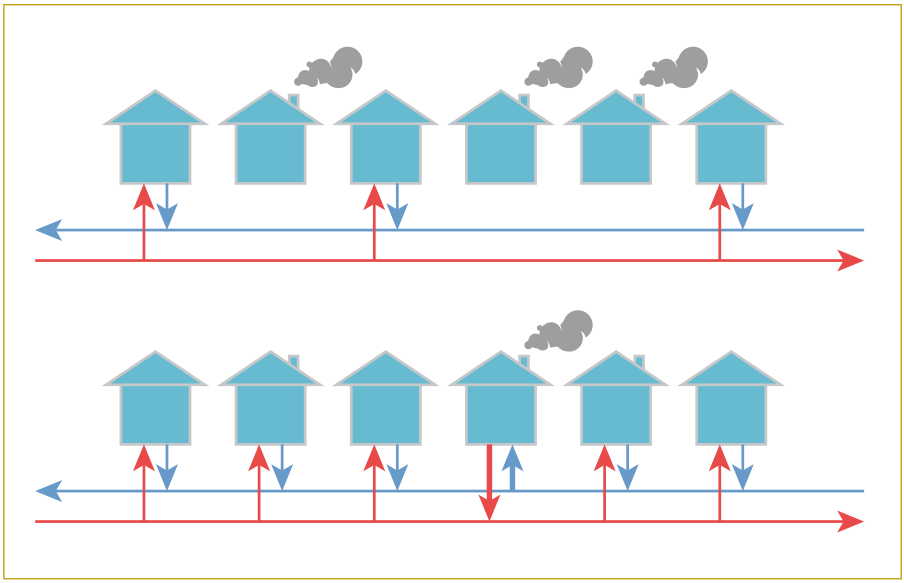


Figure 4. Basic layout of conventional (top) and bidirectional (bottom) heating grids.

A good case example of the large-scale hybrid platform in Finland is HELEN's concept based on trigeneration of heat, power and cooling for a dense urban area.[20] HELEN's goal is to be a CO_2 neutral energy utility by 2050, and wider utilisation of biomass plays a key role in the transition.

19 Lichtenegger, K.; Muschick, D.; Gölles, M.; Höftberger, E.; Leitner, A.; Wöss, D.; Reiterer, D., Bidirektionale Einbindung dezentraler Einspeiser in Wärmenetze: hydraulische, wärmetechnische und regelungstechnische Aspekte, qm Heizwerke, Salzburg 2016.

20 HELEN, (24.9.2013), Helsingin Energia is presented with international global district energy climate award, [accessed 26.5.2016], available at: https://www.helen.fi/en/news/2013/helsingin-energialle-kansainvalinen-ymparistopalkinto/

Key actions which have been targetted to increase the share of bioenergy in district heat production include wood pellet co-combustion with coal, distributed heat production with bioenergy and the use of biogas.[21] HELEN is also looking at new heat sources, such as heat pumps, solar thermal and geothermal. HELEN's Katri Vala heat pump plant, co-generating district heating and cooling, is the largest of its kind in the world. The heating and cooling capacity of the plant, produced by five heat pumps, is 90 MW and 60 MW, respectively. The plant is highly efficient since it takes advantage of waste heat streams by recovering heat from the return water of district cooling and from purified sewage water (Figure 5).[22] In 2015, the heat pump plant covered 7% and 60% of HELEN's district heating and district cooling respectively. HELEN's district cooling system is the third largest in Europe, and is expanding rapidly. During the summer period, almost all of the heating demand of the centre of Helsinki and about half of the entire city can be covered by the Katri Vala plant.[23,24,25]

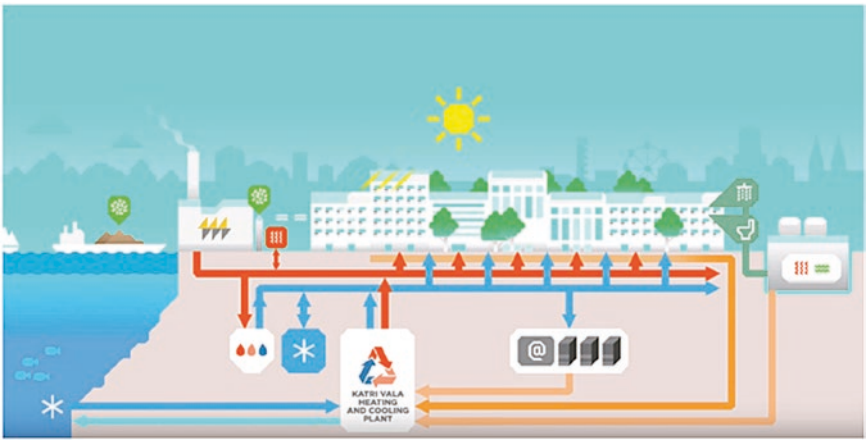


Figure 5. HELEN's integrated district heating and cooling system based on multiple heat sources.

21 HELEN, Uusiutuvaa energiaa Helsinkiin, [accessed 4.5.2016], available at: https://www.helen.fi/helen-oy/vastuullisuus/hiilineutraali-tulevaisuus/uusiutuvaa-energiaa-helsinkiin/

22 HELEN, (25.9.2015), Katri Vala heating and cooling plant, [accessed 2.5.2016], available at: https://www.youtube.com/watch?v=iVg0LyeEK90

23 HELEN, HELEN is Finland's largest producer of solar heat, [accessed 2.5.2016], available at: https://www.helen.fi/en/news/2015/helen-is-finlands-largest-producer-of-solar-heat/

24 Talouselämä, (29.3.2016), Nyt paukahti – Lämpöpumpuilla syntyi uusi ennätys, [accessed 4.5.2016], available at: http://www.talouselama.fi/uutiset/nyt-paukahti-lampopumpuilla-syntyi-uusi-ennatys-6536206?utm_campaign=56a8994cb132f20f83041897&utm_content=56fb858773a6a374e6022c86&utm_medium=smarpshare&utm_source=linkedin

25 HELEN, (20.5.2016), HELEN will build a new large heating and cooling plant in Helsinki, accessed 2.5.2016], available at: https://www.helen.fi/en/news/2016/newheating-and-cooling-plant/

Industrial application

A wide variety of applications representing bioenergy RES hybrids can be found in industry. One example is an integrated hybrid process called "GeoBio" that provides heating and cooling for a logistic centre in Sipoo by utilising ground-source heat and wood pellets. The use of heat pumps is prioritised while pellets are used during the winter period, and heavy fuel oil serves as a backup fuel. Annually, approximately half of the heat demand is covered by ground-source heat and the other half by wood pellets. In addition to ground-source heat, heat is recovered from the cooling system, and the total heat production capacity is 6.0 MW.[26,27]

Whereas in Finland industrial hybrids mainly focus on heat production to replace oil consumption, in Germany the focus has recently been on virtual power plants and various power-to-gas concepts. An overview of power-to-gas projects in combination with bioenergy is shown in Table 1. There are also other examples of industrial applications in Germany. In the regenerative power plant "RegenerativKraftwerk Bremen", an industrial location is supplied with power, heating and cooling from wind power, photovoltaics and biomethane.[28] By combining these energy sources with accumulators and charging infrastructure for electric vehicles, the plant is used as a virtual power plant to provide ancillary services.

Farm-scale applications

Integrated bioenergy hybrids constitute an attractive proposition for a farm due to the latter's high energy demand and its rather even distribution over the year, together with a farm's wide utilisation of biomass and large rooftop areas available for solar energy harvesting. Agriculture has traditionally utilised a lot of biomass for energy production, in particular for heating, and the trend is expected to continue. The availability of biomass, desire to increase energy self-sufficiency and the anticipated increase in the price of oil and electricity can be identified as the main motivators for renewable energy investments.

In Finland, bioenergy is mainly used for heating in wood chip and wood pellet boilers and the peak heat demands can be covered with bioenergy. A growing trend towards installing PV systems on farms can be identified. Farms combining small-scale biomass CHP, PV, wind, a heat pump and waste heat utilisation for wood chip drying can also be found. The production and consumption of biogas at farm-scale is still modest in Finland but gradually increasing.

Large rooftop areas for solar harvesting create great potential for biomass drying at farm-scale. Integrated hybrid concepts can significantly reduce the power consumption of drying. Solar thermal wood chip drying is technically scalable to large-scale power plants as well, but the space required by the solar collectors is a constraint. However, distributed wood

26 Adven, Bio-Hybridiratkaisu – S-ryhmä, [accessed 6.5.2016], available at: http://www.adven.fi/fi/referenssit/bio-hybridiratkaisu-s-ryhma/

27 Motiva, S-ryhmän logistiikkakeskus käyttää maalämpöä ja bioenergiaa, [accessed 6.5.2016], available at: http://www.motiva.fi/files/5124/Case_S_GeoBio_SU.pdf

28 Energy & Meteo Systems, [accessed 16.11.2016], available at: https://www.energymeteo.de/index.php

chip drying on farms would allow advantage to be taken of the technology in large-scale and would also enhance energy efficiency in transportation by reducing the amount of transported water (moisture).

Table 1. German Power-to-Gas projects in combination with bioenergy.[29]

Project name	Audi e-gas project	BioPower-2Gas	Methanisierung am Eichhof	PtG Eucolino Schwandorf	PtG Biogas-booster (MicroPyros)	Stromlückenfüller (GP Joule)
Category	Industry	Demonstration plant	Demonstration plant	Research	Pilot plant	Pilot plant
Status	Operating	Operating	Operating	Operating	Operating	Operating, first stage of expansion (4/40)
Start-up	25.06.2013	March 2015	January 2012	15.11.2012	June 2014	18.05.2015
Power consumption	6300 kW_e	Up to 1200 kW_{el}	25 kW_{el}	108 kW_{el}	unclear	20 kW_{el}, first stage; up to 200 kW_{el}
H_2-Production	1300 m³/h	60 – 220 m³/h	6 m³/h	21.3 m³/h	Unclear	40 m³/h (final stage)
SNG-Production	300 m³/h	15 – 55 m³/h	4 m³/h	5.3 m³/h	0.4 m³/h	n.a.
CO_2 source	Biogas plant (EWE AG)	Biogas plant/ Natural gas distribution network	Biogas plant	(Within) Biogas plant	Biogas plant of purification plant Straubing	Biogas
Heat usage	Hygienisation, plant periphery	District heat	No	Yes	Unclear	Local heating grid
Location	Werlte, Lower Saxony	Allendorf (Eder) and Philippsthal, Hessen, Jühnde, Lower Saxony	Bad Hersfeld, Hesse	Schwandorf, Bavaria	Straubing, Bavaria	Reußenköge, Schleswig-Holstein
Further notes				Increasing the methane content of biogas	Uses microbial methanation of hydrogen at 80°C	Co-combustion of H_2 and biogas for power production; follow-up project: comb. of PEM-electrolyzer with biogas-CHP

29 If not stated otherwise, all data from www.powertogas.info (Deutsche Energie-Agentur – dena), [accesses 9.12.2015].

Energy storage applications

Flexibility options are not only confined to generation but also include solutions for flexible energy storage. In this respect biomass drying and chemical storage of electricity through the conversion of hydrogen into biofuels were identified as potential hybrid storage concepts.

Biomass drying with VRE is a potential long-term and low-cost form of energy storage. During drying both the heating value and the quality of solid fuels is increased. Other benefits include better fuel management, particularly during wintertime when large fuel storage and better quality fuel are needed to meet demand peaks. Lower moisture content of biomass also prevents dry matter losses, and improves the efficiency of the thermal conversion processes.[30] If biomass is dried near the production site, significant cost reductions in road transportation can also be attained.

Recent improvements in the efficiency and cost of solar thermal systems also makes solar drying of biomass more feasible while the need for seasonal energy storage is simultaneously increasing. In practice the most feasible way to apply solar drying and to store dried biomass is to carry it out in small units, for example on farms, where biomass sources are closer and all logistical solutions are easier to execute compared to urban areas.

The suitability and economics of solar drying of biomass has been studied by VTT and the first tests have already been conducted to understand how solar drying differs from traditional warm air drying (see Figure 6).

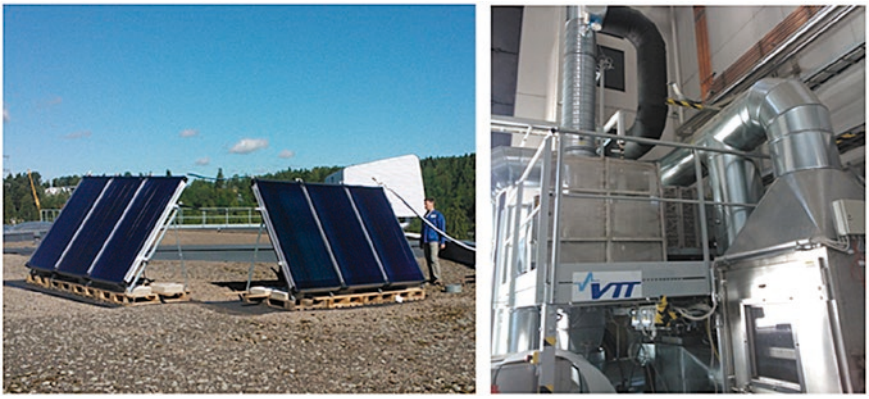


Figure 6. Solar thermal collectors and biomass dryer used by VTT to investigate the possibilities for using solar energy to dry biomass.

30 Krigstin S & Wetzel S. 2016. A review of mechanisms responsible for changes to stored biomass fuels. Fuel 175 (2016):75–86.

Using bioenergy for chemical storage of VRE has recently gained interest. The most commonly proposed concepts involve the integration of low-carbon electricity with either biogas or syngas by using electrolytic hydrogen as an intermediate. Such integration allows either intermittent or continuous operation, depending on what is eventually being pursued. Intermittent operation strategies aim to create demand for VRE during times of abundance and thus reduce the need for curtailment. Such operational strategies seek to benefit from the low wholesale price of energy during times of high supply and low demand, but suffer from the low capacity utilisation rates that lead to a high share of capital expenses in the levelised production cost.[31]

Concepts that allow continuous operation of RES integrated biofuels production are not driven by flexibility issues, but instead aim to increase biomass resource efficiency by maximising carbon conversion during biofuels production. Possibilities for equipment sharing also exist and the resulting increase in biofuel output can be very significant, reaching even up to a 2.6 or 3.1-fold improvement depending on the process configuration.[32] However, a continuous low-cost, low-carbon source of electricity is needed to ensure both feasible economics and adequate emissions savings.

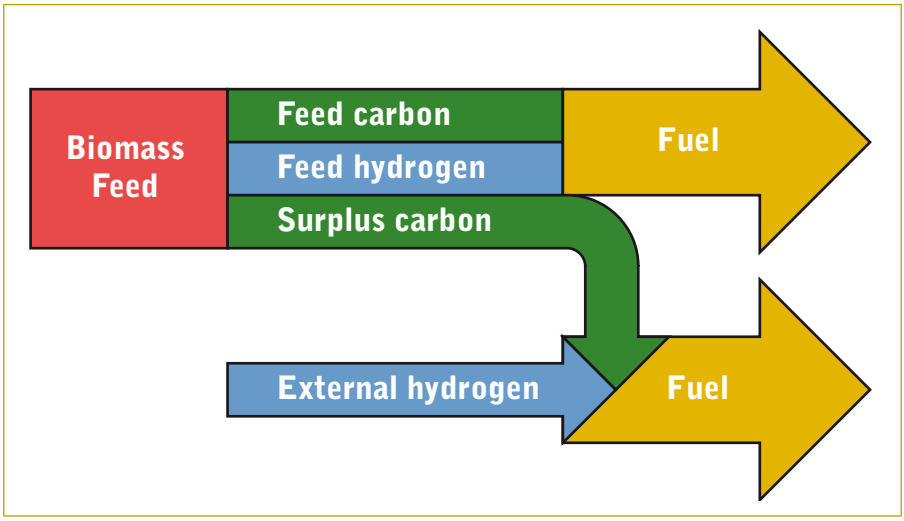


Figure 7. Idealised concept for hydrogen enhanced biofuels production that allows for significant improvements in the efficiency of biomass use.

31 Ilkka Hannula, Co-production of synthetic fuels and district heat from biomass residues, carbon dioxide and electricity: Performance and cost analysis, Biomass and Bioenergy, Volume 74, March 2015, Pages 26-46, ISSN 0961-9534, http://dx.doi.org/10.1016/j.biombioe.2015.01.006.

32 Ilkka Hannula, Hydrogen enhancement potential of synthetic biofuels manufacture in the European context: A techno-economic assessment, Energy, Volume 104, 1 June 2016, Pages 199-212, ISSN 0360-5442, http://dx.doi.org/10.1016/j.energy.2016.03.119.

Summary and recommendations

Based on our state-of-art review of integrated bioenergy hybrids in Finland, Germany and Austria, it is clear that all the required elements for implementation of RES hybrids in the heating and cooling, power and transport sectors are already in place. Region-specific characteristics in terms of configurations, applications and scales of hybrids were also identified.

An important motivation behind hybrid systems is the possibility to switch between different energy sources in an optimal way. Usually one of more of the following drivers can be expected:

- Increase in self-sufficiency in terms of energy and reliability;
- Reduction in emissions, lower environmental impact;
- Avoided cost of purchase of oil or electricity (especially peak power cost);
- Lower maintenance need for biomass or oil boiler;
- Increase in component lifetime and efficiency;
- Optimised dimensioning of system components;
- Avoided investment in a storage system (bioenergy is storable) or in new production capacity (waste heat recovery);
- Better waste management and additional incomes in the case of biogas utilisation;

Currently, most hybrid systems can be found in the heating sector, particularly in detached houses outside the district heating network. This is mainly due to simple and robust integration of different heat sources and the natural flexibility offered by the integrated system. In domestic heating systems, bioenergy and ground-source heat are typically considered as alternative options for base load production. Depending on the heating behavior of the household, bioenergy can be used either as the base load producer or to complement other heat source(s) during peak demands.

District heating and cooling networks can be considered as large-scale hybrid applications. Bioenergy offers a quick way to increase the share of RES in heat production through these networks, while utilisation of other renewable heat sources releases limited bioenergy resources to other end uses and sectors. Solar thermal is not yet a widely applied technology for district heat production in the studied countries, although a large project is currently underway in the city of Graz.[33] In general, solar thermal could make a significant contribution to the production of district heat during summer periods. Waste heat recovery is a growing trend, which reduces the need for investments in new energy generation capacity.

33 BIG Solar Graz: 500.000 m² Solarkollektoren für 20 % Solaranteil bei Grazer Fernwärme. [accessed 30.11.2016], available at: http://bit.ly/2gG2DHK

At farm-scale the traditional utilisation of bioenergy offers good preconditions for hybrid systems. Besides increasing the level of self-sufficiency in energy and reducing energy related costs, a hybrid system might allow additional revenue streams for farms.

In the power sector, the role of hybrid systems varies depending on the market conditions. In Finland, the role and potential is currently limited due to the established and strong Nordic power grid and the abundance of flexibility options through access to hydro. In Germany, virtual power plants are an interesting topic, and coupling of biogas and biomethane with hydrogen from wind is currently being demonstrated. In general, bioenergy can have a significant role as a balancing power in an energy system with an increasing amount of intermittent generation.

As already discussed, bioenergy RES hybrid technologies and applications vary between the countries studied, although some general development pathways and trends in market uptake can be identified. The overall status of technologies is summarised in Table 5

In general, the technical potential for integrated bioenergy hybrids is significant as no serious limitations have been identified. However, the market potential is difficult to estimate as there is no universal way to assess the value of flexibility in isolation from the energy system, and thus the economic feasibility is always specific to the case in question. The majority of hybrid concepts currently in the market are focused on domestic heating applications. Renewable heating and cooling sectors in general seem to be a market where hybrid systems can have a competitive edge. However, the lack of standardised interfaces between technologies is identified as a disadvantage that leads to additional costs due to the need for extra equipment (e.g. multiple control systems etc.).

Integrated bioenergy hybrids can also provide flexible solutions in energy storage applications. For example, biomass drying with renewable energy sources, and chemical storage of electricity through hydrogen in biorefineries are identified as potential future concepts.

Those hybrid concepts that have already been commercialised in case study regions would benefit from measures that accelerate technology transfer. An online database for sharing information on best practices and successful case examples could be one measure to facilitate deployment. For emerging and new hybrid technologies further investment in R&D is needed to drive costs down and to increase understanding of the value of hybrids in a VRE dominated energy system.

Table 2. Summary on existing and developed bioenergy RES hybrid solutions in case study regions. DH refers to district heating and DC to district cooling.

	Domestic scale	Utility-scale and DH/DC networks	Industry	Farm-scale
On market/ Implemented	Biomass + solar thermal Biomass + ground-source heat Biomass + waste heat recovery Biomass + electric heating Biomass + DH Biomass + PV	Biomass + waste heat recovery Biomass + passive solar energy	Biomass + ground-source heat Biomass + waste heat recovery Biomass + PV	Biomass + ground-source heat Biomass drying Biomass + PV Biomass + wind Biogas production
Ongoing developments	Two-way DH connection	Biomass + solar thermal Biomass + geothermal Hydrogen boosted biofuels Waste heat utilisation from new sources	Biogas related networks Hydrogen enhanced (boosted) biofuels	Biomass + solar thermal Liquid biofuel production

International Energy Agency

The International Energy Agency (IEA) is an autonomous organisation which works to ensure reliable, affordable and clean energy for its 29 Member Countries and beyond. Founded in response to the 1973-74 oil crisis, the IEA's initial role was to help countries co-ordinate a collective response to major disruptions in oil supply through the release of emergency oil stocks to the markets. While this continues to be a key aspect of its work, the IEA has evolved and expanded. It is at the heart of global dialogue on energy, providing authoritative and unbiased research, statistics, analysis and recommendations. Today, the IEA's four main areas of focus are:

- Energy security: Promoting diversity, efficiency, flexibility and reliability for all fuels and energy sources;
- Economic development: Supporting free markets to foster economic growth and eliminate energy poverty;
- Environmental awareness: Analysing policy options to offset the impact of energy production and use on the environment, especially for tackling climate change and air pollution; and
- Engagement worldwide: Working closely with partner countries, especially major emerging economies, to find solutions to shared energy and environmental concerns.

Objectives

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

Organisation

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

Members

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

Introducing IEA Bioenergy

Welcome to this Annual Report for 2016 from IEA Bioenergy.

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

Bioenergy is energy derived from biomass. Biomass is defined as material which is directly or indirectly produced by photosynthesis and which is utilised as a feedstock in the manufacture of fuels and substitutes for petrochemical and other energy intensive products. Organic waste from forestry and agriculture, and municipal solid waste are also included in the collaborative research, as well as broader 'cross-cutting studies' on techno-economic aspects, environmental and economic sustainability, systems analysis, bioenergy trade, fuel standards, greenhouse gas balances, barriers to deployment, and management decision support systems.

The IEA Technology Collaboration Programme (TCP) on Bioenergy, which is the 'umbrella agreement' under which the collaboration takes place, was originally signed in 1978 as IEA Forestry Energy. A handful of countries took part in the collaboration from the beginning. In 1986 it broadened its scope to become IEA Bioenergy and to include non-forestry bioenergy in the scope of the work. The number of participating countries has increased during the years as a result of the steadily increasing interest in bioenergy worldwide. By the end of 2016, 23 parties participated in IEA Bioenergy: Australia, Austria, Belgium, Brazil, Canada, Croatia, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Republic of Korea, The Netherlands, New Zealand, Norway, South Africa, Sweden, Switzerland, the United Kingdom, the USA, and the European Commission.

IEA Bioenergy is now 39 years old and is a well-established collaborative agreement. All OECD countries with significant national bioenergy programmes are now participating in IEA Bioenergy, with very few exceptions. The IEA Governing Board has decided that the Technology Collaboration Programmes may be open to non-Member Countries, i.e., for countries that are not Members of the OECD. For IEA Bioenergy, this has resulted in a number of enquiries from potential participants, and as a consequence new Members are expected. Three non-Member Countries currently participate in IEA Bioenergy – Brazil, Croatia, and South Africa.

The work within IEA Bioenergy is structured in a number of Tasks, which have well defined objectives, budgets, and time frames. The collaboration which earlier was focused on Research, Development and Demonstration is now increasingly also emphasising Deployment on a large-scale and worldwide. There were 11 ongoing Tasks during 2016:

- Task 32: Biomass Combustion and Co-firing
- Task 33: Gasification of Biomass and Waste

- Task 34: Direct Thermochemical Liquefaction
- Task 36: Integrating Energy recovery into Solid Waste Management Systems
- Task 37: Energy from Biogas
- Task 38: Climate Change Effects of Biomass and Bioenergy Systems
- Task 39: Commercialising of Conventional and Advanced Liquid Biofuels from Biomass
- Task 40: Sustainable biomass markets and international bioenergy trade to support the biobased economy
- Task 41: Bioenergy Systems Analysis
- Task 42: Biorefining in a future BioEconomy
- Task 43: Biomass Feedstocks for Energy Markets

Members of IEA Bioenergy are invited to participate in all of the Tasks, but each Member is free to limit its participation to those Tasks which have a programme of special interest. The Task participation during 2016 is shown in Appendix 1.

A progress report for IEA Bioenergy for the year 2016 is given in Sections 1 and 2 of this Annual Report.

ExCo77 study tour group on visit to Bruni Enrico e Aldo Società Agricola farm near Rome.

Progress Reports

1. THE EXECUTIVE COMMITTEE

Introduction and Meetings

The Executive Committee (ExCo) acts as the 'board of directors' of IEA Bioenergy. The committee plans for the future, appoints persons to do the work, approves the budget, and, through its Members, raises the money to fund the programmes and administer the Agreement. The Executive Committee also scrutinises and approves the programmes of work, progress reports, and accounts from the various Tasks within IEA Bioenergy. Other functions of the ExCo include publication of an Annual Report, production of newsletters and maintenance of the IEA Bioenergy website. In addition the ExCo produces technical and policy-support documents, and organises workshops and study tours for the Member Country participants.

The 77th ExCo meeting took place in Rome, Italy on 17-19 May with 41 participants. The 78th ExCo meeting was held in Rotorua, New Zealand on 9-11 November and there were 24 participants. Pharoah Le Feuvre represented IEA Headquarters at ExCo77.

Kees Kwant of The Netherlands chaired both ExCo meetings in 2016 with Sandra Hermle of Switzerland in the role of Vice-chair at ExCo77. At ExCo78, Kees Kwant was re-elected as Chair and Jim Spaeth was elected as Vice-chair for 2017.

Secretariat

The ExCo Secretariat is currently based in Dublin, Ireland under the Secretary, Pearse Buckley. The fund administration for the ExCo Secretariat Fund and Task funds is consolidated with the Secretariat, along with production of ExCo publications and newsletters, and maintenance of the website.

The contact details for the Executive Committee can be found in Appendix 7 and for the Secretariat on the back cover of this report. The work of the ExCo, with some of the achievements and issues during 2016, is described below.

Implementing Agreement

The current term of the IEA Bioenergy Technology Collaboration Programme (TCP) ends on the 29th February 2020.

Contracting Parties/New Participants

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

Estonia is expected to join the TCP in 2017. There are ongoing discussions with China, Mexico, India, Indonesia and Poland with a view to engaging them in IEA Bioenergy.

Supervision of Ongoing Tasks, Review and Evaluation

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

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

Approval of Task and Secretariat Budgets

The budgets for 2016 approved by the Executive Committee for the ExCo Secretariat Fund and for the Tasks are shown in Appendix 2. Total funds invoiced in 2016 were US$1,759,200, comprising US$252,100 of ExCo funds and US$1,507,100 of Task funds. Appendix 2 also shows the financial contributions made by each Member Country and the contributions to each Task. Very substantial 'in-kind' contributions are also a feature of the IEA Bioenergy collaboration but these are not shown because they are more difficult to recognise in financial terms.

Fund Administration

The International Energy Agency, Bioenergy Trust Account, at the Bank of Ireland Global Markets in Dublin is working well. The Trust Account consists of a Call Deposit account and a Fixed Deposit account both of which bear interest. The Call Deposit account is accessed electronically while the Fixed Deposit account is accessed through the Bank's dealers. Both accounts are denominated in US dollars. The currency for the whole of IEA Bioenergy is US dollars. Details for making payments are:

Arrange an International Telegraphic Transfer/Swift Money Transfer in **US$ only** to:

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

The main issues faced in fund administration are slow payments from some Member Countries and fluctuations in exchange rates. As of 31 December 2016, there was US$88,200 of Member Country contributions outstanding.

At ExCo78, unanimous approval was given to the appointment of KPMG, Dublin as independent auditor for the ExCo Secretariat Fund until 31 December 2018. The audited accounts for the ExCo Secretariat Fund for 2015 were approved at ExCo77.

The Tasks also produce audited accounts. These are prepared according to guidelines specified by the ExCo. The accounts for the Tasks for 2015 were approved at ExCo77, except for Tasks 38 and 39. The accounts for Task 39 were approved by written procedure in August, while those for Task 38 were outstanding on the 31st December 2016.

The audited accounts for the ExCo Secretariat Fund for the period ended 31 December 2016 have been prepared and these will be presented for approval at ExCo79 in Gothenburg.

Task Administration and Development

Task Participation

In 2016 there were 98 participations in 10 Tasks. Please see Appendix 1 on page 93 for a summary of Task participation.

There were three active projects under Task 41 and three Inter-Task projects in 2016 – see below under '**Strategic Fund/Strategic Outputs**'.

Strategic Planning and Strategic Initiatives

Strategic Plan

The Strategic Plan 2015-2020 continues to be the guiding document for the IEA Bioenergy work programme. It has an emphasis on optimising the economic, environmental and social value of sustainable bioenergy, including some focus on biorefinery value chains. The implementation of the plan can be expected to

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

Technical Coordinator

Luc Pelkmans completed his first year in the role of Technical Coordinator. At ExCo78, following a positive evaluation by the Chair, including input from ExCo Members and the Secretary who had regular interaction with the Technical Coordinator, the ExCo unanimously approved an extension to his contract to the end of 2018.

During 2016, the activities of the Technical Coordinator included facilitating and planning increased collaboration between the Tasks, maintaining links with IEA Headquarters, engaging with other international organisations, including FAO, IRENA and GBEP, and organising and publishing (in conjunction with the Secretary) the ExCo workshops. Successful workshops were organised at ExCo77 in Rome and ExCo78 in Rotorua and the *ExCo77 – Mobilising sustainable bioenergy supply chains: Opportunities for agriculture -*

Summary and Conclusions has been published. The Technical Coordinator has had significant involvement in the Inter-Task and Task 41 projects and has provided important input to these activities. He has also played a leading role in the production of the series of IEA Bioenergy webinars.

Communication Strategy

The Executive Committee has continued its focus on the communication strategy through the work of the Communications' Team. A number of actions have been further developed during 2016, including the use of social media, particularly through Twitter. Each new IEA Bioenergy publication is announced on Twitter. Another method that has been implemented in 2016 is the production of webinars. In 2016 five successful webinars were held. The recordings and presentations of each of these are available for free download at http://www.ieabioenergy.com/iea-publications/webinars/. With regard to important reports coming from both the Executive Committee and the Tasks, a decision was taken to provide two-page summaries to make the outputs more accessible to time constrained stakeholders and decision makers. This resulted in five of these summaries being published over the course of the year.

Strategic Fund/Strategic Outputs

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

Progress with strategic initiatives has continued. The summary and conclusions from the ExCo77 workshop 'Mobilising sustainable bioenergy supply chains: opportunities for agriculture' has been formally published and can be download at http://www.ieabioenergy.com/publications/exco77-mobilising-sustainable-bioenergy-supply-chains-opportunities-for-agriculture-summary-and-conclusions-23-08-16/. Publications from other ExCo workshops are available at http://www.ieabioenergy.com/iea-publications/workshops/.

Algae Review: Following comments from ExCo members a final version was sent for external peer review which was completed by the end of 2016. The report will be published early in 2017. Some of the key messages include the high photosynthetic efficiency of algas, the growth in the algae-based products industry and the potential to use algae in an integrated biorefinery context, while acknowledging the challenge posed by current low oil and natural gas prices and the absence of consistent policies on carbon pricing.

Task 41 Project 5: Bio-CCS/CCUS: This two-year project is continuing with two workshops on concepts and sustainability having been completed and two further workshops to follow in 2017. Summary reports for the first two workshops are available at http://task41project5.ieabioenergy.com/iea-publications/.

Task 41 Project 6: Bioenergy and Grid Storage: This project aims to identify those areas in the grid system where bioenergy in balancing the grid and providing storage options can play a strategic role, and to promote the commercialisation of a diverse set of such bioenergy applications and processes. In addition, it seeks to identify and disseminate sound business models for practical, cost-effective and environmentally friendly ways to facilitate the transformation of the electricity grid based to a great extent on bioenergy technologies. In addition to market prospects, the report, which will be published early in 2017, will put forward suggestions for policy and RTDD options.

Task 41 Project 7: Bioenergy RES Hybrids: This one-year project (http://task41project7.ieabioenergy.com/) looks at some of the ways that bioenergy can be integrated with other renewable energy sources to achieve one or more of flexible generation, flexible storage of variable renewable energy (VRE) and increased overall efficiency of biomass use. The project has developed a series of key findings for domestic applications, utility scale and district heating and cooling networks, industry and farm scale applications. The report, which will be published in the first quarter of 2017, includes three country reports on the status of bioenergy RES hybrids – for Austria, Finland and Germany.

Inter-Task Project: Bioenergy Success Stories: A project template has been developed and the first examples will be produced in the first quarter of 2017. Input will be provided by both Executive Committee members and Task Leaders.

Inter-Task Project: Measuring, governing and gaining support for sustainable bioenergy supply chains: The project has three objectives: (i) an overview of calculation methods; (ii) approaches on how to govern; and (iii) to understand the positions and motivations of stakeholders. The case studies will cover (a) biogas production in Germany, (b) forestry in the USA, (c) agriculture in the USA and (d) forestry in Canada. A final workshop will be held in conjunction with the IEA Bioenergy Conference 2018.

Inter-Task Project: Fuel pre-treatment of biomass residues in the supply chain for thermal conversion: The goal of the project is to expand the biomass resource base. It seeks to demonstrate this with examples. Seven case studies will show how new pre-treatment technologies can be instrumental in improving the efficiency and cost effectiveness of using various low grade biomass resources for thermal conversion. The project will be completed in the second quarter of 2018.

Countries' Report: The first IEA Bioenergy Countries' Report was published in 2016. It presents a summary of the total primary energy supply (TPES) by resources and the contribution of bioenergy in the member countries of the IEA Bioenergy Technology Collaboration Programme (TCP). It also includes a unique collation of bioenergy R&D and policy in these countries.

Database for IEA Bioenergy: The IEA Bioenergy Database, which is a global database of biomass conversion facilities, including advanced biofuels, combustion, gasification and pyrolysis plants and biorefineries, was completed in 2016 and is available at http://www.ieabioenergy.com/installations/.

ExCo Workshops

At ExCo77 in May a successful workshop was held on the topic of 'Mobilising sustainable bioenergy supply chains: opportunities for agriculture'. This workshop was organised in collaboration with Gestore dei Servizi Energetici (GSE), The Food and Agriculture Organisation of the United Nations (FAO) and The International Renewable Energy Agency (IRENA) and resulted in the preparation of a messages paper on bioenergy, which will be published in the first quarter of 2017. In November at ExCo78 a successful workshop on the topic of 'Drop-in biofuels for international marine and aviation markets' was held.

Seminars, Workshops, and Conference Sessions

A large number of seminars, workshops, and conference sessions are arranged every year by individual Tasks within IEA Bioenergy. This facilitates effective exchange of information between the participants and information transfer to stakeholders. These meetings are described in the progress reports from the Tasks later in this Annual report. The papers presented at some of these meetings are listed in Appendix 4. Examples of this outreach are:

- Task 32 organised a highly successful workshop on 'Emission reduction in stoves and boilers' as an integral part of the 21th Nanoparticle Conference in Zürich, Switzerland in June, 2016
- Task 36 organised a workshop which was focused on the development of mechanical biological treatment (MBT) and Waste-to-Energy (WtE) in sustainable waste management in Rome in May 2016 together with ATIA ISWA Italia and RSE
- Task 40 had a number of activities including two breakfast sessions and one presentation during the 6th Annual USIPA Exporting Conference, on November 6-8, 2016
- Task 42 progress meeting in Brisbane on the 14 – 18 November 2016 was coupled with the Bioenergy Australia 2016 Conference where Task 42 provided five lectures.

Collaboration with International Organisations and Implementing Agreements

Advanced Motor Fuels Implementing Agreement

IEA Bioenergy and the Advanced Motor Fuels (AMF) Technology Collaboration Programme continue to maintain close communications. This is facilitated, particularly through participants who are directly involved in both TCPs. The work programmes of each are reviewed regularly to identify further opportunities for collaboration.

GBEP

The collaboration in the framework of GBEP Activity Group 6 has proved to be very successful and the joint report Examples of Positive Bioenergy and Water Relationships includes examples that illustrate an encouraging variety both in terms of bioenergy systems and geographical distribution, and shows how solutions can be found that produce bioenergy while contributing positively to the state of water. Discussions are continuing to see how the collaboration can be continued both in the context of Activity Group 6 and regarding GBEP indicators.

FAO

The collaboration with FAO under the MoU signed in 2000 included a joint workshop (also including IRENA - see below) at ExCo77 in Rome in May 2016 with the theme 'Mobilising sustainable bioenergy supply chains: opportunities for agriculture'. Further communication with FAO has identified a number of other areas with potential for effective cooperation and the potential to hold a joint workshop on the theme of biorefineries in the bioeconomy is being examined

IRENA

The collaboration with IRENA during 2016 included a joint workshop (also including FAO - see above) at ExCo77 in Rome. There was a further related workshop in Berlin in September, which looked at the assumptions around estimates of biomass resources and sought to develop resource estmates that were well founded. IEA Bioenergy and IRENA have agreed to review outputs from each other's work programmes and potentially cooperate in future joint activities.

SE4ALL

IEA Bioenergy has signed a Memorandum of Understanding on participation in the Steering Committee of SE4ALL's high impact opportunities (HIO) initiative. A number of opportunities for collaboration with SE4ALL have been identified including the Biofuels Below 50 Initiative, in which IEA Bioenergy is represented by Task 39.

Promotion and Communication

The effective communication of IEA Bioenergy activities and information to stakeholders, in particular to decision makers, is a key priority of ExCo, which is re-emphasised in the new Strategic Plan 2015-2020. The wide range of promotional material available through the Secretariat includes Annual reports, technical brochures, copies of IEA Bioenergy news, the new Strategic Plan, strategic papers, and workshop proceedings. The IEA Bioenergy website is central to this publishing activity.

The 2015 Annual report with the special colour section on "*Energy, Fuels and Fertiliser from Biogas*", was very well received. Some copies from the original print run of 600 remain, with substantially increased distribution in electronic format.

The newsletter 'IEA Bioenergy News', which is distributed in June and December each year following the ExCo meetings, continues to be widely circulated. Two issues were published in 2016. As a special theme the first issue featured bioenergy in Italy and the second issue featured bioenergy in New Zealand. The newsletter is also produced in electronic format and is available from the IEA Bioenergy website. A single page electronic newsletter covering recent ExCo and Tasks' activities was also produced and distributed at the end of March and September 2016. A free subscription to the Agreement newsletters is offered to all interested and there is a wide distribution outside of the normal IEA Bioenergy network.

Two contributions under the banner of 'IEA Bioenergy Update' were provided to the journal Biomass and Bioenergy in 2016 bringing the total to 61. This initiative provides excellent access to bioenergy researchers as the journal finds a place in major libraries worldwide.

Interaction with IEA Headquarters

There is continuing contact between the IEA Bioenergy Secretariat, and IEA Headquarters in Paris and active participation by ExCo representatives in relevant meetings. The Chairman, Technical Coordinator, Secretary, and key Task Leaders have worked closely with Headquarters staff at both administrative and technical levels. In 2016 the Technical Coordinator has reviewed the IEA Medium-Term Renewable Energy Market Report (MTRMR) 2016 and provided input on behalf of IEA Bioenergy. He has also had regular engagements to facilitate information exchange from IEA Bioenergy to IEA Headquarters and vice-versa.

The Chair of IEA Bioenergy, Kees Kwant, attended the REWP meeting in Paris in March. He also attended the REWP meeting in October in Beijing and presented the IEA Bioenergy Annual Briefing report to the IEA.

Pharoah Le Feuvre attended ExCo77 on behalf of IEA Headquarters. This participation by Headquarters is appreciated by the Members of the ExCo and helps to strengthen linkages between the Implementing Agreement and relevant Headquarters initiatives.

Status reports were prepared by the Secretary and forwarded to the Desk Officer and the REWP following ExCo77 and ExCo78. Information was also sent to Carol Burelle, Vice Chair of the End Use Working Party (EUWP) for the Transport sector. This forms part of the exchange of information between Implementing Agreements and the Working Parties. Regular contributions are provided to the IEA OPEN Energy Technology Bulletin. This provides a very useful platform for distributing the IEA Bioenergy newsletter and publications to stake holders. The Bulletin is also one of the most used referral mechanisms for introduction to the IEA Bioenergy website.

IEA Bioenergy Website

The IEA Bioenergy website (www.ieabioenergy.com) has had incremental development in 2016. The content has been updated as required during the year.

From the website statistics for the year 2016 the key data were as follows:

- Total number of users: 23,360
- Total number of sessions: 33,700
- Total number of page views: 139,150

2. PROGRESS IN 2016 IN THE TASKS

TASK 32: Biomass Combustion and Co-firing

Overview of the Task

Task 32 aims to stimulate expansion of biomass combustion and co-firing for the production of heat and power on a wider scale. The widespread interest in the work of the Task illustrates the relevance of biomass combustion and co-firing in society. Combustion applications vary from domestic woodstoves to industrial combustion technologies, dedicated power generation and co-firing with conventional fossil fuels.

Biomass combustion technologies are commercially established with high availability and a multitude of options for integration with existing infrastructure on both large and small-scale levels. Nevertheless, there are still a number of challenges for further market introduction, the importance of which varies over time. The areas covered by the Task through different activities in this new triennium are:

- WP1. Decentralised heat production
- WP2. Efficient industrial combustion and CHP
- WP3. Near zero emissions from industrial combustion
- WP4. Cofiring and full conversion
- WP5. Low grade fuels and fuel pretreatment
- WP6. Climate impact of biomass combustion and bio-CCS
- WP7. Dissemination and outreach

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

While most of the above areas are of a technical character, Task 32 also addresses non-technical issues on fuel logistics and contracting, environmental constraints and legislation, public acceptance and financial incentives. An example is the policy report on renewable heat, which is currently being drafted.

Participating countries: Austria, Belgium, Canada, Denmark, Germany, Ireland, Italy, Japan, The Netherlands, Norway, South Africa, Sweden, and Switzerland.

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

Sub-Task Leader for Co-firing: Marcel Cremers, DNV-GL, The Netherlands

Sub-Task Leader for Industrial Combustion: Claes Tullin, SP, Sweden

Sub-Task Leader for Small Scale Combustion: Thomas Nussbaumer, Verenum, Switzerland

Operating Agent: Ir Kees Kwant, NL Enterprise Agency, The Netherlands

The Task Leader directs and manages the work programme, assisted by sub-task leaders for specific areas. A National Team Leader from each country is responsible for coordinating the national participation in the Task.

For further details on Task 32, please refer to Appendices 2, 4, 5 and 6; the new Task website task32.ieabioenergy.com and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

In 2016, the Task organised two internal meetings and an expert workshop. The internal meetings were used to monitor progress in different Task activities and plan and reflect on new Task activities. Another important aspect of all task meetings is the sharing of developments on application of biomass combustion in member countries of the Task.

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

In June 2016, a highly successful workshop on 'Emission reduction in stoves and boilers' was organised as an integral part of the 21th Nanoparticle Conference in Zürich, Switzerland. The workshop itself was attended by approx. 150 participants, varying from researchers to medical doctors, policy makers and representatives from biomass stove and boiler manufacturing industries. The workshop again showed that adverse health impacts may arise when wood is burned inappropriately in a suboptimal stove. However, the workshop also showed that the emissions can be acceptable for society if the correct fuel is burned in a modern stove or boiler. The most optimal situation arises with automatically controlled combustion systems, equipped with state of the art emission abatement equipment.

However, even for such cases it remains difficult to convince the general public, as the difference in emission levels is not always clear to the general public. There is therefore a continuous need for improved information generation. With the planned generation of deliverables D7, D14, D1 and D5 (see below), this topic will remain of key importance in the work of Task 32 in the coming years.

In early October 2016, Task 32 held a meeting with Japanese stakeholders on bioenergy, to discuss how the biomass supply chain could be further improved in Japan.

On 27 October, there was a live webinar to present the results of a report published in 2015 on the status of commercialisation of torrefaction technologies.

Several other workshops will take place in the current triennium. All workshop reports can be downloaded from the Task 32 website. Reports from internal Task meetings are available to member countries only, using login credentials.

Work Programme

The progress achieved during 2016 in the finalisation of the previous work programme and the start of the new triennium 2016-2018 is shown below:

From the previous triennium 2013-2015:

The status of large scale biomass firing - The milling and combustion of biomass materials in large pulverised coal boilers.

This report describes the history and actual status of biomass cofiring, with lessons learned in addressing technical issues related to biomass cofiring and an outlook for future development.

Technical report on particle emission measurement techniques for boilers and stoves

This report aims to summarise the opportunities for different particle emission measurement techniques and provide recommendations as to which method should be used in future. After a discussion on the results of recent relevant research projects at the Task meeting in Switzerland (June 2016), a draft report was prepared by TFZ and discussed at the Task meeting in Japan (Oct 2016). The report will be endorsed at the next Task meeting (June 2017).

Policy paper with background report on the health impact of combustion aerosols

This concerns a policy paper with a background report of emission factors and health related impacts of emissions from various biomass fired stoves and boilers. Based on the results of the Zürich workshop, a policy paper was published. The background report will be finalised in early 2017 in order to include the latest research results.

New activities for 2016-2018:

D1. Strategic study on the potential for renewable heat from biomass boilers, including options for optimal technical integration of biomass boilers with other renewable energy forms for heat (for policy makers and equipment manufacturers).

This study was started in 2016. It will provide an insight into how biomass can be optimally used to provide heat in the future energy system. The work is cofunded by the Swedish Energy Authority. In 2016 the approach was discussed and refined, and the project will continue in 2017-2018.

D2. Contribution to the Strategic Study on Bioenergy Hybrids (Inter Task project).

This strategic study is carried out to explore how bioenergy can be optimally integrated with other forms of renewable energy. In 2016 Task 32 provided input to this project in the form of specific case studies. The work was finalised in 2016, see http://task41project7.ieabioenergy.com.

D3. State of the art report on application of biomass combustion based CHP with case studies and identification and assessment of innovative developments (for potential end users)

This report will provide an insight into the success factors for the application of biomass CHP on the basis of actual installations. It will also provide an insight into new developments on small scale CHP technologies. A proposal for this action was discussed at the first Task meeting and refined at the second. The actual work will be performed mostly in 2017.

D5. Report on consequences of real life operation on boiler performance (efficiency and emissions (for policy makers)

Emissions of biomass boilers and stoves are recognised as one of the most important aspects of biomass combustion at present, and therefore receive significant attention in the upcoming years. This project recognises that there may be significant differences between emissions during type approval, and real life emissions. The project evaluates new measurement methods for stoves and boilers through two reports and a workshop, most of the work to be done in 2017.

D6. Workshop on options for cofiring in existing and new power plants (for power producers)

At the first Task 32 meeting in 2016 it was agreed to organise a workshop on biomass cofiring at the Wood Pellets Association Conference in Vancouver, Canada in Q3 2017.

D7. Review on the implication of high percentage cofiring on fly ash utilisation (for policy makers and traders)

This project was recently started under the coordination of DNV-GL with input from VGB, ECOBA, Vliegasunie, ESKOM, OPG, and other power utilities. It should review current uses of biomass ashes and provide recommendations for improved use. A draft report is planned for March 2017, with the final report in July 2017.

D8. Updated cofiring database (for utilities)

This database contains information on coal fired power plants where there is experience in biomass cofiring. As in other years, a number of records were updated or added in 2016.

D10. Inter Task project to evaluate the costs/benefits for fuel pretreatment of biomass residues in the supply chain for thermal conversion (with Task 33, 34, 36, 40 and 43)

This is a project jointly carried out with Task 33, 34, 36, 40 and 43, under the guidance of Task 32. It consists of six case studies that describe how pretreatment of biomass can make the fuel supply chain more cost effective and efficient, or help to broaden the resource base. In addition, good examples of new companies converting biomass from one form to another will be included as a new database module in the existing IEA Bioenergy Technology database. In 2016, the cases were defined and a start was made to performing the analyses.

D11. Inter Task study with Task 32, Task 33, Task 38, and IEA GHG to identify options for bio-ccs.

This inter Task study identifies options for biomass based carbon capture and storage, which would lead to negative carbon emissions. Task 32 was involved by providing information on two case studies of Bio CCU: (1) production of sodium bicarbonate from CO_2 in WtE plant and (2) CO_2 capture for greenhouse fertilisation. In 2016, two workshops were held in the framework of this project, see http://task41project5.ieabioenergy.com.

Website

The Task website (www.ieabioenergytask32.com) attracts about 4,000 visitors every month and is one of the key tools for information dissemination. The main products that are being downloaded from the website are publications and meeting reports, the database on experience with biomass co-firing in different power plants, and the databases on the composition of biomass and ash from actual combustion plants. The website is updated on a regular basis. In 2016, two electronic newsletters were produced and distributed to provide information on developments related to the work of the Task, and on biomass combustion and co-firing in general. Task participants and ExCo Members can obtain access to a secured section of the website which includes internal reports and work in progress.

Collaboration with Other Tasks/Networking

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

Deliverables

The following milestones were achieved in 2016. Organising and minuting of two Task meetings. Organising and reporting on a workshop on 'Emission reduction in stoves and boilers'; Publication of reports on 'The status of large scale biomass firing', and a policy statement on 'the need for reduction of particle emissions'. Furthermore there was a 'webinar on the status of torrefaction technologies', updating of the international overview of initiatives for biomass co-firing; and maintenance of the Task website. The Task also produced progress reports and audited accounts for the ExCo.

TASK 33: Gasification of Biomass and Waste

Overview of the Task

The objectives of Task 33 are (1) to promote commercialisation of biomass gasification, including gasification of waste, to produce fuel and synthesis gases that can be subsequently converted to substitutes for fossil fuel based energy products and chemicals, and lay the foundation for secure and sustainable energy supply; (2) to assist IEA Bioenergy Executive Committee activities in developing sustainable bioenergy strategies and policy recommendations by providing technical, economic, and sustainability information for biomass and waste gasification systems.

Participating countries: Austria, Denmark, Germany, Italy, The Netherlands, Norway, Sweden, Switzerland and USA.

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

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

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

For further details on Task 33, please refer to the Task website task33.ieabioenergy.com and the IEA Bioenergy website www.ieabioenergy.com under "Our Work: Tasks."

Progress in R&D

Task Meetings and Workshops

The first Task 33 meeting for 2016 was held 24-26 May in Trondheim, Norway. The Task business meeting was held on the first day and a workshop entitled "Aviation Biofuels through Biomass Gasification," jointly hosted by SINTEF's GAFT programme, was held on the

second day. The third day included technical tours to the SINTEF Energy Laboratory and the Statkraft Varme AS waste incinerator.

The second Task 33 meeting was held 25-27 October 2016 in Lucerne, Switzerland, and was hosted by the Swiss Federal Office of Energy and Lucerne University of Applied Sciences and Arts. The Task business meeting was held during the first day and a workshop "Gas Sampling, Measurement and Analysis (GSMA) in Thermal Gasification Processes" was held the second day. Technical tours to a gasification-based CHP plant Holzverstromung Nidwalden in Stans, Switzerland, as well as a visit to the KVA municipal solid waste incinerator in Bern were conducted during the third day.

Work Scope, Approach and Industrial Involvement

The scope of work for the current triennium is built upon the progress made in the previous triennia. In the previous years, information exchange, investigation of selected sub-Task studies, promotion of coordinated RD&D among participating countries, selected plant visits, and industrial involvement in technical workshops at Task meetings have been very effective. These remain the basic foundations for developing and implementing a programme of work that addresses the needs of the participating countries.

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

The Task monitors the current status of key operations and R&D efforts relating to biomass and waste gasification, and identifies hurdles to advance further development, operational reliability, and economics of gasification systems. The Task meetings provide a forum to discuss the technological advances and issues critical to scale-up, system integration, and commercial implementation of these processes. These discussions lead to selection of sub-Task studies and/or technical workshops that focus on advancing the state-of-the-art technology and identify the options to resolve barriers to technology commercialisation.

The Task has continued the practice of inviting industrial experts to the Task workshops to present their practical experiences and to discuss the options for development of critical process components to advance state-of-the-art biomass and waste gasification systems. The interaction with industry provides the opportunity for the National Team Leaders (NTLs) to evaluate refinements to existing product lines and/or processes. Academic experts are also invited to share information and foster cooperation in order to address and support basic research needs.

Work Program/Sub-Task Studies

The current work programme includes the following elements:

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

Meeting	Associated Workshop	Dates and Location
1st Task meeting	Aviation Biofuels through Biomass Gasification	24-26 May 2016 Trondheim, Norway
2nd Task meeting	Gas Sampling, Measurement and Analysis (GSMA) in Thermal Gasification Processes	25-27 October 2016 Lucerne, Switzerland

- Prepare and publish reports on issues relating to gasification of biomass and waste. During year 2016 the following reports were finalised and published on the Task 33 website.
  - **Performance test protocol for small scale gasifiers** – Provides useful information for suppliers and end-users of small-scale gasifiers to ensure that system performance is commensurate with what was agreed upon.
  - **Status report on thermal biomass gasification in countries participating in IEA Bioenergy Task 33** – Provides an overview of biomass gasification facilities, as well as highlights of important facilities.
- Survey the current global biomass and waste gasification RD&D programmes, commercial operations and market opportunities for gasification, and identify the technical and non-technical barriers to commercialisation of the technology. Use the survey results to prepare and update Country Reports for information dissemination.
- Conduct joint studies, conferences, and workshops with related Tasks, Annexes, and other international activities to address issues of common interest to advance biomass and waste gasification technology.
- Identify research and technology development needs based on the results from the work described above as a part of the workshop reports.
- Publish results of the work programme on the Task website (task33.ieabioenergy.com) for information dissemination. Maintain the website with Task updates.
- Maintain Task 33 database on thermal gasification facilities worldwide.

Observations from Workshop 1: *Aviation Biofuels through Biomass Gasification*

The workshop took place in Trondheim, Norway and was co-organised by IEA Bioenergy Task 33 and SINTEF's programme on Gasification and FT-Synthesis of Lignocellulosic Feedstocks (GAFT). The workshop focused on opportunities for production of aviation biofuels through gasification coupled with downstream synthesis, and considered both technological, economic and policy aspects. Workshop presentations are summarised below.

Opening session

- **About the GAFT project**
  Roger Khalil, SINTEF, Norway
- **The role and importance of aviation biofuels**
  Sierk de Jong, Utrecht University, The Netherlands and SkyNRG

Aviation biofuels production via gasification

- **Impact of torrefaction on fuel properties of woody biomass**
  Liang Wang, SINTEF, Norway
- **Bioliq® BtL Pilot Plant**
  Thomas Kolb, Karlsruhe Institute of Technology, Germany
- **Güssing – Small scale gasification-FT**
  Reinhard Rauch, TU Vienna, Austria

Aviation biofuels production from syngas

- **Status and developments in Fischer-Tropsch synthesis**
  Erling Rytter, NTNU, Norway
- **FT catalysts for direct conversion of biomass-derived syngas to jet fuel**
  Rune Myrstad, SINTEF, Norway

Viability of aviation biofuels – how to increase market uptake

- **Viability of aviation biofuels – a general overview**
  Sierk de Jong, Utrecht University, The Netherlands and SkyNRG
- **Optimal strategies for production of jet-biofuels via EF gasification based on co-processing woody biomass and wet organic waste**
  Gonzalo del Alamo, SINTEF, Norway

Aviation biofuels strategies and experiences

- **Recent developments in gasification-based aviation biofuels in the U.S.**
  Zia Haq and Borka Kostova, U.S. Dept of Energy, USA
- **Introducing aviation biofuels into Gardermoen Airport's fuel distribution infrastructure**
  Olav Mosvold Larsen, Avinor, Norway

Observations from Workshop 2: *Gas Sampling, Measurement and Analysis (GSMA) in Thermal Gasification Processes*

The workshop was held at Lucerne University of Applied Sciences and Arts and was hosted by the Swiss Federal Office of Energy and Task 33. The workshop focused on challenges and the state of the art in measurement and analysis of components present in syngas from thermal gasification processes. Presentations represented an array of contributors, from fundamental research to industrial-scale application. Workshop presentations are summarised below.

General overview for energy gas applications

- **Overview energy gas specifications**
  Martin Seifert, SVGW Switzerland
- **Just add hydrogen - Making the most out of a limited resource**
  Ilkka Hannula, VTT Finland
- **Gasification and combustion, comparison of the potential**
  Thomas Nussbaumer, Verenum, IEA Task 32 Bioenergy

Gas sampling, measurement and analysis science

- **Gas analysis working group (GAW): Status and perspectives**
  York Neubauer, TU-Berlin; Serge Biollaz, PSI
- **Measurement and characterisation of tars using the SPA method On-going developments on tar analysis**
  Kevin Whitty, University of Utah USA and Klas Engvall, KTH Sweden
- **Synergies in gas sampling research Task 32 and Task 33**
  Thomas Nussbaumer, Simon Roth, Peter Zotter, Bioenergy Research Group, Lucerne University of Applied Sciences

Gas sampling, measurement and analyses on pilot, demonstrations and early commercials

- **GSMA on the Bioliq process**
  Mark Eberhard, KIT Karlsruhe, Germany
- **GSMA in Güssing**
  Reinhard Rauch, TU-Wien, Austria
- **GSMA at the CHP-plant Stans**
  Bernhard Boecker-Riese, BR-Engineering
- **Laws and proof of legal emissions from biomass conversion installations**
  Christoph Baltzer, BECO – Dept. Environment Bern Switzerland
- **Gas quality and conversion of biogas (gas turbines and gas engines)**
  Jürgen Karg Siemens AG Power and Gas Division, Erlangen Germany

All of the workshop presentations as well as the workshop report can be found at the Task 33 website (task33.ieabioenergy.com).

Website and database

The Task website (task33.ieabioenergy.com) is the most important tool for dissemination of information and results from this Task. Descriptions of the gasification process and a description of the Task including the contact data of national experts are provided. Within 2 weeks after each Task meeting, all presentations in PDF form (Country Reports, Workshop presentations) can be found on the Task website. The Minutes are posted on the members area of the website as soon as all Task members provide their feedback. The summaries of the workshops can be found on the website in a Report form.

A Google-map based interactive database of implementations of gasification plants has been incorporated into the Task website. At the moment, there are over 150 gasification facilities, mostly in member countries, registered in the database. The database is interactive, which means that the technology, type, and status of the gasifiers can be chosen to filter all the gasification facilities registered in the database. The database is updated regularly and provides a good overview on gasifiers throughout the world.

In 2016 a status report on thermal biomass gasification in member countries was completed. The report includes the description of the technology, synthesis gas applications and a list of all biomass gasification facilities in member countries, which are active in the Task 33 database.

Deliverables

The Task deliverables include planning and conducting two semi-annual Task meetings focused on the workshops selected by the Task participants, involving academic and industrial experts; the preparation and distribution of workshop reports and newsletter; updating and publishing country reports; conducting joint studies, conferences, and workshops with related Tasks, Annexes, and other international bodies to address mutually beneficial issues; and preparation of periodic progress, financial and annual reports as required by the IEA Bioenergy Executive Committee (ExCo).

TASK 34: Direct Thermochemical Liquefaction

Overview of the Task

The overall objective of the continuing Task is to facilitate commercialisation of liquid fuels from biomass and particularly fast pyrolysis and hydrothermal processing to maximise liquid product yield and production of renewable fuel oil and transportation fuels. The Task will contribute to the resolution of critical technical areas and disseminating relevant information particularly to industry and policy makers. The scope of the Task will be to monitor, review, and contribute to the resolution of issues that will permit more successful and more rapid implementation of biomass liquefaction technology, including identification of opportunities to provide a substantial contribution to bioenergy. This will be achieved by all the activities described in Work Programme below.

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

The work of the Task will address the concerns and expectations of the following:

• Conversion technology developers	• Bio-oil/biocrude application developers
• Equipment manufacturers	• Bio-oil users
• Chemical producers	• Utilities providers
• Policy makers	• Decision makers
• Investors	• Planners
• Researchers	

Industry will be actively encouraged to be involved as Task participants, as contributors to Workshops or Seminars, as Consultants, or as technical reviewers of Task outputs to ensure that the orientation and activities of the Task match or meet their requirements.

Participating countries: Canada, Finland, Germany, The Netherlands, Sweden, New Zealand, and USA

Task Leader: Mr Alan Zacher, Pacific Northwest National Laboratory, USA

Operating Agent: Mr Jim Spaeth, US Department of Energy, USA

The Task Leader directs and manages the work. A National Team Leader from each country is responsible for coordinating the national participation in the Task. For further details on Task 34, refer the Task website task34.ieabioenergy.com and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Progress in R&D

Task Meetings

The first Task meeting in 2016 was scheduled for June 13-15 in Luleå/Piteå, Sweden, but was postponed and modified due to last minute travel disruptions that prevented the Task members from travelling within Sweden to the final destination. It was planned for all member NTLs to convene and discuss the combined foci of pyrolysis and liquefaction, this to be followed by a domestic workshop in thermochemical liquefaction and upgrading of biomass commissioned by the Bothnia Bioindustries Cluster (BOBIC). While NTLs were en-route to Luleå, the first destination in northern Sweden, a domestic airline strike prevented them from reaching the final destination. Alternate routes to Luleå were unavailable, and after one day of delay, the decision was made to postpone the meeting when it became clear that the strike would continue through the period allotted for the Task meeting and Workshop.

The BOBIC workshop was also inaccessible to the Task 34 team, which was unfortunate as it had a well planned programme and included talks on Bioenergy commercialisation including from SunPine (byproducts to diesel and chemicals), Preem (renewable conventional motor fuel), EMPYRO (commercial pyrolysis project), followed by a panel discussion. Complementary research talks were planned in the areas of bio-oil fractionation in cyclone pyrolysis, co-gasification of pyrolysis oil with black liquor, liquefied biomass upgrading, and an additional panel discussions. Included in the programme were Technical Visits to LTU Green fuel for a demonstration of co-gasification, SP ETC for pyrolysis oil fractionation applied research, a tour of the SunPine mill at Haraholmen, and a discussion of the renewable diesel and chemicals produced from tall oil.

A modified programme for the workshop was held with the domestic participants, and presentations were provided from the international speakers who were unable to attend. Urgent items for the Task meeting were discussed via electronic communications and the priority discussions were postponed until after the holiday season.

The second Task meeting in 2016 was held in Rotorua, New Zealand on 7-8 November adjacent to ExCo78, the ExCo workshop on Marine and Aviation fuels, and the Advanced Biofuels Research Network symposium. The programme also included a tour of Scion.

Presentations were made by Task 34 NTLs to both the ExCo workshop and to the ABRN symposium. This proved an excellent opportunity to provide input and leadership in the area of advancing Marine and Aviation biofuels as well as identifying the future research needs and challenges posed by these industries. The ABRN conference provided a forum for establishing links with the New Zealand research community and an international dialogue on challenges faced by all.

Introductions:

Each of the participating countries were represented by their national team leaders or delegate: Fernando Preto, Canada; Christian Lindfors, Finland (attending for Anja Oasmaa; Nicholaus Dahmen, Germany; Bert van der Beld, The Netherlands; Ferran de Miguel Mercader, New Zealand; Magnus Marklund, Sweden; and Alan Zacher, US. Also in attendance were observers from participating countries: Antti Arasto, Finland; Kirk Torr, New Zealand, and Luc Pelkmans from ExCo.

The IEA Bioenergy Task 34 members at Scion in Rotorua, New Zealand

Participating Members Institutional Reports:

Reports from each of the NTLs on the current activities of interest were presented. As there had been a lot of changes in the NTLs, and as we had not met in a year, it was decided to also give a background on the participants as context. Presentations ran much longer than 10 minutes each, but it was valuable because a lot had changed with the addition of HTL and SvTL technologies to the Task.

Presentations on direct thermal liquefaction activities at their organisations were given by Fernando Preto (CanmetENERGY), Christian Lindfors (VTT), Nicolaus Dahmen (KIT), Bert van de Beld (BTG), Ferran de Miguel Mercader and Kirk Torr (Scion), Magnus Marklund (SP-ETC/RISE), and Alan Zacher (PNNL).

It was noted that the UK was currently not part of Task 34, and it was unclear if that would change this triennium. Norway was also not part of the Task and there was no additional news.

Systematisation of DTL technology elements, and potential brochure:

A discussion was held with regard to modifying the previous publication plan for the update of the pyrolysis brochure. It was recognised that a new format would be required in order to encompass the expanded focus on liquefaction technologies beyond pyrolysis. Nicholaus Dahmen presented a harmonised framework for seeing direct thermochemical liquefaction, with a presentation to set up the discussion and thoughts.

The value of the new systematisation:

1. Can highlight the differences and similarities among FP, HTL, SvTL and their various liquid products.
2. Creates a uniform framework for reports on DTL within our individual countries.
3. One possible output is a version of the pyrolysis brochure that can be a liquefaction brochure.
4. A good starting point for explaining why (or why not) a particular technology fits into the framework.
5. Shows the interfaces between the feedstock, outputs, and other Tasks
6. Can be the framework with which to navigate the technology in communications and on the webpage.

The effort will evolve into an update of the earlier IEA Bioenergy Biomass Pyrolysis document.

Round Robin:

A progress report on the draft manuscript for the prior round robin was given. The summary of this is captured in the Progress section.

Next Round Robin:

A presentation was made on the summary of historical rounds robin going back 20 years in the Task history in order to provide context for future rounds robin. It was identified that the next round robin should include HTL and SvTL elements in addition to pyrolysis in order to identify research linkages to prior research conclusions. Ten potential topics were identified, and will be decided upon prior to the next Task meeting.

Newsletter:

Writing assignments were made for the next issue of the newsletter due out in in early 2017.

Presentation of country reports:

Presentations were made by NTLs covering ongoing activities within the member countries. Presentations were extended due to the year hiatus since the last meeting and due to the addition of HTL and SvTL technologies to the Task.

Reports were given by Fernando Preto (Canada), Christian Lindfors (Finland), Nicolaus Dahmen (Germany), Bert van de Beld (The Netherlands), Ferran de Miguel Mercader (New Zealand), Magnus Marklund (Sweden), and Alan Zacher (USA).

Luc Pelkmans reported on the ExCo communication strategy.

The new transitional web page on the IEA bioenergy server was reviewed. It is acknowledged that it is currently under construction. Suggestions on improvements were made.

Task meetings for the rest of the Triennium were planned out as follows:

Q2 2017: Gothenburg Sweden.

Q3/Q4 2017 was proposed for Canada.

Q1/Q2 2018 in The Netherlands was offered as an option.

Q3/Q4 2018 in San Francisco was suggested in order to coincide with the end of the triennium ExCo.

Work Programme and Progress in 2015

Work under the DTL Task 34 primarily consists of publications and outreach, Task meetings, technical seminars, technical tours, and Task projects, in addition to management and ExCo support actions. The work efforts in 2016 included:

- A new Task website was commissioned at http://task34.ieabioenergy.com. Transition of historical resources and creation of new resources, particularly in support of the expanded focus on similar biomass thermochemical liquefaction technologies including, but not limited to, pyrolysis.
- The final version of the manuscript was completed in order to disseminate the results from the round robin on bio-oil production on research that concluded in 2015. As previously reported, sixteen laboratories in the six participating countries returned bio-oil samples produced from the three biomass feedstocks distributed. The product bio-oils were analysed by Thünen Institute. The manuscript detailing those results was submitted to the technical journal Energy and Fuels and will be published after incorporating peer reviewer revisions.
- The standards development effort in Europe continued forward. Pyne 39 contained a report on the current output, as several of the Task participants collaborated with other WG members in a technical publication on norms and standards for bio-oil.
- A continuing effort is the sharing of updated country reports by each of the participants at each of the Task meetings. These country reports are the basis for the continually updated Country Report portion of the Task website.
- Updates are being maintained on the web-based demo plant database developed by Bioenergy 2020+

Newsletter

The Task has continued the tradition of the PyNe newsletter, a pillar of the biofuels community dating back to 1996. This year, for the first time in 20 years, the focus of the newsletter was expanded beyond pyrolysis. Recent newsletter now features thermochemical liquefaction technologies including pyrolysis and solvent liquefaction. The prior newsletter contract was not renewed per guidance given to the Task by ExCo77 and the Task leader has assumed responsibility until more permanent arrangements can be made. This resulted in a delay during 2016. It is circulated to participants via the new Task 34 website in electronic format. Issue 39 was published in October 2016.

Website/Dissemination

The Task 34 website is an important mechanism for information and technology transfer. The website was transitioned to the ieabioenergy servers. The transfer of the website has resulted in some challenges in setting up a new face, but it has also provided an opportunity to update the format and information to modern standards and to incorporate the new focus on DTL. This is still a work in progress.

Deliverables

Deliverables for 2016 were: reporting to the ExCo (Annual Report, progress reports, and audited accounts); complete rebuild and updating of the Task website on bioenergy servers; Task newsletter; organisation and minutes of Task meetings. Completion and reporting of a Round Robin on bio-oil production.

TASK 36: Integrating Energy Recovery into Solid Waste Management Systems

Overview of the Task

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

of technical and policy changes in the waste area that impact the integration of energy into solid waste management; and to provide support by disseminating and exchanging information on these developments.

Waste production varies markedly across the work, in terms of composition and quantity. Strategies and solutions that are appropriate in one region may not be suitable elsewhere. The consequence of this is that countries have different approaches to challenges in waste arisings, reflected in different mixtures of treatment and disposal. Nevertheless there are also common themes. Uppermost in these are concerns relating to the increasing quantities of waste needing to be treated and the impact of landfilling mixed wastes on the environment. In some regions additional pressures arise from decreasing available landfill void space. This is driving policy makers to examine alternatives to landfill, including reduction and recycling of waste, and recovery of value from waste, commonly encompassed in the 'Waste Hierarchy', which is governed by a set of principles dedicated to minimising the impacts of waste and improving resource use. In some regions there are calls for 'zero waste to landfill' and for policy to encourage the circular economy or 'smart waste management'. These moves are most advanced in the European Union and other regions where landfill is expensive or scarce. Elsewhere, notably in North America and Australia, countries continue to rely on landfill, but in these countries there are also increasing pressures to reduce waste production and to recycle or recover where possible, leading to increased interest in recovery of energy from the residual waste. Globally these policy pressures have led to a proliferation of research work on waste management, including policy development, environmental systems analysis, technology development and economic drivers. Whilst this has assisted in the development of more sophisticated waste management systems, in many cases it has also delayed deployment of energy recovery systems (specifically for residual wastes), in particular due to confused policy making, public awareness (and opposition) and uncertainty over environmental performance and technology performance.

Against this background decision makers continue to require guidance and information on waste and resource management systems that are environmentally and economically sustainable. Task 36 provides a unique opportunity to draw together information on how systems, policies and technologies are being applied in different countries to provide guidance for decision makers on key issues.

Participating countries: France, Germany, Italy, Singapore (observer), and Sweden.

Task Leader: Mr. Inge Johansson, SP Technical Research Institute of Sweden, Sweden

Operating Agent: Dr. Åsa Forsum, Swedish Energy Agency, Sweden

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

For further details on Task 36, please refer to the Task website www.task36.ieabioenergy.com and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Task meetings and workshops

The Task's core work was undertaken as structured Task meetings, each of which was accompanied with a themed workshop. The aim of these workshops is to allow Task members to present work on the nature of the issues concerned within their own country; to invite speakers to present work of relevance and to allow discussion of the issues presented. In 2016 the Task held the following workshop

- Towards a sustainable waste management, (Italy, May 2016)

The workshop held is outlined in more detail below:

A workshop focused on the development of mechanical biological treatment (MBT) and Waste-to-Energy (WtE) in a sustainable waste management. *Rome, May 2016. The workshop was arranged together with ATIA ISWA Italia and RSE*.

Workshop aim:

Different countries have developed their waste management systems in different ways. Some counties have a large portion of mechanical biological treatment facilities whilst others have opted for a larger number of fractions being source separated. The aim of the workshop was to investigate the role of MBT and WtE in sustainable waste management. The focus was on the situation in Italy but experiences from France and Germany were added.

Workshop outcomes:

MBT should not be considered as an end waste treatment option but rather as an intermediary method. This is important to remember so that waste streams are not double counted or compared on the wrong basis. It is also important to look at the output qualities when considering the effect of the method.

WtE plays an important role in building a sustainable integrated waste management, both now and in a foreseeable future. There might still be some expansion in capacity in Italy while the capacity in Germany and France currently are quite well balanced relative to the need.

MBT has played a quite large role in many countries; however in the effort to divert organic waste from landfills the method has limitations. There does not seem to be a large increase in new capacity of MBT. However there is potential to divert more of the MBT residues from landfill through optimisation of the process.

Although there are large differences between different member states in the EU, it is also worth noting that there can be large differences within a member state as well. Italy illustrates this well with the differences between north and south.

The presentations from the workshop together with a summary of the workshop are available at the homepage. (www.task36.ieabioenergy.com).

Task Meetings and site visits

The Task held one meeting in 2016. This one took place in Rome, Italy 16-17 May and was held in association with the workshop on the development of sustainable waste management. The Task also had the opportunity to visit the Malagrotta MBT plant in Rome and to hear about the experiences of both the MBT plant as well as the gasification plant that has been taken out of operation.

Deliverables

The deliverables for the Task in 2016 have included presentations from the workshop including the summary report. Two reports initiated during the former triennium were published, one on the subject of Small scale Energy from waste and another on an assessment of the export of RDF from the UK. A further deliverable was the presentation of the small scale energy from waste report at the Bioenergy Australia conference (14-15 Nov. 2016). The homepage was also moved under the umbrella of ieabioenergy.com which took some time and resources. The Task also prepared two progress reports and an end of triennium report for the Executive Committee.

Website

The website (task36.ieabioenergy.com) is the key tool used for dissemination of information from the Task. It provides access to the latest publications produced by the Task, including the presentations from the workshop. The website also provides access to past reports, articles, case studies and presentations at workshops associated with Task meetings. In addition, it provides a 'members only' forum, to allow rapid access to the latest drafts of documents and to information on Task meetings. In 2016 this website was modernised and transferred to a new platform under the umbrella of ieabioenergy.com. During the last three months of 2016 there were 588 visitors to the site where 60% were new visitors. Where the country of origin is known, the most page views were from users in Russia, the UK, the USA, Austria, Italy, Sweden, France, Germany and Australia.

TASK 37: Energy from Biogas

Overview of the Task

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

The approach of Task 37 involves the review and exchange of information and promotion of best practices for all steps of the process chain for anaerobic digestion (AD) of biomass residues and energy crops for the production of biogas as a clean renewable fuel for use either directly in combined heat and power generation or after up-grading to biomethane where it replaces natural gas. In addition, there is growing interest in the use of biogas and biomethane to help stabilise power grids that are increasingly fed from variable sources of generation like wind and solar.

The Task also addresses utilisation of the residues of the AD process, the digestate, and the quality management methods for conversion to high quality organic fertiliser. The scope of the work covers biogas production at small and large farm-scale, in waste water treatment plants and treatment of the biodegradable fraction of municipal waste (biowaste), energy crops and algae.

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

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

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

Task Leader: Prof. Jerry D Murphy, MaREI Centre, Environmental Research Institute, University College Cork, Ireland

Operating Agent: Matthew Clancy, Sustainable Energy Authority of Ireland, Dublin, Ireland

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

For further details on Task 37, please refer to Appendices 2, 4, 5 and 6; the Task website http://task37.ieabioenergy.com/ and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Progress in R&D

In 2016 the work programme consisted of the following Topics:

- Initiation of preparation of technical reports;
- Collaboration with other Tasks;
- Country Reports;
- Success Stories and Case Studies;
- Website, Newsletters and Webinars;
- Task Meetings and Workshops;
- Deliverables of Task 37 in 2016.

Initiation of preparation of Technical Reports

The progress on the content of new technical brochures/reports is summarised below.

Methane Emissions

This report is continued from the last trimester. An extensive quantity of work has been undertaken thus far but the report is not yet finalised. The deadline for a completed report has being revised until May 2017. This will be a long detailed report, which will describe and assess methodologies for assessing fugitive emissions from biogas facilities, the main sources of emissions, how to minimise such emissions and the impact of these emissions on the sustainability of biogas systems.

Food Waste Digestion Systems

The variability of food waste was suggested as a major issue in digestion of food waste. Asian food is very different from Mediterranean food, which is very different from British food. The collection system is hugely important. Does it include green waste? How often is it collected? The report will not be overly technical or scientific. The audience will be policy makers and the waste collection industry. Case studies and best practice will be introduced. The structure was suggested as follows: Food waste as a global challenge; Collection systems; Digestion systems; End use of gas and digestate; Case Studies.

Grid Injection and Greening of the Gas Grid

The Green Gas Commitment includes 6 European Gas Grids who have an ambition of substituting 100% of natural gas with green renewable gas by 2050. The report will discuss how such an industry will evolve. It will discuss the gas grid, gas quality and the role of the gas grid in the future. It will discuss why biogas would be used to produce biomethane instead of CHP. It will set out the importance of green gas in supplying renewable energy in transport and in renewable heat such as for industries on the gas grid. The potential route to green gas and scale of the potential industry may be outlined by member countries.

International Approaches to Sustainable Anaerobic Digestion

The key objective of this report is cost effective biogas technologies, which are economically and environmentally sustainable. The target audience is NGOs, development co-operation, industries and institutions. The concepts of sustainability must be taken into consideration and put in context with regard to cost. Is a simple system, which has some methane slippage preferable to not employing any anaerobic digestion system? The report should emphasise simple well-designed systems, which are cost effective and have a minimum reliance on subsidies. However it should outline systems that involve good practice and highlight potential for bad practice.

The Role of Anaerobic Digestion and Biogas in the Circular Economy

Anaerobic digestion systems tend to form parts of circular economies. It is difficult to compare anaerobic digestion to a wind turbine. Anaerobic digestion is a multi-process system including waste treatment, environmental improvement, renewable energy production and biofertiliser production. Anaerobic digestion processes can be considered scavenger type systems producing biogas from a large variety of wet organic wastes, residues and feedstocks. Biogas is an incredibly flexible end product having applications in renewable electricity, heat and transport fuel. Innovative systems will be described. Seaweed biogas may have a role in multi-trophic aquaculture. Micro-algae may scrub CO_2 from a bioenergy power plant and provide feed for a biogas plant. Anaerobic digestion has applications in liquid biofuel and biorefinery systems.

Veracity and Applicability of Biomethane Potential Assay Results

The BMP assay is a limited test in which the inoculum is usually twice the quantity of the substrate. This has the tendency to mask limitations in the feedstock such as non-ideal C/N ratios and lack of micronutrients. The importance of inoculum in the BMP result will be discussed and whether the inoculum is suitable for the feedstock. It may be prudent to allow for acclimatisation when the substrate is different to the substrate in the system, which produced the inoculum. Different BMP systems can yield different BMP results. Nor does the BMP assay give data on optimal organic loading rate and operating conditions for a digester. It may be more beneficial (but also more costly) to undertake continuous digestion of the substrate over a period of time to give specific methane yields (SMY) corresponding to different organic loading rates (OLR) and hydraulic retention times (HRT).

Biomethane as a transport fuel

This will be a short report yielding up to date data on assessment of modern natural gas vehicle engines

Collaborations with other Tasks

IEA Bioenergy Inter-Task Strategic Project: 2016 State of Technology Review - Algae Bioenergy

This extensive report (ca. 150 pages and 450 references) was led by Task 39 and included contributions from Task 37. It is now in external review and should be published in Q1 2017.

Sustainable Bioenergy Chains

This task is led by Task 40 and will include contributions from Task 37. There are three objectives:

1. How to measure and quantify progress towards more sustainable practices?
2. How to improve the input and output legitimacy of existing and proposed governance systems?
3. How to engage more successfully with the broad range of stakeholders so that policies and sustainability governance are perceived as legitimate and help build-up social capital, trust and support among all stakeholders?

National Biogas Mirror Groups

The Task maintains close links with national mirror groups. Linked to the task meeting in Wallingford in April 2016, the Task contributed to the UK Task 37 workshop (see below). The Task also provided a webinar for Bioenergy Australia on the 28th April (see webinars below).

Country Reports

The Task published an updated Country Report Summary for 2015 in January 2016. The summary contains information on the biogas sector in each of the Task member countries, including energy recovery data, biogas utilisation data, details of support schemes and key research projects. The next combined report for 2016 will be uploaded in Q1 2017.

Success Stories and Case Studies

A list of preliminary proposals for success and case stories includes:

1. A facility at a brewery in Guuesser, Austria;
2. Gasification to biomethane at the GoBiGas facility in Gothenburg;
3. Biomethane at a sugar beet factory with up-grading in Switzerland;
4. Application of biogas to the pork industry in Australia;
5. Small scale biogas facilities in Holland;
6. Three upgrading biogas units including landfill gas in Holland;
7. Very large digester in Denmark;
8. Circular Economy in Finland;
9. Gas to grid system in Oxfordshire;
10. Food waste digester in Oxfordshire;
11. Grass digester with bioplastic production and use of fibres for insulation;
12. A biological Power to Gas system

Website, Newsletter and Webinars

Website

The website (http://task37.ieabioenergy.com/) is updated with news, biogas data and publications (including national biogas reports using a new "biogasreports" tool - www.biogasreports.com). The Country Reports as well as the Task publications, proceedings of the workshops and newsletters were made available along with important publications from the participating countries. The website was updated a number of times.

- Two Task 37 reports were added, namely: "Sustainable biogas production in municipal wastewater treatment plants" and "Exploring the viability of small scale anaerobic digesters in livestock farming."
- The case study on Solrød Biogas was added.
- The Inter Task Project synthesis report "Mobilising Sustainable Bioenergy Supply Chains" was added.

- The workshop presentations in Wallingford were uploaded
- Notification of a Workshop MetHarmo was added - European harmonisation of methods to quantify methane emissions from biogas plants
- The proceedings of the IBBA Workshop, Esbjerg, Denmark, August 25th 2016 were added/

Data on website visits for the 6 month period February 1st 2016 to July 31st 2016 is included in table 1

	Total	Average per month
Users	5614	936
Sessions	7878	1313
Page views	19,530	3255

Table 1. Results of visits to web page http://task37.ieabioenergy.com/ between February 1, 2016 and 31st July 2016

Newletters

There were 11 newsletters issued in 2016.

Webinars

1. April 28th 2016: Webinar for Australia Bioenergy: (http://www.bioenergyaustralia.org/pages/resources.html) On April 28th IEA Bioenergy Task 37 Australia produced a webinar with presentations by the Australian Team Leader for Task 37 - Prof. Bernadette McCabe and Prof. Jerry Murphy Task Leader of Task 37
2. June 2nd 2016: IEA Bioenergy Webinar Series: (http://www.ieabioenergy.com/iea-publications/webinars/). A presentation entitled "Green Gas" was delivered by Prof. Murphy Task leader with an audience of 438 people.

Task Meetings and Workshops

Task 37 Meeting Wallingford, Oxfordshire, UK, April 2016

A Task meeting was held from April 13 to April 15 in Wallingford, Oxfordshire in the UK. On the 14th of April a workshop was held at which the Technical Brochure "Exploring the viability of small scale anaerobic digesters in livestock farming" was officially launched. Close to 70 members of the anaerobic digestion industry and stakeholders were present at this workshop. Guest presenters included: William McManus of WRAP; Harry Waters of Agrivert

Ltd; Oliver Harwood of RH and RW Clutton; James Browne of Gas Networks Ireland and David Baxter (EC Joint Research Centre Petten). A number of Task 37 members presented including Jerry Murphy (Task leader), Guenther Bochman (Task 37, Austria), Clare Lukehurst (Task 37, UK), Bernadette McCabe (Task 37 Australia), Charles Banks (Task 37, UK)

The Task and the workshop participants visited two biogas facilities: Icknield Farm Biogas Plant, which is a gas to grid system, which digests pig manure and ensiled crop; and Battle Farm Biogas Plant, which produces combined heat and power based on a food waste substrate.

Task 37 Meeting Toowoomba, Australia, November 2016

A Task meeting was held from November 17 to November 18 in Toowoomba, Australia. The Task undertook a site visit to Oakey Beef Exports Anaerobic Digestor Plant. Immediately prior to the Task meeting the Task hosted a session in the Australia Bioenergy Conference in Brisbane, from November 14 to 16. The session was chaired by Prof. Murphy and included the following presentations:

- Biogas in the Circular Economy, Clare Lukehurst, United Kingdom;
- The Role Of Biogas In Supporting Intermittent Renewable Electricity, Jerry Murphy, Ireland;
- IEA Bioenergy - Task 37 Energy from Biogas: Knowledge Sharing Opportunities For Australia During The 2016-2018 triennium, Bernadette McCabe, Australia;
- Biomethane Market Potential -Opportunities And Challenges Ahead, Mattias Svensson, Sweden;
- Monitoring And Process Control Of Biogas Plants, Günther Bochmann, Austria;
- Resource Recovery Via Distributed Biogas Production, Saija Rasi, Finland

Three site visits were organised to the following facilities:

- Queensland Centre for Advanced Technologies (CSIRO)
- UQ Pinjarra Hills – Algal biofuels and solar biofuels (including for digestion of algae residues)
- XXXX Brewery Milton - Anaerobic digestion

Workshop Presentations:

1. 17 May 2016 Rome Italy: Mobilising sustainable bioenergy supply chains: opportunities for agriculture. Workshop organised by IEA Bioenergy, in collaboration with GSE, FAO and IRENA "Biogas production from seaweed, grass silage and slurry in rural coastal areas" – Prof. Jerry Murphy, Task Leader Task 37 IEA Bioenergy.

2. 14 June 2016 EUSEW Workshop: Bioenergy in balancing the grid and providing storage options _IEA Bioenergy EUSEW Workshop, Breydel Auditorium Brussels "The potential role of biogas in smart energy grids" – Prof. Jerry Murphy, Task Leader Task 37 IEA Bioenergy. Lecture prepared but event cancelled at short notice

Planning of Future Task Meetings and Workshops

Task meetings in 2017 will be held in the Holland (5-7 April), in Denmark Q3 2017. The proposed meetings in 2018 are in Helsinki in May 2018 and in Cork in Q3 2018.

TASK 38: Climate Change Effects of Biomass and Bioenergy Systems

Overview of the Task

Bioenergy is promoted as a low-carbon renewable fuel, and has been identified to play an important role in achieving climate stabilisation by the Intergovernmental Panel on Climate Change (IPCC). However, the value of bioenergy in climate change mitigation has been challenged with increasing vigour over recent years, by various academic and environmental groups. These concerns have fuelled an on-going debate about the appropriate role for bioenergy in climate policy, particularly in Europe and the USA.

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

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

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

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

Operating Agent: Stephen Schuck, Bioenergy Australia, Australia

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

For further details on Task 38, please refer to the Task 38 website http://task38.ieabioenergy.com/ and the IEA Bioenergy website www.ieabioenergy.com under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

During 2016 Task 38 held one face-to-face meeting of national team leaders, participated in a joint workshop/study tour, and held one online meeting.

Task 38 Business Meeting: Savannah (USA) 15th April

- Five of the six participating countries (Australia, Finland, Germany, Sweden, USA) were represented at the meeting.
- Key discussion points:
  - Finalising paper on choosing the reference system with which to compare a bioenergy system;
  - Presentations from task members on time dependence of climate change mitigation; Climate change mitigation challenges for wood utilisation in Finland; Bioenergy pathways for cars; ClimWood2030 project;
  - Inter-task projects on Bio-CCUS and Sustainable bioenergy supply chains
  - Report comparing the Q and Yasso decomposition models, and report on albedo effects of bioenergy.

Study tour, SE, USA April 10 – 14, 2016 Joint activity with Task 43

The Bioenergy in the Southeastern United States Study Tour (hosted by Oak Ridge National Laboratory) commenced in Knoxville and travelled to Savannah 10-14/4/2016. The Study Tour highlighted innovations developed by the US Department of Energy (DOE) national laboratories that support deployment of a sustainable bioeconomy. The Tour began with a one-day symposium on April 11 and included site visits and presentations that demonstrated innovations developed by the Bioenergy Technologies Office (BETO) of the US Department of Energy (DOE) in support of deployment of a sustainable bioeconomy, visited forests and mills, and discussed sustainability considerations associated with forest-based bioenergy.

Task 38 Business Meeting: Online 25 October

- Five of the six participating countries (Australia, Finland, France, Sweden, USA) were represented at the meeting.
- Key discussion points:
  - progress of work on 1) metrics for quantifying climate change effects, and 2) choosing the reference system, towards completing papers for submission for publication;

- planning for next meeting which will be held in Växjö, Sweden, 9-11 January 2017, and will focus on comparing models of forest bioenergy systems.
- updates on significant international developments of relevance to Task 38 members;
- reviews of two reports: 1) albedo effects, and 2) modelling of soil carbon and litter turnover.
- contribution to the Inter-Task project "Measuring, governing and gaining support for sustainable bioenergy supply chains";
- Brief input from NTLs on recent developments in each country.

Next Meeting

The next Task 38 Business Meeting will be held in Sweden in January 2017.

Work Programme

In 2016 the Task:

- Organised one Task 38 face to face business meeting (see above)
- Organised one Task 38 online business meeting (see above)
- Participated in a study tour of SE USA to view the wood pellet industry (see above)
- Published a response to a misleading paper on climate impacts of bioenergy policy published in the high-profile journal Nature Climate Change: Cowie et al. (2016) Reply to "Rethinking forest carbon assessments to account for policy institutions", by Andrew Macintosh, Heather Keith and David Lindenmayer. Published Online: 29 June 2015/DOI: 10.1038/Nclimate2695 (2015), Nature Climate Change.
- Contributed to a report on Carbon neutrality of Bioenergy, with Task 43, for European Forest Institute: "Forest biomass, carbon neutrality and climate change mitigation" (Berndes, Asikainen, Cowie, Egnell, and others)
  - Full report: http://www.efi.int/files/attachments/publications/efi_fstp_3_2016.pdf
  - Brief: http://www.efi.int/files/attachments/publications/efi_thinkforest-brief_carbon_neutrality.pdf
- Progressed the preparation of scientific papers:
  - Metrics for quantifying the climate effects of bioenergy systems :
  - Reference Systems for evaluating climate effects of bioenergy
- Participated in two Inter-Task projects (Bio-CCUS and "Measuring, governing and gaining support for sustainable bioenergy supply chains")

Scientific Papers

The following two scientific papers are nearing completion:

Reference systems for evaluating climate effects of bioenergy

This paper discusses the importance of the reference system in evaluating the climate effects of bioenergy and presents guidance on choosing the most appropriate reference system according to the purpose of the study, with particular focus on the land use reference. A decisions tree is presented to aid researchers and decision-makers in identifying the relevant reference system for their objective.

Metrics for quantifying climate effects of bioenergy

This paper discusses the implications of different metrics in evaluating the climate impacts of bioenergy. Climate change effects, including those of biomass and bioenergy systems, are traditionally measured with the cumulative radiative forcing of greenhouse gas emissions (using GWP100 to combine impacts of different gases) as the indicator, but other indicators such as global temperature potential could be used. The paper uses three simplified bioenergy systems to illustrate the effects of using different metrics.

Two reports have been commissioned jointly by Task 38 and Task 43:

Albedo effects of biomass production: A review

This report reviews recent findings on the extent to which changes in albedo can enhance or diminish the climate change benefits of bioenergy. The albedo effect is dependent on the latitude, and the bioenergy system (woody or annual crop, and its management).

Climate impact assessments of forest bioenergy affected by decomposition modelling

This report compares the Q and Yasso models, that are used to model decomposition of forest litter. The study found that the choice of the decomposition model results in different quantitative estimates. However, the decomposition model choice does not lead to diverging conclusions about the warming impact of extracting forest residues for bioenergy

LCA methods and models

Several papers are under preparation addressing: (1) tools used in policy implementation for GHG emissions in Europe, United States, and Canada; (2) other environmental impacts for commercial biofuels; and (3) prospective models used in conjunction with technology development evaluation. This work was commenced in collaboration with Task 39 and has been expanded under the Inter-task project "Measuring, governing and gaining support for sustainable bioenergy supply chains".

A book chapter has been prepared for publication in Elsevier Encyclopedia for Sustainable Technologies providing guidance on conducting consequential life cycle assessment: 'Consequential Life Cycle Assessment: What, how and why?"

Inter-task Projects

Study tour of pellet industry in SE USA (see above)

Tasks 38 joined Task 43 in this study tour to view the pellet industry, to learn about the forests, their management and how sustainability issues are addressed. A paper presenting an overview of the industry has been prepared for publication.

Measuring, governing and gaining support for sustainable bioenergy supply chains

Annette Cowie and Göran Berndes (Task 43) are co-leading Objective 1, which will provide an overview of calculation methods & tools to assess the sustainability of various biomass and bioenergy supply chains and discuss pros and cons of a global, uniform or harmonised framework. Helena Chum is coordinating the comparison of tools for assessing biofuels. Annette Cowie is assessing the applicability of sustainability criteria to biomass supply chains based on invasive scrub, a common issue in the world's drylands.

Website/Communication

Task Website

The Task 38 website (http://task38.ieabioenergy.com/) is the repository of publications and other material produced by Task 38 and predecessor task "Greenhouse Gas Balances of Biomass and Bioenergy Systems".

Information on the site includes:

- Documentation from Joint workshop on Forests, bioenergy and climate change mitigation, Copenhagen, May 19-20 2014: workshop statement, background documents, presentations, summary of discussion
- presentations from all Business Meetings and Workshops
- case studies (identified by both country and process)
- publications of Task 38
- Guidance on methods for quantifying greenhouse gas balance of bioenergy systems
- FAQ page
- list and contact details of national team leaders.

Collaboration with Other Tasks

Joint activity: Study tour South East USA

Study tour of forestry in the South Eastern USA to gain first-hand experience of the wood pellet industry, that is producing pellets that are shipped to Europe for bioenergy. (see above)

Intertask projects (see above).

Within the inter-Task project "Measuring, governing and gaining support for sustainable bioenergy supply chains" (led by Task 40) Task 38 is co-leading Objective 1, with Task 43, and Task 38 is working with Task 39 to review GHG assessment tools for liquid biofuels.

Task 38 is also contributing to the Bio-CCUS project.

Joint publications:

Bentsen, N.S., Nord-Larsen, T., Larsen, S., Berndes, G., Birdsey, R., Cowie, A., Felby, C., Junginger, M., Kant, P., Kurz, W. and Lamb, D., 2016. RE: Forests and forest management plays a key role in mitigating climate change. Science.

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

Cintas, O., Berndes, G., Cowie, A.L., Egnell, G., Holmström, H., Marland, G. and Ågren, G.I., 2016. Carbon balances of bioenergy systems using biomass from forests managed with long rotations: Bridging the gap between stand and landscape assessments. GCB Bioenergy.

Stupak, I., Joudrey, J., Smith, C.T., Pelkmans, L., Chum, H., Cowie, A., Englund, O., Goh, C.S. and Junginger, M., 2016. A global survey of stakeholder views and experiences for systems needed to effectively and efficiently govern sustainability of bioenergy. Wiley Interdisciplinary Reviews: Energy and Environment, 5(1), pp.89-118.

Networking

1. Task 38 members contributed to the report on carbon neutrality of forest-based bioenergy prepared for the European Forest Institute (see above).
2. Annette Cowie presented a paper at the 30th Annual Conference of the U.S. Regional Association of the International Association for Landscape Ecology, in Asheville, North Carolina, April 3–7, 2016, titled "How emission accounting and reporting influence perceptions of bioenergy", as part of the session "Opportunities and Barriers for Sustainable Bioenergy" organised by Keith Kline and Virginia Dale of Oak Ridge National Laboratory. Bioenergy is criticised by some ecologists, and this session provided the opportunity for dialogue with researchers who are concerned about its impacts.

3. Task 38 was represented at the European Biomass Conference and Exhibition (Amsterdam, 6-9 June) by Miguel Brandão, the Task 38 Manager and Helena Chum, representative for USA. Miguel and Helena also attended a planning meeting for the inter-Task project "Measuring, governing and gaining support for sustainable bioenergy supply chains", led by Task 40.
4. Leif Gustavsson presented a webinar "Climate change effects of bioenergy and fossil energy - a focus on cars" 2 November 2016, to Bioenergy Australia.
5. Kati Koponen participated in a workshop on Bio-CCUS in November in Switzerland and presented on the climate impacts of bioenergy systems and the role of CC(U)S.
6. On behalf of the Task 38-Task 39 collaborative project, Antonio Bonomi presented the comparison of tools for assessing climate effect of biofuels at Bioenergy Australia 2016 conference.
7. Annette Cowie presented a webinar for IEA Bioenergy: "Bioenergy: Is it good for the climate?" IEA Bioenergy Webinar series 21 April 2016
8. Annette Cowie presented a summary of Task 38 activities to the quarterly meeting of Bioenergy Australia in September 2016, and delivered a presentation on quantifying climate effects of bioenergy to the Bioenergy Australia conference in November 2016.
9. Annette Cowie met with Prof. Gregg Marland and Prof. Eric Marland, collaborators on Task 38 research into effects of timing of bioenergy emissions, at Appalachian State University, Boone, Tennessee, 8-9 April, 2016, and presented a lecture on "Quantifying the impacts of greenhouse gases" and a seminar to the Biology Department "Is bioenergy good for the climate?"

Deliverables

Apart from the wide range of deliverables mentioned above, the Task also produced progress reports and audited accounts for the ExCo, and minutes of the Task meetings. In addition, individual task members published scientific papers that were informed by interactions with Task members, and some of these outputs were formally reviewed by Task 38 members.

TASK 39: Commercialising Conventional and Advanced Liquid Biofuels from Biomass

Overview of the Task

Task 39 continues to play a key role in facilitating the commercialisation of liquid biofuels from biomass. While cost competitive production economics remain challenging within a low oil price environment, the past year has seen ongoing progress in the development of advanced biofuel technologies. The completion of the Algae report by IEA Bioenergy members provided an important update of this technology, including a detailed assessment of the challenges that still have to be resolved. Although the Task continues to be active in the technology/commercialisation space, the crucial role that policy plays, and will continue to play, is increasingly apparent as the world strives to decrease emissions associated with human activities. One area that has received increasing attention from the Task has been drop-in biofuels, particularly for use in international marine and aviation sectors. Good progress has been made in the various conversion technologies to produce marine biofuels and aviation biofuels, however the right policies will be essential to advance market penetration of these types of drop-in biofuels. As one prominent example, the agreement on a Carbon Offsetting and Reduction Scheme in International Aviation reached in October 2016 at the International Civil Aviation Organisation, while a highly positive development, is unlikely by itself to significantly promote the development of biojet fuels without effective national policies being in place.

The goal of Task 39 is to support the commercialisation of liquid biofuels from biomass, with a focus on conventional and advanced technologies, including "drop-in" biofuels and algae-based biofuels. Through a coordinated focus on technology, commercialisation, sustainability, policy, markets and implementation, the Task assists participants in their efforts to develop and deploy biofuels. These include cellulosic ethanol, biomass-based diesel, renewable aviation fuel, etc., through various technology routes such as oleochemical, biochemical, thermochemical and hybrid technologies. It also continues to identify and facilitate opportunities for comparative technical assessment and support for policy development. The success of the Task has been, in large part, a direct result of providing a forum for these types of integrated discussions, with the active involvement of participants from industry, government and academia. The Task continued to lead and coordinate activities in three main programme areas:

- **Technology and Commercialisation** with a focus to:
  - develop and commercialise improved, cost-effective bio-based processes for the generation of advanced biofuels, particularly "drop-in" biofuels from biomass;
  - work with other Tasks to develop and commercialise improved, cost-effective thermochemical-based processes, such as the Fischer-Tropsch process for converting syngas to synthetic biodiesel and other advanced biofuels; and
  - understand advancements and challenges in 'next-generation' liquid biofuel technologies, including biomass-to-hydrogen and algae-to-biofuel processes.

- **Policy, Markets, Implementation and Sustainability** encompassing issues that address policy/legislative/regulatory and infrastructure concerns regarding expanding conventional and advanced liquid biofuels; and to provide information and analyses on policies, markets, and implementation issues (including regulatory and infrastructure development) that will help participants encourage commercialisation of liquid biofuels as a replacement for fossil-based fuels, by continuing the deployment of conventional (so called first generation) biofuels and supporting development of advanced (so called 2nd generation) biofuels and 'future-generation' biofuels.
- A **Multifaceted Communication Strategy** to facilitate knowledge transfer, dissemination of information, outreach to stakeholders, and coordination with related groups both within IEA Bioenergy and externally.

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

Participating countries: Australia, Austria, Brazil, Canada, Denmark, European Commission, Germany, Japan, South Korea, The Netherlands, New Zealand, South Africa, Sweden, and United States of America

Task Leader: Dr Jim McMillan, National Renewable Energy Laboratory, USA

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

Operating Agent: Mr Alex McLeod, Natural Resources Canada, Canada

Task Manager: Dr Susan van Dyk, University of British Columbia, Canada

The Task leadership is shared between the National Renewable Energy Laboratory (USA) as represented by Jim McMillan, and the University of British Columbia (Canada) as represented by Jack Saddler. Both Task Leaders are engaged in all aspects of the Task's operations. Sub-Task leaders for technology and commercialisation include Antonio Bonomi, Franziska Müller-Langer, Nicolaus Dahmen, Christian Koolloos, Claus Felby, Tomas Ekbom and Les Edye. Sub-Task leaders for policy, markets, implementation and sustainability include Warren Mabee, Dina Bacovsky, Timo Gerlagh, Emile van Zyl, Shiro Saka, Jin-Suk Lee, Luisa Marelli and Ian Suckling. The Task leadership is assisted by Dr Susan van Dyk (UBC), who acts as Editor of the Task Newsletter and Webmaster. Dina Bacovsky (Austria) manages the demonstration plant database. Franziska Müller-Langer has been acting as the Task's liaison to the Advanced Motor Fuels Implementing Agreement. A National Team Leader for each country is responsible for coordinating their respective national participation in the Task.

For further details on Task 39, please refer to Appendices 2, 4, 5 and 6; the Task website (http://task39.ieabioenergy.com/) and the IEA Bioenergy website (www.ieabioenergy.com) under 'Our Work: Tasks'.

Task Meetings and Workshops

Task 39 remains highly active in terms of both business meetings (which involve significant knowledge exchange between participants in the form of Country Reports) as well as special sessions hosted in conjunction with established biofuels events. In 2016, the Task held two formal business meetings (Delft, The Netherlands and Rotorua, New Zealand).

The Task business meeting was held in Delft, The Netherlands, on 9-10 March 2016 in conjunction with the ECO-BIO conference held in Rotterdam from 7-9 March 2016. The meeting discussed the current status of ongoing deliverables (Advanced Fuels in Advanced Engines; Updated Algae report; LCA model comparisons, etc.) and progress reports were presented at the meeting. The representatives from member countries presented country report updates at the meeting. The country reports are invaluable to Task members as they provide insights into the unique characteristics of each member country as well as the latest news on research, commercialisation and policy aspects of biofuels across the member countries. The country reports are also used to update the Implementations Agenda report (the compare-and-contrast of national policies) which provides useful insights into what policies have been successful (or not so successful) for advancing biofuels implementation in member countries. At the ECO-BIO conference, the Task-arranged sessions included 8 talks by Task 39 country representatives highlighting technology and industry developments in their respective countries.

The Task held another business meeting in Rotorua, New Zealand on Nov 8, 2016 in conjunction with the IEA ExCo78 Workshop on Aviation and Marine Biofuels Nov 9, the ABRN Science Symposium Nov 10 and the Bioenergy Australia conference Nov 14-16. The business meeting received progress reports from Task members on different deliverables, both completed and in-progress, and future work was discussed. Task 39 members participated in the Workshop on Aviation and Marine Biofuels, giving a number of presentations. The Task also participated in the ABRN Science Symposium and many Task members gave presentations at this forum, as well as at the Bioenergy Australia conference in Brisbane the following week.

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

Work Programme

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

Technical Aspects of Advanced Biofuels

Advanced biofuels remain a topic of key importance, including a continued focus on cellulosic ethanol production and commercialisation, although drop-in biofuels production has become more prominent as these fuels offer a direct replacement for petroleum fuels, requiring no changes to infrastructure.

The need for drop-in biofuels is especially relevant in industries such as aviation where no other alternatives exist. The Task's publication of the "drop-in biofuels report" and ongoing updates to this report assesses the potential and challenges of these advanced biofuels across the whole spectrum of production technologies – oleochemical, biochemical, thermochemical and hybrid conversion technologies. As these technologies develop from research and development through to pilot, demonstration and commercialisation, it is the role of Task 39 to monitor these developments and develop update reports to disseminate information to the biofuels community as an objective observer to give stakeholders, including governments and policy makers the information and tools necessary to support decision-making. A specific area that has been at the forefront internationally, is the need for renewable aviation biofuels to reduce emissions in the aviation industry. This is driven by voluntary initiatives from aviation organisations, OEMs such as Boeing, as well as by airlines investing in new technologies and entering into offtake agreements for biojet fuels. Task 39 has a critical role in monitoring, evaluating and reporting on developments, in addition to providing guidance on essential policy to foster and facilitate biojet development and deployment. In addition, the role of biofuels in the international shipping and marine sector has become important as a way of reducing emissions contributed by this industry. Part of the update to the drop-in biofuels report involves a special report on biofuels for marine applications, a draft of which was completed during 2016.

The potential of algal biofuels as a next-generation biofuel has been under investigation by Task 39 over a number of years and this area will continue to be monitored to determine how multiproduct algal-based biorefineries can provide a means to bring algal biofuels to market, including advances in technology and commercialisation. One of the major conclusions from the recently completed update algae report is that primary production of bioenergy by algal systems is not likely to be economically feasible in the short-to-medium term, primarily due to the relatively high cost of producing and harvesting algae.

The Task continues to update its database of advanced biofuels facilities (coordinated by Austria's national team leader, Dina Bacovsky). This database provides up-to-date information on over 100 companies and includes biochemical, thermochemical, and hybrid conversion approaches to producing biofuels. It remains difficult to obtain detailed and accurate information from many of the companies as the various processes approach

commercialisation, particularly in areas such as China and India that do not (yet) form part of the IEA Bioenergy network. This reinforces the need for ongoing efforts to recruit these countries into IEA Bioenergy Task 39.

Providing Information on Policy, Regulatory, Infrastructure and Sustainability Issues

The overall objective of this component of the Task is to provide governments and policy makers with information that will help them identify and eliminate non-technical barriers to liquid biofuels deployment. The Task continues to compile country-specific information on biofuels including fuels usage, regulatory changes, major changes in biofuels policies, and related items. One business meeting annually allocates time for country representatives to present updates on developments in their respective regions. Country report presentations along with the meeting minutes and other presentations from the business meetings are posted in the 'members only' section of the Task website. The report titled "Implementation Agendas" compiles the country specific information into a single document and is revised every triennium. The purpose of this effort is to maintain the Task's role as a central source of relevant information on biofuels. In 2016, the Task completed a report on "The potential of biofuels in China" which analysed the current biofuel situation in China and the prospects for the future of biofuels in this important country. This report examines the historical development of biofuels production in China as part of its strategy to address energy security and climate change concerns. Although the Chinese government has set ambitious targets to increase annual biofuels production to 12.7 billion litres of ethanol and 2.3 billion litres of biodiesel by 2020, it is unlikely that these targets will be met, primarily because biofuels for transport currently take a back seat to other forms of renewables in China's future renewable energy development plans.

Policy has globally played a key role in advancing the development and deployment of biofuels and lack of stable policy has a clear detrimental impact on investment in the industry. It is also apparent that the aviation industry represents a unique situation as an international industry and will require a different policy approach to advance biojet fuels. As biojet fuel is the only long-term solution for the aviation industry to meet their emission reduction targets, establishing a stable, commercial supply of biojet volumes has become imperative. However, even as technologies continue to develop and mature, strong policies at national and international levels will be essential to achieve this important objective.

Biofuels can play an important role in reduction of emissions from transportation to meet long-term climate goals. However, not all biofuels offer the same reduction potential and the ongoing analysis of emission reduction potential of different feedstock and technology combinations is vital to measure the carbon intensity and sustainability of biofuels. While many life cycle analysis models are available, they often give different results for the same scenario and the Task's work (joint with Task 38) in comparing models and providing reliable information on emission reduction potential forms an essential component of our work. The Task's work on comparison of the LCA models will be carried out over three years with Phase I initiated and progressed to near completion in 2016.

Newsletter

The Task has published three newsletters in 2016 (featuring the country reports of Sweden, Australia and Austria). These newsletters provide information about Task activities and international events related to biofuels. The newsletter has an active distribution list of nearly 3,000 individuals worldwide and copies are routinely downloaded from the Task website. The country specific feature story in each newsletter provides a unique source of information to biofuel stakeholders worldwide and we have had regular requests for permission to republish these reports in other magazines.

Website

The Task continues to build on its already considerable influence within the international community working in the liquid biofuels area. The recently redesigned website (http://task39.ieabioenergy.com/) and the newsletter have had very positive reviews. The website is heavily visited/cited and has generated many enquires that are typically handled by the Task coordinators and webmaster, or referred to experts within the Task 39 network.

Collaboration with Other Tasks/Networking

The report on Update on the Status of Algal Biofuels (and products) was a multi-Task project with participation from Tasks 34, 37, 38 and 43. The Advanced Fuels in Advanced Engines project is a collaboration with IEA AMF and the Comparison of GHG Models for Advanced Biofuels project is being carried out in conjunction with Task 38. Task 39 also has and will continue to collaborate with IEA HQ in updating relevant IEA reports.

Deliverables

The deliverables for the Task in 2016 included: organisation of two business meetings throughout the year; two progress reports and audited accounts (submitted to ExCo); development and maintenance of the Task 39 website; three newsletters; the update to the Task 39 Advanced Biofuel Demonstration Database; a completed report on "The Potential of Biofuels in China"; and a completed update on "Algae Bioenergy State of Technology Review". The full library of Task reports, country specific reports, etc. are available through the Task website (http://task39.ieabioenergy.com/). These are detailed in Appendix 4.

TASK 40: Sustainable biomass markets and international bioenergy trade to support the biobased economy

Overview of the Task

There is increasing need to develop biomass resources and exploit biomass production potentials in a sustainable way and to understand what this means in different settings. In 2011, the European Commission started to stimulate the further development of the biobased economy[34], which has shown promising developments in the last four years, in particular investments in technological innovation in several member countries. However, more efforts still need to be made in the establishment of European standards and the related certification of biobased products. The UNFCCC Conference of the Parties, or COP 21 have come up with historical decisions[35] to reaffirm the goal of limiting global temperature increase well below 2 degrees Celsius and establish binding commitments by all parties to make nationally determined contributions as well as to pursue domestic measures aimed at achieving them. By the end of 2016 the European Union has committed to cut GHG emissions by at least 40% by 2030[36] (from 20% in 2020) while modernising the EU's economy and delivering on jobs and growth for all European citizens as well as achieving global leadership in renewable energies.

In view of these perspectives, biomass markets have possibilities to grow; however, they are still immature and vulnerable, and this is particularly true for the demand side of the market *(various Task 40 studies, available on Task 40 website)*. Many biomass markets, e.g. solid biofuels, rely on policy support and incentives. It is important to develop both supply and demand for biomass, and energy carriers derived from biomass, in a balanced way and to avoid distortions and instability that can threaten investments in biomass production, infrastructure and conversion capacity. Understanding how this is best organised and managed needs further investigation. International biomass markets have been mapped by the Task, but the analyses, statistics, and modelling exercises undertaken so far still have limitations.

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

34 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0060&from=EN
35 http://newsroom.unfccc.int/unfccc-newsroom/finale-cop21/
36 https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/COM-2016-707-F1-EN-MAIN.PDF

The Task Leaders direct and manage the work programme. In 2016, Martin Junginger and Peter-Paul Schouwenberg have indicated that they will resign their task leader role after this Triennium and they asked Task 40 members to consider the nomination of successors. At the end of 2015, Norway and Brazil have officially decided to withdraw their membership. National Team Leaders from each country are responsible for coordinating the national participation in the Task.

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

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

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

Secretary: Ms. Thuy Mai-Moulin, Copernicus Institute of Sustainable Development, Utrecht University, The Netherlands

Operating Agent: Ir Kees Kwant, RVO, The Netherlands

For further details on Task 40, please refer to Appendices 2, 4, 5 and 6; the Task website (http://task40.ieabioenergy.com/) and the IEA Bioenergy website (www.ieabioenergy.com) under 'Our Work: Tasks'.

Progress in R&D

Task Meetings and Workshops

The Task organised three Task meetings and several workshops in 2016. The programme and presentations (and in some cases summaries) can be downloaded from the Task website: http://task40.ieabioenergy.com/.

On the 24-26 May 2016, the International Biorefining Week (IWB), a leading international event for the woodbased biorefining industries, was held in Stockholm, Sweden. The conference hosted a large number of interesting speakers speaking on four parallel conference tracks focusing on bioenergy, biobased products and innovations. Among the speakers were specialists from the forest industry as well as other manufacturing industries with an interest in biobased products. During the first day there was a common opening ceremony followed by a session focusing on biomass markets. Task 40 members presented in the session Sustainable and Intelligent Bioeconomy. Lena Bruce (Sveaskog, Sweden) gave a presentation on The Forest Resource for the Bioeconomy whilst Patrick Lamers (Idaho National Laboratory, US) discussed Developing the Global Bioeconomy – Technical, Market and Environmental lessons from Bioenergy. Olle Olsson (Stockholm Environment Institute, Sweden), presented his study with Task 40 colleagues on Cascading of Wood Biomass – Principles, Policies and Effects on Market and Trade. More information on the global bioeconomy and cascading of wood biomass study can be found on the website of Task 40.

During the 6th Annual USIPA Exporting Conference, November 6-8, 2016, Task 40 had a number of activities including two breakfast sessions and one presentation. On the 7 November, Olle Olsson, Patrick Lamers and Ruben Guisson led the breakfast session on Cascading woody biomass: - impacts on forest markets and trade. The leaders discussed the cascading term (resources should be re-used and recycled for as long as possible for as many demanding purposes as possible) in the EU policy where cascading has been put in the perspectives of bioeconomy and forest strategy, circular economy package and iLUC directive; however it is still unclear how cascading will be implemented. The speakers raised the question of how any cascading requirements (e.g. on a max. diameter for logs, e.g. 10 cm) could be implemented in real life, and what problems this would cause for the major sourcing areas - especially the US SE exports a large amount of pellets from softwood or hardwood pulp-quality logs. In the situation of Flanders, Belgium, cascading definition and application has led to six-month on-hold of the largest Flemish bio-power installation. The presenters recommended a new study on a possible assessment framework with criteria & indicators for cascading as well as on the definition of what is meant by an 'optimal or desired cascade'. They also concluded that implementing a solely scientific approach on how to apply cascading will create difficulties in real life- and will fail to provide a conclusive and objective answer that is universally applicable.'

In addition, during the main conference, Lena Bruce also gave a presentation on *Growth and Opportunities of Non-Subsidised Markets* which focused on potential second generation uses for industrial-grade wood pellets utilising existing supply chains. Lena provided background on how the future may hold the opportunity to move past pellets for power generation, and indicated the possibilities of these markets as well as the need to jump from power generation to second generation.

On the 8 November 2016, during a second breakfast session, Daniela Thrän presented the Overview of current developments in the wood pellet industry and market. In addition, Thrän introduced another Task 40 study on The European wood pellet market for small-scale heating; the results showed that Italy is the main importing country whilst Austria has the largest uni-directional trade and Germany indicates the strongest bi-directional trade of the small-scale heating sector. Michael Wild continued the session with a presentation on the future role of processed pellets and torrefaction technologies which shows a number of advantages such as high volumetric energy densification, limited or no biodegradation of product when stored and significant cost savings. Markets for torrefied products have just begun to emerge, but the hope is that volumes will continue to increase. Issues of sustainability requirements for wood pellets as well as standards for torrefied products have received interests from workshop attendees.

Peter-Paul Schouwenberg provided his presentation *Update on Dutch SDE+ Scheme and Dutch Foundation for Biomass Certification* under the Policy and Sustainability in Europe. He mentioned the Dutch 2013 Energy Agreement for Sustainable Growth (SDE+) which intends to make the Dutch energy supply more sustainable (complying with EU sustainability requirements) whilst stimulating the use of renewable energy including biomass pellets. Under SDE+, the Verification Protocol has been developed to certify/verify sustainable wood pellets and currently focuses on the US forests. The Dutch biomass certification foundation (DBCF) has been established in parallel for the certification of small forest owners in North America with regard to FSC or equivalent. This should lead to the use of 100% certified biomass for co-firing in Dutch coal facilities in 2020/2023 at the latest. DBCF expects to further establish its structure, develop and agree upon processes and decision making structures, build partnerships and re-select (pilot) regions/pellet mills to start implementation in the near future.

Martin Junginger presented an outlook on possible policy developments in the European Commission, particularly the various options for how the commission may attempt to govern the sustainable production and import of solid biomass in the future. He highlighted the positions of various stakeholders in the process, and discussed what the consequences of different actions (or no action at all) could be.

Future Meetings and Workshops

In the Task meetings in Miami, Florida on the 5-6th November 2016, Task 40 members agreed to have the next meeting of Task 40 scheduled on the 15-17th May 2017 in Copenhagen, Denmark. If Task 40 members are interested in attending the IEA Bioenergy Intertask Sustainability workshop *"Measuring, governing and gaining support for sustainable bioenergy supply chains"* (in which some of Task 40 members are also involved) organised on the 19-20th May 2017, they can travel to Goteborg, Sweden afterwards. Other Task 40 meetings are supposed to be organised in Sept/Oct 2017 at Drax office, England where a visit to Drax facilities is planned and the meetings can be linked with another event, possibly with Imperial College London.

In Feb-March 2018, the Task 40 meeting is tentatively planned in Belgium, e.g. in Antwerp. There is one optional meeting in May/June 2018; however the location needs to be discussed. At the end-of-triennium an IEA Bioenergy conference in October/Nov 2018 is proposed but the location and date are not yet known.

TASK 41: Bioenergy Systems Analysis

Overview of the Task

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

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

A project leader directs and manages the work of each project. For new projects an appropriate project leader is appointed by the project participants acting through the Executive Committee. The ExCo Member from each participating country acts as the National Team Leader and is responsible for coordinating national input to the projects undertaken.

For further details on Task 41, please refer to Appendices 2, 4 and 5; and the IEA Bioenergy website www.ieabioenergy.com under 'our Work: Tasks'.

Work Programme

The work programme is comprised of a series of projects. Each project has its own budget, work description, timeframe, and deliverables and is approved by the participants. The focus is on the needs of the participants by way of project outputs. Three projects were active in 2016 as follows:

Project 5: Bio-CCS and Bio-CCUS in Climate Change Mitigation

This two-year special project has been set up in order to fully define concepts of Bio-CCS and Bio-CCU, and to define their realistic significance in the medium and long term. Two workshops were held in 2016 (http://task41project5.ieabioenergy.com/iea-publications/) with two furhter workshops to take place in 2017 prior to project completion with a final report.

Participating Countries: The European Commission, Finland, The Netherlands and Norway

Status: Expected completion in December 2017

Project 6: Bioenergy in balancing the grid and providing storage options

This project aims to identify those areas in the grid system where bioenergy in balancing the grid and providing storage options can play a strategic role, and to promote the commercialisation of a diverse set of such bioenergy applications and processes. In addition, it seeks to identify and disseminate sound business models for practical, cost-effective and environmentally friendly ways to facilitate the transformation of the electricity grid based to a great extent on bioenergy technologies.

Participating countries: The European Commission and Finland

Status: Completed in December 2016 with the final report expected in the first quarter of 2017

Project 7: Bioenergy RES Hybrids

This one-year project (http://task41project7.ieabioenergy.com/iea-publications/) looks at some of the ways that bioenergy can be integrated with other renewable energy sources to achieve one or more of flexible generation, flexible storage of variable renewable energy (VRE) and increased overall efficiency of biomass use. The project has developed a series of key findings for domestic applications, utility scale and district heating and cooling networks, industry and farm scale applications. The report, which will be published in the first quarter of 2017, includes three country reports on the status of bioenergy RES hybrids – for Austria, Finland and Germany.

Participating countries: Austria, the European Commission, Finland and Germany

Status: Completed in December 2016 with the final report expected in the first quarter of 2017

TASK 42: Biorefining in a Future BioEconomy

www.iea-bioenergy.task42-biorefineries.com

Overview of the Task

Biorefining, the sustainable processing of biomass into a range of marketable biobased products and bioenergy/biofuels, is an innovative and efficient approach to using available biomass resources for the synergistic co-production of power, heat and biofuels alongside food and feed ingredients, pharmaceuticals, chemicals, materials, minerals and short-cyclic CO_2. Biorefining is one of the key enabling technologies of a Circular Economy[37], closing biomass raw materials (re-use of agro, process and post-consumer residues), minerals, water and carbon loops. Therefore, biorefining is the optimal strategy for large-scale sustainable use of biomass in the BioEconomy resulting in cost-competitive co-production of food/feed ingredients, biobased products and bioenergy with optimal socio-economic and environmental impacts (efficient use of resources, reduced GHG emissions, etc.).

The Circular Economy mainly focuses on the efficient use of finite resources and ensures that these are reused as long as possible. The BioEconomy integrates the production, efficient use and reuse of renewable resources, in particular renewable carbon. Growth of the BioEconomy means growth of the renewable Circular Economy. Bioenergy – i.e. fuels, power and/or heat – will always be part of full sustainable biomass cultivation – processing – end-use chains.

Bioenergy being the lubricating oil of the Bio(based)Economy[38] as part of the overall Circular Economy [IEA Bioenergy Task 42].

37 **Circular Economy** (CE): An economy that is restorative and regenerative by design, and which aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles [Ellen Macarthur Foundation].

38 **BioEconomy** (BE): An economy that encompasses the production of renewable biological resources and their conversion into food, feed, fibres, materials, chemicals, fuels, energy and minerals through efficient and innovative technologies [European BioEconomy Alliance]. The Biobased Economy (BbE) is the BE without the food/feed sectors.

Biorefining is not a fully new approach. Thousands of years ago the production of vegetable oils, beer and wine already required pre-treatment, separation and conversion steps; whereas paper production started around 100 AD. Industrial conventional biorefineries currently still can be found mainly in the food and paper sectors.

Within recently constructed biorefineries, bioenergy/biofuel based facilities are more common. In these, heat, power and biofuels are the main products, and both agroicultural and process residues are used to produce additional biobased products.

In product based biorefineries, higher-value food and feed ingredients, pharmaceuticals, chemicals, fibrous materials (e.g. pulp, paper) and/or fertilisers are the main products, with low-quality agroicultural and process residues used for the production of bioenergy and less commonly, biofuels. Product based biorefineries are mainly found in the food, feed and dairy, and pulp and paper industries at the current time.

Assessing the number of biorefinery facilities currently in operation globally is challenging. However, based on specific country reporting, being part of Task 42 of the International Energy Agency (IEA) Bioenergy Technology Collaboration Programme, over 100 commercial, demonstration and pilot facilities have been identified in the participating countries (www.iea-bioenergy.task42-biorefineries.com).

It is expected that within the next 10-20 years biomass-use for non-food/feed applications will shift from an energy to a more product-based approach; however, also on the longer-term, part of the biomass resources is still expected to be used for the production of advanced biofuels for transport (heavy duty transport aviation and shipping).

In the short-term (up to 2020) advanced biorefineries may be introduced in a variety of market sectors, mainly by means of upgrading of existing infrastructures, reducing both initial investment costs and the time-to-market. Bioenergy will play both an initiating and central role for the market deployment of these advanced biorefineries.

- Certified sustainable biocommodities that are now being developed and mobilised for energy applications on the mid/longer-term will also be available as raw materials for the biorefinery facilities ensuring sustainable biomass supply.
- Industrial bio-transportation fuel production facilities and digestion facilities can be further upgraded to integrated biorefineries co-producing fuels and added-value biobased products to optimise their overall sustainability, i.e. increase their financial market competitiveness.
- Low-quality value chain residues, i.e. residues that cannot be reused for added-value applications in an economically attractive way, like agro-residues, process residues and post-consumer residues, will be used for bioenergy production.

A portfolio of new biorefining concepts – i.e. whole crop biorefineries, lignocellulosic feedstock biorefineries, oleo-chemical biorefineries, green biorefineries, thermochemical biorefineries, micro and macro algae (marine) biorefineries, next generation hydrocarbon biorefineries... – is currently being developed and they are expected to be implemented into the market in the medium-term (2020-2025). However, the current economic conditions (low oil price, credit crisis, recessions in part of the world) might cause severe delays in their market deployment.

A very important non-technical barrier for the market deployment of product-based biorefineries is the availability of sufficient sustainable biomass resources. Product based biorefineries can accelerate their market deployment by using both the certification expertise and logistical infrastructures that are currently being developed and set-up for the use of sustainable biobased commodities for energy purposes.

Towards 2050, the portfolio of product based biorefinery concepts could expand further. Lignocellulosic feedstock, herbaceous (green), oleo-chemical and marine (microalgae and seaweeds) biorefineries may enter the market. However, expansion will require further technology development as product-based biorefinery facilities are generally less technically mature than bioenergy/biofuel alternatives. In addition, current policy support is more favourable towards bioenergy and biofuels than the production of biobased products. As such, facilitating the market development of product-based biorefineries is likely to require more widespread policy frameworks to support biobased products.

However, since such materials are generally higher-value products than bioenergy and biofuels, expanding markets for biobased products will be a key factor in product-driven refinery expansion.

Initiatives to support industry development include: a Biorefineries Roadmap in Germany in 2012, a Strategic Biomass Vision 2030 in The Netherlands, and ongoing funding for innovative biorefinery projects from the US Department of Energy (DOE). Deployment in Europe should be boosted by the Bio-Based Industries Joint Undertaking, a partnership between the European Union and the private sector to invest USD 4.1 billion in innovative technologies and biorefineries to produce biobased products from biomass wastes and residues. In addition, the European Commission's Circular Economy package includes biomass and biobased products as a priority sector, and outlines the promotion of support for innovation in the BioEconomy.

Bioenergy markets will play a central role in facilitating the growth of product based biorefineries through the development of sustainability certification processes and biomass fuel and feedstock supply chains. In addition, biofuel and biogas plants offer potential to upgrade integrated biorefineries co-producing fuels and added-value biobased products, with such facilities benefiting from diversified product streams and increased market competitiveness. Furthermore, even in the context of wider deployment of product based biorefineries, lower-value biomass feedstocks, such as agricultural and post-consumer residues that are less suitable for economic biobased product manufacture are likely to remain destined for bioenergy markets.

Aim of Task 42

To facilitate the commercialisation and market deployment of environmentally sound, socially acceptable, and cost-competitive biorefinery systems and technologies, and to advise policy and industrial decision makers accordingly. Task 42 provides an international platform for collaboration and information exchange between industry, SMEs, GOs, NGOs, RTOs and universities concerning biorefinery research, development, demonstration, and policy analysis. This includes the development of networks, dissemination of information, and provision of science-based technology analysis, as well as support and advice to policy makers, involvement of industry, and encouragement of membership by countries with a strong biorefinery infrastructure and appropriate policies. Gaps and barriers to deployment are addressed to successfully promote sustainable biorefinery systems market implementation.

Challenges to be tackled

- Develop industry legitimacy, including social acceptance and a level-playing field, for sustainable biomass use.
- Global sustainable biomass sourcing and development of an international trading market, incl. the development of biocommodities.
- Internalisation of externalities (CO_2-price).
- Multi-sectorial stakeholder involvement in the deployment of sustainable value chains, incl. industrial symbiosis of full sustainable biomass use for Food AND Non-food, and advanced communication (still separate languages between food/non-food and cultivation/processing).
- Technology development and biorefinery scale-up using best practices, i.e. for lignocellulosic-based biorefineries, herbaceous and aquatic biomass based biorefineries, protein-based biorefineries, food/non-food flexible biorefineries, mobile/decentralised biorefineries, integral Bio Industrial Complexes, etc.
- Unlock available expertise and industrial infrastructure in energy/fuel, agro/food, material and chemical manufacturing sectors
- Standardisation/regulation of biobased products (BBPs).
- Develop the necessary human capital by training students and other stakeholders to become the biorefinery experts of tomorrow

Task data

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

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

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

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

Operating Agent: Ir Kees Kwant, NL Enterprise Agency, Ministry of Economic Affairs, The Netherlands.

For further details on Task 42, please refer to Appendices 2, 4, 5 and 6; the Task website (www.IEA-Bioenergy.Task42-Biorefineries.com), and the IEA Bioenergy website (www.ieabioenergy.com) under 'Our Work: Tasks'.

Progress in R&D

Task Meetings & Workshops

On 18 and 19 April 2016 Task 42 organised its **20th Progress Meeting** in Dublin, Ireland. The aims of this meeting were: to come-up with a Consolidated Task 42 Work Programme 2016 – 2018, incl. changes to be made due to a significant number of NTL replacements (AT, CAN, IR, US), and to discuss biorefinery opportunities in Ireland at a specific Irish Stakeholder Event "Irish BioEconomy Strategy Development". Both aims were successfully met.

21st Task 42 Progress Meeting, May 2016, Dublin (IR)

The **21st Task 42 Progress Meeting** was organised from 14 – 18 November 2016 in Brisbane/Mackey, Australia. It was coupled with the Bioenergy Australia 2016 Conference in Brisbane where Task 42 provided 5 lectures, and an extensive excursion programme in Mackay with visits to Wilmar Ethanol Distillery, QUT Biocommodities Pilot Plant, Mackay Sugar Cogen Plant en Sugar Australia.

The **22nd Task 42 Progress Meeting** will be organised on 15 May 2017 in Gothenburg (SWE) linked to ExCo79. Together with IEA IETS, Task 42 will co-organise the Workshop "The role of industrial biorefineries in a low-carbon economy" on 16 May 2017 at the same location.

Most recently Task 42 co-organised the **International BioBased Economy Student SymbioSUM** that took place in August 2016 in Wageningen, The Netherlands.

2016 – 2018 Work Programme & Major Achievements

The work **programme 2016 – 2018** is based on four Activity Areas (AAs) with composing activities, viz.:

AA1) Biorefinery Systems – Analysis and assessment of biorefining in the whole value chain.

- Biorefinery expert system [D1]
- Biorefinery fact sheets [D2]
- Upgrading industrial infrastructures to integrated biorefineries [D3]

AA2) Product Quality – Reporting on related biobased products/bioenergy standardisation, certification and policy activities at national, European and global levels.

- International developments in biomass standardisation/certification [D4]
- Role Bioenergy and Biorefining in a Circular Economy [D5]
- Sustainable supply chains (JTP) [D6]

AA3) Evolving BioEconomy – Analysing and advising on perspectives biorefining in a Circular BioEconomy

- Monitoring of the Evolving BioEconomy in co-operation with EC DG JRC [D7]
- Biorefinery Success Stories [D8]

AA4) Communication, Dissemination and Training – Knowledge exchange by stakeholder consultation, reporting and lecturing

- Biorefinery Country Reporting [D9]
- Report Biobased Chemicals [D10]
- Report Proteins for Food/Feed and Industrial Applications [D11]
- Report Biobased Fibrous Materials [D12]
- Task 42 dissemination items (brochure, banner, website) [D13-15]
- Task 42 Progress Meetings [D16]
- Task 42 Newsletters [D17]
- Training Activities [D18]
- Papers/lectures International Events [D19]
- Thematic Stakeholder Workshops (TSWs) [D20]

Biorefinery Systems – Analysis and assessment of biorefining in the whole value chain

In the second half of 2016, the Austria NTL started with the development of the expert system. This system will be developed in close cooperation with EC DG JRC (Ispra, IT) to minimise budget requirements, share expertise, and optimise final dissemination.

Product Quality – Reporting on related biobased products/bioenergy standardisation, certification and policy activities at national, European and global levels

The international developments in the field of biomass and biobased products standardisation and certification are enormous. These were monitored in 2016 by the German NTL, and internally reported to the participating countries at the biannual Task Progress Meetings.

Evolving BioEconomy – Analysing and advising on perspectives biorefining in a Circular BioEconomy

Wageningen UR has executed a 1st literature and web analysis concerning the potential role of biomass, biorefining and bioenergy in the future BioEconomy and Circular Economy. The result (slide-deck) was presented in January 2017 both at an IEA Workshop in Paris (F) and the International Biomass Conference in Graz (AT). First contacts have been initiated with FAO, OECD, EC JRC, EERA Bioenergy and ETIP Bioenergy to analyse the possibilities to synergistically cooperate within the field of the BioEconomy. An attempt will be made to organise a joint event around mid-2017 to discuss further details.

The Italian NTL (ENEA) has started with some activities within the field of monitoring of the progress of the BioEconomy in both Task 42 and IEA Bioenergy countries and beyond in close cooperation with EC DG JRC.

Communication, Dissemination and Training – Knowledge exchange by stakeholder consultation, reporting and lecturing

A glossy Task 42 report "Proteins for Food, Feed and Biobased Applications – Biorefining of Protein Containing Biomass" was published in the 2nd half of 2016, and distributed globally, with the goal to inform stakeholders in the energy sector on the potential financial added-value of proteins separation and valorisation in combination with energy production from protein-rich biomass sources.

Task 42 wrote a chapter in the book "Developing the Global BioEconomy" that was published by IEA Bioenergy.

Major publications Task 42 in 2016

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

Task Website

In spite-of-the-fact that all deliverables can be found on the Task 42 website – www.IEA-Bioenergy.Task42-Biorefineries.com – the website still has to be updated to meet the 2016-2018 work programme structure. This will be done asap, and will be finalised in Q1 2017.

TASK 43: Biomass Feedstocks for Energy Markets

Overview of the Task

The work of the Task in the current triennium will address issues critical to mobilising sustainable bioenergy supply chains, including all aspects of feedstock production, its markets and environmental, social and economic impacts. The objective is to promote sound bioenergy development that is driven by well-informed decisions by land owners, businesses, governments and others. This will be achieved by collecting, analysing, and sharing technical and non-technical information related to biomass feedstock supply and providing relevant actors with timely and topical analyses, syntheses and information.

The Task has a global scope and includes commercial, near-commercial and promising feedstock production systems in agriculture and forestry. The primary focus is on land use and land management of biomass production systems. The Task work builds upon the work of the previous triennium and seeks new opportunities for collaboration with other Tasks as well as organisations outside IEA Bioenergy. The Task will also interact with other research networks and programmes that have workplans in the same areas.

Participating countries (as in Dec 2016): Australia, Canada, Croatia, Denmark, European Commission, Finland, Germany, Ireland, The Netherlands, Norway, Sweden, and the USA

Task Leader: Associate Professor Ioannis Dimitriou, Swedish University of Agricultural Sciences, Sweden

Work Package Leaders: Göran Berndes, Chalmers University of Technology; Mark Brown, University of the Sunshine Coast; Hans Langeveld, Bioenergy Research; Tat Smith, University of Toronto

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

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

The Task leader will together with the WP Leaders manage the work of the Task. A Steering Committee (SC), consisting of the Task Leader, WP Leaders and the National Team Leaders (NTLs), will be responsible for reviewing progress and making overall priorities. Each NTL forms a national team of experts that supports the NTL in making national contributions to the collaboration. Other associated experts are also be involved.

For further details on Task 43, please refer to the Appendices of this report and the Task website www.ieabioenergytask43.org and the IEA Bioenergy website www.ieabioenergy.com.

Task Meetings and workshops

A SC meeting was held once a month to update the SC members about the work in progress, plan new activities and decide about different Task matters.

A number of business/planning meetings were held in 2016. In the following list meetings held to plan activities within the Task and the inter-Tasks in which Task 43 is participating are not included.

i) Task 43 kick-off meeting, Wageningen, The Netherlands (main focus on updating the scope and aim of the Task and further development of our key areas and topics in the framework of our three WPs);

ii) Workshop: "Landscape management and design for food, bioenergy and the bioeconomy: methodology and governance aspects", Gothenburg, Sweden (networking and the sharing of views and experiences about methodologies and tools for assessing land-use impacts on biodiversity and ecosystems services – in collaboration with several other organisations);

iii) Bioenergy Study Tour at Southeast United States (organised by US DOE with active involvement of a number of Task 43 members - list of topics included: landscape design approach to making progress toward a sustainable bioeconomy; forestry practices with and without an active pellet industry and associated sustainability issues; status of old-growth low-elevation forests; biofuels for transportation; opportunities and constraints of a wood-based pellet-industry in SE US; stakeholder engagement; handling of agricultural crops for bioenergy; pellet industry operations);

iv) Kick-off meeting of inter-Task project "Measuring, governing and gaining support for sustainable bioenergy supply chains", Utrecht, The Netherlands (description of content and input for the three different tasks);

v) IEA Bioenergy Task 43 Business meeting, Savannah, Georgia, USA (in collaboration with Task 38, discussions and presentations about work within the inter-Task "Sustainability" project was discussed and other activities);

vi) IEA Bioenergy ExCo77 workshop "Mobilising sustainable bioenergy supply chains: opportunities for agriculture" Rome, Italy (several outcomes in the subject, discussions with FAO and IRENA about common position paper);

vii) Webinar "Examples of Positive Bioenergy and Water Relationships in the Americas" (in collaboration with GBEP);

viii) Workshop "The world needs more land use change" (in collaboration with GBEP, IRENA and ICRAF at the European Biomass Conference and Exhibition (EUBCE) – Amsterdam, The Netherlands); workshop "Mobilisation of forest bioenergy: Green dream or reality?" (in collaboration with SUPERGEN Bioenergy Hub at the EUBCE;

ix) Workshop: Landscape Management and Design for Bioenergy and the Bioeconomy (Vancouver, Canada - Presentations available at the Task 43 website);

x) Workshop: Mobilisation of forest biomass to produce bioenergy, biofuels and bioproducts: Challenges and opportunities (Vancouver, Canada - Presentations available at the Task 43 website).

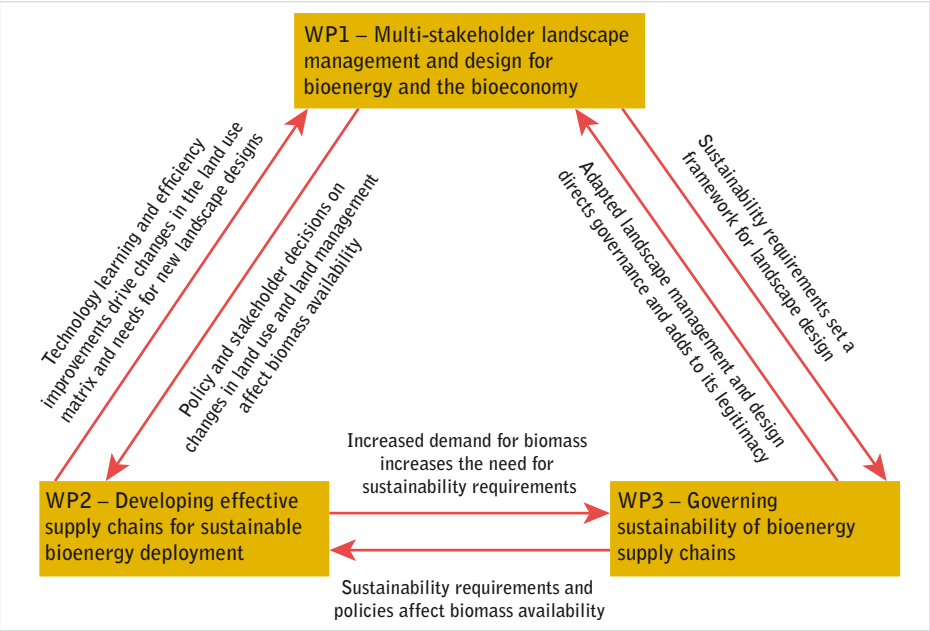
Work Programme

The objective of the Task work is to promote sound bioenergy development that is driven by well-informed decisions by land owners, businesses, governments and others. This will be achieved by collecting, analysing, and sharing technical and non-technical information related to biomass feedstock supply and providing relevant actors with timely and topical analyses, syntheses and information. The work of the Task addresses issues critical to mobilising sustainable bioenergy supply chains, including all aspects of feedstock production, its markets and environmental, social and economic impacts.

Studies integrating several disciplines are conducted to analyze trade-offs, compatibility and synergies between food, fibre and energy production systems and the bio-economy. The Work Programme is organised in three WPs that are each organised in a set of Task Activities. Research priorities include Landscape management and design for bioenergy and the bio-economy (WP1); Developing effective supply chains for sustainable bioenergy deployment (WP2); Governance sustainability of bioenergy supply chains (WP3). The Task also participates in three strategic inter-Task projects run in the 2016-2018 triennium: i) Measuring, governing and gaining support for sustainable bioenergy supply chains; ii) Fuel pretreatment of biomass residues in the supply chain for thermal conversion; iii) Bioenergy Success Stories.

The three WPs represent the main elements to achieve the general Task objectives. Specific focus areas and associated work and activities have been outlined within each WP. Topics addressed are critical for deployment of sustainable biomass supply chains and many are relevant for more than one WP as exemplified in the figure overleaf.

WP1 aims at supporting landscape management and design for bioenergy and the bio-economy, by expanding the knowledge base required for sustainable expansion of biomass production systems that also contribute positively to biodiversity and the generation of other ecosystem services. The work takes a landscape level approach to deployment of biomass production for bioenergy and integration of this objective with ownership and societal objectives for existing land use and associated systems. The WP activities address the overarching questions below, which are relevant for both agricultural and forestry systems and reflect the fact that agriculture and forestry activities often co-exist and shape the landscape together.



Which are the most suitable areas for production and/or extraction of various biomass feedstocks? How can biomass feedstock production systems be located, designed and managed to increase resource use efficiency, avoid/mitigate negative and promote positive environmental, economic, and social effects? How can outcomes be optimised to meet the goals of individual stakeholders and society as a whole, including environmental, economic, and social goals? How can analysis and assessment inform participatory processes engaging land owners, policy makers, and other stakeholders in further developing and re-defining goals and plans for landscape management and designs?

A number of feedstock systems and landscapes are analysed and compared with each other and with relevant reference systems, e.g., cultivation of conventional food/feed crops and forest management to produce saw timber and pulpwood. The feedstock alternatives, their location in the landscape, and the needed management systems vary in how they perform relative to different stakeholder objectives (e.g., biomass yields, economy, nutrient use efficiency, energy efficiency, water quality, soil quality, biodiversity and GHG balances). Comparison with stakeholders' preferences, existing guidelines and regulations will help clarify benefits and trade-offs related to choices and alternatives.

The aim of WP2 is to identify opportunities, strategies and practices for improved supply chains and supply chain technology to support large-scale bioenergy deployment. WP2 synthesises and advances state-of-the-art knowledge on biomass supply chains to increase understanding, development and deployment of effective, efficient and sustainable biomass production, harvest, and delivery options. The roles of technologies and of logistics and other management aspects are analysed in varying regulatory and policy contexts. Particular

attention is given to integration and interaction between biomass supply chains and the operating and regulatory environment in which they are set, and how that impacts the efficient, sustainable production and use of the biomass resource. The WP is organised around four main activities: Biomass resource assessment and system mapping; technology learning and systems mapping; integration of natural resources and energy systems; and integration of biomass supply chains with existing forest and agricultural supply chains.

The aim of WP3 is to identify how public or private regulatory systems governing the sustainability of land use and bioenergy supply chains can be improved in terms of abilities to monitor, assess and promote achievement of economic, social, and environmental goals while considering the perspectives of land owners, biomass users, and the society as a whole. WP3 examines the interactions among sustainability governance, bioenergy supply chain deployment and climate change. WP3 uses field research, modelling, reviews, syntheses of scientific knowledge, assessments of existing and emerging governance systems, and surveys to determine the views and experiences of different stakeholder groups with sustainability governance. The work intends to inform development of governance from local to international levels, and focuses on the following activities: Improving legitimacy, including effectiveness and efficiency, of governance developed to address sustainability of biomass and bioenergy at different scales; advancing governance mechanisms and science-based assessment of GHG balances and climate effects of LULUCF activities associated with biomass and bioenergy systems.

The work within the different WPs is interrelated and conducted in close co-operation with the WPs; findings in activities of one WP affect the baselines of other activities and therefore close collaboration is a prerequisite to successfully tackle the great number of open questions that the Task has identified and aims to give answers.

Website

The Task website (www.ieabioenergytask43.org) is under change in line with changes of the IEA Bioenergy website. However, extensive information concerning the Task 43 work is available and updated constantly.

Collaboration with Other Tasks/Networking

As mentioned above, Task 43 is involved in three Inter-task projects: i) Measuring, governing and gaining support for sustainable bioenergy supply chains (Leader: Martin Junginger, Task 40), Bioenergy success stories (Leader: Uwe Fritsche, Task 40); Fuel pretreatment of biomass residues in the supply chain for thermal conversion (Leader: Jaap Koppejan, Task 32). Concerning the inter-Task project "Measuring..." Göran Berndes (Task 43) and Annette Cowie (Task 38) coordinate the work of Objective 1 while Tat Smith and Inge Stupak (both Task 43) coordinate the work of Objective 2. Several Task 43 members (including Biljana Kulisic, Jörg Schweinle, and Ioannis Dimitriou) are involved in the work of Objective 3. In the "Pretreatment" intertask, there will be involvement of Task 43 collaborators in two

sub-case studies: Wolter Elbersen in ag-residues leaching and potential, and Antti Asikainen and Évelyne Thiffault in forest residues. Additionally, Task 43 has expressed the interest to participate in the initiative taken by Task 32 which concerns a potential intertask project on "Wood fuel cooking and indoor air pollution" if the subject will be broadened and include other aspects that are related to feedstock supply. Discussions on this are on-going.

There has been extensive collaboration with GBEP-AG6 on Bioenergy and Water and Task 43; two webinars in collaboration with GBEP-AG6 have taken place in 2016 and a workshop has been arranged in association with the GBEP annual meetings in Rome (tentative date Nov 30). Göran Berndes (WP1 leader) serves as chair of AG6 and several other Task 43 members are also engaged in AG6.

The white paper involving FAO, IRENA and IEA Bioenergy on bioenergy indirect effects and LUC in governance systems is a concrete example of co-operation with IRENA. Members of Task 43 have been active in this co-operation which will hopefully increase with more common activities in the coming years. The Co-operation of Task 43 with FAO is developing on several levels: the Bioenergy and Food Security (BEFS RA) division at FAO (Irini Maltsoglou) has been invited and participated in our workshops aiming at closer collaboration, e.g. on sustainability assessment issues.

Task 43 has been collaborating with several networks worldwide who are engaged in the same topics and has co-organised several events in 2016 (see list above) which resulted in several publications (see Appendix 4). Collaboration with the Biofuelnet Canada community has occurred during the workshops in Vancouver, and the ambition is to continue with this co-operation in the future. The same is true for Task 43's co-operation with USDA-FS, Oak Ridge National Laboratory and other National Labs and their collaborating organisations, with several common activities planned in the coming years that address topics that are central for Task 43 and collaboration plans are discussed. Networks such as CAR-ES (Centre of Advanced Research on Environmental Services from Nordic Forest Ecosystems), which brings together Nordic and Baltic forest researchers with the aim to provide scientific knowledge on the impacts of forest management, and the SNS "Effects of bioenergy production from forests and agriculture on ecosystem services in Nordic and Baltic landscapes" bring Task 43 researchers (Bentsen, Berndes, Dimitriou, Stupak, and others) with several research projects in the area.

Several Task 38 and Task 43 members contributed to a report titled "Forest biomass, carbon neutrality and climate change mitigation" that has been published by the European Forest Institute. The report has been presented in seminars at the European Commission and the European Parliament.

TASK PARTICIPATION IN 2016

TASK	AUS	AUT	BEL	BRA	CAN	CRO	DEN	FIN	FRA	GER	IRE	ITL	JAP	KOR	NEL	NZE	NOR	SA	SWE	SWI	UK	USA	EC	Total
32		•	•		•		•			•	•	•	•		⊗		•	•	•	•				13
33		•					•			•		•			•		•		•	•		⊗		9
34					•			•		•					•	•			•			⊗		7
36									•	•		•							⊗					4
37	•	•		•			•	•	•	•	⊗			•	•		•		•	•	•			14
38	⊗							•	•	•									•			•		6
39	•	•		•	⊗		•			•			•	•	•	•		•	•			•	•	14
40		•	•				•	•		•		•			⊗				•		•	•		10
42	•	•			•		•			•	•	•			⊗							•		9
43	•				•	•	•	•		•	•				•		•		⊗			•	•	12
Total	5	6	2	2	5	1	7	5	3	10	4	5	2	2	8	2	4	2	9	3	2	7	2	98

⊗ = Operating Agents • = Participant

BUDGET IN 2016 – SUMMARY TABLES

Budget for 2016 by Member Country (US$)

Contracting Party	ExCo funds	Task funds	Total
Australia	11,700	77,500	89,200
Austria	12,700	91,500	104,200
Belgium	8,700	30,000	38,700
Brazil	8,700	29,000	37,700
Canada	11,700	80,500	92,200
Croatia	7,700	15,000	22,700
Denmark	13,700	106,500	120,200
Finland	11,700	78,000	89,700
France	9,700	45,400	55,100
Germany	16,700	155,900	172,600
Ireland	10,700	61,500	72,200
Italy	11,700	77,900	89,600
Japan	8,700	30,000	38,700
Korea	8,700	29,000	37,700
The Netherlands	14,700	124,500	139,200
New Zealand	8,700	33,000	41,700
Norway	10,700	59,000	69,700
South Africa	8,700	30,000	38,700
Sweden	15,700	138,400	154,100
Switzerland	9,700	44,000	53,700
UK	8,700	29,000	37,700
USA	13,700	111,500	125,200
European Commission	8,700	30,000	38,700
Total	**252,100**	**1,507,100**	**1,759,200**

BUDGET IN 2016 – SUMMARY TABLES

Budget for 2016 by Task (US$)

Task	Number of participants	Annual contribution per participant	Total Task funds
Task 32: Biomass Combustion and Co-firing	13	15,000	195,000
Task 33: Gasification of Biomass and Waste	9	15,000	135,000
Task 34: Direct Thermochemical Liquefaction	7	18,000	126,000
Task 36: Integrating Energy Recovery into Solid Waste Management Systems	4	15,400	61,600
Task 37: Energy from Biogas	14	14,000	196,000
Task 38: Climate Change Effects of Biomass and Bioenergy Systems	6	16,000	96,000
Task 39: Commercialising Conventional and Advanced Liquid Biofuels from Biomass	14	15,000	210,000
Task 40: Sustainable biomass markets and international bioenergy trade to support the biobased economy	10	15,000	150,000
Task 41: Bioenergy Systems Analysis	5	0	0
Task 42: Biorefining in a future BioEconomy	9	17,500	157,500
Task 43: Biomass Feedstocks for Energy Markets	12	15,000	180,000
Total			**1,507,100**

CONTRACTING PARTIES

Bioenergy Australia (Forum) Ltd

The Republic of Austria

The Government of Belgium

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

Natural Resources Canada

The Energy Institute "Hrvoje Pozar" (Croatia)

The Ministry of Transport and Energy, Danish Energy Authority

Commission of the European Union

Tekes, Finnish Funding Agency for Technology and Innovation

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

Federal Ministry of Food and Agriculture (Germany)

The Sustainable Energy Authority of Ireland (SEAI)

Gestore dei Servizi Energetici – GSE (Italy)

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

Ministry of Knowledge Economy, the Republic of Korea

NL Enterprise Agency (The Netherlands)

The New Zealand Forest Research Institute Limited

The Research Council of Norway

South African National Energy Development Institute (SANEDI)

Swedish Energy Agency

Swiss Federal Office of Energy

Department of Business, Energy and Industrial Styrategy (United Kingdom)

The United States Department of Energy

LIST OF REPORTS AND PUBLICATIONS

The Executive Committee

Final Minutes of the ExCo77 meeting, Rome, Italy, May 2016.

Final Minutes of the ExCo78 meeting, Rotorua, New Zealand, November 2016.

IEA Bioenergy News February 2016

IEA Bioenergy News Volume 28(1), June 2016

IEA Bioenergy News September 2016

IEA Bioenergy News Volume 28(2), December 2016

IEA Bioenergy Update. Number 58. Biomass and Bioenergy. Published, JBB 85, February 2016

IEA Bioenergy Update. Number 59. Biomass and Bioenergy. Published, JBB 86, March 2016

IEA Bioenergy Update. Number 60. Biomass and Bioenergy. Published, JBB 93, October 2016

IEA Bioenergy Update. Number 61. In press.

Anon. IEA Bioenergy Annual Report 2015. IEA Bioenergy ExCo:2016:01.

Anon. Mobilising sustainable bioenergy supply chains: opportunities for agriculture. Summary and Conclusions from the IEA Bioenergy ExCo77 Workshop. IEA. Bioenergy ExCo:2016:02

Bacovsky et al. IEA Bioenergy Countries' Report. Bioenergy ExCo:2016:03

Anon. Report on IEA Bioenergy Tasks' Activities 2013-2015. IEA Bioenergy ExCo:2016:04.

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

TASK 32

Minutes of the Task meeting in Horw, Switzerland, June 2016.

Minutes of the Task meeting in Maniwa, Japan, Oct 2016.

IEA Bioenergy Task 32 Newsletter, Issue 13, June, 2016.

IEA Bioenergy Task 32 Newsletter, Issue 14 Dec, 2016.

Thomas Nussbaumer, Needs to reduce particle emissions from biomass combustion - Conclusions from the IEA Bioenergy Task 32 session at 20th ETH Conference on Combustion Generated Nanoparticles in Zurich, Switzerland, ISBN 3-908705-32-0, IEA Bioenergy Task 32, 14 June 2016

W.R. Livingston (lead author), J. Middelkamp, W. Willeboer, S. Tosney, B. Sander, S. Madrali, M.T. Hansen, J. Koppejan, M.F.G. Cremers, The status of large scale biomass firing - The milling and combustion of biomass materials in large pulverised coal boilers, ISBN 978-1-910154-26-7, 2016

Koppejan, J., Cremers, M., Wild, M., Junginger, M., Biomass Torrefaction – Technology Status and Commercialisation, Applications for Torrefied Biomass and its Role in Logistics and Trade, IEA Bioenergy, 27 Oct 2016

Progress report for ExCo77, Rome, May 2016

Progress report for ExCo78, Roturua, Nov 2016

Nussbaumer, T., Report from the Workshop 'Biomass Combustion Generated Nanoparticles, 14 June 2016

Thomas Nussbaumer, Switzerland, Particulate Matter (PM) from biomass combustion: An overview on particle types and measures to reduce particle emissions

Jorma Jokiniemi, Finland, Chemical and physical properties of biomass combustion aerosols

Hans Hartmann, Germany, User and fuel impact on emissions of wood stoves

Christoph Schmidl, Austria, Real-life emission of automatically stoked biomass boilers

Morten Seljeskog, Norway, Variables affecting particulate emissions from residential wood combustion - simultaneous sampling on hot and ambient filter

Please visit the new Task website for the reports and original presentations: task32.ieabioenergy.com

TASK 33

Please also visit the Task website: http://task33.ieabioenergy.com/

TASK 34

Minutes of the Task meeting in Rotorua, New Zealand, November 2016.

Progress report for ExCo77, Rome, Italy, May 2016.

Progress report for ExCo78, Rotorua, New Zealand, November 2016.

Task 34 Newsletter No. 39, October 2016.

Please also visit the Task website: http://task34.ieabioenergy.com/

TASK 36

End-of-triennium report (2013-2015)

Minutes of the Task meeting in Rome, Italy, May 2016.

Progress report for ExCo77, Rome, May 2016

Progress report for ExCo78, Rotorua, November 2016.

Proceedings of workshop on moving towards a sustainable waste management, Rome, May 2016

Report – Small scale Energy from Waste – Drivers and barriers, May 2016

Report – An Assessment of the Export of Municipal Solid Waste from the UK as Refuse Derived Fuel using a Mass Balance Technique, May 2016

Presentations:

Task members or representatives made the following presentation on behalf of the task in 2016:

Small scale Energy from Waste – drivers and barriers, Bioenergy Australia, Brisbane, 14 Nov 2016

TASK 37

Minutes from the Task meeting in Oxfordshire, April 2016;

Minutes from the Task meeting in Toowoomba, Australia, November 2016

Progress report for ExCo77, Rome, Italy, May 2016

Progress report for ExCo78, Rotorua, New Zealand, November 2016

Presentations from Energy from Biogas Workshop Wallingford UK, April 14th 2016 http://www.iea-biogas.net/workshops.html

- IEA Bioenergy Task 37 Energy from biogas – An Overview, Jerry Murphy;
- The role of digestate in the location of AD plants and the industry's future, William McManus, WRAP, UK;
- Monitoring biogas plants - An overview of methods and application to industry, Günther Bochmann;
- Financial implications of process management and monitoring, Harry Waters, Commercial Director Agrivert Ltd. UK;
- The psychology of small scale AD, Clare Lukehurst;
- Why small scale – an Irish approach to meet BtG policy targets? Dr. James Browne, Gas Networks, Ireland;
- Small scale technology needs of tropical countries Bernadette McCabe.

Presentations from members of Task 37 at the Bioenergy Australia 2016 conference, Brisbane, Australia, November 15: http://www.bioenergyaustralia.org/pages/bioenergy-australia-conference-2016.html#spontrade

- Biogas in the Circular Economy, Clare Lukehurst, United Kingdom;
- The Role Of Biogas In Supporting Intermittent Renewable Electricity, Jerry Murphy, Ireland;
- IEA Bioenergy - Task 37 Energy from Biogas: Knowledge Sharing Opportunities For Australia During The 2016-2018 triennium, Bernadette McCabe, Australia;
- Biomethane Market Potential -Opportunities And Challenges Ahead, Mattias Svensson, Sweden;
- Monitoring And Process Control Of Biogas Plants, Günther Bochmann, Austria;
- Resource Recovery Via Distributed Biogas Production, Saija Rasi, Finland

Newsletters: 11 issues in 2016

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

TASK 38

Minutes from the Task Business Meeting: Savannah (USA).

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Progress Report for ExCo77, Rome (Italy). May 2016.

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Cowie, A., Ximenes, F., Berndes, G., Brandão, M., Lamers, P. and Marland, G., 2016. Policy institutions and forest carbon. Nature Climate Change, 6(9), pp.805-805

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De Rosa, M., Schmidt, J., Brandão, M. and Pizzol, M., 2016. A flexible parametric model for a balanced account of forest carbon fluxes in LCA. The International Journal of Life Cycle Assessment, pp.1-13.

Gustavsson, L. and Truong, N.L., 2015. Effects of different bioenergy pathways on primary energy efficiency, climate mitigation and energy system integration. In The 10th Conference on Sustainable Development of Energy, Water and Environment Systems–SDEWES 2015.

Gustavsson, L. and Le Truong, N., 2016. Bioenergy pathways for cars: Effects on primary energy use, climate change and energy system integration. Energy.

Gustavsson, L., Haus, S., Lundblad, M., Lundström, A., Ortiz, C.A., Sathre, R., Le Truong, N. and Wikberg, P.E., 2017. Climate change effects of forestry and substitution of carbon-intensive materials and fossil fuels. Renewable and Sustainable Energy Reviews, 67, pp.612-624.

Helin, T., Salminen, H., Hynynen, J., Soimakallio, S., Huuskonen, S., & Pingoud, K. (2015). Global warming potentials of stemwood used for energy and materials in Southern Finland: differentiation of impacts based on type of harvest and product lifetime. GCB Bioenergy 8(2), 334-345.

Hildén, M., Soimakallio, S., Seppälä, J. and Liski, J., 2016. Forest carbon sinks must be included in bioeconomy sustainability assessments. SYKE Policy brief

Jones, C.D., Ciais, P., Davis, S.J., Friedlingstein, P., Gasser, T., Peters, G.P., Rogelj, J., van Vuuren, D.P., Canadell, J.G., Cowie, A. and Jackson, R.B., 2016. Simulating the Earth system response to negative emissions. Environmental Research Letters, 11(9), p.095012.

Koponen, K. Doctoral thesis. Aalto University. ISBN 978-952-60-6795-7. Available: https://aaltodoc.aalto.fi/handle/123456789/20377

Mohammadi, A., Cowie, A., Mai, T.L.A., de la Rosa, R.A., Brandão, M., Kristiansen, P. and Joseph, S., 2016. Quantifying the Greenhouse Gas Reduction Benefits of Utilising Straw Biochar and Enriched Biochar. Energy Procedia, 97, pp.254-261

Mohammadi, A., Cowie, A., Mai, T.L.A., Anaya de la Rosa, R., Kristiansen, P., Brandão, M. and Joseph, S., 2016, April. Life cycle assessment of biochar application in Vietnam using two pyrolysis technologies. In EGU General Assembly Conference Abstracts (Vol. 18, p. 11736).

Smith, P., Davis, S.J., Creutzig, F., Fuss, S., Minx, J., Gabrielle, B., Kato, E., Jackson, R.B., Cowie, A., Kriegler, E. and Van Vuuren, D.P., 2016. Biophysical and economic limits to negative CO_2 emissions. Nature Climate Change, 6(1), pp.42-50.

Soimakallio, S., Saikku, L., Valsta, L. and Pingoud, K., 2016. Climate Change Mitigation Challenge for Wood Utilisation: The Case of Finland. Environmental science & technology, 50(10), pp.5127-5134.

Please also visit the Task website: http://task38.ieabioenergy.com/

TASK 39

Minutes from the Task meeting in Delft, The Netherlands, March 2016.

Minutes from the Task meeting in Rotorua, New Zealand, November 2016

Progress report for ExCo77, Rome, Italy, April 2016.

Progress report for ExCo78, Rotorua, New Zealand, September 2016.

Van Dyk, S. (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 42, May 2016.

Van Dyk, S. (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 43, August 2016.

Van Dyk, S. (Ed.) IEA Bioenergy Task 39 Newsletter Vol. 44, December 2016.

The publications are available on the Task website: http://task39.ieabioenergy.com/

TASK 40

Task documents

Minutes from the Task meeting in Utrecht, The Netherlands, January 2016.

Minutes from the Task meeting in Stockholm, Sweden, May 2016.

Minutes from the Task meeting in Miami, the United States, November 2016.

Progress report for ExCo77, Rome, Italy, May 2016.

Progress report for ExCo78, New Zealand, November 2016.

Mai-Moulin T, Junginger M, and Schouwenberg P-P. (Eds) Task 40 Newsletter. Issue 1, September 2016.

Presentations

Olsson, Lamers et Guisson (2016): *Cascading of woody biomass: - impacts on forest markets and trade*, Breakfast session Effects and Impacts of Cascading Policy on Forest Markets and International Trade, USIPA 6th Annual Exporting Pellets conference

Thraen et Wild (2016): *Overview of current developments in the wood pellet industry and market*, Breakfast session Overview of current developments in the wood pellet industry and market, USIPA 6th Annual Exporting Pellets conference

Bruce (2016) *Growth and Opportunities of Non-Subsidised MarketsPresentation on potential second generation uses for industrial-grade wood pellets utilising existing supply chains*, USIPA 6th Annual Exporting Pellets conference

Schouwenberg (2016) *Update on Dutch SDE+ Scheme and Dutch Foundation for Biomass Certification*. Presentation on Policy and Sustainability in Europe, USIPA 6th Annual Exporting Pellets conference

Junginger (2016) *Update on Proposed EU Bioenergy Policy and Brussels Activity*. Presentation on Policy and Sustainability in Europe, USIPA 6th Annual Exporting Pellets conference.

Reports

Country reports 2014: Flanders, Belgium (published in 2016)

Wild M et al. (2016): *Ongoing developments for torrefaction of biomass*

Olsson et al. (2016): *Cascading of woody biomass: definitions, policies and effects on international trade*

Schipfer et al (2016): *The European wood pellet market for small scale* heating (in the final stage)

Books

Lamers et al. (2016): *Developing the Global Bioeconomy: Technical, Market, and Environmental Lessons from Bioenergy* (cooperation of Task 40 & 42)

Junginger et al. (2016): *Mobilisation of Forest Bioenergy in the Boreal and Temperate Biomes: Challenges, Opportunities, and Case Studies* (cooperation of Task 37, 38, 39, 40, 42 & 43)

TASK 42

Ree van R., The Role of Biorefining in the BioEconomy, Irish Stakeholder Meeting at Task 42 Progress Meeting, Dublin, Ireland, 19 April 2016.

Bell G., Second Generation Bio-Refineries – Implications for Australia, Irish Stakeholder Meeting at Task 42 Progress Meeting, Dublin, Ireland, 19 April 2016.

Jorgensen H., Biorefinery RD&D in Denmark, Irish Stakeholder Meeting at Task 42 Progress Meeting, Dublin, Ireland, 19 April 2016.

Mandl, M.G., Green Biorefining: Grass for Generating Products and Bioenergy, Irish Stakeholder Meeting at Task 42 Progress Meeting, Dublin, Ireland, 19 April 2016.

Bell G. and Jong de E., IEA Bioenergy Task 42 – Biorefining in a Future BioEconomy, webinar and Participation Group Meeting, Bioenergy Australia, 25 May 2016.

Mulder W., Protein-driven Biorefining: Sustainable Biomass Use for Food and Non-food, EUBC&E-2016, Amsterdam, The Netherlands, 6 June 2016.

Jungmeier G. et al., Implementing Strategies of Biorefineries in the BioEconomy, EUBC&E-2016, Amsterdam, The Netherlands, 6-9 June 2016.

Jungmeier G. et al., The Approach of Life-Cycle Sustainability Assessment of Biorefineries, paper linked to EUBC&E-2016, 2016 (to be published).

Ree van R., Integration of Advanced Biofuels in the Circular Economy, 7th Stakeholder Plenary Meeting, European Biofuels Technology Platform, Brussels, Belgium, 21 June 2016.

Ree van R., Biorefinery Market Developments, feature article IEA Mid-term Renewable Energy Market Report, 2016.

Bell G. and Jong de E., What is Australia's biofuel future?, Ecogeneration, 28 October 2016.

Bos H., Annevelink B. and Ree van R., The Role of Biomass, Bioenergy and Biorefining in a Circular Economy, IEA Bioenergy Task 34 Workshop, Paris, 10 January 2017.

Mandl M. and Ree van R., Biorefining – Activities and Current Results of IEA Bioenergy Task 42, 4th Central European Biomass Conference, Graz, Austria, 15-18 January 2017.

Ree van R., Biorefinery Approach in the EU and Beyond, Workshop on EU-AU R&I Partnership on Food and Nutrition Security and Sustainable Agriculture (FNSSA), Brussels, 23 January 2017.

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

TASK 43

Task 43 Technical Reports

The contribution of Danish forestry to increase wood production and offset climate change 2010-2100 (Scott-Bentsen et al.) (IEA Bioenergy Task 43 TR2016:01)

Balancing different environmental effects of forest residue recovery in Sweden: A stepwise handling procedure, Björkman and Börjesson (IEA Bioenergy Task 43 TR2016:03)

State of the art in sustainable biomass recovery technology/supply chain in forest operations, Ghaffariyan et al. (IEA Bioenergy Task 43 TR2016:02)

Agricultural Residues for Energy in Sweden and Denmark – Differences and Commonalities, Bentsen et al. (IEA Bioenergy Task 43 TR2016:05)

Bioenergy Feedstock Production on Grasslands and Pastures: Brazilian experiences and global outlook, Berndes et al. (IEA Bioenergy Task 43 TR2016:06)

Examples of Positive Bioenergy and Water Relationships (Common publication with GBEP)

"Forest Energy for a Sustainable Future -Composite Report from the R&D Programme, Efficient Forest Fuel Supply Systems 2011-2015 (Skogforsk, financed by the industry and Swedish Energy Agency)

Position paper on "May we have some more land use change, please?" (Available at: http://www.ieabioenergy.com/publications/may-we-have-some-more-landuse-change-please/)

Peer-review paper "Opportunities to encourage mobilisation of sustainable bioenergy supply chains", (Smith et al., Wires Energy and Environment)

Report: Mobilising Sustainable Supply Chains-Biogas Cases, Langeveld et al. (IEA Bioenergy Task 43 TR2016:04)

Forest biomass, carbon neutrality and climate change mitigation, Berndes et al. (EFI report - http://www.efi.int/files/attachments/publications/efi_fstp_3_2016.pdf)

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

KEY PARTICIPANTS IN EACH TASK

TASK 32 — Biomass Combustion and Co-firing

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

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

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

Country	National Team Leader	Institution
Austria	Christoph Schmidl	Bioenergy 2020+
Belgium	Pierre Martin	Valbiom
Canada	Sebnem Madrali	National Resources Canada
Denmark	Morten Tony Hansen	Ea Energy Analyses
Germany	Hans Hartmann	Technologie- und Forderzentrum
Ireland	William Smith	University College of Dublin
Italy	Roberta Roberto	ENEA Research Center of Saluggia
Japan	Nobuyuki Tahara	New Energy and Industrial Technology Development Organisation (NEDO)
The Netherlands	Jaap Koppejan	Procede Biomass BV
	Marcel Cremers	DNV GL
	Kees Kwant	RVO
Norway	Øyvind Skreiberg	SINTEF
South Africa	Yokesh Singh	ESKOM
Sweden	Claes Tullin	SP Technical Research Institute of Sweden
Switzerland	Thomas Nussbaumer	Verenum

TASK 33 — Gasification of Biomass and Waste

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

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

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

Country	National Team Leader	Institution
Austria	Reinhard Rauch	Vienna University of Technology
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Germany	Thomas Kolb	KIT
Italy	Donatella Barisano	ENEA
The Netherlands	Berend Vreugdenhil	ECN
Norway	Judit Sandquist	SINTEF

Sweden	Lars Waldheim	Waldheim Consulting
Switzerland	Martin Rüegsegger	ETECA
USA	Kevin Whitty	University of Utah

TASK 34 — Direct Thermochemical Liquefaction

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

Task Leader: Alan Zacher, PNNL, USA. For contacts see Appendix 6.

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

Country	National Team Leader	Institution
Canada	Fernando Preto	CanmetENERGY, Natural Resources Canada
Finland	Anja Oasmaa	VTT (Technical Research Centre of Finland Ltd.)
Germany	Nicolaus Dahmen	Thünen Institute for Wood Research
The Netherlands	Bert van de Beld	BTG (Biomass Technology Group)
New Zealand	Ferran de Miguel Mercader	Scion
Sweden	Magnus Marklund	SP ETC (Energy Technology Centre)
USA	Alan Zacher	PNNL (Pacific Northwest National Laboratory)

TASK 36 — Integrating Energy Recovery into Solid Waste Management Systems

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

Task Leader: Inge Johansson, SP Technical Research Institute of Sweden, Sweden. For contacts see Appendix 6.

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

Country	National Team Leader	Team Leader Institution
France	Elisabeth Poncelet	ADEME
Germany	Dieter Stapf	KIT, Karlsruhe
Italy	Giovanni Ciceri	RSE
Sweden	Inge Johansson	SP Sweden

TASK 37 — Energy from Biogas

Operating Agent: Matthew Clancy, Sustainable Energy Authority of Ireland, Dublin, Ireland. For contacts see Appendix 7.

Task Leader: Prof. Jerry D Murphy, MaREI Centre, Environmental Research Institute, University College Cork, Ireland. For contacts see Appendix 6.

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

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Denmark	Teodorita Al Seadi	BIOSANTECH
Finland	Saija Rasi	Natural Resources Institute Finland (Luke)
France	Olivier Théobald	Ademe
Germany	Jan Liebretrau	DBFZ, Leipzig, Germany
Ireland	Jerry D Murphy	University College Cork
Korea	Ho Kang	Chungnam National University
The Netherlands	Mathieu Dumont	Netherlands Enterprise Agency
Norway	Tormod Brieid	Norwegian Institute for Bioeconomy Research (NIBIO)
Sweden	Mattias Svensson	Energiforsk
Switzerland	Urs Baier	ZHAW Zürcher Hochschule für Angewandte Wissenschaften
United Kingdom	Clare Lukehurst	Probiogas UK

TASK 38 — Climate Change Effects of Biomass and Bioenergy Systems

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

Task Leader: Annette Cowie, NSW Department of Primary Industries, Australia. For contacts see Appendix 6.

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

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

Country	National Team Leader	Institution
Australia	Annette Cowie	NSW Department of Primary Industries
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	Kati Koponen	VTT Technical Research Centre of Finland
France	Alice Gueudet	Ademe Service Bioressources
	Miriam Buitrago	

Germany	Sebastian Rüter	Thünen Institute of Wood Research
Sweden	Leif Gustavsson	Linnaeus University
USA	Alison Goss Eng	US Department of Energy
	Kristen Johnson	
	Helena Chum	National Renewable Energy Laboratory

TASK 39 — Commercialising Conventional and Advanced Liquid Biofuels from Biomass

Operating Agent: Alex McLeod, Natural Resources Canada, Canada.
For contacts see Appendix 7.

Task Leader: Jim McMillan, NREL, USA.
For contacts see Appendix 6.

Associate Task Leader: Jack Saddler, University of British Columbia, Canada.

The Task is organised by 'National Teams' from participating countries. The contact person (National Team Leader) and other representatives from each country are listed below:

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Australia	Les Edye	Queensland University of Technology
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	Anders Kristoffersen	Novozymes
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Germany	Franziska Mueller-Langer	DBFZ
	Nicolaus Dahmen	DBFZ
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The Netherlands	Timo Gerlagh	NL Agency
	Christian Koolloos	DSM
New Zealand	Ian Suckling	Scion
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	Bernard Prior	University of Stellenbosch
South Korea	Jin Suk Lee	Korean Institute of Energy Research
	Kyu Young Kang	Dongguk University
	Seonghan Park	Pusan National University
Sweden	Tomas Ekbom	Swedish Bioenergy Association
USA	Jim McMillan	NREL

TASK 40 — Sustainable biomass markets and international bioenergy trade to support the biobased economy

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

Task Leader (Scientific): Martin Junginger, Copernicus Institute of Sustainable Development, Utrecht University, The Netherlands.
For contacts see Appendix 6.

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

Task assistant (Secretary): Thuy Mai-Moulin, Copernicus Institute of Sustainable Development, Utrecht University, The Netherlands.

The Task is organised with 'National Teams' in the participating countries. The contact persons (National Team Leaders) as of December 2016 in each country are listed below:

Country	National Team Leader	Institution
Austria	Lukas Kranzl	Vienna University of Technology
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Denmark	Wolfgang Stelte	Danish Technological Institute
	Anders Evald	HOFOR
Finland	Tapio Ranta	Lappeenranta Technical University
	Jussi Heinimö	Miktech
Germany	Uwe Fritsche	IINAS
	Daniela Thrän	Deutsches BiomasseForschungsZentrum
Italy	Luca Benedetti	Gestore Servizi Energetici (GSE)
The Netherlands	Martin Junginger	Copernicus Institute, Utrecht University
	Peter-Paul Schouwenberg	RWE Generation
Sweden	Lena Bruce	Sveaskog
UK	Rocio Diaz-Chavez	Imperial College
	Laura Cragg	Drax
USA	Richard Hess	Idaho National Laboratory

TASK 42 — Biorefining in a future BioEconomy

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

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

Assistant Task Leader: Ed de Jong, Avantium Technologies B.V., The Netherlands.
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The Task is organised with 'National Teams' in the participating countries. The contact person (National Team Leader) in each country is listed below:

Country	National Team Leader	Institution
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Canada	Eric Soucy	CammetENERGY, Natural Resources Canada
Denmark	Henning Jorgensen	University of Copenhagen
Germany	Heinz Stichnothe	Thunen-Institute of Agricultural Technology
Italy	Isabella de Bari	ENEA C.R.TRISAIA
Ireland	Bart Bonsall	Technology Centre for Biorefining and Bioenergy
The Netherlands (coordinator)	René van Ree	Wageningen UR – Food and Biobased Research
	Ed de Jong	Avantium B.V.
	Bert Annevelink	Wageningen UR – Food and Biobased Research
United States of America	James Spaeth a.i.	U.S. Department of Energy

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TASK 43 — Biomass Feedstocks for Energy Markets

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

Task Leader: Ioannis Dimitriou, Swedish University of Agricultural Sciences, Sweden.
For contacts see Appendix 6.

Work Package Leaders:
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National Team Leaders:
Mark Brown (Australia)
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Antti Asikainen (Finland)
Jörg Schweinle (Germany)
Ger Devlin (Ireland)
Wolter Elbersen (The Netherlands)
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Marilyn Buford (USA)

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