IEA Bioenergy
Technology Collaboration Programme

Bioenergy
Accelerating to Net Zero

Annual Report 2022

IEA BIOENERGY : EXCO : 2023 : 01

IEA Bioenergy is an international collaborative agreement set up in 1978 by the International Energy Agency (IEA) to improve international cooperation 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.

Paul Bennett

Chair of the IEA Bioenergy TCP in 2022

To: IEA Headquarters, Paris

IEA BIOENERGY ANNUAL REPORT 2022

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 2022. This year, we have presented a special feature 'Material and energy valorization of waste as part of a circular model', prepared by Task 36.

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

Paul Bennett
Chair

Andrea Rossi
Secretary

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INTRODUCING IEA BIOENERGY

IEA Bioenergy is an authoritative voice on sustainable bioenergy, providing scientific facts and analysis backed by experts and scientists from all over the globe.

Welcome to this Annual Report for 2022 from IEA Bioenergy.

IEA Bioenergy is the short name for the IEA Technology Collaboration Programme (TCP) on Bioenergy, which was formed in 1978 under the auspices of the International Energy Agency (IEA). A brief description of the IEA is given in the next section.

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.

IEA Bioenergy Core Group for 2022.

IEA Bioenergy is a Technology Collaboration Programme (TCP) set up in 1978 by the International Energy Agency (IEA) with the aim of improving cooperation and information exchange between countries that have national programmes in bioenergy research, development and deployment. Technology Collaboration Programmes are independent bodies operating in a framework provided by the IEA. There are 42 currently active Technology Collaboration Programmes, one of which is IEA Bioenergy.

IEA Bioenergy's ***vision*** is that modern bioenergy is, and will continue to be, a leading type of renewable energy, making an important contribution in reaching an energy secure and net-zero energy mix. Bioenergy is an integral part of developments towards a circular biobased economy. By accelerating the sustainable production and efficient use of biomass, economic and environmental impacts will be optimised resulting in more cost-competitive bioenergy and biobased applications and reduced greenhouse gas emissions.

The ***mission*** of IEA Bioenergy is to increase knowledge and understanding of bioenergy systems in order to facilitate the commercialisation and market deployment of environmentally sound, socially acceptable, and cost-competitive, low-carbon bioenergy systems and technologies, and to advise policy and industrial decision makers accordingly. IEA Bioenergy realises the mission by providing platforms for international collaboration and information exchange in bioenergy research, technology development, demonstration, and policy analysis—including through network development, information dissemination, and the provision of science-based analysis and advice.

By the end of 2022, 26 parties participated in IEA Bioenergy: Australia, Austria, Belgium, Brazil, Canada, China, Croatia, Denmark, Estonia, Finland, France, Germany, India, 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.

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 largescale and worldwide. There were 11 ongoing Tasks during 2022:

- Task 32: Combustion & emissions
- Task 33: Gasification
- Task 34: Liquefaction
- Task 36: Waste & circular economy
- Task 37: Anaerobic digestion / biogas
- Task 39: Transport biofuels
- Task 40: Biobased deployment
- Task 42: Biorefining
- Task 43: Biomass supply
- Task 44: Energy system / flexibility
- Task 45: Climate & sustainability

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.

In addition, Strategic Projects are developed and implemented within IEA Bioenergy, with the engagement of various Tasks and in collaboration with other TCPs as well (see Figure 1).

The Task participation during 2022 is shown in Appendix 1. A progress report for IEA Bioenergy for the year 2022 is given in Sections 1 and 2 of this Annual Report.

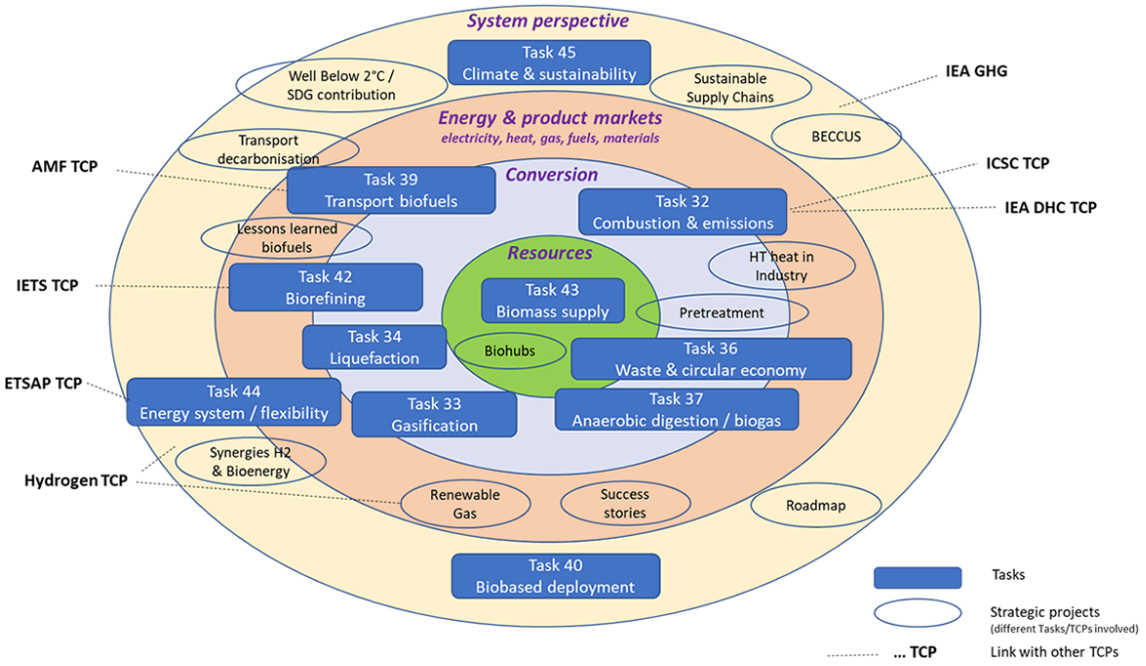

Figure 1. IEA Bioenergy Tasks and Strategic projects, and links with other TCPs.

IEA Bioenergy Core Group for 2023

Mrs Dipl-Ing Dina Bacovsky

ExCo Chair

BEST – Bioenergy and Sustainable Technologies
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INTERNATIONAL ENERGY AGENCY

Mission

The IEA (https://www.iea.org/) works with governments and industry to shape a secure and sustainable energy future for all and is at the heart of global dialogue on energy, providing authoritative analysis, data, policy recommendations, and real-world solutions to help countries provide secure and sustainable energy for all. The IEA was created in 1974 to help co-ordinate a collective response to major disruptions in the supply of oil. While oil security remains a key aspect of its work, the IEA has evolved and expanded significantly since its foundation. Taking an all-fuels, all-technology approach, the IEA recommends policies that enhance the reliability, affordability and sustainability of energy. It examines the full spectrum of issues including renewables, oil, gas and coal supply and demand, energy efficiency, clean energy technologies, electricity systems and markets, access to energy, demand-side management, and much more. Since 2015, the IEA has opened its doors to major emerging countries to expand its global impact, and deepen cooperation in energy security, data and statistics, energy policy analysis, energy efficiency, and the growing use of clean energy technologies.

The areas of work of the IEA are:

- Promoting energy efficiency: advising governments on developing, implementing, and measuring the impact of efficiency policies
- Ensuring energy security: work on energy security ensures that markets remained well supplied, providing information to governments, and helping improve system resilience
- International collaborations: working with a broad range of international organisations and forums to ensure secure, affordable and sustainable energy systems
- Data and statistics: energy data collection and training is at the heart of the IEA's work
- Training: establishing ongoing working relationships with participating countries for continual capacity building
- Technology collaboration: advancing the research, development and commercialisation of energy technologies
- Energy security: ensuring the uninterrupted availability of energy sources at an affordable price
- Global engagement: marking a new era of international energy co-operation
- Industry engagement: sharing insights on how policies shape real-world investments and actions
- Programmes and partnerships: working with governments, organisations and agencies around the world to deliver programmes focused on countries, regions or topics
- Promoting digital demand-driven electricity networks: digital solutions to support power systems in transition

Structure

The IEA is an autonomous body within the OECD framework. The Governing Board is the main decision-making body of the IEA, composed of energy ministers or their senior representatives from each member country. Through the IEA Ministerial Meeting that takes place every two years, the IEA Secretariat develops ideas for existing or new work programmes, which are then discussed with member countries in various IEA committees and ultimately presented to the Governing Board for approval. In addition to the Governing Board, the IEA has several Standing Groups, Committees and Working Parties made up of member country government officials that meet several times a year.

Member Countries

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

Accession Countries

Chile, Colombia, Israel, Latvia.

Association Countries

Argentina, Brazil, China, Egypt, India, Indonesia, Morocco, Singapore, South Africa, Thailand and Ukraine.

IEA BIOENERGY – SELECTED HIGHLIGHTS FROM 2022

Key messages

The main results and recommendations emerging from recent work conducted within the IEA Bioenergy TCP and its 11 Tasks are summarised below.

- Reaching climate neutrality globally requires an unprecedented, rapid transformation of all sectors of society and especially of the energy system. **Biomass can have an important role to reduce fossil fuel consumption in the short to medium term - but also has a role in the longer term in difficult to abate sectors**, in balance with other renewables, to provide negative greenhouse gas (GHG) emissions and to valorise biogenic process residues.
- **The IEA Roadmap 'Net Zero Emissions by 2050' recognises bioenergy as an important option**, providing around **18% of total energy supply in 2050**, and playing a **significant role to reach carbon neutrality** of the global energy system. A growing role of biomass/biofuels would be needed in industry, transport as well as heat and power production.
- **Forest bioenergy**, which is mainly based on silviculture residues, thinning and forest industry side streams, **is one of the key tools to reach carbon neutrality and diversify the energy supply**. However, the sustainability of forest bioenergy is being questioned by a number of NGOs, oftentimes on the basis of misconceptions.
- **Bioenergy should not be considered in isolation, but as part of a broader, circular bioeconomy** in which materials, food and energy are co-produced.
- In the longer-term Carbon Dioxide Removal (CDR) will need to be applied where possible to achieve negative GHG emissions. **Bioenergy with carbon capture and storage (BECCS) is one of the critical options to achieve negative emissions**, combining renewable energy production with CO_2 removal from the atmosphere.
- **Sustainability governance is key**. There needs to be a clear understanding of what sustainable biomass means and how much can be mobilized. Sustainable biomass sourcing and resource efficiency are key principles.
- **Increased efforts for sustainable biomass mobilisation are needed**. This also requires connecting a local and dispersed biomass feedstock base with centralised processing at scale.
- **The transition of the economic and energy systems is accelerating**. Companies and sectors (energy providers, transport sectors, industries, …) are taking concrete steps towards climate neutrality.
- **Priorities of biomass use for energy will evolve and are gradually shifting to difficult-to-electrify sectors** (e.g., aviation).
- **Reliable and coherent political framework conditions are of key importance** to motivate investments and to scale up new technologies.
- **Flexibility (short and long term) is one of the key characteristics of bioenergy** in an energy system with increasing shares of variable renewables.

Bioenergy Review 2023 – How bioenergy contributes to a sustainable future

The report, which is based on work conducted by some 200 experts active within the IEA Bioenergy Tasks, presents an evidence-based assessment of the status of bioenergy around the world. The report's goal is to reinvigorate awareness and interest in bioenergy, address concerns that arise in the public debate, and demonstrate the synergies between bioenergy and other renewable as well as the biobased economy. It also seeks to point out opportunities that can be seized by IEA Bioenergy member countries, most of which have a strong bioenergy strategy already in place, and also by countries outside the IEA Bioenergy membership. The report is divided into two parts: Part A "Strategic View on Biomass and Bioenergy" deals with bioenergy and its contribution to a sustainable future. Part B "Technologies for Sustainable Bioenergy" describes the status and perspectives of different bioenergy technologies. While primarily directed at policy and decision makers, it is also an authoritative reference for a broad stakeholder audience

The web-based report is available here.

The role of biogas and biomethane in pathways to net zero

Biogas is produced as the main product of anaerobic digestion (AD) of wet biomass. Biogas can be used locally for heat purposes or for power and heat production (CHP); as an alternative, biogas can be upgraded to bio-methane to replace natural gas. As such, it is one of the means to reduce the consumption of fossil fuels and contribute to the transition towards a net zero energy system.

This position paper – developed by members of IEA Bioenergy Task 37 (Anaerobic digestion / biogas) – provides central knowledge and features of biogas and biomethane.
The main conclusion is that biogas and biomethane have plenty of options to be used in a pathway to net zero. They provide sustainable flexible systems that play essential roles in circular economy, energy, and environmental systems.

The position paper is available here.

ExCo90 Workshop (Vienna, 17 October 2022): Technology advances in liquid biofuels and renewable gas

Both the accelerating climate change as well as the energy crisis related to the war in Ukraine, call for urgent action to move away from fossil fuels such as oil and gas. Energy savings and renewable energy are the key tools to achieve that. Renewable transport fuels and renewable gases will need to have an increasing role in the transport system and the gas distribution system. A strong growth in so-called 'advanced technologies' will be required, starting from a variety of feedstocks, particularly underutilised heterogeneous biomass resources. Meanwhile, increasing prices for oil and gas have totally changed the picture and prospects of renewable fuels compared to one or two years ago.
On 17 October 2022, in conjunction with its Executive Committee meeting (ExCo90) in Vienna, IEA Bioenergy held its biannual workshop, which was themed "Technology Advances in Liquid Biofuels and Renewable Gas". The event was organized in collaboration with the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) and BEST – Bioenergy and Sustainable Technologies GmbH. It explored advances being made in new biofuels technologies, as well as technologies to produce renewable gas (biomass based), and discussed what is needed to accelerate their roll out to the market. The workshop comprised three parts: the first session considered advances in renewable gas / biomethane, the second advances in liquid biofuels, and the third session showed concrete developments in Austria. The event had around 100 physical participants in Vienna. More than 150 people followed it online.

The summary report and the presentations are available here.

Key conclusions from ExCo90 Workshop

Both climate change and energy security are major reasons to urgently move away from fossil fuels such as oil and gas. This requires a combination of energy conservation, energy efficiency, electrification and shifting applications to renewable fuels – there is no silver bullet.
Renewable liquid transport fuels will need to have an increasing role in the transport system and the role of renewable gases will need to increase in the gas distribution system. In both cases bioenergy plays a vital role. The current push on biomethane at (European) policy level also helps further developments.

ExCo89 *e*-Workshop (23-24 May 2022): Bioenergy and sustainable development – climate change mitigation and opportunities for sustainability co-benefits

Modern bioenergy is the largest source of renewable energy in the world and is expected to grow substantially as one of complementary pathways to support decarbonization initiatives to limit global warming by 1.5°C. Given these trends, it is expected that there will be a significant increase in sustainably sourced biomass. In 2021, IEA Bioenergy published an overview of 37 case studies from 18 nations worldwide to understand how biomass supply chains can support bioenergy production, while simultaneous contributing to sustainable development goals[1]. Beyond directly contributing to the provision of affordable and sustainable energy and climate change mitigation, several of the analyzed cases contributed to sustainable land management, restoration of degraded lands, and improving economic opportunities and resilience in rural areas.

IEA Bioenergy held its biannual workshop on 23-24 May 2022 in conjunction with the ExCo89 meeting. The workshop on 'Bioenergy and Sustainable Development' was held in virtual form and was organised in collaboration with the Global Bioenergy Partnership (GBEP) and the Biofuture Platform. The workshop consisted of two separate sessions. The first session examined debates surrounding the contribution of bioenergy to climate change mitigation. The second session considered opportunities for sustainability co-benefits (beyond climate) and ways to create win-win approaches, e.g. to lift socio-economic perspectives in rural areas and

[1] This publication is available here.

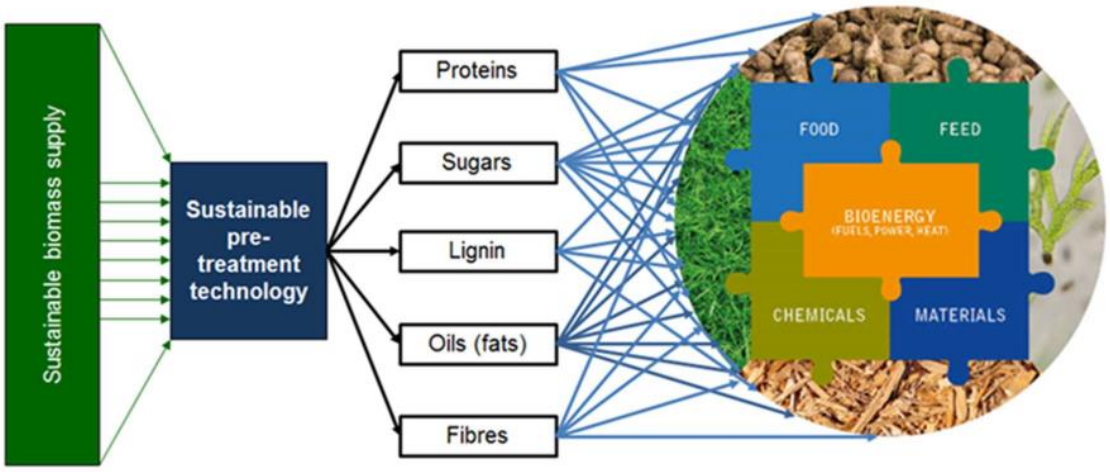
improve the way landscapes are managed. Each session consisted of keynote presentations, followed by a panel discussion. The workshop sessions had 244 and 173 participants respectively.

The summary report and the presentations are available here.

Key conclusions from ExCo89 Workshop

Bioenergy will make an important contribution to climate change mitigation; it represents between 15 and 30% of primary energy supply 2050 in global scenarios that limit warming to 1.5°C. The relative importance of different bioenergy options varies depending on the anticipated development for other non-bioenergy options. Apart from waste and residues, biomass from dedicated cultivation systems will also be needed as bioenergy feedstock.
Apart from climate change mitigation, bioenergy systems and biomass supply chains can have important environmental and socio-economic co-benefits that can be important motivation for bioenergy deployment. There can also be trade-offs, e.g., with food production and biodiversity, which need to be managed in environmentally and socially sustainable ways through good governance practice.
There are important opportunities for developing countries to shift away from traditional bioenergy and fossil fuels towards modern, sustainable bioenergy as part of a circular economy approach. This can provide opportunities for land-use diversification and employment creation, reduce health problems related to air pollution, and support restoration of degraded lands.

Global Biorefinery Status Report



The Global Biorefinery Status Report provides an overview of recent biorefinery developments. The report, which was prepared by Task 42 (Biorefining), gives a description of the current situation of biorefineries in a representative selection of countries: how many biorefineries exist, which types, which feedstocks, which technology, what products, etc.

The overall goal of the status report is to provide a sound source that will help to accelerate further development and the worldwide market implementation of biorefineries in the circular economy, for example by identifying trends and new developments. Focus is on IEA Bioenergy member countries. However, also other important countries/ continents are described in a qualitative way. An important part of the status report is an analysis of the deployment status of biorefineries in the different areas of the world. Moreover, the report presents both major technical and non-technical deployment barriers and applied/potential solutions to tackle these barriers. Furthermore, key examples were identified.

The report is available here.

Carbon accounting across Bio-CCUS supply chains – Identifying key issues for science and policy

Bio-CCUS (bioenergy with carbon capture and utilization or storage) is increasingly becoming a matter of on-the-ground deployment. However, while the technological aspects of capture, utilization and storage of biogenic CO2 are rather well understood and have in many cases already been used in commercial settings, there are still substantial gaps on the policy and governance side. Particularly important aspects here are carbon accounting, how to quantify the climate impact of Bio-CCUS systems and how to include these elements in policy frameworks. This report – developed by IEA Bioenergy Task 45 (Sustainability) and Task 40 (Deployment) – reviews key issues to focus on and discusses different options for how these could be addressed from a scientific as well as from a policy perspective.

The report is available here.

Hot Topics

Paul Bennett
Chair of the Executive Committee IEA Bioenergy

IEA Bioenergy
Technology Collaboration Programme

"A transition away from fossil-based heating is necessary to move towards a carbon neutral and secure energy system. Bioenergy is the overlooked giant of the energy transition - particularly for renewable heat.
And due to its great decarbonization potential, it is a decisive key to energy security."

Bioenergy
Accelerating to Net Zero

In 2022, IEA Bioenergy issued three press releases to shed light on the important role of bioenergy for energy supply/security, climate change mitigation and sustainable development, and to dispel some misconceptions on bioenergy being circulated in the media.

Biomethane Expansion Provides Local Alternatives for Imported Gas and Synthetic Fertiliser (20 October 2022) - link.

Facts, not Fiction: Bioenergy from Wood Contributes to Europe's Energy Security and is Part of a Sustainable Energy Mix (9 September 2022) - link.

The Dawn of Greater Energy Independence (3 May 2022) - link.

MATERIAL AND ENERGY VALORIZATION OF WASTE AS PART OF A CIRCULAR MODEL: SUMMARY

Inge Johansson, RISE Research Institutes of Sweden, Sweden

Mar Edo Giménez, RISE Research Institutes of Sweden, Sweden

Daniel Roberts, CSIRO, Australia

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Michael Becidan, SINTEF Energy Research, Norway

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Thomas P. Curran, UCD University College Dublin, Ireland

Dieter Stapf, Karlsruhe Institute of Technology, Germany

Circularity - there is room for further improvement

According to the last Circularity Gap Report[2], the world is only 8.6% circular, leaving significant room to consumers, businesses, cities, and governmental bodies to increase circularity by (1) reducing virgin material extraction; (2) promoting recovery, reuse and recycling of those materials that already entered the system, and (3) generating energy in a clean and efficient way. Material recovery from waste streams has become an important driver in this transition.

In addition, today's global energy crisis resulting from several factors such as the pandemic and Russia's invasion of Ukraine[3] is accelerating initiatives to develop new and support the already existing energy efficient solutions. Incineration (also referred to as Waste-to-Energy) technologies at industrial scale have been used as a way of handling waste for few decades. However, with the emergence of implementing circular models in our societies, and the lack of public support for combustion-based WtE in some countries, new technologies also come into play and could provide energy and material recovery solutions closer to the principles associated with circular economy[4].

[2] The Circularity Gap Report 2022, Circularity Gap Report Initiative. CGR 2022 (circularity-gap.world)

[3]Global Energy Crisis. IEA Bioenergy, 2022 – Link: Global Energy Crisis – Topics - IEA, website visited 13th December 2022.

[4] Material and Energy Valorisation of Waste in a Circular Economy – Roberts D., Edo M., Johansson I., Hoffman B., Becidan M., Ciceri G., Murphy F., Trois C., Curran T. Link: IEA Bioenergy Task 36 report, website visited 13th of December 2022.

Waste management sector needs to evolve

The World Bank[5] has estimated around 3.5 billion tonnes of waste will generated worldwide by 2050. The waste management sector is critical to the success of the Circular Economy movement[6]. While the manufacturing sector clearly plays an important role from the perspective of material and products design and process, changes to more circular manufacturing practices will have little impact if the waste management sector does not also evolve. Recycling is considered consistent with Circular Economy principles[7]; however, global recycling rates are generally low.

Circular Economy and Waste-to-Energy

Circular Economy avoids waste generation by "*decoupling economic activity from the consumption of finite resources*[8]" and its principles are (1) eliminate waste and pollution; (2) circulate products and materials, and (3) regenerate nature[8] (see Figure 2).

Figure 2. Linear Economy versus Circular Economy.

[5] What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. Kaza, Silpa; Yao, Lisa C.; Bhada-Tata, Perinaz; Van Woerden, Frank. 2018. Urban Development; Washington DC: World Bank. Link.

[6] Material and Energy Valorisation of Waste in a Circular Economy – Roberts D., Edo M., Johansson I., Hoffman B., Becidan M., Ciceri G., Murphy F., Trois C., Curran T. Link: IEA Bioenergy Task 36 report, website visited 13th of December 2022.

[7] *Trends and drivers in alternative thermal conversion of waste*. Stapf D., Ciceri G., and Johansson I., IEA Bioenergy Task 36, 2020.

[8] *What is a circular economy?*, Ellen MacArthur Foundation. Link to the website visited on the 24th of November 2022.

As Circular Economy principles become embedded in the policies of governments and the strategies of organisations around the world, there are greater expectations on waste management systems to contribute to 'keeping molecules in use for longer' (Table 1). Retrofitting and modifying processes to make them more circular is not without cost and complexity.

FROM	TO
Waste Management	Material Recycling and resource handling
Energy Recovery	Molecules in use for longer
Heat and Power	Energy, chemicals, and manufacturing feedstocks.

Table 1. The shift in focus for waste management and energy recovery driven by the emergence of circular economy principles[9].

The circular economy principles, and the emerging technology pathways, will see waste management and resource recovery transcend the traditional areas of waste, heat, and power, and intersect more with the manufacturing, construction, and transport sectors. Energy recovery is still important, especially when the waste streams have a significant component that is considered renewable, and the energy can be used to abate greenhouse gas emissions as well as keep molecules in use for longer. The concept of energy can also be broadened, as we see waste conversion pathways emerge that can produce energy carriers such as hydrogen[9].

Implications for Energy Recovery from Waste

Modern waste-to-energy plants usually include advanced separation and resource recovery stages[10], meaning they also contribute to increased recycling rates. Combustion-based waste-to-energy systems were not designed with circular economy principles in mind. However, from the waste perspective, it ensures a safe treatment of non-recyclable materials[11]; while from the resource perspective, it provides a good use for these materials and reduces CO_2 emissions by replacing fossil fuels.

[9] Material and Energy Valorisation of Waste in a Circular Economy – Roberts D., Edo M., Johansson I., Hoffman B., Becidan M., Ciceri G., Murphy F., Trois C., Curran T. Link: IEA Bioenergy Task 36 report, website visited 13th of December 2022.

[10] Example of this kind of facilities: Sorting Technologies: Case study about a MSW sorting facility in Norway- IVAR. Edo M., Meisser R., Nilsson J. Link: IEA Task 36 report, website visited 7th of January, 2023.

[11] CEWEP. The Confederation of European Waste-to-Energy Plants. Link to the website visited on the 25th of November 2022.

Recycling and energy recovery

Biogas and Biomethane: The fact that a large variety of feedstock can be fed into anaerobic digestors system, leading to a range of products, ensures the crucial role of this technology in a circular and bio-based economy. Biomethane is considered as an expensive product; however, there, are alternative methods being developed that either might reduce its price or increased its yield.

Nutrients recovery: One large waste stream that can also be used to produce biomethane, but where the utilisation of the fertilizer part is put more into question, is biosolids/sewage sludge. The risk of lingering residues of pharmaceuticals is one of the arguments raised against the use of biosolids on farmland. Although it varies[12], the legislation in some countries is now forcing the development of new technologies for the recovery of nutrients, such as phosphorus recovery from the ash, while others rely on pyrolysis or hydrothermal carbonization (HTC).

Landfilling: Landfills are having a severe impact on the greenhouse gas emissions globally, and there is a large potential to both decrease the greenhouse gas emissions and contribute to energy production, through collection of gas at the sites that do not do so today, as well as using engineered landfills as a first step away from the open dumps. In addition, landfilling mining has been a subject for research and pilot tests for several years.

Plastic recycling: Efficient recycling of plastic waste is a challenge mainly due to the large number of different plastics, many of them consisting of a combination of different polymers as well as a combination of functional additives. Today, the main pathway for recycling of plastics is mechanical recycling producing granulate as product. Since the demand and value of the granulate depends highly on the purity and colour of the granulate, this imposes natural limitations on the mechanical recycling. Chemical recycling encompasses technologies like solvolysis, pyrolysis and gasification. Today, the commercial experience of chemical recycling is limited, but interest is increasing and there are a few new and upcoming plants[13].

Other energy carriers: Some of the technologies (mainly pyrolysis and gasification) used for chemical recycling of plastics can also be used to transform a more mixed stream of waste into other energy carriers like hydrogen or jet fuel[14]. This segment is not a very mature area, but it shows that there is interest in converting what we consider as waste into something else with the potential of replacing fossil resources.

Beyond technologies

Policies and social licenses to operate: Policy settings that encourage the deployment and uptake of new technologies, and regulations that specify the extent to which waste can be

[12] Nutrient recovery from waste, Johansson I., Edo M., IEA Bioenergy Task 36 workshop report (Task 36 05:2019). Link to the report.

[13] Chemical recycling of plastic waste through pyrolysis, Staph D. IEA Bioenergy Task 36 workshop, Durban, South Africa, Nov 30 2022.

[14] Press release, Fulcrum Bioenergy, Fulcrum BioEnergy Successfully Produces First Ever Low-Carbon Fuel from Landfill Waste at its Sierra BioFuels Plant (prnewswire.com)

landfilled or recyclable material used as manufacturing feedstock, for example, are known to drive change.

The public's acceptance of new technologies is crucial to succeed in the transition to a circular economy. While there is a stigma attached to combustion-based WtE in some countries, the emerging alternative pathways are not guaranteed to have a simpler process towards public and community acceptance – there are different challenges associated with technologies that are less proven or less understood[15].

Environmental and resource aspects: Any type of waste generates a negative environmental impact – even if managed in an efficient way. As an example, there are greenhouse gases emitted from technologies like combustion based WtE that could be decreased by increasing plastic recycling. There is also increased interest in carbon capture and storage (CCS/BECCS) to handle these emissions where a negative contribution could be accomplished through the CCS of the biogenic carbon while neutralising the fossil emissions.

Way forward

The circular evolution has just started. Although it will take time overall, some parts will change rapidly while others will take longer. Material and energy circularity will grow in the coming years and new business models, products and consumption habits will be implemented. Waste will be turned into high value products; waste management will become resource management; energy will come from more sustainable sources; new technologies, materials and products will arise in the market. The waste management system will have to adapt and innovate to bring forth new solutions that can fit into the circular system and face a transformation into resource management. New waste-to-energy technology solutions will be created, and the "old ones" will either adjust to the new times or make way to the new ones coming.

Will all of this happen automatically? No, definitely not. The need for this change is large all around the globe, but the resources to make it happen are not evenly distributed, and the maturity differs as well.

Changes to the legal and policy framework are also needed in the more mature systems. Security of supply is another aspect that might be considered when looking at recycling and recycling capacity. The Covid-pandemic and the war in Ukraine have highlighted some of the weaknesses of complex global supply chains. Consideration also needs to be given to the consumption of the products that generate waste. This would affect both consumer behaviour and business models for the producers.

A lot still needs to be done…

For more details, read the full publication – link.

[15] Material and Energy Valorisation of Waste in a Circular Economy – Roberts D., Edo M., Johansson I., Hoffman B., Becidan M., Ciceri G., Murphy F., Trois C., Curran T. Link: IEA Bioenergy Task 36 report, website visited 13th of December 2022.

PROGRESS REPORT

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 Technology Collaboration Programme (TCP). 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 webinars, 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 89th ExCo meeting was held as a Virtual meeting in three separate sessions on the 16th, 18th and 19th May 2022. The 90th ExCo meeting was held in Vienna (Austria) on the 18th and 19th October 2022.

Kazuhiro Kurumi represented IEA Headquarters at both ExCo89 and ExCo90.

Paul Bennett of SCION chaired both ExCo meetings in 2022 with Dina Bacovsky of BEST – Bioenergy and Sustainable Technologies (Austria) and Sandra Hermle of the Swiss Federal Office of Energy SFOE in the roles of Vice-chairs.

At ExCo90, Dina Bacovsky was elected as Chair, while Birger Kerckow of FNR – Fachagentur Nachwachsende Rohstoffe, Germany, and Mark Brown of Forest Research Institute – USC, Australia, were elected as Vice-chairs for 2023-2024.

Secretariat

The ExCo Secretariat is currently based in San Casciano in Val di Pesa (FI), Italy under the Secretary, Andrea Rossi. 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 Secretariat can be found on the back cover of this report. The list of Executive Committee Members and Alternate Members is available in Appendix 6. The work of the ExCo, with some of the achievements and issues during 2022, is described below.

Implementing Agreement

The current term of the IEA Bioenergy Technology Collaboration Programme (TCP) covers the period 1st March 2020 to 28th February 2025. Following an extensive consultation process among the members of IEA Bioenergy, at the ExCo89 meeting in May 2022, ExCo voted to approve the new Implementing Agreement (IA) of the IEA Bioenergy TCP. The new IA was then definitively approved via written procedure in July 2022. Compared to the previous version of the IA, an effort was made to align the new text with the way IEA Bioenergy is structured and operates.

Contracting Parties/New Participants

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

At the ExCo88 meeting in October 2021, Turkey made a presentation to the ExCo and was invited to join the TCP. The related administrative process is still ongoing.

The U.S. Grains Council joined Task 39 (Transport biofuels) for the 2022-2024 triennium as a Limited Sponsor. Limited Sponsors are not entitled to appoint a representative to the Executive Committee and may not vote on decisions or recommendations of the Executive Committee.

Supervision of Ongoing Tasks, Review and Evaluation

At the ExCo89 meeting in May 2022, the Tasks presented their 2019-2021 End of Triennium Reports, and their Audited Accounts Reports for 2021. At the ExCo90 meeting in October 2022, the Tasks presented their Progress reports, updating ExCo on the kick-off of the projects and activities foreseen during the 2022-2024 triennium.

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 2022 approved by the Executive Committee for the ExCo Secretariat Fund and for the Tasks are shown in Appendix 2. Total funds received in 2022 were US$1,854,800 comprising US$264,800 of ExCo funds and US$1,590,000 of Task funds. Appendix 2 also shows the financial contributions made by each Contracting Party 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

Following the change in Secretary as of 1 January 2022, a new bank account has been set up in Italy to manage the IEA Bioenergy ExCo Secretariat Fund. The Secretary uses this account to receive funds from the Contracting Parties and to distribute funds to the Task Leaders. The account, which is interest-bearing, is denominated in US dollars. The currency for the whole of IEA Bioenergy is US Dollars. The account can be accessed electronically and transactions can be executed by the Secretary at all times. For outgoing funds, a double-signature by a third party is required.

The main issues faced in fund administration are slow payments from some Contracting Parties and fluctuations in exchange rates. As of 31 December 2022, there was US$126,900 of contracting parties' contributions outstanding.

The audited accounts for the ExCo Secretariat Fund for 2021 were approved at ExCo89. In November 2022, ExCo approved (via written procedure), the appointment of Ernest & Young, Florence (Italy) as independent auditors for the ExCo Secretariat Fund to the end of 2024.

The Tasks also produce audited accounts. These are prepared according to guidelines specified by the ExCo. The accounts for the Tasks for 2021 were approved at ExCo89.

The audited accounts for the ExCo Secretariat Fund for the period ended 31 December 2022 have been prepared and these will be presented for approval at the ExCo91 Virtual meeting.

Task Administration and Development

Task Participation

In 2022 there were 110 participations in 11 Tasks. Please see Appendix 1 for a summary of Task participation.

Two new Inter-Task projects were kicked-off in 2022. In addition, using surplus Secretariat funds and following a call for tender, the ExCo awarded a contract to the Communications Specialist MFM - Menschen für Medien to advise on how to improve the effectiveness and impact

of IEA Bioenergy's communication activities. For further details on these see below under 'Strategic Fund/Strategic Outputs'.

Strategic Planning and Strategic Initiatives

Strategic Plan

The Executive Committee of IEA Bioenergy has adopted a new Strategic Plan for the term 2020-2025. The objectives of the plan are to enable bioenergy to substantially contribute to future global energy demand within a growing global bioeconomy; provide significant greenhouse gas savings across all energy sectors; and contribute to the Sustainable Development Goals. The Plan recognises that bioenergy can and must deliver increasing results in decarbonising transport, heat, power and electricity, including through its capacity to deliver negative emissions by, among many pathways, bioenergy with carbon capture and storage/utilisation (BECCS/BECCUS).

Technical Coordinator

In 2022, the Technical Coordinator continued working closely with the Tasks including keeping updated on Tasks' publications and supporting the associated dissemination activity. He took part in a number of online Tasks' meetings and workshops and he coordinated the TCP response to misconceptions on bioenergy being circulated in the media. The Technical Coordinator provided feedback on the Bioenergy Review 2023 report (see section "IEA Bioenergy – Selected Highlights from 2022" in this Annual Report). He also coordinated the preparation of the programmes for the ExCo89 and ExCo90 workshops, and he led the drafting of the summaries and conclusions reports from these events. In addition to his key role in the execution of the Communication Strategy (see below), the Technical Coordinator acts as an important link with the IEA Secretariat, other IEA TCPs and international organisations. He provided input to the IEA Renewables 2022 Report and to the IEA Tracking Clean Energy Progress (biofuels), and he participated in the IEA workshop 'Innovative renewables and hydrogen solutions for industry' (28 June 2022). In addition, he joined and contributed to selected meetings and discussions held by other organisations such as Biofuture Platform (particularly the Working Group on Sustainability), Euractiv and FuelsEurope.

Communication Strategy

The focus on communications continued in 2022 with nine meetings of the Communications Team. In January 2022, the TCP engaged the services of a Communications Specialist (MFM) to further improve dissemination of IEA Bioenergy outputs and reach beyond the bioenergy bubble. At the ExCo90 meeting in October 2022, MFM presented a set of recommendations, especially in relation to media awareness, stakeholder dialogue and communication competence. Based on these recommendations, the Comms Team is currently identifying priority actions for consideration by ExCo.

The use of social media to disseminate outputs from the TCP has expanded with around 4,800 followers on Twitter and over 5,000 followers on LinkedIn. The webinar programme has continued with four webinars being presented in 2022. The webinars included (i) Integrated Biogas Systems – Sustainable Solutions Beyond Energy, (ii) Circular Economy, Energy Recovery from Waste, and Emerging Pathways, (iii) Integration of Gasification Processes in Biorefineries, (iv) An Introduction to Quantifying the Climate Effects of Bioenergy. The recordings and presentations are available here.

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. Two new Inter-Task projects were approved by ExCo in April 2022: one on "Management of Biogenic CO2: BECCUS Inter-task Phase 2" and one on "Synergies of Green Hydrogen and Bio-Based Value Chains Deployment".

Inter-Task Project: Management of Biogenic CO2: BECCUS Inter-task Phase 2: This project, which comprises eight working packages, aims to: facilitate cross-Task, cross-TCP and cross-sector learning on bio-CCUS; shed light on (bio)energy system integration of bio-CCUS; and address CO2 mitigation potential of bio-CCUS. It will allow for a more systemic consideration of how to take different BECCUS applications to deployment, thereby building upon, but going beyond, Phase 1. The main outputs of the project, which started in Q2 2022 and will end in Q4 2024, will include four reports, two workshops and one webinar. Collaboration is foreseen with various TCPs (ETSAP, GHG, IETS), in addition to the Synergies ITP.

Inter-Task project: Synergies of Green Hydrogen and Bio-Based Value Chains Deployment: The objective of this project is to identify and assess synergies in the deployment of green hydrogen and bio-based value chains that can enhance the use of both energy carriers and the energy system under different conditions. The focus will be on value chains directly linked to bioenergy, i.e., biomass as a source of hydrogen and bio-based processes consuming electrolytic hydrogen. The project comprises six working packages, with three reports, two webinars and a series of factsheets foreseen as key outputs. It started in June 2022 and it will end in November 2024. Collaboration is foreseen with the Hydrogen TCP and the ETSAP TCP, in addition to the BECCUS Phase 2 ITP.

ExCo Workshops

Two ExCo workshops were held in 2022 (for further details, see the section above on Selected Highlights from 2022).

On 17 October 2022, a hybrid ExCo90 Workshop themed "Technology Advances in Liquid Biofuels and Renewable Gas" was organized in Vienna (Austria) by IEA Bioenergy, in collaboration with the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) and BEST – Bioenergy and Sustainable Technologies GmbH.

The presentations and summary report from the workshop are available here.

On 23-24 May 2022, a virtual ExCo89 Workshop themed "Bioenergy and Sustainable Development – Climate Change Mitigation and Opportunities for Sustainability Co-Benefits" was organized by IEA Bioenergy, in collaboration with the Global Bioenergy Partnership (GBEP) and the Biofuture Platform. The presentations and summary report from the workshop are available here.

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 as follows:

Task 33 organized a workshop on "Valuable (by-)products of gasification", on 19-20 October 2022 in Vienna (Austria) - link.

Tasks 33 and 39, in collaboration with the CONVERGE consortium and TNO, organized a hybrid workshop on "Innovations in advanced biofuels production" on 18 May 2022 - link.

Task 36 organized a workshop "Decarbonization of the Waste Sector from a global perspective" on 29-30 November 2022 in Durban (South Africa) - link.

Task 39 organized a virtual workshop on "Decarbonizing the rail sector via the use of low carbon intensity fuels" on 12 May 2022 - link.

Tasks 40, 42, 43, 44, 45 organized a virtual inter-task collaboration workshop on "Regional development opportunities based on flexible biomass value networks" on 2 November 2022 - link.

Task 44 organized a virtual workshop on "Flexibility Provision from Biogenic Gases" on 23 November 2022 - link.

Task 45 was involved in the organisation of the 2nd International Conference on Negative Emissions, which was held from 14 to 17 June 2022 in Gothenburg (Sweden) - link.

Collaboration with other Technology Collaboration Programmes and International Organisations

The Executive Committee of the IEA Bioenergy TCP continues to place strong emphasis on collaboration with other Technology Collaboration Programmes and International Organisations, including those mentioned in the following.

Technology Collaboration Programmes

Exchanges were held with the Hydrogen TCP, the ETSAP TCP and the AMF TCP in relation to the new Inter-Task project on "Synergies of Green Hydrogen and Bio-Based Value Chains Deployment"; and with the ETSAP TCP, the GHG TCP and the IETS TCP regarding the other new Inter-Task project ("Management of Biogenic CO2: BECCUS Inter-task Phase 2"). The AMF and Hydrogen TCPs were invited to present at the ExCo89 and ExCo90 meetings.

Biofuture Platform

IEA Bioenergy and the Biofuture Platform signed a Memorandum of Understanding to implement collaborative activities in the field of bioenergy, with a focus on biofuels and biorefineries. The two organizations and GBEP collaborated on the organization of the ExCo89 Workshop on "Bioenergy and Sustainable Development – Climate Change Mitigation and Opportunities for Sustainability Co-Benefits".

FAO

IEA Bioenergy and FAO continue to exchange on areas of cooperation under the MoU between the two organisations.

Global Bioenergy Partnership (GBEP)

IEA Bioenergy continues to collaborate with GBEP on biomass sustainability through IEA Bioenergy Tasks 45 and Task 40. IEA Bioenergy is also involved in GBEP Activity Group 7 on 'Biogas' through IEA Bioenergy Task 37 and in Activity Group 8 on 'Advanced Liquid Biofuels' through IEA Bioenergy Task 39. IEA Bioenergy, GBEP and the Biofuture Platform collaborated on the organization of the ExCo89 Workshop on "Bioenergy and Sustainable Development – Climate Change Mitigation and Opportunities for Sustainability Co-Benefits".

IRENA

IEA Bioenergy and IRENA continue to review outputs from each other's work programmes, particularly through the Technical Coordinator, and to examine areas of potential cooperation.

Integrated Biorefineries Mission

Synergies are being explored with the recently-established Integrated Biorefineries Mission under Mission Innovation (MI).

UNIDO

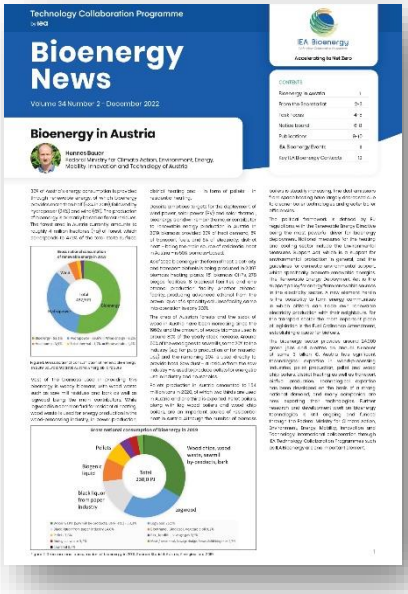
UNIDO participated as an Observer in the ExCo90 meeting in October 2022 in Vienna (Austria). IEA Bioenergy and UNIDO are collaborating on the organization of the ExCo91 Workshop on "Opportunities of Bioenergy and Biofuels in Developing Economies".

Promotion and Communication

Effective communication of IEA Bioenergy activities to the broader stakeholder community is a priority for the Executive Committee of IEA Bioenergy. The engagement of ETA Florence has been continued. As explained above, in 2022 the TCP engaged the services of a Communications Specialist (MFM) to further improve dissemination of IEA Bioenergy outputs and reach beyond the bioenergy bubble. Based on MFM's recommendations, which were discussed at the ExCo90 meeting, a draft list of priority actions was identified by the Communications Team.

The 2021 Annual report included the special colour section on "Sustainability of Biomass for the Biobased Economy". A limited number of printed copies were produced, with substantially increased distribution in electronic format.

The newsletter 'IEA Bioenergy News', which is distributed in July and December each year following ExCo meetings, continues to be widely circulated. Two issues were published in 2022. The first issue in 2022 featured an article by Tasks 37 and 40 on "Renewable gases: deployment, markets, trade and role of the gas grid". The second issue in December 2022 featured an article by Task 39 on "The challenges and potential of biojet / Sustainable Aviation Fuels (SAF), and policies needed". The newsletter is available from the IEA Bioenergy website, and it is widely distributed outside of the normal IEA Bioenergy network.



Two contributions under the banner 'IEA Bioenergy Update' were provided to the journal Biomass and Bioenergy in 2022 bringing the total to 73. This initiative provides excellent access to bioenergy researchers as the journal finds a place in major libraries worldwide.

As part of a broader effort to improve the effectiveness and impact of its communication, in 2022, IEA Bioenergy issued a few press releases to shed light on a few key topics related to bioenergy, and to dispel some misconceptions being circulated in the media. The press releases are available here.

In addition, the Technical Coordinator joined a number of key events (e.g., EUBCE2022, Biofuel International Conference, ESOF2022), where he presented relevant IEA Bioenergy work and related key messages.

Interaction with IEA Headquarters

Interaction with IEA Headquarters in Paris is of high importance to IEA Bioenergy and has been facilitated in 2022 particularly through the Chair, Vice-chairs, Technical Coordinator, Secretary and a number of Task Leaders at both technical and administrative level.

The Chair of IEA Bioenergy, Paul Bennett, attended the REWP online meetings in April and October 2022. He presented the IEA Bioenergy Mid Term Report to the April meeting, and the IEA Bioenergy Annual Briefing report to the October meeting.

In 2022 the Technical Coordinator provided input to the IEA Renewables 2022 Report and to the IEA Tracking Clean Energy Progress (biofuels), and he participated in the IEA workshop 'Innovative renewables and hydrogen solutions for industry' (28 June 2022).

IEA Bioenergy participates in the GREET+ Extension Project of IEA. Representatives of Task 39 participated in meetings of the Transport Coordination Group on behalf of IEA Bioenergy. IEA Bioenergy representatives also participated in workshops on Circular Carbon and Industry decarbonization co-organized by the IEA Secretariat and the IETS TCP.

Kazuhiro Kurumi attended both ExCo89 and ExCo90 on behalf of IEA Headquarters and made presentations to the IEA Bioenergy Executive Committee on activities in the IEA. This participation by Headquarters is appreciated by the Members of the ExCo and helps to strengthen linkages between the Technology Collaboration Programme and relevant Headquarters initiatives.

Status reports were prepared by the Secretary and forwarded to the Desk Officer and the REWP following ExCo89 and ExCo90. Status reports were also sent to Carina Alles, Vice Chair of the End Use Working Party (EUWP) for the Transport sector. This forms part of the exchange of information between Technology Collaboration Programmes and the Working Parties.

IEA Bioenergy Website

The IEA Bioenergy website (www.ieabioenergy.com) continues to be updated with the latest outputs from the IEA Bioenergy TCP. The transfer of the Tasks' websites to the new IEA Bioenergy brand identity and design is almost complete.

Progress in the Tasks

TASK 32: Combustion & Emissions[16]

Participating countries: Austria, Canada, Denmark, Germany, Japan, The Netherlands, Norway, Switzerland, USA (Observer).

Operating Agent: Katharina Paarup Meyer, Danish Energy Agency – Centre for Energy Administration

Task Leader: Morten Tony Hansen, Ea Energy Analyses, Denmark

Co-Task Leader: Christoph Schmidl, BEST – Bioenergy and Sustainable Technologies, Austria

Task 32 website - link

Overview of the Task

The objective of Task 32 is to collect, analyse, share, and disseminate strategic, technical and non-technical information on biomass combustion applications, leading to further acceptance, deployment and performance in terms of environment, costs and reliability, and to support the existing momentum in market introduction of improved combustion and co-firing systems and finally to describe its role in future energy systems in the member countries, especially in a future with focus on net negative CO2 emissions.

[16] Official name: Biomass Combustion.

The current Task 32 members have identified the challenges to biomass combustion that they experience:

Emission reductions remain important - small and larger scale.
- PM important in small scale - residential heating.
- NOx important in small to medium sized district heating.

Transition away from fossil fuels in industry.
- Becoming even more important.
- Electrification not always desired.
- Efficiency improvement and co-generation could be included.

Integration and flexibility of biomass combustion.
- Role of biomass combustion in energy systems.
- Role of biomass combustion in a CCS and PtX future.
- Public perception and sustainability.

Carbon neutrality of woody biomass.
- Biodiversity in large scale supply chains.
- Negative campaigns currently prevailing in some countries.

Task 32 has proposed to continue supporting the deployment of stoves and boilers for residential heating, boilers for district heating, industrial boilers and utility size units while addressing the above topics with a technical approach focusing on these key technical, economic, environmental, and social issues that impede market dissemination of biomass combustion technologies.

The work programme for Task 32 comprises the following:

- WP1: Substituting fossil fuels in industry.
- WP2: Sustainable biomass combustion negative emissions.
- WP3: Innovative low emission biomass heating plants.
- WP4: Low emission residential appliances.

Selected highlights from Task 32

During 2022, Task 32 has kicked off the new triennium by fitting the work programme to country commitments, discussing and specifying the content in further detail and starting up all proposed activities. Significant achievements include:

- WP2 of the BECCUS 2.0 inter-task project:
  - Host plant for modelling case found and accepted.
  - Discussions with potential venues for workshop on Biomass Combustion and BECCUS initiated and close to finalisation.
- Low emission operation of automatic wood boilers operated in cascades - report published.

During this first part of the triennium, Task 32 has successfully followed up on finalisation of the pending projects from the previous triennium.

Furthermore, the task has had its annual (and first in a long time) physical meeting in form of one week with three site visits in Copenhagen, Denmark in September.

District heating plant in Sorø, Denmark (Photo: Steen Knarberg).

Progress in R & D

Work programme and key deliverables
Updates on the work packages are described here.

WP1
Activities have awaited finalisation of the pending case reports from the previous triennium.

WP2

- 2.1 Manage and contribute to WP2 of the BECCUS 2.0 inter-task project.
  - A host - a Danish large, wood chip fuelled CHP plant - has been found and accepted to take part in the modelling case. It is planned to model implementation of full scale CC technology during Q1-Q2 2023.
  - In the discussions with potential venues for workshop on Biomass Combustion and BECCUS Task 32 has approached organisers of TCCS 12 in Trondheim, Norway and EUBCE 2023 in Bologna, Italy. Both take place in June 2023. The latter seems most promising. The workshop will discuss BECCS experiences from biomass combustion and waste as well.

- 2.2 Contribute to WP3 of the Synergies with H2 inter-task project.
  - Like in 2.1, the case host has been found and the modelling work is expected to take place in Q1-Q2 2023.
  - 2.3 Ideas for development of the wood chips workshop have been discussed. Most promising seems an idea to collaborate with VGBE.
  - 2.4 It has been discussed how Task 32 can best contribute to the debate on sustainability.

WP3

- 3.1 The state-of-the-art study on low emission biomass boilers has been developed and potential cases identified.

- 3.2 Phase II of the study of the nitrogen cycle around biomass combustion has awaited the finalisation of the scoping report (phase I). The scoping report draws up interesting perspectives and has now been published. It has been presented at the CEBC 2023 in Graz and attracted great interest.
- 3.3 Low emission operation of automatic wood boilers operated in cascades - the report has been prepared, commented by task members and published on Task 32 website.

WP4

- 4.1 Production of the report of state-of-the-art residential boilers has begun and potential venues for the corresponding workshop have been contacted. The event may also be a webinar.
- 4.2 Further work on the inventory of emission policy strategies has awaited finalisation of the inventory synthesis report from last triennium. Now, we are ready to proceed.
- 4.3 Potential content for the webinar on stoves has been discussed. The event may also be a workshop depending on 4.1 and potential venues have been contacted.

During the first part of the triennium, Task 32 has finalised most of the pending projects from the previous triennium that were delayed partly due to the pandemic.

- D1.1 Testing methods and real-life performance of pellet stoves - published on the website.
- D1.2 Technical guidelines for design of low emission wood stoves - published on the website.
- D1.3 Inventory of national strategies for reducing the impact on air quality from residential wood combustion - synthesis report has been published on the website.
- D1.4 Workshop: Improved combustion in stoves and small biomass boilers - the workshop report has been published on the website.
- D2.5 Biomass for high temperature heat in industry - additional combustion tasks; the Austrian ready for publication, the Danish pending after another delay/change of case.
- Additional project: Study of the Nitrogen Cycle in Biomass Combustion Plants (Phase I) - scoping report has been published on the website. The issue on mass balances of reactive nitrogen attracts attention and the scoping report shows that the detailed study in phase II is important and much needed.

Task meetings, workshops and webinars

Task 32 has had three task meetings during 2022:

- In three virtual meeting sessions in December 2021 - January 2022, we discussed the work programme proposal, worked on finalisation of the 2019-2021 work programme and presented country updates.
- In September, the first in a long time physical meeting took place in Copenhagen, Denmark. At the meeting, the activities of the current triennium were formally kicked-of. The meeting also covered country updates and focus on finalising activities from the past triennium. The participants visited three biomass and waste combustion facilities, partly together with Task 40.

Task 40 and Task 32 visiting Unit 4 at Amagerværket in Copenhagen, Denmark. (Photo: Morten Tony Hansen)

- At the virtual meeting session in December, focus was on progress of the current work programme.

For upcoming webinars and workshops, please refer to the section above on work programme activities.

Collaboration with other Tasks and organisations

Task 32 and Task 40 keep lines warm re. the joint organisation of the workshop on experiences with large scale wood chip combustion and BECCUS. Collaboration has also taken place with Task 40 and Task 44 regarding contribution from Task 32 to the inter-task projects on BECCUS 2.0 respectively Synergies with hydrogen. The collaboration also involves Task 36 on case studies.

During 2022, Task 32 has collaborated with other IEA Bioenergy representatives on Country reports and on the Bioenergy Review Update and with the IEA Renewable Energy Division on their online heat economics calculator and briefly been advising the division on a workshop contribution.

We remain in contact with VGB to participate in their biomass working group meetings and a potential collaboration on the wood chip combustion workshop. Contact has been established to French CIBE on a collaboration.

Task 32 receives and responds to inquiries from around the world regarding biomass combustion and related topics.

Dissemination
During 2022, the new website design has been put online and the website has been updated with relevant events, recent publications, new bios and is continuously being updated. ETA was very helpful doing a great job by merging content from the two former websites.
Publication of Task 32 reports takes place on the task website as well as on the IEA Bioenergy main website. In most cases, a corresponding post has been made on LinkedIn by ETA.
Task 32 contributes to the IEA Bioenergy newsletter. The NTL's distribute newsletters and news from IEA Bioenergy and task 32 to their national networks.

Main activities in 2023
Task 32 will take up the thread from the high temperature heat for industry by generating new case reports and a searchable list of cases and references.
As a part of the inter-task projects, Task 32 will produce the modelling case studies on full scale implementation of CCUS technology at an existing wood chip fuelled CHP plant. Results are expected to be presented along with our outlook on options for BECCUS in small scale biomass combustion as well as with selected experiences from ongoing CCS developments on a Task 32 workshop that can hopefully be held as a side event to a suitable biomass conference.
We look forward to carry out phase II of the nitrogen cycle study and to publish the report on low emission operation of automatic wood boilers in cascades.
Then, we plan to resume collaboration with the Alaska Wood Energy Conference in Fairbanks and organise a side event based on recent and current projects and focusing on application in remote communities.

TASK 33: Gasification[17]

Participating countries: Austria, Belgium, Canada, China, France, Germany, India, Italy, The Netherlands, Sweden, UK, USA.

Operating Agent: Bas Heukels, Netherlands Enterprise Agency (RVO).

Task Leader: Berend Vreugdenhil, Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek (TNO), The Netherlands.

Co-Task Leader: Jitka Hrbek, Universität für Bodenkultur (BOKU), Austria.

Task 33 website - link

Overview of the Task

IEA Bioenergy Task 33 is dedicated to supporting the deployment of biomass and/or waste gasification in industry. Gasification as a technology is extremely versatile, resulting in a shift in focus in the current triennium on the main applications of gasification. These entail heat and power (CHP), the production of green gas (SNG), the production of fuels, the production of chemicals and the production of hydrogen. These possible applications are at various stages of development. For gasification to CHP is widely applied with several thousands of units in operation worldwide.

Given the energy transition, which is propelled by events such as the war on the Ukraine, the need for renewables in a broader sense are gaining momentum as well. This is clear for pathways to heat and power or SNG and biofuels. However, for the production of chemicals and hydrogen this is not that evident yet and through our work we aim to support this pathway as well.

As part of the various applications, the greenhouse gas (GHG) balance is also considered. Often this is overlooked or its effect underestimated. Through a separate support activity the Task

[17] Official name: Gasification of Biogenic Residue and its Applications.

will work on providing fact based evidence of the benefits of using biogenic residues in gasification pathways to heat, power, SNG, fuels, chemicals and hydrogen.
The activities undertaken by Task33 in the current triennium are supported by the United Kingdom (Aston), United States of America (NREL), Sweden (LTU), Italy (ENEA), China (TJU), India (IndianOil), Belgium (ECAM), France (ATEE), Austria (BOKU), Germany (KIT), the Netherlands (TNO) and Canada (NRCan).

Selected highlights from Task 33

• The position paper on green gas production using gasification came at the exact right moment. The war initiated by Russia has severely influenced the energy market, hence the need for biomethane become more evident.
• The RePowerEU plan present recently sets targets of 35 BCM biomethane. This target could be more ambitious since biogas aims to fulfil most of this.
• The Sierra Biorefinery has begun production of Fischer Tropsch product, processing prepared waste feedstock and successfully producing the high-quality hydrocarbon synthetic gas needed for the synthesis.
• The FUREC RWE project to produce hydrogen from waste via gasification received funding from the European Investment Bank. This will support the build up of a plant in the Netherlands and is an important boost for gasification technology as such.

Progress in R & D

Work programme and key deliverables

The first position paper was written with respect to Sustainable Natural Gas (SNG). As SNG became extremely important in Europe due to the war against the Ukraine, the paper and its message came at the right moment. The paper highlighted the advantages of SNG, including the improvement in security of energy supply (less dependencies), the benefits of SNG for hard to abate sectors (older inner cities or high temperature heat applications) and simplicity of making use of the exiting gas distribution infrastructure. The paper concluded with some suggestions to policy makers on for instance to allocate production targets all over Europe, supporting mechanisms for the pre-commercial validation and de-risking of the technology and the harmonization in feedstocks allowed and SNG quality before injecting into the grid. It also highlighted another benefit with respect to the carbon balance, which offers the potential of removing carbon from the global carbon cycle through SNG production.

Task meetings, workshops and webinars

- Task meeting in the Netherlands at TNO 18 - 20 May.
- Workshop on biofuels (co-organized with EU project CONVERGE) 18 May.
- Webinar on gasification in (bio)refineries together with Task39 on 30 June.
- Task meeting in the Austria at TNO 18 - 20 October.

- Workshop on biofuels (co-organized with EU project CONVERGE) 18 May.
- Workshop on biorefineries in the circular economy (organized by CSIR) 28 October.
- Workshop on Flexibility provision from biogenic gases (organized by Task44) on 23 November.

Collaboration with other Tasks and organisations
The collaboration within two ITP's has started. The ITP Synergies on the hydrogen will develop new insights in the production of hydrogen via gasification (as one of the pathways) and it will explore the utilization of hydrogen in various process. Sweden is leading these efforts on behalf of Task33.
Supporting this activity, the informal collaboration between Task33 and IEA Hydrogen has started as well. By keeping each other informed of this production pathway and looking for ways to collaborate in each other efforts to develop new material in this field.
The ITP on BECCUS has also started in which we will establish more insights about what it means to capture CO2 in gasification processes. These activities are led by the UK.

Dissemination
- Country reports and task meeting reports are published on the website.
- Summaries of the workshops organized as well as presentations can be found on the website.
- The position paper has been published through our website.
- A summary of the GCEAF in Pittsburgh is published on the website as well.

Main activities in 2023
In 2023 the new website of Task33 will go online. This will identify the different applications and give supporting background information.
An update on leaflets on the different applications under development by the task will be finished in Q3 of 2023.
A synthesis report on hydrogen production will be realized in 2023 in which ongoing initiatives and research developments will be highlighted.

TASK 34: Liquefaction[18]

Participating countries: Canada, Denmark, Finland, Germany, India, The Netherlands, New Zealand, USA.

Operating Agent: Birger Kerckow, Fachagentur Nachwachsende Rohstoffe e.V. (FNR), Germany.

Task Leader: Axel Funke, Karlsruhe Institute of Technology (KIT), Germany.

Co-Task Leader: Alexandra Böhm, Karlsruhe Institute of Technology (KIT), Germany.

Task 34 website - link

Overview of the Task

The objective of Task 34 is to advance the international implementation of bioenergy technology through strategic information analysis and dissemination in the areas of direct thermochemical liquefaction of biomass (including bio-based waste) for bioenergy applications such heat, power, transportation fuel, and the production of chemicals/ materials. The covered scope includes activities on thermal and catalytic fast pyrolysis, hydrothermal and solvo-thermal liquefaction, as well as feedstock pre-treatment, bio-oil/biocrude upgrading and bio-oil applications. Specific work packages follow market driven needs. In order to meet the task objectives, Task 34 continues to actively involve industry and decision-makers and exploit interactions with other Tasks and Intertask Projects.

In 2022, Task 34 was supported by eight member countries (Canada, Denmark, Finland, Germany, India, New Zealand, The Netherlands, and U.S.A.) and comprises of technical experts from the field of (catalytic) fast pyrolysis and hydrothermal liquefaction. The work programme is based on a well-defined technical and non-technical work packages in which smaller groups

[18] Official name: Direct Thermochemical Liquefaction.

of participants contribute. The work groups focus on internal and external information exchange, technology reviews, and technology implementation issues and opportunities. The priority topics for Task 34 in the current triennium are:

Technical

1. Deployment of marketable commodities from DTL.
2. DTL system services for a future circular economy.

Dissemination and facilitation

3. Support commercialization through knowledge transfer.
4. Facilitate information exchange with stakeholders.

Each priority topic is covered by 3-4 work packages that detail individual actions to support the objectives of Task 34 as follows:

1.1 (Pathways to) Transportation fuels from HTL and FP
1.2 Production of chemicals and materials from HTL and FP oil
1.3 DTL oils for gasification
2.1 DTL in the context of flexible power supply
2.2 DTL as BECCS/ BECCU technology
2.3 Hydrogen use for DTL product upgrading
3.1 Round Robin for validation of analytical method
3.2 Lessons learnt from FPBO REACH & GHS registration
3.3 Update commercial DTL facilities
3.4 TEE of DTL biorefinery
4.1 Website management
4.2 PyNe Newsletter
4.3 Workshops, seminars and/or site visits with key stakeholders
4.4 Country reports

Selected highlights from Task 34

- Publication of a report that reviews 'Electrochemical transformations of fast pyrolysis bio-oils and related bio-oil compounds'.
- Newly introduced a publication series entitled 'Technical Notes' to improve dissemination of lessons learned in the field of direct thermochemical liquefaction. It aims at advancing development in this field by communicating common pitfalls and sources of confusion. The first two notes are on DTL specific mass balancing issues and risks assessment for chemical compounds found in DTL bio-oils.
- Task 34 observe a continuing increase in industrial activities in all fields of DTL, i.e. in terms of increasing production capacity of mature technology, demonstration of new technologies and emerging DTL bio-oil applications

Progress in R & D

Work programme and key deliverables

Upgrading of oils produced from direct thermochemical liquefaction of biomass is important to unlock value added applications. Electrochemistry is an increasingly important area of research and offers unique opportunities as compared to more classical upgrading via hydrodeoxygenation. Task 34 published a report that reviews 'Electrochemical transformations of fast pyrolysis bio-oils and related bio-oil compounds' with a focus on summarizing fundamentals of this innovative approach and outlining recent developments (link).
To improve dissemination of lessons learned, Task 34 has introduced a new set of reports called 'technical notes'. They aim at providing relevant information to cope with specific challenges/ issues in the field of DTL and further enhance efficient research and development. The first Technical Note explains quality aspects of mass balances and how to avoid the most common inconsistencies/ artefacts. It clarifies different balancing methods and reference states for biomasses and its liquefaction products with a specific focus on the role of water. Also, the use of different solvents for biocrude extraction after hydrothermal liquefaction is reviewed. The second technical note discusses the influence of specific compounds on safety related aspects of DTL oils to point out potential areas of risk when testing new feedstocks and/or new process conditions. (link).

Task meetings, workshops and webinars

Apart from monthly videoconferences to keep track of ongoing work and developments, Task 34 conducted a meeting in person at VTT in Espoo/ Finland from May 23rd to 24th, 2022 together with a technical tour in VTT's laboratories. A workshop to involve Finish stakeholders relevant to the field of direct thermochemical liquefaction was held subsequent to this meeting on the following day. Industrial activities in Finland around DTL are among the highest worldwide, both in terms of installed plant capacity and technology providers, most of which were present during that day. A report that summarizes this workshop has been published in IEA Bioenergy Task 34 newsletter PyNe 51 (available here).
This meeting was organized as hybrid event to allow for online participants that could not join in person.

Collaboration with other Tasks and organisations

Task 34 is actively involved in both inter task projects on 'Synergies of green hydrogen and bio-based value chains deployment' and 'Management of biogenic CO2: BECCUS'. This is an important development to be able to showcase the versatile services DTL technologies can provide in a future energy system next to the production of liquid biofuels. For both projects, internal work packages have been identified to provide in-depth information for relevant case studies. Two case studies will be elaborated as part of these work packages: 1. Chemical storage of hydrogen in HTL biocrude via hydrodeoxygenation to produce biofuels and 2. Different alternatives for the production of CO2 negative biofuels via DTL by using byproducts for negative emission technologies.
Additionally, there are initiatives with representatives from Task 33, Task 39 and Task 42 to set up joint activities.

Dissemination

IEA Bioenergy Task 34 issues the PyNe newsletter twice a year, featuring divers contributions from the field of direct thermochemical liquefaction. PyNe 51 was published July 2022 and PyNe 52 December 2022. They are available here.

In 2022, the series of country reports was continued with updates around DTL related activities in New Zealand and The Netherlands. They are available here.
The website of IEA Bioenergy Task 34 was changed to meet the standard IEA Bioenergy design; at the same time the content was revised and several pages updated to account for the development in this field. Special care is taken to have all created reports available and up to date on the website.

Main activities in 2023
Early 2023 a report around 'Lessons learnt from FPBO REACH & GHS registration' will provide valuable information around the challenges when introducing products from direct thermochemical liquefaction to the market. To achieve market introduction, significant formal procedures are required because these products are classified as new chemicals.
Two additional reports are scheduled for 2023 that focus on new applications of the produced liquids. The first will review latest developments in the use of DTL oils as chemicals and materials while the second focusses on its use as fuel for gasifiers.
Moreover, an update of commercial DTL facilities is planned to keep track of latest developments. Industrial activity is constantly increasing in the field of DTL around the globe, both for mature (TRL 9) and developing technologies (TRL 7-8). There are also important projects in the field of emerging DTL bio-oil applications that will be part of this report.
The second physical task meeting is planned for early 2023 to take place at our latest participant entry India. The meeting will take place at HP Green R&D Centre in Bangalore, India. Another meeting is planned November 2023 to take place in the U.S. at the National Renewable Energy Laboratories in Golden, Colorado.

TASK 36: Waste & Circular Economy[19]

Participating countries: Germany, Ireland, Italy, Norway, South Africa, Sweden, USA.

Operating Agent: Jonas Lindmark, Swedish Energy Agency.

Task Leader: Mar Edo, RISE Research Institutes of Sweden.

Task 36 website - link

Overview of the Task

Task 36 Material and Energy Valorisation of Waste in a Circular Economy (previously known as Integrating Energy Recovery into Solid Waste Management Systems) is an international working work which seeks to raise public awareness of sustainable energy generation from biomass residues and waste fractions including municipal solid waste (MSW) as well as to increase technical information dissemination. As outlined in the 3-year work programme, Task 36 seeks to understand what role energy from waste and material recycling can have in a circular economy and identify technical and non-technical barriers and opportunities needed to achieve this vision.

Those countries participating in this triennium are Germany, Italy, Norway, Ireland, Sweden, South Africa and United States. Australia is participating as "invited technical expert".

[19] Official name: Material and Energy Valorisation of Waste in a Circular Economy.

Selected highlights from Task 36

- 3 on-line meetings and one physical meeting in Durban, South Africa.
- 4 reports have been published:
  - Inter-task BECCUS 1.0 Synthesis Report (covering 2019-2021) (December 2022).
  - Case study about valorisation of biowaste in the United States (June 2022).
  - Case study about IVAR MSW sorting facility in Norway (May 2022).
  - Final Report – Material and energy valorisation of waste in a circular economy (April 2022).
- 2 workshops organized in collaborations with South African associations.
  - WS1: Transition towards a decarbonized circular economy- Focus on Waste-to-Energy (June 2022).
  - WS2: Decarbonization of the waste sector from a global perspective (December 2022, is the first one of a Sustainability workshop that will be organized by the task during 2023-2024 and that are arisen lot of attention from the audience.
- Contribution to the report: Bioenergy in Australia's Circular Economy. Our overlooked renewable energy opportunity (February 2022).

Progress in R & D

Work programme and key deliverables

- CASE STUDY ABOUT VALORISATION OF BIOWASTE IN THE UNITED STATES (JUNE 2022). Biomethanation is demonstrating itself as a scalable and robust technology for producing renewable natural gas while simultaneously increasing the methane yield from a given biogas source. By utilizing a biological organism to perform this carbon dioxide conversion, the technology operates at more benign temperatures and is resistant to impurities and toxic compounds found in biogas. The technology has also demonstrated its ability to provide ancillary services to the grid in terms of load peaking. This enables greater penetration of other renewable generation technologies. Worldwide, several thousand hours of continuous operations have been demonstrated at a small number of plants. As the process continues to demonstrate performance and robustness, this will improve investor confidence in this technology and encourage further deployments.

- CASE STUDY ABOUT IVAR MSW SORTING FACILITY IN NORWAY (May 2022).
  With today's state-of-art recycling technology only the pure, high quality recyclates can be reused on the market, and the remaining ones ends up in energy recovery. The bottle neck for recycling industry with the technology available now is the quality of the plastic waste. This means that no matter how much plastic the sorting plants recover, only part of it will be suitable for recycling.

- FINAL REPORT - MATERIAL AND ENERGY VALORISATION OF WASTE IN A CIRCULAR ECONOMY (April 2022).
  This report summarized all the work, key messages and learning from the task in the past triennium:

- Waste management will turn into materials recycling and resource handling.
- Energy recovery: molecules in use for longer rather than extracting energy from materials.

- Broadening products obtained from waste/materials: energy, chemicals, and manufactures feedstock.
- New technologies are required that as they are developed, their costs will decrease.
- Many non-technical challenges: public acceptance and developing of new policy.

- CONTRIBUTION TO THE REPORT BIOENERGY IN AUSTALIA'S CIRCUALR ECONOMY. Our overlooked renewable energy opportunity (February 2022) - Bioenergy as a proportion of total energy supply is low in Australia due to financial, regulatory, supply and institutional barriers.

Task meetings, workshops and webinars

WEBINARS
- Decarbonizaton of the waste sector from a global perspective (December 2022, Durban, hybrid). Organized by SANEDI (South African National Energy Development Institute) & Task 36.
- Transition towards a decarbonized circular economy- Focus on Waste-to-Energy (June 2022). Organized by SABIA (South African Biogas Industry Association) & Task 36.

TASK MEETINGS
- Task meeting 28 November - 1 December 2022 in Durban (South Africa). Country reports and discussions about prioritize deliverables.
- On-line Task meeting 21 September 2022 - Planning meeting in Durban, discussions about priority if the budget reduces and follow up on deliverables.
- On-line Task meeting 9-10 March 2022- Planning of the work for the triennium.
- On-line Task meeting 23 February 2022 - Follow up on previous triennium deliverables.

Collaboration with other Tasks and organisations
- Collaboration with SANEDI (South African National Energy Development Institute) in the workshop about Decarbonization of the Waste Sector from a global perspective (December 2022, Durban, South Africa). Contribution as organizers as well as speakers.

- Inter-task BECCUS 2.0 (phase 2) initiated: digital kick-off in June 2022.
- Collaboration with SABIA (South African Biogas Industry Association) in the workshop Transition towards a decarbonized circular economy- Focus on Waste-to-Energy (June 2022). Contribution as organizers as well as speakers (4 task members had presentations in the event).
- Collaboration with Bioenergy Australia contributing for the report Bioenergy in Australia's Circular Economy - our overlooked renewable energy opportunity in February 2022.

Dissemination

WEBSITE
The website has been constantly updated with new publications and events. Changes in the content have also been made to simplify it as much as possible and make it more attractive for the reader.

NEWSLETTERS
Unfortunately, no newsletter has been sent this year.

Main activities in 2023

MEETINGS

- On-line meetings in February and June.
- Potential physical meeting in autumn in Norway. To be discussed.

WORKSHOPS/WEBINARS

- Task 36 is aiming at organizing a workshop on Sewage Sludge Treatment for Nutrient Recycling and Energy Recovery in Italy in the late spring/beginning of summer. The workshop can be organized following an event that is already planned and dedicated small and medium size Italian operator in the sector. The workshop will involve big operator in Italy (A2A, ACEA, etc) some University, as well of international organizations and speakers.
- Continuation with the Sustainability workshops series. Date not decided yet.

DISSEMINATION

- 2-3 newletters (Feb/Mar, Summer and end of the year).
- Keep website up to date.

TASK 37: Anaerobic Digestion / Biogas[20]

Participating countries: Austria, Brazil, Canada, China, Denmark, Finland, France, Germany, India, Ireland, Italy, The Netherlands, Norway, Sweden, Switzerland, UK.

Operating Agent: Birger Kerckow, Fachagentur Nachwachsende Rohstoffe e.V. (FNR), Germany.

Task Leader: Jan Liebetrau, Rytec Consulting, Germany.

Task 37 website - link

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 the development of the biogas sector in many OECD countries has been characterised by many new installations, in other countries the lack of support of the sector has the consequence of very limited construction activities. The perception of perspectives and future of biogas has changed within the last years. Whereas biogas was seen as source of electricity and heat in past, the current discussion emphasizes the provision of renewable gas. While large facilities tend to upgrade the biogas to biomethane, CHP at smaller sites is still first choice due to higher specific costs at smaller sites. Biomass based biomethane is on the other side not the (sole) focus of the renewable gas discussion. A second focus is on sustainability and subsequent requirements for substrates, technology and operation.

[20] Official name: Energy from Biogas.

Major challenges for the development of the sector are the costs of energy from biogas, the acceptance of the technology and discussion about sustainability. Biogas technology is rarely a stand-alone application, it is closely integrated in energy and material flows of waste management and agricultural practice. In the context of sinking costs for renewable electricity, but presumably high costs for decarbonisation of the irreplaceable part of the gas sector and an emerging CO_2 pricing, biogas and biomethane have to find their place.
The technology is highly flexible in regards of substrates and type of energy output; organic residues and waste materials are a solid basis for the development of sustainable renewable gas sector. Due to its broad substrate spectrum the process has potential to become integrated element in the biorefineries of the future.
Gaseous renewable energy carriers are needed in a future energy system and play a key role in decarbonising heat and transport. Renewable gas at present is dominated by biomethane, which can be generated from the anaerobic digestion of organic biomass and residues produced in agriculture, food production and waste processing.
In 2018, there were 577 biogas-upgrading plants in operation in the 15 IEA Bioenergy Task 37 countries. The market for biomethane is still growing. Sweden, the UK, Switzerland, France, Germany, the Netherlands and emerging markets like the US and China have or are about to implement considerable biomethane capacities.
In the current triennium the Task 37 will address the co-benefits of AD against this background, the conditions for a better manure utilization, the role of biomethane in industry and transportation and last but not least costs and marginal abatement cost. Within the technical questions, test systems and technologies for emission reduction are looked at.

Selected highlights from Task 37

- Presentation at EUBCE "Integration of biogas systems into the energy system".
- Presentation at IEA Workshop "Scaling up biomethane in the European Union Biomethane, methane emissions and impacts on the GHG balance".
- Monthly Newsletter.
- Nordic Biogas conference Linköping; Moderation of session "A resilient, circular and biobased economy" and presentation "Integration of biogas systems into the energy system.
- Participation in JRC/EBA workshop "Fugitive methane emissions from AD plants: the effect on GHG calculations", 26 Oct 2022.
- Moderation during IEA Bioenergy workshop "Technology advances in liquid biofuels" Vienna, 19 Oct 2022.
- Contribution to Webinar of Task 44 "Flexibility Provision from Biogenic Gases", 23 Nov 2022, with presentation "Integration of biogas systems into the energy system".
- IEA Bioenergy Webinar "Integrated Biogas Systems – Sustainable Solutions Beyond Energy".
- Position Paper "The role of biogas and biomethane in pathways to net zero".

Progress in R & D

Work programme and key deliverables

- IEA Bioenergy Webinar “Integrated Biogas Systems – Sustainable Solutions Beyond Energy”.
  On 15 December 2022, IEA Bioenergy Task 37 (Energy from Biogas) hosted a webinar on biogas systems, their integration in complex energy systems and related trans-sectoral benefits.
  Biogas systems are more than plants for mere energy provision. They can for instance enhance recycling of nutrients, reduce air pollution, improve water quality and soil fertility – depending on the infrastructure they are integrated in. Biogas systems offer a variety of production and gas utilization options suitable for a highly customizable technology.
  The first presentation of the webinar started with examples of integrated biogas solutions, focusing on the diversity and multifunctionality of biogas and biomethane pathways in a circular economy. For a comprehensive assessment of the technology the various effects need to be considered in their entirety.
  The second presentation did hence discuss the sustainability assessment of biogas systems by means of multicriteria analysis and discuss most favourable solutions. Last but not least the successful implementation of biogas systems requires adequate policy measures.
  The third presentation compared different approaches and concludes with recommendations for sector development.

  The presentations were concluded by a panel discussion with the additional participation of:
  - Mats Eklund, BSRC – Swedish Biogas Solutions Research Center / Linköping University (Sweden)
  - Stefan Anderberg, Department of Management and Engineering, Linköping University (Sweden)
  - Kari-Anne Lyng, Norwegian Institute for Sustainability Research (Norway)

- Position paper “The role of biogas and biomethane in pathways to net zero”.
  Biogas is produced as the main product of anaerobic digestion (AD) of wet biomass. Biogas can be used locally for heat purposes or for power and heat production (CHP); as an alternative, biogas can be upgraded to bio-methane to replace natural gas. As such, it is one of the means to reduce the consumption of fossil fuels and contribute to the transition towards a net zero energy system.
  This position paper – developed by members of IEA Bioenergy Task 37 – provides central knowledge and features of biogas and biomethane. The main conclusion is that biogas and biomethane have plenty of options to be used in a pathway to net zero. They provide sustainable flexible systems that play essential roles in circular economy, energy, and environmental systems.
  Main findings available here.

Task meetings, workshops and webinars

- Task meetings: Milan, Italy (May 2022); Linköping, Sweden (October 2022).
- Moderation within IEA Bioenergy ExCo90 Workshop "Technology advances in liquid biofuels and renewable gas", Vienna, 17 October 2022.
- Contribution to Webinar of Task 44 "Flexibility Provision from Biogenic Gases", 23 November 2022, with presentation "Integration of biogas systems into the energy system".
- IEA Bioenergy Webinar “Integrated Biogas Systems – Sustainable Solutions Beyond Energy”, 15 December 2022.

Collaboration with other Tasks and organisations

- BECCUS ITP: Additional case study on biomethane and CO2 capture.
- Contribution to ITP: Synergies of green hydrogen and bio-based value chains deployment.

Dissemination

- Monthly Newsletter.
- Website transferred to the new format.
- Webinar “Integrated Biogas Systems – Sustainable Solutions Beyond Energy”.
- Position paper “The role of biogas and biomethane in pathways to net zero”.

Main activities in 2023

- Publish pending reports: “Increasing the range of feedstocks for anaerobic digestion" and "Anaerobic digestion in the food and beverage industry and the pulp and paper industry".
- Publish report on methane slip reduction.
- Task meetings in India and China with workshops.
- Monthly Newsletter.
- Further upgrading of the website.

TASK 39: Transport Biofuels[21]

Participating countries: Austria, Belgium, Brazil, Canada, China, Denmark, Estonia, European Commission, Germany, Ireland, Japan, Korea, The Netherlands, New Zealand, Sweden, USA, U.S. Grains Council (Limited Sponsor).

Operating Agent: Jonas Lindmark, Swedish Energy Agency.

Task Leader: Tomas Ekbom, SVEBIO, Sweden.

Co-Task Leader: Glaucia Mendes Souza, University of São Paulo, Brazil.

Task 39 website - link

Overview of the Task

Task 39 is a group of international experts working on commercializing sustainable biofuels used for transportation. The goal of Task 39 is to provide participants with comprehensive information to assist with the development and deployment of transportation biofuels. The Task coordinates both technical and the infrastructure issues related to biofuels. To meet this goal, the Task objectives are to:

[21] Official name: Biofuels to Decarbonize Transport.

1. Provide information and analyses on policy, markets and implementation issues that help encourage the adoption of sustainable conventional biofuels and help commercialize advanced liquid biofuels as a replacement for fossil-based fuels
2. Catalyze cooperative research and development projects that will help participants develop improved, cost-effective processes for the production of advanced liquid biofuels.
3. Provide information dissemination, outreach to stakeholders, and coordination with other related groups.

The vision is to accelerate the production and use of environmentally sound, socially accepted and cost-competitive bioenergy on a sustainable basis. To achieve a substantial bioenergy contribution to future global energy demands by thus providing increased security of supply while reducing greenhouse gas emissions from energy use. The mission is to facilitate the commercialization and market deployment of environmentally sound, socially acceptable, and cost competitive bioenergy systems and technologies, and to advise policy and industrial decision makers accordingly. The strategy is to provide platforms for international collaboration and information exchange in bioenergy research, development, demonstration, and policy analysis.

Starting from 2023 the members of Task 39 comprise fifteen countries including Austria, Belgium, Brazil, Canada, China, Denmark, European Commission, Germany, Ireland, Japan, The Netherlands, New Zealand, South Korea, Sweden and the USA. Australia participated during 2022 as Observer but has not confirmed participation and is not a member. Estonia was introduced during 2022 but is not a member. During 2022 China joined the Task as the newest member. US Grains Council participates as Limited Sponsor, with same terms as other participating countries. Their participation is limited to one Task and to one triennium and there is no ExCo representation.

The Task leadership is continuing its efforts to expand Task membership and currently trying to re-recruit other countries including Norway, Finland and Turkey. With the collaboration among these countries, Task 39 is set to deliver cooperative research projects to address and assess policy, markets and sustainable biofuel implementation issues.

Selected highlights from Task 39

- Task 39 increased its number of members during 2022 to 17, which is the largest of all IEA Bioenergy Tasks. Belgium, China, Estonia and US Grains Council joined in 2022, with the latter as Limited Sponsor. The Task has held three virtual Business Meetings and one in-person Business Meeting in Stockholm in September 2022.
- The Task arranged a Workshop and Study visit and presented Task 39 projects and activities with eight speakers at the Advanced Biofuels Conference in Stockholm in September 2022.
- The Task 39 Programme includes program areas of Technology and Commercialization (T-projects) and Sustainability and Policy (P-projects). Out of ten proposed projects in the programme the Task has achieved to start six projects.

Progress in R & D

Work programme and key deliverables

The Task 39 Programme of Work includes activities in three main working areas:

- Technology and Commercialization (T-projects): Technical/commercial aspects of producing and using low carbon intensity (CI) liquid and gaseous biofuels for transport, including both "conventional" and "advanced" biofuels
- Sustainability (P-projects): Sustainability and carbon intensity metrics are playing an ever-increasing role in the policies used to develop and use biofuels. Biofuels sustainability/LCA assessment will stay a priority for the Task.
- Policy (P-projects): The "right" policies (such as LCFSs) significantly influence the rate and extent of development, deployment and use of biofuels (e.g., bioethanol, biodiesel, renewable diesel, drop-in biofuels, etc.).

From previous triennium, the Inter-task project (Task 39, Task 40 and Task 45) with the title "Successes and Lessons Learned for Biofuels Deployment" is in the final stage of completion.
The list of projects which have been started is provided below:

- T39-T1 Ongoing progress in the commercialization of SAF/biojet fuel.
- T39-T2: Progress in the commercialization of drop-in biofuels and co-processing to produce low-CI transport fuels.
- T39-T4: Assessment of demonstration plants and commercialization progress.
- T39-T6: Inter-Task project 'Synergies of green hydrogen and bio-based value chains deployment'.
- T39-P1: Implementation Agendas compare-and-contrast report of each member country's biofuels policies that have been/are being used to develop, deploy and expand biofuels production and use.
- T39-P4: Biofuel's production and use status in "emerging" economies.

The Task produces reports and peer/reviewed journal papers to reach the broader transport biofuels community. There were two papers published in 2022:

- Improvement opportunities for policies and certification schemes promoting sustainable biofuels with low GHG emissions. Part 1: A review of policy frameworks (van Dam et al., 2022).
- Challenges in determining the renewable content of the final fuels after co-processing biogenic feedstocks in the fluid catalytic cracker (FCC) of a commercial oil refinery (Su et al., 2021; Journal of Fuel).

Task meetings, workshops and webinars

The Task held its first business meeting 23 February, followed by two additional virtual meetings on 21 April and 8 June. These included individual member country updates and the project leaders presented proposals with progress updates.
The fourth business meeting 21-22 September was made in person in Sweden in conjunction with the Advanced Biofuels Conference in Stockholm where eight Task 39 presentations were made. The conference was organized by the Swedish Bioenergy Association and comprised 28 speakers and 104 delegates (19 persons online) from 22 countries.
A workshop was then organized with expert presentations on developments in Sweden regarding biofuels technology, policy and experience in introducing on large-scale environmental-friendly

biofuel-based vehicles. Discussions were made in how lessons learnt and experiences from these developments can be transferred to other countries, and what success stories have become business as usual now.

Collaboration with other Tasks and organisations

Task 39 aims to continue its already good communications with IRENA, FAO and national/ international organisations to collaborate on biofuels developments. The Task will also ensure that its activities are complementary to those of other initiatives such as Mission Innovation, the Biofuture Platform, etc.

Task 39 will build on contacts taken during the webinars and conferences which are organized and where members are engaged to further collaborate with other tasks and organisations. There have been two discussions for joint meetings with other Tasks and webinars, e.g. with Task 33.

There are two active Inter-task projects. The project “Successes and Lessons Learned for Biofuels Deployment” involves Task 39, Task 40 and Task 45. The project "Synergies of green hydrogen and bio-based value chains deployment" involves all Task groups. The objective is to identify and assess synergies in the deployment of green hydrogen and bio-based value chains.

Dissemination

During 2022, Task 39 made many successful dissemination efforts. Apart from the publications, the Task publishes regular newsletters. In total, three were published and distributed in 2022. The first newsletter was published in June with an article about biofuels production and consumption in Belgium. The second newsletter was published in October featuring an article about biofuels policy, production, and use in Austria. The third was published in December with a feature on biofuels production and consumption in Japan.

The newsletters were uploaded on the website and distributed via email, with over 1,600 receivers/subscriptions. There will be three newsletters each year in the triennium.

Another important milestone of the year was the migration and re-modeling of the Task 39 website together with ETA Florence - the new website was launched in October. The new website is more appealing, organized, and easier to maneuver if compared to the previous one.

Main activities in 2023

Task 39 plans for two virtual Business meetings in 2023 and one meeting in person in Leipzig, Germany hosted by DBFZ in October 2023. It will be a joint meeting with IEA AMF.

The expected focus of the next Business meeting on 23 February will be updates on Task projects which are within the Task’s program of work for the current triennium. In addition there will be proposals on new projects which are outlined in the Program of Work to be started. Possibly they will be discussed in a webinar before the proposal to gather support and form the scope.

There will be publications via the peer reviewed literature and webinars. During the joint meeting with IEA AMF, two workshops will be organized.

The preliminary plan for 2024 is also to have two virtual business meetings and a concluding business meeting in person in Sao Paulo, Brazil in conjunction with the BBEST conference in October 2024.

TASK 40: Biobased Deployment[22]

Participating countries: Austria, Denmark, Germany, The Netherlands, Sweden, USA.

Operating Agent: Birger Kerckow, Fachagentur Nachwachsende Rohstoffe e.V. (FNR), Germany.

Task Leader: Uwe R. Fritsche, IINAS – International Institute for Sustainability Analysis and Strategy, Germany.

Co-Task Leader: Christiane Hennig, DBFZ- Deutsches Biomasse Forschungszentrum, Germany.

Task 40 website - link

Overview of the Task

The focus of Task 40 in the current triennium is on the development and design of efficient, economically viable, and low-risk (bankable) value chains to support a larger deployment of sustainable biomass for energy, for biobased chemicals and materials, considering food, feed, and fibre markets, i.e., the bioeconomy, and for a long-term renewable carbon management. In short, the Task will work on deploying sustainable biomass for energy in the context of the larger bioeconomy and a future renewable carbon economy.
Within this scope, international, national, and regional biomass trade remains an issue. However, it is key to understand biobased value chains and how to sustainably maintain or transform them. For this, the barriers and drivers for sustainable biomass deployment will be

[22] Official name: Deployment of biobased value chains.

identified, and policy developments will be reflected that could foster biomass uptake in existing and new (emerging) markets.
A key new issue to be addressed from a deployment point of view is the impact of developing carbon markets and of limited CO2 emission budgets on the deployment of biogenic energy carriers, products, and services.
The Task has three core areas of operation which all include Inter-task projects considering the various biobased value chains, markets, and applications; Task 40 sees itself as "horizontal" among IEA Bioenergy Tasks.

- WP1: Market developments.
  - Regional bioenergy markets and transitions.
  - Sustainable biobased value chains in the circular bioeconomy context.
- WP2: BECCUS & carbon markets/valorisation.
  - Industrial processes: technologies, markets, and deployment.
  - Management of Biogenic CO2: BECCUS Inter-task Phase 2 (follow-up strategic inter-task project).
- WP3: Deployment Strategies.
  - Guidance on sustainable financing.
  - Synergies of green hydrogen and bio-based value chains deployment (new Inter-task project).

Selected highlights from Task 40

- Start of the project "Management of Biogenic CO_2: BECCUS Inter-task Phase 2" (BECCUS 2.0) in June 2022, with 6 other Tasks (32, 33, 34, 36, 44 & 45) participating. Work concerns cross-sector and cross-country learning on implementation of BECCUS using different energy conversion processes. A key question to be answered is: *In a given situation should biogenic CO2 be sequestered, or utilised?* Further work concerns GHG emission balances of various BECCUS schemes, experiences from case studies, and governance approaches. Task 40 leads this project in which also IEA and IEA GHG, IEA ETSAP and IEA IETS network.
- Task 40 leads WP1 "Status quo of synergy value chains" of the new Inter-task project "Synergies of green hydrogen and bio-based value chains deployment" which started in May 2022. As core output of WP1 an expert workshop is planned on discussing value chains combining hydrogen production and deployment of hydrogen and bio-based processes for different bio-based end-products (case studies) and their assessment. For this different IEAB Tasks and stakeholders (industry, academia, other TCPs liky Hydrogen and AMF etc.) are going to be invited.
- Finalizing the project proposals and starting first activities of the three Task 40 projects "Bioeconomy Synergies 2.0" (on how bioenergy can benefit the bioeconomy, and vice versa), "Regional Transitions 2.0" (on regional mobilization of biomass and respective value chains), and "Guidance on sustainable financing" (supporting financing agencies in evaluating bioenergy).
- Task 40 physical meeting in Copenhagen (hybrid) and site visit at HOFOR-Amagerværket as joint activity with Task 32.
- Adaptation of the Task 40 website by ETA Florence and transfer of the content to a new design.
- Publication of Task 40 Newsletter.

Progress in R & D

Work programme and key deliverables

- Fritsche, U (2022) "Renewable Gases – Hydrogen in the Grid". Task 41 Special Project synthesis report. IEA Bioenergy.
- Key messages: Challenges replacing natural gas by renewable gas were identified and discussed. Biomethane and renewable synthetic methane can be carried by existing gas network infrastructure without problems. Larger quantities of H2 up 100% H2 will require step-by-step technical modifications or further development of the gas distribution networks and the customer facilities connected to them. Open questions remaining: Is H2 more favorable than direct electricity use for (non-industrial) heat and road transport, and what is the longer-term perspective of H2 vs. renewable synthetic methane.
- Olsson, O (2022) Carbon accounting across BECCUS supply chains. Study for the intertask project "Deployment of bio-CCUS value chains". IEA Bioenergy.
- Key messages: For Bio-CCS, the CO2 captured is stored permanently which should entail a reduction of atmospheric CO2 provided that capture rates are high. For Bio-CCU CO2 being re-released into the atmosphere fairly soon, in most cases too rapidly to be effective in terms of effectively reducing the warming effect.
- Fritsche, U et al. (2022) Summary Report of the IEA Bioenergy Intertask project "Renewable Gas: Deployment, markets and sustainable trade". IEA Bioenergy.
- Key messages: Renewable gases (RG) will be key to a global energy system aiming at net zero GHG emissions by 2050. There is agreement that among RG, biomethane and hydrogen will be critical, with biomethane the largest contributor. A growing number of countries' national H2 strategies position renewable methane as well, and international trade of RG will grow strongly.
- Hennig, C et al. (2022) BECCS - Delivering negative emissions in power and industrial sectors. EUBCE European Biomass Conference & Exhibition 2022. 11 May 2022.
- Key messages: Combining CCS and flexible operation is technically possible. More flexible operation under current mode of operandi may lead to a lower level of CO2 captured per installation due to ramping up and down.
- Schipfer, F (2022) WP2 Report on the Task 40 “Bioeconomy Synergies” project summary.
- Key messages: Case studies of synergies between food/feed, material and energy uses of biomass and providing a first version of a resource flow database for modelling synergies in a Circular Bioeconomy.
- Burli, P; Hennig, C & Hoefnagels, R (2022) Sustainable biomass supply chains for international markets. Contribution to the IEA Bioenergy ITP "Assess successes and lessons learned for biofuels deployment".
- Key messages: One of the most critical barriers to developing advanced biofuels is the high production cost compared to fossil fuels and mature conventional biofuel technologies. When smaller quantities are transported the share of transport costs in full costs of product is very significant. This situation disadvantages resources in remote areas and even cuts off possibly valuable resources.
- Olsson, O et al. (2022) Synthesis Report of ITP Deployment of BECCUS value chains: From concept to commercialization, IEA Bioenergy: Task 40, 36, 44 & 45.
- Key messages: much of the BECCUS technology required to a large extent can be considered proven, there is still R&D needed into finding models of on-the-ground deployment, such as specific designs, technology choice, deployment scales, choice of site locations. Many concepts are looking for (right) business models for the captured carbon. In many cases the carbon is utilized rather than stored and often actually lack a model for implementing CCS.

Task meetings, workshops and webinars

- 5 online Task meetings including an online Kick-off meeting 2022-2024 on 10.02.2022.
- One physical meeting in Copenhagen 07-08.09.2022 as joint meeting with Task 32.

- 02.06.2022 Kick-off ITP "Synergies of green hydrogen and bio-based value chains deployment".
- 22.06.2022 Coordinating Kick-off ITP "Management of Biogenic CO2: BECCUS Inter-task Phase 2".
- 17.10.2022 ExCo WS 28: Technology advances in liquid biofuels and renewable gas, Uwe Fritsche.
- 19.10.2022 WS ITP Synergies of green hydrogen and bio-based value chains deployment "KPIs for assessment of green hydrogen and bio-based value chains", coordinated by Christiane Hennig (T40) and Elina Mäki (T44).
- 02.11.2022 WS Regional development opportunities based on flexible biomass value networks, coordinated by Fabian Schipfer (T40) and Biljana Kulisic (T43).
- 20.12.2022 Metrics team meeting, ITP BECCUS 2.0: specifics on metrics for BECCS/U system assessment, coordinated by Christiane Hennig (T40) and Patricia Thornley (T33).

Collaboration with other Tasks and organisations

- Two industrial partners participate directly as members within Task 40: RWE and Wild & Partner.
- Cooperation with TCPs IEA ETSAP, IEA IETS, IEA GHG and the IEA headquarters within the scope of the inter-task project “Deployment of Bio-CCS/CCU Value Chains”.
- Cooperation with other Tasks and TCPs takes place within the two ITPs “Deployment of Bio-CCS/CCU Value Chains” and “Synergies of green hydrogen and bio-based value chains deployment”, in particular with Tasks 32, 33, 34, 36, 37, 39, 42, 44 & 45 and Hydrogen TCP.

- Collaboration workshop: "Regional development opportunities based on flexible biomass value networks"; IEA Bioenergy TCP Task 40, 42, 43, 44, 45 and the Horizon 2020 BRANCHES project coordinated by Fabian Schipfer (Task 40) and Biljana Kulisic (Task 43).

Dissemination

- Publication of Task 40 Newsletter in June 2022 – link.
- Contribution to IEA Bioenergy newsletter
- EUBCE 2022 presentations by Christiane Hennig and Uwe Fritsche. EUBCE Conference proceedings are indexed in Scopus.
- Participation and contribution to the ExCo Workshop 28, Uwe Fritsche.
- Participation and organization of ITP Synergies Workshop for framing WPs 1-3, Christiane Hennig.
- Together with ETA Florence, the Task 40 website was adapted and the content transferred to a new design. The website is updated regularly and contains information about the members, the work programme, current and upcoming events and a Task 40 library – link.

Main activities in 2023

- 6 Task meetings virtual.
- Physical Task meeting in Europe.
- WP1 expert workshop of ITP Synergies of green hydrogen and bio-based value chains deployment "Assessment framework for case studies" (coordinator) and report.
- WP 2 expert workshop BECCUS 2.0, co-organizers.
- ExCo 91 Workshop "opportunities of biofuels/bioenergy in developing economies" (member of the preparation working group).
- Contribution to EUBCE 2023.
- Work on sustainable bioenergy financing options.
- Newsletter publication.

TASK 42: Biorefining[23]

Participating countries: Austria, Denmark, Germany, Ireland, Italy, The Netherlands, USA.

Operating Agent: Bas Heukels, Netherlands Enterprise Agency (RVO).

Task Leader: Bert Annevelink, Wageningen Food and Biobased Research (WFBR), The Netherlands.

Co-Task Leaders: Michael Mandl, tbw research GesmbH, Austria; Ed de Jong, Avantium Technologies BV, The Netherlands.

Task 42 website - link

Overview of the Task

The aim of Task 42 is to facilitate the commercialisation and market deployment of environmentally sound, socially acceptable, and cost-competitive biorefinery systems and technologies, and to advise policy and industrial decision makers accordingly. 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

[23] Official name: Biorefining in a Circular Economy.

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 will be addressed to successfully promote sustainable biorefinery systems market implementation. For this 2022-2024 triennium, the focus of the activities will be on:

- Provision of quantitative, scientifically sound, and understandable data on the technical, economic and environmental added-value of biorefining to co-produce bioenergy and bio-products in a sustainable way (TEE Biorefinery Assessment methodology, Biorefinery Fact Sheets, Report on the techno-economic assessment of the integration between green hydrogen and biorefinery processes, Synthesis report on biorefineries based on lignocellulosic waste and side streams and their potential contribution to a circular economy);
- description of global implementation status, major deployment barriers and market data (Biorefinery database and web GIS, Biorefinery Country Reports and summary at end of Triennium, Report on Green Biorefinery Status, case study on biorefinery bottlenecks and solution strategies); and
- utilization of this international platform to actively stimulate cooperation and information exchange (Task 42 website, lectures, webinars, broad stakeholder workshop, national stakeholder events).

The real added value of Task 42 is its holistic approach of optimal sustainable use of biomass for a spectrum of non-food applications within the framework of a Circular Bioeconomy. Therefore, Task 42 plays a central role in IEA Bioenergy linking the more (single) technology-oriented Tasks to the Tasks dealing with biomass supply, climate and sustainability assessment, deployment. Its activities, often performed in cooperation with the other Tasks, will provide real added value info for the other Tasks by providing technological, market and stakeholder data to further optimize their biomass conversion technologies to integrated biorefineries optimising their overall sustainable performance.

Selected highlights from Task 42

- Report on Technical, Economic and Environmental (TEE) Assessment of Integrated Biorefineries – Gasification based biorefinery case studies. This report is in cooperation with Task 33 Gasification and is available here.
- Four new fact sheets related to the following versatile pathways: i) Methanol-to-gasoline gasification (MtG), ii) Dimethyl ether (DME)-to-gasoline, iii) Fischer-Tropsch to produce gasoline and diesel substitutes (FCC) and iv) Fischer-Tropsch to produce gasoline and diesel substitutes (HG), available here.
- Global Biorefinery Status Report 2022, available here.
- Barriers and incentives for the market diffusion of biorefineries in a circular economy, available here.

Progress in R & D

Work programme and key deliverables

- TEE assessments of Integrated Biorefineries – Gasification based biorefinery case studies.

Technical conclusions.

- The integration of gasification in biorefineries offer flexibility in end-products by predominant formation of gases rich in calorific value CO, H2 (and less CO2) and thus high net energy and organic chemicals production potential.
- The goal of integration of gasification in biorefineries is to achieve a high overall efficiency and feedstock valorisation towards high value hydrocarbons.
- Flexible fuel gasifiers with high feedstock flexibility have lower requirements for raw material quality.

Environmental conclusions.

- The main focus of the TEE assessments is to showcase to stakeholders the significant carbon dioxide / global warming reduction potential via emission factor-based calculation including upstream emissions.
- Allocation procedures are avoided in the TEE assessments by extending the system boundaries for the multi-products on the biorefinery case and fossil reference system.
- All variants investigated showed CO2eq savings potentials of > 90 % compared to fossil reference product systems based on the biogenic feedstock and process integration.
- Environmental performance highly dependent on process energy supply. An integrated set-up based on renewable supply in the plant may lead to higher primary energy consumption, but it is essential for a comprehensive sustainability claim.
- As with all renewables scale-up and market division, this needs to be linked to stringent sustainability criteria to take full advantage. A framework for analysis is currently evolving within Task 42.

Economic conclusions.

- There are few high TRL projects in operation for which little economic data has been published, so economic considerations will be a difficult prediction and only simulation-based analysis.
- To characterise biorefinery technologies, specific production costs from input/raw material to standardized products based on HHV (higher heating value) can be used, but for such multi-product systems, the overall balancing of reference plants in case studies appears to be anyhow equally adequate.
- The main factors influencing the economic evaluation are the full-load operating hours, the time horizon, the scaling of the reference plant.
- Despite significant investments, we deduce from our case studies that it is necessary to focus more on OPEX optimization in the sense of favourable feedstocks.
- Current price increases for fuel commodities and CO2 emission certificates are at levels that can be considered tipping points to generate business cases.

- Global Biorefinery Status Report 2022.
  The Global Biorefinery Status Report 2022 aims to give an overview of recent biorefinery developments. First of all it is based on a summary of data and information that is reported by the representatives of partnering countries member states in the Task 42 Biorefinery Country Reports. This information was extended with important biorefinery initiatives in

other countries outside Task 42. So, the status report gives a description of the current situation of biorefinery in a representative selection of countries: how many biorefineries exist, which types, which feedstocks, which technology, what products, etc.

Task meetings, workshops and webinars

- Teams Task 42 progress meeting (40) - 23 March 2022.
- Teams Task 42 progress meeting (41) - 9 June 2022.
- Webinar 'Integration of gasification processes in biorefineries' together with Task 33 - 30 June 2022 - Presentation Johannes Lindorfer 'TEE assessment of integrated gasification based biorefineries' .
- Conference EUBCE 2022 - Presentation by Kees Kwant - 9 May 2022 - Presentation Kees 'Mission integrated biorefineries'.
- National consultation Mission Innovation – Integrated Biorefineries- 21 June - Input delivered for Innovation Roadmap.
- Teams Task 42 progress meeting (42) - 1 November 2022.

Collaboration with other Tasks and organisations

IETS Annex XI on Biorefineries is focusing on the system analysis of biorefineries, while Task 42 is also looking broader at characterization of biorefineries. However, Task 42 is also working on a TEE tool for analysing biorefineries so this is where we could complement each other by broadening the common tool box.

Specific other international organizations and networks that will be contacted by Task 42 during the Triennium are (in alphabetic order): Department of Energy (DOE), EERA Bioenergy, European Commission DG JRC, European Technology ETIP Bioenergy, Biobased Industries Consortium (BIC), FNR (GER), Food and Agriculture Organization of the United Nations (FAO), nova Institute (GER), OECD.

The European Society of Biochemical Engineering Sciences (ESBES) stimulates scientific advances through 9 Sections devoted to various aspects of biochemical engineering, and provides a platform for communication, education and interdisciplinary exchange in this important scientific discipline.

The aim of the Renewable Carbon Initiative (RCI) is to support and speed up the transition from fossil carbon to renewable carbon for all organic chemicals and materials.

Dissemination

Dissemination and communication are essential to achieve impact. The goal in this Triennium is to involve even more relevant stakeholders in Task 42, and to increase its platform role. The major Task 42 deliverables produced in this 2022-2024 Triennium will be actively disseminated to all target groups. This will be done by means of operating an up-to-date Task 42 website, lecturing at international conferences, and organising webinars. Furthermore, the publication of articles in scientific journals will get more attention in this Triennium. Efforts will be made to organize a Special Issue in a Scientific journal to disseminate our information, and also relevant information obtained by other groups active in our area. Finally the possibility to initiate a new journal on Biorefineries and related topics will be investigated.

Main activities in 2023

- WP1. Techno Economic Environmental (TEE) assessment of biorefinery and dissemination of results.
- Update and maintain TEE assessment methodology.
- Factsheets.
- WP2. Global Biorefineries Atlas portal with WMS and WFS services.
- Update and maintain Global Biorefineries Atlas portal.
- WP3.Current status of biorefinery deployment and best practice identification.
- Biorefinery country reports (slide decks).
- Green biorefinery status report.
- Barriers and incentives for market diffusion.
- WP4. BIOCarbon-to-Chemicals by Integration of biorefineries and green hydrogen (BIOCCI).
- Integration of biorefineries with renewable electricity systems.
- WP5. Dissemination & Communication.

TASK 43: Biomass Supply[24]

Participating countries: Australia, Canada, Croatia, European Commission, Finland, Germany, Japan (Observer), New Zealand, Sweden, USA.

Operating Agent: Shahana McKenzie, Bioenergy Australia Ltd.

Task Leader: Mark Brown, University of the Sunshine Coast, Australia.

Co-Task Leaders: Bruno Gagnon, Canadian Forest Service, Natural Resources Canada; Kelly Murphy, University of the Sunshine Coast, Australia.

Task 43 website - link

Overview of the Task

Task 43 supports collaborative research to develop and deploy sustainably-sourced biomass for future bio-based products, energy, and fuels. Efforts are placed on integration with sustainable and circular economies to provide reliable biomass supply within with primary production, waste, by-products and residues in line with cascading use of biomass to:

- Leverage international expertise, explore and promote innovative sustainably-sourced biomass quantification and utilization that contribute to climate action strategies and efficiently integrate biomass production with sustainable land management systems.
- Enhance biomass supply and pre-processing strategies to support bioenergy within sustainable and circular economies in achieving highest value use, reuse, repurpose, and recycling of biomass resource.
- Foster international collaboration and shared views on strategies to increase the quantity, quality, value, and reliability of biomass supply within biobased economies.

[24] Official name: Biomass Supply in Sustainable and Circular Economies.

The task works exclusively with terrestrial biomass sources including residues, by-products and co-products from forest and agriculture production systems; residues, by-products and co-products from bio-based manufacturing industries; cellulosic biomass from post-consumer waste; as well as dedicated biomass crop systems as part of broader land management strategies. The Task focuses on integrated biomass supplies and effective capture of biomass resources from waste and residue to meet biomass quantity and quality demands within a growing sustainable and circular bioeconomies.

Selected highlights from Task 43

- Intertask collaboration workshop held jointly with T40,42,43,44 on 2 November 2022, which resulted in a report titled "Regional development opportunities based on flexible biomass value networks" by the BioSyn working group on lifting Bioeconomy Synergy potentials.
- Task 43 published report titled “To be or not to be a biocommodity” by Wolter Elbersen. Using biomass for biobased applications is hampered by a lack of possibilities to efficiently link the biomass to markets which include both energy applications such as heat and electricity production, conversion to transport fuels and chemicals and materials. This report identified the necessity that all steps in the production chain need to work toward creating commodities that can link all the potentially available and diverse lignocellulosic biomass resources worldwide with global markets.
- Task 43 published article titled “Industrial End-Users’ Preferred Characteristics for Wood Biomass feedstocks”. From the end-user’s perspective, a pre-defined biomass assortment is the most important factor when deciding on feedstock procurement at a bioenergy facility. These results can help biomass supply chain development and biohub planning, to help target pre-processing for value adding to the biomass resource.

Progress in R & D

Work programme and key deliverables

- Towards an improved assessment of indirect land-use change - Evaluating common narratives, approaches, and tools – link.
  Existing approaches to assess impacts of indirect land-use change are leading to conflicting conclusions. This activity and associated report identified two alternative narratives and explained how these approaches are built on assumed causal relations between biofuel production, crop markets and land-use change. An analysis of changes following the introduction of U.S. biofuels policy showed that crucial assumed relations were not observed and that existing frameworks should be improved.

- The Role of Biomass Supply Chains for Bioenergy in the Post-COVID-19 Economy - link.
  This exercise was conducted to identify the best forward-looking policy actions and strategies by which to advance societal goals. The COVID-19 pandemic and resulting cascading impacts have thrust the world into an altered state with novel challenges and opportunities. The results of this foresight exercise indicated where specific investments would stimulate economic growth and create cleaner and more resilient energy systems even under a more drawn-out pandemic.

- Development of Techno-economic Model for Assessment of Bio-hubs in Canada - link. Around 10% of the energy consumed globally is produced from biomass resources. Some challenges with biomass facilities have limited their progress and use. The quality and quantity of biomass feedstock varies considerably; this makes large-scale biomass use in a biomass-based facility challenging. Generally, biomass feedstocks have low density, heating value, and yield (the quantity produced per unit area). All of these bring high biomass delivery costs, leading to high biomass conversion costs. This activity and associated report present the techno-economic model, CANBIO-HUB, developed in this study for Canada.

Task meetings, workshops and webinars

The Task Leadership group hosted 9 virtual meetings and 1 in-person meeting, in Vienna on 20 October 2022.

- Workshops:

- Collaborative workshop with T40, 42, 43, 44 and 43.
- Task 43 made a considerable contribution to the ExCo89 Workshop on “Bioenergy and Sustainable Development – Climate Change Mitigation and Opportunities for Sustainability Co-Benefits”.

Collaboration with other Tasks and organisations

- Inter-task collaboration workshop held jointly with T40,42,43,44 on 2 November 2022.
- Task activity titled "Sustainability assessment of biohub archetypes using life cycle assessment" led by Dr Rory Monaghan, collaborating with Task 45.
- The task is involved in the strategic inter-task project "The Role of Bioenergy in a WB2/SDG world" in collaboration with members from tasks 40, 44 and 45.

Dissemination

Findings and other information is shared on the Task website. In 2022, 10 new reports were posted to the publications page – link.

Main activities in 2023

- Post-harvest management facilities as bio-hubs for agrarian biomass.
- Current energy crisis potential impact on sustainable biomass supply in the EU.
- Biohubs business models.

TASK 44: Energy System / Flexibility[25]

Participating countries: Austria, European Commission, Finland, Germany, The Netherlands, Sweden, Switzerland, USA.

Operating Agent: Jussi Mäkelä, Business Finland.

Task Leader: Elina Mäki, VTT – Technical Research Centre of Finland Ltd.

Co-Task Leader: Daniela Thrän, DBFZ - Deutsches Biomasse Forschungszentrum, Germany.

Task 44 website - link

Overview of the Task

Task 44 contributes to the development and analysis of bioenergy solutions that can provide flexible resources for a low-carbon energy system. The objective is to improve understanding of the types, quality and status of flexible bioenergy and its future role, and identification of barriers and future development needs in the context of the entire energy system (power, heat and transport).

Task 44 is a horizontal, cross-cutting Task, which covers both technical, policy, market and systemic aspects of flexibility. Task 44 has previously concluded that multiple technical options for flexibility provision from bioenergy are already implemented, or under demonstration or development, but policy frameworks and market mechanisms to valorize the benefits from flexible bioenergy are not yet in place. Thus, the focus of the Task is in showing system services and value it can provide, and connecting flexible bioenergy to broader integrated energy system. For this, Task 44 generates information through concrete Best Practice examples, collaborates with energy system modelling community to advance the presentation of the value of flexibility in energy system models, and analyzes the status of flexible bioenergy implementation in different countries. Potential synergies with green hydrogen and BECCS/U value chains are of special interest.

[25] Official name: Flexible Bioenergy and System Integration.

Key objectives of Task 44 are:

- To identify and evaluate viable flexible bioenergy concepts for supporting low-carbon energy systems.
- To accelerate the implementation of flexible bioenergy concepts.
- To identify system requirements for flexible bioenergy concepts.

Task activities are divided into four Work Packages that together address the main objectives of the Task:

- WP1: Flexible bioenergy concepts - Best Practice examples.
- WP2: Flexible bioenergy integration in energy systems.
- WP3: Acceleration of flexible bioenergy concepts implementation.
- WP4: Inter-Task projects and collaborative projects.

Selected highlights from Task 44

In 2022, Task 44 successfully started and conducted many activities of the Work Programme 2022-2024:

- Online workshop on 'Flexibility provision from biogenic gases' was hold in November in collaboration with Task 33 and Task 37, with speakers from HELEN, Wien Energie and Siemens.
- Delivering three new Best Practice examples on flexible bioenergy at Task 44 website.
- Making a country status questionnaire on flexible bioenergy implementation and sharing it to different country representatives. Resulting report will be published in 2023.
- Successful kick-off meeting of Inter-Task project 'Synergies of green hydrogen and bio-based value chains deployment' and start of multiple project activities, in particular collection of case studies.
- Three online Task meetings, and the first and long-awaited physical meeting in Leipzig in September (in hybrid format).
- Mini Workshop on ‘Flexible bioenergy and energy crisis’ at DBFZ in Leipzig with DBFZ colleagues.

Progress in R & D

Work programme and key deliverables

- WP1 - 'Flexible bioenergy concepts - Best Practice examples' focuses on identification and monitoring of flexible bioenergy concepts and producing Best Practice examples.
- Task 44 organized a workshop on Flexibility provision from biogenic gases in collaboration with IEA Bioenergy Task 33 (Gasification) and Task 37 (Biogas), with industrial speakers from HELEN, Wien Energie and Siemens. The workshop focused in particular on technology options and Best Practices to provide flexibility from biogenic gases through gasification, biogas and Power-to-X pathways. As a major conclusion, for a cost-effective and efficient future sustainable energy system with large shares of variable renewable energy (VRE), multiple (bio-based) technology options are needed to create sufficient short-term and long-term flexibility. All energy sectors, not just the power sector, should be considered. A

wide spectrum of technologies is already in place at different technology readiness levels and commercial readiness levels – all of them will be needed, but a framework showing the best fit for different technologies is needed as well. Moreover, proper and stable financial incentives and regulatory measures should be put in place to boost the market introduction of these technology options.

- Task 44 produces a Best Practice collection on flexible bioenergy at its website - link. In 2022, three new Best Practice examples were added, namely Ethtec lignocellulosic bioethanol pilot plant in Australia, Power-to-Gas integrated with waste-to-energy in Finland, and Siemens Energy on the path to decarbonization through gas turbines, Sweden.

- WP2 - 'Flexible bioenergy integration in energy systems' focuses on energy system modelling. The value of flexible bioenergy is often created by optimization of the overall energy system and thus, flexible bioenergy options integrated into the models is a precondition to optimize their possible value in energy system transition. This WP aims towards recognition and quantification of value from different system services from bio-based value chains, also in connection to hydrogen and BECCS/U value chains. A joint-workshop with IEA ETSAP TCP is foreseen in 2023.
- WP3 - 'Acceleration of flexible bioenergy concepts implementation' analyses drivers and bottlenecks for flexible bioenergy in different countries, and political frame conditions and market designs to incentivise flexible bioenergy.
- WP4 - 'Inter-Task projects and collaborative projects' includes two Inter-Task projects: Synergies of green hydrogen and bio-based value chains deployment, led by Task 44, and Management of Biogenic CO2: BECCUS Inter-Task Phase 2. Both projects were successfully started in 2022.

- Olsson, O. et al. (2022). Synthesis Report on Deployment of BECCUS value chains: From concept to commercialization, IEA Bioenergy: Task 40, 36, 44 & 45.
  Key messages: Much of the BECCUS technology necessary can be considered proven, but there is still R&D needed to find business models for on-the-ground deployment, such as specific designs, technology choice, deployment scales, and choice of site location.
- Schipfer, F., Mäki, E., Schmieder, U., Lange, N., Schildhauer, T., Hennig, C., Thrän, D. (2022). Status of and expectations for flexible bioenergy to support resource efficiency and to accelerate the energy transition. Renewable and Sustainable Energy Reviews 158:112094. DOI: 10.1016/j.rser.2022.112094.
  The scientific publication summarizes the key findings of Task 44 during 2019-2021.

Task meetings, workshops and webinars

- Organization of online workshop 'Flexibility provision from biogenic gases' in collaboration with Task 33 and 37.
- Three online meetings and one physical meeting in Leipzig in September 2022 (in hybrid mode). The meeting was hosted by DBFZ and included lab tours in their facilities and mini workshop 'Flexible bioenergy and energy crisis'.

- Several online meetings between the Task meetings to advance Task activities.
- Organization of the kick-off meeting of Inter-Task project 'Synergies of green hydrogen and bio-based value chains deployment' and participation to kick-off meeting of Inter-Task project 'Management of Biogenic CO2: BECCUS Inter-Task Phase 2' in June 2022.
- Task 44 and 40 organized a hybrid meeting in Vienna in October 2022 for Synergies ITP and three Work Package Lead meetings.
- Participation in IEA Bioenergy collaboration workshop 'Regional development opportunities based on flexible biomass value networks' between Task 40, 42, 43, 44 and 45 in November 2022.

Collaboration with other Tasks and organisations

- Task 44 organized an online workshop on Flexibility provision from biogenic gases in collaboration with Task 33 and 37. In addition, speakers from industry took part.
- Task 44 collaborates with Task 32, 33, 34, 36, 37, 39, 40, 42 & 45 in Inter-Task project 'Synergies of green hydrogen and bio-based value chains deployment'. Collaboration with other IEA TCPs, namely Hydrogen, AMF and ETSAP, is foreseen. Also, exchange with IEA headquarter and Inter-Task project 'Management of Biogenic CO2: BECCUS Inter-Task Phase 2' is anticipated.

- Task 44 participated in collaboration workshop 'Regional development opportunities based on flexible biomass value networks' between IEA Bioenergy TCP Task 40, 42, 43, 44 and 45 and the Horizon 2020 BRANCHES project.
- Task 44 participated in IEA Wind TCP Task 25 'Design and operation of energy systems with large amounts of variable generation' meetings. Kick-off meeting of Task 51 'Forecasting for the Weather Driven Energy System' was also participated.

Dissemination

- Task 44 website (link) is actively updated with relevant content, e.g., events, workshop summaries, and news. Best Practice examples on flexible bioenergy are collected to the website.
- The Task maintains and updates a LinkedIn group on Flexible Bioenergy (link).
- Task 44 disseminates key updates of its activities also in IEA Bioenergy Newsletters.

Main activities in 2023

- Task 44 will organize a hybrid Task meeting on 16-17 January 2023 in Graz, Austria, BEST Bioenergy and Sustainable Technologies GmbH as the host.
- Task 44 will participate and give a presentation in IEA Cross TCP Workshop ‘Towards a flexible, cross-sectoral energy supply’ on 18 January 2023 in Graz, Austria. The workshop is part of the CEBC 2023 program. A workshop summary will be available afterwards.
- New Best Practice examples on flexible bioenergy will be published at Task 44 website.
- Report on 'Flexible Bioenergy Policies' will be published.
- A joint-workshop with IEA ETSAP TCP on flexibility in energy system modelling will be organized.
- Task 44 will participate in an expert workshop and organize a workshop on system level synergies and energy system services within Synergies ITP.
- Task 44's key activities in ITP 'Management of Biogenic CO2: BECCUS Inter-Task Phase 2' will be started.
- Task 44 will give a presentation based on its findings at EUBCE 2023.

TASK 45: Climate & Sustainability[26]

Participating countries: Brazil, China, Denmark, European Commission, Finland, France, Germany, Ireland, The Netherlands, Norway, Sweden, United Kingdom, USA.

Operating Agent: Jonas Lindmark, Swedish Energy Agency.

Task Leader: Göran Berndes, Chalmers University of Technology, Sweden.

Co-Task Leaders: Floor van der Hilst, Copernicus Institute, Utrecht University, The Netherlands; Uwe R. Fritsche, IINAS – International Institute for Sustainability Analysis and Strategy, Germany.

Task 45 website - link

Overview of the Task

T45 will identify and address critical issues related to climate and other sustainability effects of bioenergy and other biobased products and systems. The objective is to promote sound development for bioenergy as an integral component of the overall bioeconomy. This objective will be achieved by providing analyses that support well-informed decisions by land owners, communities, businesses, governments and others. One key goal is to increase understanding of the environmental, social and economic effects of producing and using biomass for bioenergy, within the broader bioeconomy. A central aspect concerns the development and application of science-based methodologies and tools for assessing the effects of biobased systems to contribute to available knowledge and experiences. More specifically, the Task aims to:

[26] Official name: Climate and Sustainability Effects of Bioenergy within the Broader Bioeconomy.

- Develop, refine, compare and promote suitable metrics, methods and tools for assessing the climate and sustainability impacts of bioenergy systems. Methods for assessing GHG emissions and removals and other climate forcers represent a focus area (WP1), as well as other environmental, economic and social criteria and indicators (WP2) relevant for bioenergy and the broader bioeconomy. Methods for analysing and mapping ecosystem services in landscapes are required to inform governance and spatially explicit deployment strategies that meet multiple objectives. The Task will not primarily undertake new assessments of individual systems but will rather collect, synthesize and disseminate results and learning from existing assessments, including studies produced by other IEA Bioenergy Tasks, assessments completed by IPBES, and others. Assessments and analyses will focus on developing, improving, comparing and promoting methods and tools.
- Identify how regulatory systems governing 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 objectives of land owners, biomass users, and society as a whole.
- Foster international collaboration and shared views on key technical and methodological issues. Discuss needs, possibilities and limitations of global, uniform/harmonized assessment and governance frameworks (WP3). The Task will seek key roles in evaluation and further development of existing assessment methodologies and governance models.
- Aid decision makers in identifying and promoting implementation strategies that reflect local/regional context as well as corresponding developments in legislation and policies (WP3). Special focus will be placed on the implementation of the SDGs and energy-climate-land-water synergies in terms of agriculture/forestry and bioenergy integration. This includes addressing issues associated with land use intensification, LUC, and reclamation/improved use of marginal and degraded lands in the context of integrated land use planning in pursuit of Land Degradation Neutrality.

Selected highlights from Task 45

- The WP2 report in the Lessons learned biofuels project found that it is possible to supply large amounts of biofuels to help to replace fossil fuels and reduce global warming. However, the expansion of biofuel production and the replication of successful country/regional models in other places is not without challenges. The dependency of crop feedstocks availability and price fluctuations may limit biofuel production is some instances, as shown by changes and postponements of mandates in several countries.
- Feedback from Wiley shows that the publication from 2021 "Applying a science-based systems perspective to dispel misconceptions about climate effects of forest bioenergy" published in Global Change Biology - Bioenergy was one of the top cited papers in 2022 - link.

Progress in R & D

Work programme and key deliverables

- Scientific publications

- Iordan, Cristina-Maria, Baptiste Giroux, Jan Sandstad Næss, Xiangping Hu, Otávio Cavalett, and Francesco Cherubini. “Energy potentials, negative emissions, and spatially explicit

environmental impacts of perennial grasses on abandoned cropland in Europe." Environmental Impact Assessment Review 98 (2023): 106942 - link.

- Englund, O., Mola- Yudego, B., Börjesson, P., Cederberg, C., Dimitriou, I., Scarlat, N., & Berndes, G. (2022). Large-scale deployment of grass in crop rotations as a multifunctional climate mitigation strategy. GCB Bioenergy, 00, 1–19 - link.
  Key message: The results indicate a substantial climate mitigation potential, with combined annual GHG savings from soil-carbon sequestration and displacement of natural gas with biogas from grass-based biorefineries, equivalent to 13%-48% of current GHG emissions from agriculture in Europe. The environmental co-benefits are also notable.
- Isabel Cañete Vela, Teresa Berdugo Vilches, Göran Berndes, Filip Johnsson, Henrik Thunman, 2022. Co-recycling of natural and synthetic carbon materials for a sustainable circular economy, Journal of Cleaner Production,Volume 365 – link.
- Cavalett, O., Watanabe, M.D.B., Fleiger, K. et al. LCA and negative emission potential of retrofitted cement plants under oxyfuel conditions at high biogenic fuel shares. Sci Rep 12, 8924 (2022) – link.
- Ivan Vera, Birka Wicke, Patrick Lamers, Annette Cowie, Anna Repo, Bas Heukels, Colleen Zumpf, David Styles, Esther Parish, Francesco Cherubini, Göran Berndes, Henriette Jager, Luis Schiesari, Martin Junginger, Miguel Brandão, Niclas Scott Bentsen, Vassilis Daioglou, Zoe Harris, Floor van der Hilst 2022. Land use for bioenergy: Synergies and trade-offs between sustainable development goals, Renewable and Sustainable Energy Reviews, Volume 161 - link.
  Key message: An almost equal number of synergies and trade-offs were found between GHG emission reduction and SDGs 2 (Zero hunger), 3 (Good health and well-being), 6 (Clean water and sanitation), 8 (Decent work and economic growth), 13 (Climate action-other indicators), 14 (Life below water) and 15 (Life on land). However, more synergies were found related to SDGs 3, 13, 14 and 15, while more trade-offs were found related to SDGs 2, 6 and 8.

- IEA Bioenergy reports:
- Carbon accounting in Bio-CCUS supply chains – identifying key issues for science and policy. IEA Bioenergy: Task 45 & Task 40 February 2022. ISBN 979-12-80907-05-9

- Project report:
- WP2 report in the Lessons learned biofuels project (Meta-analysis on existing studies). The successful cases of several biofuels, as discussed in the report, indicates that it is possible to supply large amounts of biofuels to help to replace fossil fuels and reduce global warming. However, the expansion of biofuel production and the replication of successful country/regional models in other places is not without challenges. The dependency of crop feedstocks availability and price fluctuations may limit biofuel production is some instances, as shown by changes and postponements of mandates in several countries. Recent developments were described, and markets discussed. The WP2 report includes a comprehensive dataset derived from the analysis.

Task meetings, workshops and webinars

- Task meetings: During 2022 the task had seven remote meetings and a physical meeting hosted by IIASA in Vienna 19-21 October.
- The task participated and took part in the organization of the following workshops and conferences:

- Virtual workshop, 2 November: Regional development opportunities based on flexible biomass value networks. Organized by Biljana Kulišić (Task 43) and Fabian Schipfer (Task 40 and Task 44).
- ExCo89 workshop Bioenergy and Sustainable Development – Climate Change Mitigation and Opportunities for Sustainability Co-Benefits, 23-24 May 2022. Workshop organized by IEA Bioenergy, in collaboration with the Global Bioenergy Partnership (GBEP) and the Biofuture Platform
- The 2nd International Conference on Negative CO2 Emissions, Gothenburg, Sweden, June 14-17, 2022.

• Webinars:

- An introduction to quantifying the climate effects of bioenergy. IEA Bioenergy Webinar Series – 31 March 2022.

Collaboration with other Tasks and organisations

Task 45 continues to collaborate with other Tasks as well as UNCCD secretariat, FAO, GBEP, IRENA, and BioFuture Platform. We investigate possibilities for cooperation with organizations working specifically with Nature-Based Systems (NBS). The objective is to disseminate information on how bioenergy systems can deliver towards multiple objectives identified for NBS. Finally, collaboration with UNEP is being discussed related to the UNEP White Paper on adaptation-mitigation co-benefits for enhanced climate action.

Task 45 members have also engaged in the specifications of scope and work plans for Task 45 projects and our contribution in the two inter-task projects that have started this triennium:

- Synergies of green hydrogen and bio-based value chains deployment.
- Management of biogenic CO2: BECCUS phase 2.

Dissemination

Statistics for the task webpage (link) from Jan 1 to Dec 31 2022 reveals a low activity with in total 529 users, 734 sessions, and 1552 page views. More than 80% of the users are new users suggesting that an update/improvement of the page may attract more visitors that return to the page for more information. The task has the ambition to update the website during 2023 with the aim to increase the number of visitors and to link it tighter to the IEA Bioenergy main webpage where most of the dissemination should be aimed.

Main activities in 2023

- Regular monthly task meetings.
- Update of the webpage.
- Activities in the two ITPs 1) Synergies of green hydrogen and bio-based value chains deployment; 2) Management of biogenic CO2: BECCUS phase 2.
- Work on new task projects 1) Linking life cycle assessment (LCA) and integrated assessment modelling (IAM) to capture spatial and temporal impact variations for carbon dioxide removal (CDR); 2) Investigating bioenergy expansion in Brazil and impact on forest coverage - The efficacy of the RenovaBio approach and governance to manage land use emissions.
- Publication of:

- Project report "A guide on tools for the quantification of the climate effects of bioenergy".
- Project report "Approaches to sustainability compliance and verification for forest biomass".

• Task 45 webinar/workshops:

- Q1/Q2: virtual webinar/workshop “Forests, forestry and carbon balances: importance of policies and forest sector responses”.
- 17 April, Joint T39-T45 workshop on LCA methodologies.

APPENDIX 1: TASK PARTICIPATION IN 2022

	Aus	Aut	Bel	Bra	Can	Cn	Cro	Den	Est	EC	Fin	Fra	Ger	In	Ire	Itl	Jap	Kor	Nel	Nze	Nor	SA	Swe	Swi	UK	USA	USGC*	Total
Task 32		1			1			1					1				1		1		1			1		O		8
Task 33		1	1		1	1						1	1	1		1			1				1		1	1		12
Task 34					1			1			1		1	1					1	1						1		8
Task 36													1		1	1					1	1	1			1		7
Task 37		1		1	1	1		1			1	1	1	1	1	1			1		1		1	1	1			16
Task 39		1	1	1	1	1		1	1	1			1		1		1	1	1	1			1			1	1	17
Task 40		1						1					1						1				1			1		6
Task 42		1						1					1		1	1			1							1		7
Task 43	1				1		1			1	1		1				O			1			1			1		9
Task 44		1								1	1		1						1				1	1		1		8
Task 45				1		1		1		1	1	1	1		1				1		1		1		1	1		13
Total	1	7	2	3	6	4	1	7	1	4	5	3	11	3	5	4	2	1	9	3	4	1	8	3	3	9	1	111

* Limited Sponsor

1 = Participating in Task
1 = Operating Agent
O = Observer

APPENDIX 2: BUDGET IN 2022: SUMMARY TABLES

Budget for 2022 by Member Country (US$)

Contracting Party	ExCo funds	Task funds	Total
Australia	7,700	15,000	22,700
Austria	13,700	106,500	120,200
Belgium	8,700	30,000	38,700
Brazil	9,700	44,000	53,700
Canada	12,700	91,000	103,700
China	10,700	59,000	69,700
Croatia	7,700	15,000	22,700
Denmark	13,700	108,500	122,200
Estonia	7,700	15,000	22,700
Finland	11,700	76,000	87,700
France	9,700	44,000	53,700
Germany	17,700	170,500	188,200
India	9,700	46,000	55,700
Ireland	11,700	78,500	90,200
Italy	10,700	63,500	74,200
Japan	8,700	30,000	38,700
Korea	7,700	15,000	22,700
Netherlands	15,700	138,500	154,200
New Zealand	9,700	47,000	56,700
Norway	10,700	61,000	71,700
South Africa	7,700	17,000	24,700
Sweden	14,700	121,000	135,700
Switzerland	9,700	44,000	53,700
UK	9,700	44,000	53,700
USA	15,700	141,500	157,200
European Commission	10,700	60,000	70,700
USGC	1,000	15,000	16,000
Total	**285,200**	**1,696,500**	**1,981,700**

Budget for 2022 by Task (US$)

Task	Number of participants	Annual contribution per participant	Total Task funds
Task 32: Combustion & emissions	8	15,000	120,000
Task 33: Gasification	12	15,000	180,000
Task 34: Liquefaction	8	17,000	136,000
Task 36: Waste & circular economy	7	17,000	119,000
Task 37: Anaerobic digestion / biogas	16	14,000	224,000
Task 39: Transport biofuels	17	15,000	255,000
Task 40: Biobased deployment	6	15,000	90,000
Task 42: Biorefining	7	17,500	122,500
Task 43: Biomass supply	9	15,000	135,000
Task 44: Energy system / flexibility	8	15,000	120,000
Task 45: Climate & sustainability	13	15,000	195,000
Total			**1,696,500**

APPENDIX 3: 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

Energy Research Institute ERI (China)

The Energy Institute “Hrvoje Pozar” (Croatia)

The Ministry of Transport and Energy, Danish Energy Authority

The Ministry of Economic Affairs and Communications (Estonia)

Commission of the European Union

Innovation Funding Agency Business Finland

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

Federal Ministry of Food and Agriculture (Germany)

Ministry of Petroleum & Natural Gas (India)

The Sustainable Energy Authority of Ireland (SEAI)

Gestore dei Servizi Energetici – GSE (Italy)

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

Ministry of Knowledge Economy, the Republic of Korea

NL Enterprise Agency (The Netherlands)

SCION (New Zealand)

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 Strategy (United Kingdom)

The United States Department of Energy

APPENDIX 4: LIST OF REPORTS

Assessment of Bio-hubs in Canada

Bioenergy from forest biomass can play an important role in Canada's transition to a low-carbon economy, considering its huge forest resources. This report – produced in the frame of IEA Bioenergy Task 43 (biomass supply) – presents a first-of-its-kind study on the assessment of bio-hubs in Canada.

Read more

Economic and operational feasibility of establishing Biohubs in the Private Native Forests of SouthEast Queensland, Australia

A biohub is a local/regional connection between supply and market demand of biomass. This report – produced in the frame of IEA Bioenergy Task 43 (biomass supply) – presents a case study to evaluate the financial and operational viability of biohubs in SouthEast Queensland, Australia.

Read more

Integrated land management using smallscale harvesting operations for biomass utilization

This study – produced in the frame of IEA Bioenergy Task 43 (biomass supply) – reports research conducted to evaluate small-scale biomass harvesting as a silvicultural thinning treatment for forest management in the Private Native Forests (PNF) of Southeast Queensland, Australia.

Read more

Widespread deployment of grass in crop rotations – A multifunctional climate mitigation strategy

Strategic establishment of perennial plants in agricultural landscapes can provide environmental benefits while maintaining total biomass production. One option is to include grass in rotations with annual crops to provide biomass while remediating soil organic carbon losses and other environmental impacts.

Read more

Valuable products and by-products of biomass gasification – Task 33 Workshop Report

IEA Bioenergy Task 33 (Gasification of biomass and waste) organised a workshop in Vienna on 19 October 2022 showing actual developments in products / by-products from biomass and waste gasification pathways.

Read more

Gasification based biorefineries – technical, economic and environmental (TEE) assessment for specific case studies

This report, developed by IEA Bioenergy Task42 (Biorefining in the Circular Economy) in cooperation with members of IEA Bioenergy Task 33 (Gasification of biomass and waste), is focused on case studies for gasification based biorefineries.

Read more

Advanced Test Methods for Pellet Stoves

Pellet stoves become more popular as renewable and sustainable heating technology in Europe. Compared to manually operated firewood room heating appliances pellet stoves are featured with an automatic fuel supply into the combustion chamber and offer various options for an automatic as well as low-maintenance operation.

Read more

Technical Guidelines for the Design of Low Emission Wood Stoves

This report summarizes the experience from several recent research and development projects for lowemission wood stoves. The guidelines in this report focus on technological measures, e.g., stove design, flue gas cleaning and automatic control systems.

Read more

Supply potential of lignocellulosic energy crops grown on marginal land in the EU

This study quantifies spatially explicit the availability of marginal land in the EU, its production biomass potentials for eight different crops, and the greenhouse gas (GHG) performance of advanced biofuel supply chains.

Read more

Environmental impacts of perennial grasses on abandoned cropland in Europe

This study quantifies spatially explicit the primary energy potentials and associated potential environmental impacts of large-scale deployment of three perennial grasses (miscanthus, switchgrass, and reed canary grass), on abandoned cropland in Europe.

Read more

Position Paper - The role of biogas and biomethane in pathways to net zero

This position paper – developed by members of IEA Bioenergy Task 37 ("Energy from Biogas") – provides central knowledge and features of biogas and biomethane. The main conclusion is that biogas and biomethane have plenty of options to be used in a pathway to net zero.

Read more

WS27 Summary Report: Bioenergy and Sustainable Development - Climate Change Mitigation and Opportunities for Sustainability Co-Benefits

IEA Bioenergy held its biannual workshop on 23-24 May 2022 in conjunction with its Executive Committee meeting (ExCo89). The workshop on 'Bioenergy and Sustainable Development' was held in virtual form and was organised in collaboration with the Global Bioenergy Partnership (GBEP) and the Biofuture Platform.

Read more

Sustainability assessment of ethanol and biodiesel production in Argentina, Brazil, Colombia, and Guatemala

This study assesses the production, land use, environmental impacts, and energy balance associated with ethanol and biodiesel production in Argentina, Brazil, Colombia, and Guatemala. The official data for each country are used to quantify the biofuel production and land required for their production.

Read more

Inventory of national strategies for reducing the impact on air quality from residential wood combustion

Reduction of air pollution is a major societal goal, and great efforts are currently undertaken. Over the last 30 years, significant progress has been made, but wood combustion remains a significant source of air pollution, particularly for carbon monoxide (CO) and particulate matter (PM) emissions.

Read more

Co-recycling of natural and synthetic carbon materials for a sustainable circular economy

This work presents an alternative vision to the management of carbon-based materials that integrates the two cycles and enables the phasing-out of fossil carbon from the material system. The aim is to investigate the benefits and global potential of a co-recycling system, as an alternative to conventional recycling systems.

Read more

Press Release - Biomethane expansion provides local alternatives for imported gas and synthetic fertiliser

The major advantage of biomethane production is that it can be produced from local resources and immediately fed into the existing infrastructure. This reduces dependence on energy imports, especially from Russia.

Read more

Global biorefinery status report

The Global Biorefinery Status Report of IEA Bioenergy Task 42 (biorefining) provides an overview of recent biorefinery developments. The report gives a description of the current situation of biorefineries in a representative selection of countries: how many biorefineries exist, which types, which feedstocks, which technology, what products, etc.

Read more

Industrial end-users' preferred characteristics for wood biomass feedstocks

The use of sustainably sourced biomass is an important tool for mitigating the effects of climate change; but biomass is far from being a homogeneous resource. Biohubs are increasingly recognized as important part in an effective raw material supply chain for pulp and paper and biomaterial industries and the energy sector.

Read more

LCA and negative emission potential of retrofitted cement plants under oxyfuel conditions at high biogenic fuel shares

In this paper, authors perform a prospective life cycle assessment of two state-of-the art cement plants, one in Sweden and one in Germany, under conventional and retrofitted oxyfuel conditions considering alternative fuel mixes with increasing bio-based fractions of forest residues or dedicated bioenergy crops

Read more

Position Paper - Sustainable Natural Gas production through gasification

Sustainable natural gas (SNG) is methane produced from biogenic feedstocks, also referred to as biomethane. These feedstocks are for instance forest residues, agro residues or waste streams containing plastics (MSW). With Russia's aggression against the Ukraine, the dependency on fossil natural gas is reconsidered.

Read more

IEA Bioenergy Annual Report 2021

The IEA Bioenergy Annual Report 2021 includes a special feature article 'Sustainability of Biomass for the Biobased Economy' prepared by Task 45. The Annual Report also includes a report from the Executive Committee and a detailed progress report on each Task. Also included is key information such as Task participation, Contracting Parties, budget tables and substantial contact information plus lists of reports and papers produced by the Technology Collaboration

Valorisation of biowaste in the United States through anaerobic digestion and distributed biogas upgrading to Renewable Natural Gas through biomethanation

Decentralized solutions for resource and energy recovery from waste streams are a critical aspect of the circular economy. For key fractions of organic waste such as food waste, municipal sludge, fats, oils, and greases, amongst others, they are highly correlated with population.

Read more

Turning Circle: How bioenergy can supercharge Australia's circular economy

The report highlights that by shifting from a linear waste management model to a circular economy, Australia can move from being one of the highest per capita waste generators in the world to a recycling and remanufacturing powerhouse.

Read more

Material and Energy Valorisation of Waste in a Circular Economy

This report discusses some of the drivers for a more circular approach to waste management in the context of energy recovery. It considers the role of emerging technology pathways – not only thermochemical pathways, but those based on biological and other novel technologies.

Read more

Electrochemical transformations of fast pyrolysis bio-oils and related bio-oil compounds

Electrochemical reactions leading to deoxygenation of organic compounds are likely to reduce the bio-oils' acidity while increasing its stability and energy content. This could improve the long-term storage of pyrolysis liquids, thereby enabling subsequent upgrading treatments to further improve biofuel quality.

Read more

To be or not to be a biobased commodity

This report, carried out by Wageningen Food & Biobased Research, and financially supported by IEA Bioenergy Task 43 looks into requirements and candidates for lignocellulosic biomass-based commodities

Read more

Integrated biomass residue management in Sandalwood Plantations in Australia

To support emerging local and regional biomass markets and to improve the sustainable management of the tropical sandalwood plantation resource, this study – which was carried out in the frame of IEA Bioenergy Task 43 (Biomass supply) – explores the potential availability and market feasibility of integrated biomass supply for bioproducts.

Read more

Carbon accounting in Bio-CCUS supply chains - Identifying key issues for science and policy

This report – developed by IEA Bioenergy Task 45 (Sustainability) and Task 40 (Deployment) – reviews key issues to focus on and discusses different options for how these could be addressed from a scientific as well as from a policy perspective.

Read more

Case study about a MSW sorting facility in Norway – IVAR

The purpose of this report is to showcase examples from which countries can get inspiration and support in implementing solutions in the waste/resource management and Waste-to-Energy sector that would facilitate their transition towards circularity.

Read more

Impact of the COVID-19 pandemic on the Canadian Wood Pellet Industry

To determine the effect of the COVID-19 pandemic on the Canadian wood pellet industry, economic and market data were analyzed, in parallel with a survey of Canadian manufacturers on their experiences during the first three waves of the pandemic, covering the period from March 2020 to September 2021.

Read more

Land use for bioenergy: synergies and tradeoffs between Sustainable Development Goals

Using the United Nations Sustainable Development Goals (SDGs) framework, this paper identified the main synergies and trade-offs associated with land use for dedicated energy crop production and identified the context-specific conditions which affect those synergies and trade-offs.

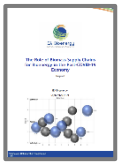
Read more

Renewable gas - Deployment, markets and sustainable trade

The reports provide state-of-the-art overviews on prospects, opportunities and challenges for deploying biogas, biomethane and other renewable gases in energy markets. It discusses technological and sustainability issues of renewable gases from a deployment perspective, derives recommendations for policymakers, and identifies open research issues.

Read more

The Role of Biomass Supply Chains for Bioenergy in the Post-COVID-19 Economy



The aim of research was to provide evidence-based advice, supported by expert opinion, that would aid policy framing related to biomass supply chains in a recovery programme and beyond. This exercise was conducted to identify the best forward-looking policy actions and strategies by which to advance societal goals.

Read more

Implementation of Transport Biofuels Policies

The increasing global production and use of biofuels plus the growing numbers of national and regional policies that support the development of biofuels markets. This recent update describes ongoing developments in the biofuels sector and the successful policies used by member countries to facilitate the production and use of low-carbon-intensive biofuels.

Read more

How can biomass supply for bioenergy deliver multiple benefits and contribute to sustainable development goals?

A virtual workshop was organized by IEA Bioenergy and GBEP on June 15th and 16th, 2021. The objectives of the workshop were to: explore the importance of the SDGs for biomass supply chains; share best practice case studies; explore and propose preliminary recommendations.

Read more

A perspective on the state of the biogas industry from selected member countries of IEA Bioenergy Task 37

Each country report summary includes information on the number of biogas plants in operation, biogas production data, how the biogas is utilised, the number of biogas upgrading plants, the number of vehicles using biomethane as fuel, the number of biomethane filling stations, details of financial support schemes in each country and some information on national biogas projects and production facilities.

Read more

Innovative bio-based pile cover for biomass chip storage

This study aimed to investigate the performance of an innovative bio-based wood chip pile cover compared to conventional treatments (plastic-covered and uncovered) in eastern Finnish conditions. The innovative pile covering method was developed to protect biofuel piles from rain and meltwaters, without the use of plastic.

Read more

Status report on thermal gasification of biomass and waste

This report, produced by IEA Bioenergy Task 33, provides an overview of research activities on gasification of biomass and waste in Austria, France, Germany, India, Italy, the Netherlands, Spain, Sweden, UK and the USA. Gasification as a thermochemical conversion offers great potential to further improve aspects related to feedstock variation, process parameters, products and by-products. The technology could bestand-alone or integrated into other processes for the production of value-added products.

Read more

Strategies for the mobilization and deployment of local low-value, heterogeneous biomass resources for a circular bioeconomy

This paper builds upon the work of the IEA Bioenergy Task 40 experts, who transfer and extend their knowledge on current bioenergy carrier provision structures to the local, low-value feedstock base of the circular bioeconomy . It aims to cluster mobilization measures into three assessment levels: the legislative framework, technological innovation and market creation.

Read more

Renewable Gases – Hydrogen in the Grid

This report provides a synthesis of an IEA Bioenergy project on renewable gases (RG) and the effect of hydrogen in gas grids. The activity was funded by the European Commission, Germany, and Sweden, with contributions from the Netherlands. The project collected existing data, performance indicators, information on RG studies & projects and analysed national strategies.

Read more

Success story: Biobased gasoline from sawdust via pyrolysis oil and refinery upgrading

The pyrolysis plant is situated at the Setra Kastet sawmill and has just been commissioned; production started in September 2021. The facility is designed to produce about 25 000 ton of biobased pyrolysis oil per year and the target is that all this pyrolysis oil will be upgraded to renewable fuel at Preem's refinery in Lysekil, Sweden

Read more

Bioenergy for climate change mitigation: Scale and sustainability

The article summarizes the state of knowledge concerning potential co-benefits and adverse side effects of bioenergy systems and discusses limitations of modelling studies used to analyse consequences of bioenergy expansion.

Read more

Decarbonizing industrial process heat: the role of biomass

This report highlights the opportunities for bioenergy technologies to deliver heat in industry and compares it with alternatives for decarbonisation such as CCS, electrification and hydrogen. The report provides specific policy recommendations to accelerate its adoption.

Read more

Perspectives on biomethane as transport fuel within a circular economy, energy, and environmental system

This report, produced by IEA Bioenergy Task 37 (biogas), provides exemplars of very good biomethane based transport solutions from Sweden, the UK, Norway and the US. Transport biomethane sits well in the broad circular economy, energy, and environmental system. In essence biomethane can be considered as one of the products or services of a broad biogas system.

Read more

Overview of Thermochemical Liquefaction activities in Denmark and Norway

This report provides an overview of research activities, demonstration activities and commercial applications of Direct Thermochemical Liquefaction of biomass in Denmark and Norway.

Read more

Combustion of wood chips and grain residues for process heat supply in the largest bakery in Switzerland

In order to substitute fossil fuels, a biomass combustion plant was realized to provide process heat for the bakery by thermal oil. Since the treatment of the raw materials for the bakery causes residues in the up-stream milling process, the vision to use milling residues as energy for the bakery arose.

Read more

Deployment of bio-CCS in the cement sector: an overview of technology options and policy tools

This report reviews the prospects for implementation of CCS in the cement sector. Particular attention is given to the opportunities of combining this with the use of biogenic fuels for process heat, socalled BECCS or bio-CCS. Bio-CCS could prove to be a vital tool to make cement production with net-zero CO2 emissions possible and could potentially also enable “negative emissions”, also referred to as carbon dioxide removal (CDR).

Read more

International assessment of bioenergy stakeholders research requirements of GIS based biomass analytics

This study aimed to determine what category of GIS-based research biomass/bioenergy stakeholders consider the most valuable.
A voluntary questionnaire was distributed to bioenergy stakeholders from a variety of countries to discern perceived usefulness ratingsfor various analytics.

Read more

Status of and expectations for flexible bioenergy to support resource efficiency and to accelerate the energy transition

The paper explores the current status of, and stakeholder expectations for, bioenergy flexibility, drawing on recent questionnaire data gathered in the IEA Bioenergy TCP to provide a technological and deployment status review for eleven countries.

Read more

Gasification applications in existing infrastructures for the production of sustainable value-added products

The aim of this report, prepared by IEA Bioenergy Task 33 (gasification of biomass and waste), is to suggest gasification-based process routes to be implemented either into existing industries, either in new process chains with a focus on biorefinery systems.
Gasification technology can be applied in different, already existing industrial and agricultural infrastructures.

Read more

Decentralized micro-biodigester systems for rural areas in South Africa

This report presents the results of a study contextualised within two interrelated, but distinct, rural bioenergy projects. These two projects encompassed repairs to 26 existing household digesters and design and implementation of new integrated biogas provision and sanitation systems at five Early Childhood Development Centres (ECDCs).

Read more

APPENDIX 5: KEY PARTICIPANTS IN EACH TASK

TASK 32 – Combustion & Emissions

Operating Agent: Ane Katharina Paarup Meyer, Danish Energy Agency.

Task Leader: Morten Tony Hansen, Ea Energy Analyses, Denmark.

Co-Task Leader: Christoph Schmidl, BEST – Bioenergy and Sustainable Technologies, Austria.

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Germany	Hans Hartmann	Technologie- und Förderzentrum
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The Netherlands	Jaap Koppejan	Pro Biomass BV
Norway	Øyvind Skreiberg	SINTEF
Switzerland	Thomas Nussbaumer	Verenum
USA (Observer)	David Nicholls	USDA Forest Service

TASK 33 – Gasification

Operating Agent: Bas Heukels, Netherlands Enterprise Agency (RVO).

Task Leader: Berend Vreugdenhil, Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek (TNO), The Netherlands.

Co-Task Leader: Jitka Hrbek, Universität für Bodenkultur (BOKU), Austria.

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Germany	Thomas Kolb	Karlsruhe Institute of Technology (KIT)
India	Rajesh Badhe	Indian Oil
Italy	Donatella Barisano	CR Enea Trisaia
The Netherlands	Berend Vreugdenhil	TNO
Sweden	Joakim Lundgren	LTU - Luleå University of Technology
United Kingdom	Patricia Thornley	Aston University
USA	Robert Baldwin	National Renewable Energy Laboratory (NREL)

TASK 34 – Liquefaction

Operating Agent: Birger Kerckow, Fachagentur Nachwachsende Rohstoffe e.V. (FNR), Germany.

Task Leader: Axel Funke, Karlsruhe Institute of Technology (KIT), Germany.

Co-Task Leader: Alexandra Böhm, Karlsruhe Institute of Technology (KIT), Germany.

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The Netherlands	Bert van de Beld	BTG (Biomass Technology Group)
New Zealand	Francois Collard	Scion
USA	Justin Billing	PNNL (Pacific Northwest National Laboratory)

TASK 36 – Waste & Circular Economy

Operating Agent: Jonas Lindmark, Swedish Energy Agency.

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South Africa	Cristina Trois	University of KwaZulu-Natal
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Operating Agent: Jonas Lindmark, Swedish Energy Agency.

Task Leader: Tomas Ekbom, Swedish Bioenergy Association (SVEBIO).

Co-Task Leader: Glaucia Mendes Souza, University of São Paulo, Brazil.

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Estonia	Ain Laidoja	Estonian Biomass Association
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Germany	Franziska Mueller-Langer	Deutsches Biomasseforschungszentrum (DBFZ)
Ireland	To be announced	
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Korea	Chan Hyun Ko	Korean Institute of Energy Research
The Netherlands	Paul Sinnige	Netherlands Enterprise Agency (RVO)
New Zealand	Paul Bennett	Scion
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U.S. Grains Council*	Mackenzie Boubin	U.S. Grains Council (USGC)

* Limited Sponsor

TASK 40 – Biobased Deployment

Operating Agent: Birger Kerckow, Fachagentur Nachwachsende Rohstoffe e.V. (FNR), Germany.

Task Leader: Uwe R. Fritsche, IINAS – International Institute for Sustainability Analysis and Strategy, Germany.

Co-Task Leader: Christiane Hennig, DBFZ- Deutsches Biomasse Forschungszentrum, Germany.

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TASK 42 – Biorefining

Operating Agent: Bas Heukels, Netherlands Enterprise Agency (RVO).

Task Leader: Bert Annevelink, Wageningen Food and Biobased Research (WFBR), The Netherlands.

Co-Task Leaders: Michael Mandl, tbw research GesmbH, Austria; Ed de Jong, Avantium Technologies BV, The Netherlands.

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Denmark	Solange I. Mussatto	DTU Bioengineering
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TASK 43 – Biomass Supply

Operating Agent: Shahana McKenzie, Bioenergy Australia Ltd.

Task Leader: Mark Brown, University of the Sunshine Coast, Australia.

Co-Task Leaders: Bruno Gagnon, Canadian Forest Service, Natural Resources Canada; Kelly Murphy, University of the Sunshine Coast, Australia.

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Estonia	Ain Laidoja	Estonian Biomass Association
European Commission	Nicolae Scarlet	Joint Research Centre (JRC), European Commission
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USA	Thomas M. Schuler	USDA Forest Service

TASK 44 - Energy Systems / Flexibility

Operating Agent: Jussi Mäkelä, Business Finland.

Task Leader: Elina Mäki, VTT – Technical Research Centre of Finland Ltd.

Co-Task Leader: Daniela Thrän, DBFZ - Deutsches Biomasse Forschungszentrum, Germany.

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TASK 45 - Climate & Sustainability

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Co-Task Leaders: Floor van der Hilst, Copernicus Institute, Utrecht University, The Netherlands; Uwe R. Fritsche, IINAS – International Institute for Sustainability Analysis and Strategy, Germany.

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