Annual Report 2024

BBEST – IEA Bioenergy Conference, São Paulo (Brazil), 22-24 October 2024

IEA BIOENERGY : EXCO : 2025 : 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's mission 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 this 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.

Dina Bacovsky

Chair of the IEA Bioenergy TCP in 2024

To: IEA Headquarters, Paris

IEA BIOENERGY ANNUAL REPORT 2024

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 2024. This year, we have presented a special feature 'Flexible bioenergy – Enabler for Energy Transition for Zero Emission Energy Systems', prepared by Task 44.

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

Dina Bacovsky
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 2024 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.

Modern bioenergy is the main source of renewable energy today, and it is one of the main pillars of the energy transition, playing a key role in all sectors (heat, power, industry and transport). In the IEA Net Zero Emissions by 2050 Roadmap (NZE), bioenergy meets between 15% and 20% of total energy needs. This implies that modern bioenergy would need to triple from now to 2050, while at the same time traditional (inefficient and high-polluting) uses of biomass are phased out.

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 around 40 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 optimized 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 commercialization 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 realizes 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.

IEA Bioenergy ExCo94 meeting, São Paulo (Brazil), October 2024

The ***Strategic Objectives*** of the IEA Bioenergy TCP for the 2025-2030 Term are to realize our Vision by:

1. Providing science-based information to support technology innovation, policy development and deployment.
2. Improving understanding of key features of sustainability in bioenergy systems, including biomass resources, biodiversity linkages, climate effects, and socio-economic impacts, such as contribution to local energy security.
3. Exploring synergies of sustainable bioenergy systems with other clean energy technologies and bio-based sectors.
4. Demonstrating how sustainable bioenergy, within the broader circular economy, can contribute to international climate targets and other Sustainable Development Goals.

By the end of 2024, 24 parties participated in IEA Bioenergy: Australia, Austria, Belgium, Brazil, Canada, China, Denmark, 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 2024:

- 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 2024 is shown in Appendix 1. A progress report for IEA Bioenergy for the year 2024 is given in Sections 1 and 2 of this Annual Report.

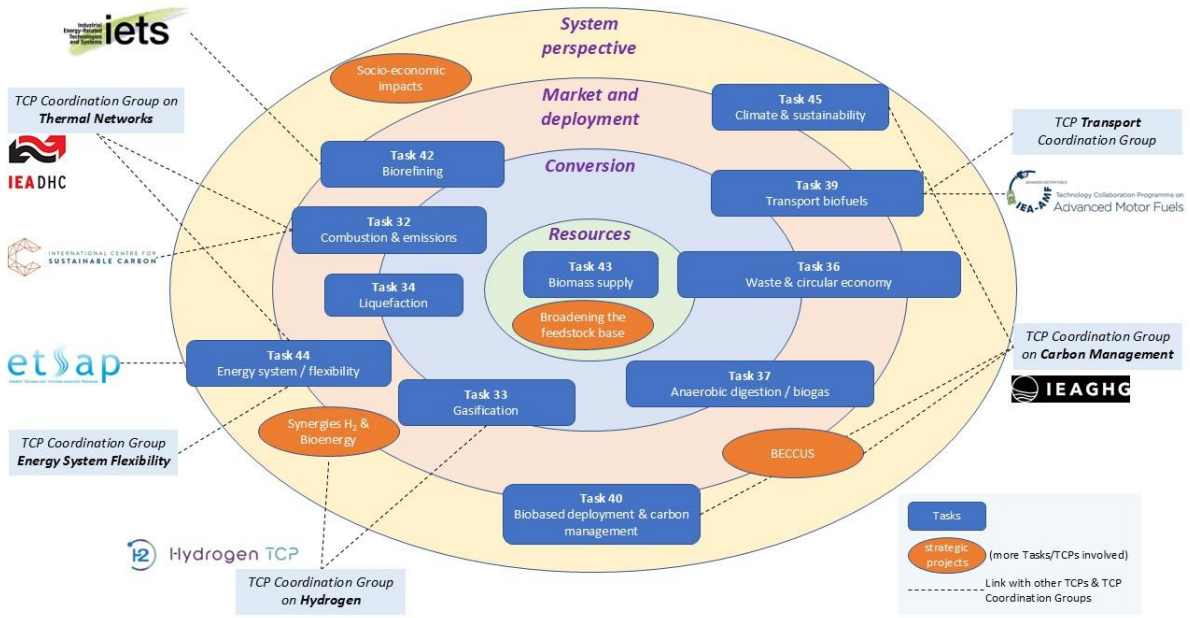


Figure 1. IEA Bioenergy Tasks and Strategic projects, and links with other TCPs and TCP Coordination Groups.

IEA Bioenergy Core Group for 2025

Professor Mark Brown

Chair

University of the Sunshine Coast
Australia

Mr Birger Kerckow

ExCo Vice Chair

Fachagentur Nachwachsende Rohstoffe e.V. (FNR)
Germany

Ms Anna Malmström

ExCo Vice Chair

Swedish Energy Agency
Sweden

Mrs Dipl-Ing Dina Bacovsky

ExCo Past Chair

BEST – Bioenergy and Sustainable Technologies
Austria

Dr Zoe M. Harris

Head of Communications Team

University of Surrey
United Kingdom

Mr Eric van den Heuvel

ExCo Technical Coordinator

Studio Gear Up
The Netherlands

Mr Andrea Rossi

ExCo Secretary

BioSmart Strategies S.r.l.
Italy

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, Latvia, 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, Costa Rica and Israel.

Association Countries

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

IEA BIOENERGY – SELECTED HIGHLIGHTS FROM 2024

Key messages

The main results and recommendations emerging from recent work conducted within the IEA Bioenergy TCP and its 11 Tasks are summarised below. These are complemented by the key takeaways of the BBEST – IEA Bioenergy Conference 2024, which are described on pages 14-15.

- **Modern bioenergy is one of the pillars of the energy transition**. In the IEA Net Zero Emissions by 2050 roadmap (NZE), modern bioenergy is projected to triple from now to 2050, while at the same time traditional uses of biomass are phased out. Altogether, bioenergy represents 15-20% of total energy needs in 2050 in the IEA NZE roadmap.
- **Feedstock mobilization is one the main challenges** for bioenergy deployment. This requires setting up efficient collection systems; investing in biomass crops, particularly on marginal/abandoned lands; and developing approaches with local biohubs to facilitate logistics. On technology side, it is also critical to support the development and deployment of advanced technologies that can cope with wide ranges of (low quality) biomass feedstocks.
- While substantial amounts of sustainable biomass are available and/or can be mobilized, the resource base still has its limits. To maximize the greenhouse gas (GHG) emission reduction impact, **prioritisation of certain bioenergy applications may be required** to make the best use of the available biomass feedstocks.
- For the transport sector, the current **production capacity of renewable fuels**, together with planned and under construction projects, **needs to grow by a factor of more than 5** to produce the renewable fuels (biofuels and e-fuels) that will be required worldwide by 2050. We need faster progress and learn lessons from biofuels deployment so far to support their further deployment in an efficient way.
- **An enabling policy environment, good prospects for market offtake, and improved access to finance are key for the required investments in biofuels production**. Viable business models / cases are key to mobilize investment, in particular from the private sector. Stable, supportive government policies are essential to provide the right investment signals. Successful bioenergy deployment also necessitates cross government coordination.
- Reaching net zero by 2050 and net negative GHG emissions thereafter requires high amounts of carbon dioxide removal (CDR) from the atmosphere. **Long term storage of captured biogenic CO2 from bioenergy projects is one of the key CDR options**, with the unique advantage that BECCS provides a combination of both carbon storage and renewable energy provision.

Implementation of bioenergy in the IEA Bioenergy member countries - update 2024

The updated IEA Bioenergy Country Reports show the trends of bioenergy in the IEA Bioenergy member countries up to 2022, highlighting the role of bioenergy in their energy mix. The analysis is based on data from the 2024 IEA World Energy Balances and Renewables Information, combined with input provided by the IEA Bioenergy Executive Committee members.
The summary report presents a comparative overview of the results for the different countries.

The summary report and the individual country reports are available here.

Wildfire Resilience and Biomass Supply

Climate change has more than doubled the likelihood of extreme forest weather conditions in Canada. Over the years, in Canada, the annual area burned by wildfires has witnessed a steady increase, with an average rise of 330,000 hectares each decade. The intensified fire seasons in Canada and other countries necessitates urgent efforts to promote wildfire resilience while facilitating a sustainable and reliable biomass supply. Wildfire management involves prevention and mitigation treatments such as thinning, as well as post-fire harvest activities including the sustainable extraction of biomass from affected areas. However, the complexities and risks associated with the conditions of recently burned areas make it challenging to manage the collection of this biomass.
On October 5, 2023, a hybrid workshop titled “Wildfire Resilience and Biomass Supply” was held in Quebec, Canada. The workshop, organized by IEA Bioenergy Task 43 (Biomass Supply) and Université Laval, brought together experts from Canada, Europe, Australia, and the United States to gather insights and best practices to promote sustainable wildfire and biomass management. This report shows the main conclusions of the workshop.

The report is available here.

Progress in Commercialization of Biojet/Sustainable Aviation Fuels (SAF): Technologies and policies

In the past few years, the production and use of SAF have grown substantially. Furthermore, the number of new facilities that have been announced and are under construction should result in an exponential increase in SAF production by 2030. There has been significant progress in the commercialization of technologies accompanied by considerable investment in research and development. The lipid-derived HEFA-pathway – currently the only fully commercial pathway – will continue to supply the majority of SAF volumes up to 2030. However, alternative technologies, such as gasification with Fischer-Tropsch and alcohol-to-jet, are nearing commercial status.
This report prepared by Task 39 (Transport Biofuels) provides an overview of these technologies, of key developments in their commercialization, and of recent research-and-development trends.

The report is available here.

Flexible Bioenergy and System Integration: Best Practices

IEA Bioenergy Task 44 (Energy System / Flexibility) published a series of Best Practice examples to showcase the multiple benefits and services that flexible bioenergy can provide. The global coverage of the examples aims to highlight different operational environments and how bioenergy can fulfil different requirements. In addition to being available as pdf files, the Best Practices compiled by Task 44 can be explored through an interactive map.

The Best Practice examples are available here.

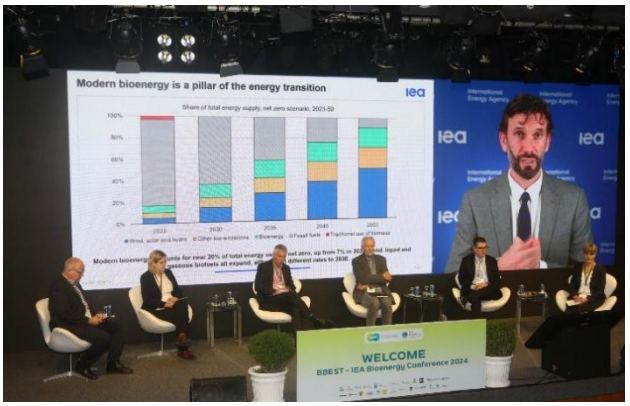
Circular Economy Approaches to Integration of anaerobic digestion with Power-to-X technologies

The future of decarbonisation will lead to significant increases in commercial availability of renewable electricity, which could be used to produce other energy carriers and chemicals in the future. Generically known as 'Power to X' technologies, these technologies can produce renewable hydrogen molecules, which may be integrated with anaerobic digestion systems for production of methane, methanol and ammonia.

This report from IEA Bioenergy Task 37 (Anaerobic Digestion / Biogas) provides an overview of the role that anaerobic digestion can play in Power to X technologies, by outlining processes which integrate anaerobic digestion with electrolysis; detailing the design evolution of an experimental laboratory biomethanation process; examining real world circular economy applications of integration of anaerobic digestion with power to methane systems; assessing future applications integrating anaerobic digestion with Power to X technologies such as production of methanol and ammonia; and discussing optimal routes and applications for Power to X technologies.

The report is available here.

BBEST – IEA Bioenergy Conference (São Paulo, Brazil, 22-24 October 2024): Bioenergy in a Net Zero Future



Every three years IEA Bioenergy organizes a conference to present the main developments in the bioenergy field. After successful events in 2012 (Vienna), 2015 (Berlin), 2018 (San Francisco) and 2021 (online), we teamed up with BBEST – the Brazilian Bioenergy Science and Technology Conference – which is held every three years in Brazil.

Under the overall theme of 'Bioenergy in a net Zero Future', the conference addressed important topics such as responsible land use and agricultural productivity; feedstock mobilization; sustainability of bioenergy pathways; biofuels for air, sea and road transport; heat and power from biomass and waste; renewable gases; the future of biorefineries; the use of biogenic carbon; and strategies for the circular carbon economy.

In total, 354 people attended the conference in person. There were 140 speakers from 31 countries, representing academia, research institutes, industries, governments and non-government organizations.

The summary report and the presentations are available here.

Group of Conference participants visits the sugarcane operations at the São Martinho - Iracema Sugar Mill (State of São Paulo, Brazil)

Key takeaways of the Conference

- **Modern bioenergy is a pillar of the transition to a global 'net zero' energy system, but action is required to stimulate its deployment.**
  At the global level, modern bioenergy is a pillar of the transition to a net zero energy system. It provides an accessible, secure source of energy, which is affordable and compatible with a wide range of technologies. There are enough sustainable biomass supplies without having negative impacts on food production or forested lands if bioenergy resources are developed responsibly. Modern bioenergy accounts for nearly 20% of total energy use by 2050 in IEA's net zero scenario, with biofuels being one of the critical means to decarbonize/defossilize aviation and maritime transport. However, bioenergy deployment is not on track to meet its contribution to the net zero pathway. Near-term policy priorities are the development of a clear, global ambition; the implementation and expansion of demand and supply policies (including rewarding carbon intensity reduction); seeking consensus on performance-based sustainability requirements; and the acceleration of technology deployment.

- **The key to realizing a true bioeconomy will be tied to the ability to source biomass feedstocks in a sustainable way.**
  The necessary significant expansion in the production of bio-based fuels, chemicals and materials requires a substantial increase in the supply of sustainable biomass. In addition to traditional feedstocks (woody biomass, sugarcane, corn), there is plenty of room for different sorts of residues and crops from different regions of the world. The key to realizing a true bioeconomy will be tied to the ability to source feedstocks and unlock sustainable biomass potentials. This depends on the participation of biomass producers and the ability to overcome the barriers that they perceive. The scale of feedstock sourcing is important, but there is also room for small holding farmers, or farmers in developing countries, including indigenous populations. There are several sustainability concerns of bioenergy, but the main concerns are related to the use of land for dedicated energy crops. Sustainability impacts and therefore sustainability trade-offs of biomass feedstock production highly depend on context. For a sustainable biobased economy, we must consider the entire land use system, not just the part used for energy. Understanding and quantifying trade-offs will enable better informed decision making.

- **Bioenergy - and the bioeconomy in a broader sense - allows for greater sustainable development when done responsibly. There can be a major role for modern bioenergy in emerging economies.**
  Biofuels and bioproducts bring much more than greenhouse gas reduction: when done responsibly, they allow for greater sustainable development, with its social and economic dimensions. Substantial production of biomass for different bioenergy applications and bioproducts is possible in many countries where land is available.
  There is a major role for modern bioenergy in emerging economies, especially in the Global South. Many of these countries have considerable biomass potentials; most countries are fossil fuel importers, they have a significant population growth and increasing energy demand, and at the same time they also want to decarbonize their energy and transport system. Biofuels offer a lot of opportunities, not just in reducing GHG emissions, but also in creating jobs and stimulating economic development in these regions, bringing technology and infrastructure to rural areas, as well as reducing the dependency on fossil fuel imports.

Key takeaways of the Conference (continued)

- **Clear and interoperable rules to assess sustainability – including a consensus on carbon accounting – are needed to advance bioenergy and bioeconomy.**
  Different jurisdictions are establishing different criteria for evaluating or determining sustainability, but these are not always interoperable with each other, particularly related to the carbon intensity of products. This creates uncertainties that make investments and free trade difficult. For bioenergy and bioeconomy to advance in an inclusive and sustainable way, we need to have agreement on clear and interoperable rules to assess sustainability with consistent and common criteria in the various countries and sectors. Transparency is important and objective science should be used as guidance. Countries should learn from what goes on around the world and not reinvent the wheel. We need to acknowledge that there are distinctions among starting conditions and available resources, e.g. for emerging economies, and it is essential to provide incentives (and time) for all parties to improve.

- **We should aim for a smart use of available biomass to maximize its impact. But any prioritization of biomass uses is regional specific and evolves over time.**
  Demand for biomass will increase in many sectors. The aim should be to unlock sustainable biomass potentials and make smart use of the available biomass to maximize its impact. In future there will be a range of integrated biorefineries that can produce fuels and biochemicals. Over time, the focus may shift, depending on market demands.
  The limits to biomass availability also imply a focus of biofuels/bioenergy on gaps in the energy system, so called 'difficult to abate' applications (e.g. long-distance transport, high temperature heat in industries) where electrification is difficult to implement or where complementarity with other (variable) renewables can be pursued through flexible bioenergy solutions. Moreover, the ability to capture and store biogenic CO2 from bioenergy and biobased processes is an important opportunity to extract CO2 from the atmosphere and can have a major role in the strive to carbon neutrality. Biogenic CO2 may also serve as input for green fuels or chemicals.
  Any prioritization of biomass uses is regional specific and evolves over time and therefore should not be generalized. We also need to consider the essential needs for people and the economy. For example, the ability to heat their homes is essential for people, as well as the need to cook their food, particularly in developing countries which now largely rely on unsustainable traditional biomass use for these applications. This can be addressed with modern bioenergy, which can provide this service in an affordable way without moving to fossil fuels.

- **Technologies should be expanded to broaden the feedstock base. Nevertheless, realism is needed on how fast new technologies can reach commercial scale.**
  A further deployment of biofuels requires expanding technologies beyond current feedstocks such as sugar, starch and oils. Biomass plants in future will need to be more flexible in their feedstocks. A much broader feedstock base is available when (lignocellulosic) sources can be included; the types and amounts of these feedstock sources are regionally dependent. But it takes time for new biofuels pathways to reach commercial scale. They need to go through a learning curve, progressing from pilot to demonstration to commercial scale without skipping steps; there is a risk of unrealistic expectations.
  Biofuels and bioenergy industries require very broad international collaboration to most effectively develop the global industry.

Launch of statement on sustainable bioenergy by UN and International Organizations, Rome, Italy, 20 June 2024

Hot Topics

In 2024, IEA Bioenergy issued sixteen bulletins covering important news in the bioenergy sector and featuring key IEA Bioenergy publications and events. The most significant bulletins were:

Brazil Hosts an International Event on Bioenergy, amid G20 Discussions for the Decarbonization of Global Economies – link.

UN and International Organizations: Sustainable Bioenergy is Key for Achieving Climate and Development Goals – link.

Turin Joint Statement on Sustainable Biofuels Presented to G7 Climate, Energy and Environment Meeting – link.

FLEXIBLE BIOENERGY – ENABLER FOR ENERGY TRANSITION FOR ZERO EMISSION ENERGY SYSTEMS

Daniela Thrän[1], Nora Lange[2], Miia Nevander[3], Fabian Schipfer[4], Christiane Hennig[2], Tiia Kanto[3], Jaap Kiel[5], Tilman Schildhauer[6], Kjell Anderson[7]

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Task 44 – Energy System / Flexibility

Flexibility in energy supply and the crucial role of biomass

Achieving least-cost reliable and sustainable energy systems is a global challenge. Renewable energy sources are key for all energy sectors to realise a climate neutral energy supply until the mid of the current century at the latest. There is wide agreement on the need to dramatically increase the share of variable renewable energy (VRE) like wind and solar photo-voltaic (PV) to expand energy access and enable electrification based on clean energy, driven by market opportunities, substantial cost reductions, and a favourable policy environment. This essentially changes the structure and operation of power systems, but also influences the heat and transport sectors (Thrän et al. 2021).

Bioenergy is a key option in fields where alternative renewable energy sources are difficult or costly to provide. Climate-efficient and cost-effective flexibility of bioenergy is key, for example when providing flexible electricity, and also in different energy system services such as biofuels provision, renewable heat implementation as well as carbon capture and utilization options and the reduction of grid operation costs in systems with high shares of VRE like wind and PV (Figure 2). Therefore, we see flexible bioenergy in the broader framework of energy flexibility.

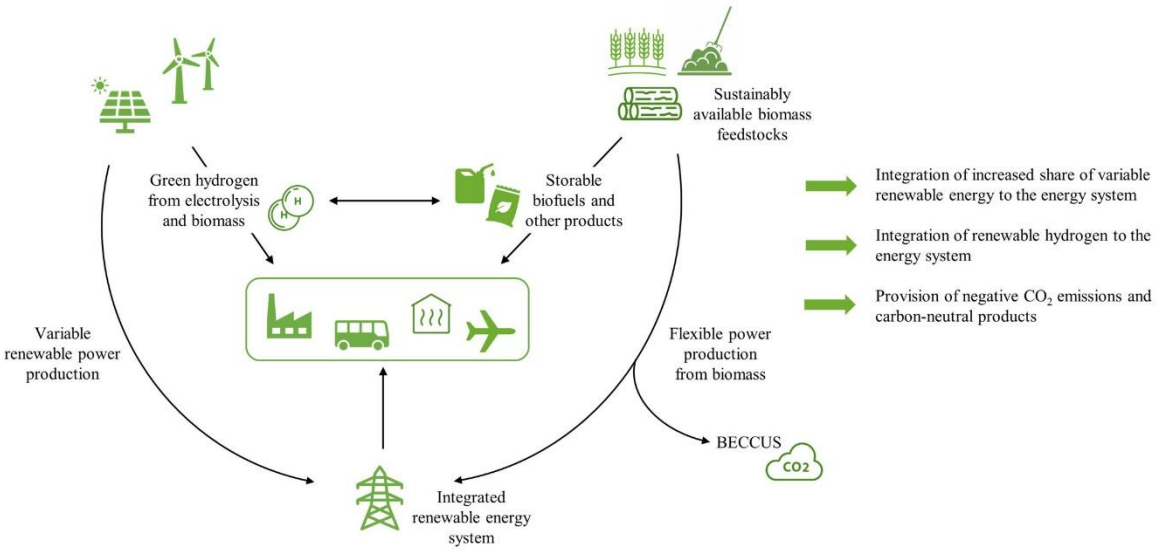

Figure 2. Expectations on the role of bioenergy in the renewable energy system and resulting energy and climate system services from bioenergy. (Mäki et al. 2024)

Energy flexibility is the ability to effectively cope with variations in the supply or demand of energy and provide dedicated options to support the energy transition by providing

flexible energy in different energy system services. In this context, flexible bioenergy is defined as deployment of sustainable biomass to provide multiple services and benefits to the energy system under varying operating conditions and/or loads contributing to energy security (Schipfer et al. 2022). The definition of flexible bioenergy includes:

- Utilisation of **sustainable biomass feedstocks of varying types and qualities** depending, for example, on feedstock availability or accessibility due to meteorological or seasonal conditions or the impacts of climate change;
- **trade and storage of bioenergy carriers** such as wood pellets, biomethane and bioethanol over longer periods to meet energy demand during winter months;
- **flexible generation of power for grid stability and ancillary services** for power systems;
- **flexible and/or poly-generation of power, heat and fuels**, according to market demand and trends, for example, matching seasonal demand patterns between power and heat or continuous changes in output shares of heat for residential heating and biofuels; and
- **flexible provision and processing of biogenic CO_2** converted to synthetic fuels (with for example hydrogen from PV or wind surpluses) or captured and stored (i.e. bioenergy carbon capture and storage, BECCS).

Additionally, the possible contribution of flexible bioenergy goes even beyond the energy sector, when it is integrated with biorefineries or Power-to-X-systems, and when by-products, such as CO_2, bio-sludge, digestate or biochar are used to remove CO_2 from the atmosphere (carbon dioxide removal, CDR).

To unlock this enormous potential of flexible bioenergy's contribution to the transformation of the energy system, favourable conditions are necessary (Thrän et al. 2021). Behind this background, the main objective of the IEA Bioenergy Task 44 is to improve understanding on the types, quality and status of flexible bioenergy, and identification of barriers and future development needs in the context of the entire energy system (https://task44.ieabioenergy.com/).

Central results from Task 44 work are summarised in the following, including the technology portfolio of flexible bioenergy (Chapter 2), best practice examples (Chapter 3), flexible bioenergy policies (Chapter 4), synergies of flexible bioenergy with green hydrogen and BECCS (Chapter 5), first attempts to the value of flexible bioenergy (Chapter 6) and an outlook to the next triennium (Chapter 7).

The technology portfolio of flexible bioenergy

A multitude of bioenergy or broader biobased technology options will bring flexibility in the energy (and materials) system, either by themselves or in combination with other renewable technology options. These flexible biobased technology options may concern different parts of pathways from the wide range of biobased feedstocks, potentially via intermediates and or biobased energy carriers, to various energy (and materials) applications. Several of these technologies have been implemented under economically favourable conditions already, others have been demonstrated technically but are missing a favourable business case so far, or are still in the earlier R&D phases. This chapter describes the status of flexible bioenergy technology options, based on a detailed updated technologies report, (Schildhauer et al. 2025).

Biobased technologies consist of several conversion steps between biobased feedstock, intermediates, energy carriers and/or applications. Feedstock-to-application pathways may contain multiple conversion steps. In general, they allow a decoupling of feedstock availability and end-use in time, location and also in scale through favourable transport and storage properties. This is shown schematically in Figure 3.

In terms of time horizons short and long term flexibility can be distinguished:

1. Short term flexibility, e.g., to balance and stabilize electricity and heat grids by both positive and negative ancillary services.
2. Long term flexibility by biomass-based energy carriers that can be stored over longer periods of time and easily transported (within existing infrastructure) creating temporal and spatial flexibility, and allow use in different sectors such as industrial heat, transport and chemicals/materials. Moreover, some pathways and conversion technologies enable negative CO_2 emissions.

In the electricity market, *positive ancillary service* means that a biomass-based power plant can flexibly increase its electricity production to compensate for drops in renewable electricity by photovoltaic systems, hydropower plants or wind turbines or to complement them, if they do not cover the demand e.g. because of lack of wind or solar radiation. Similarly, in heating services such as district heating, biomass based energy carriers can cover demand peaks, especially during very cold phases.

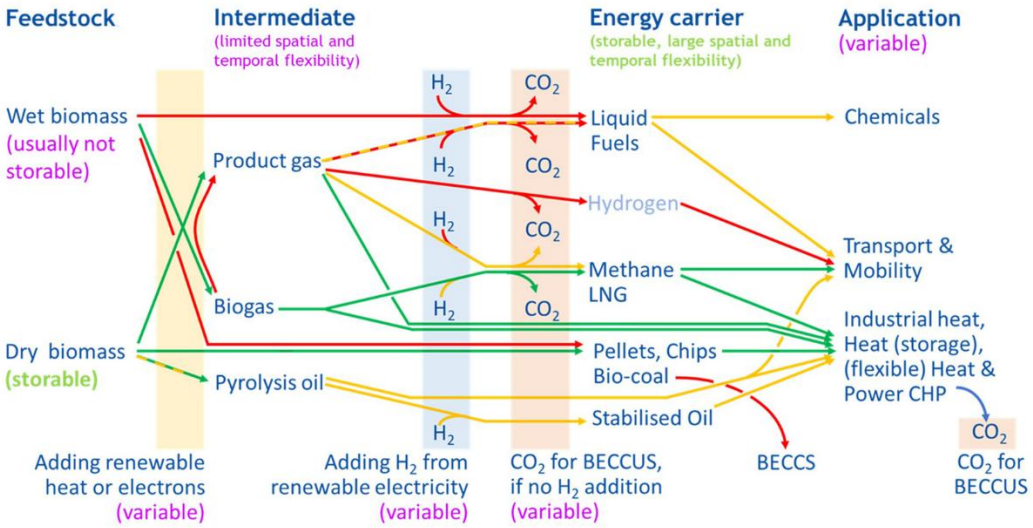

Figure 3. Schematic showing multiple possible technology pathways to produce energy (and materials) products from (sustainable) biobased feedstock. Green arrows indicate technology pathways which are already applied; yellow arrows indicate technology pathways which have been demonstrated technically, but do not yet have a working business case; red arrows indicate technology pathways under development. The schematic shows main options without the intention of giving an exhaustive overview. (Schildhauer et al. 2025)

Using biomass for *negative ancillary service* (e.g., for the uptake of electricity, when more is produced than can be consumed at the given location or can be transported away) is less obvious. Currently, only few biomass conversion technologies allow the direct incorporation of electricity for process heat or within electrochemical reactions, but the topic attracts increasing R&D attention. Alternatively, the surplus electricity can be used to operate water electrolysis, which produces hydrogen, which can be used immediately or stored. If larger amounts of hydrogen have to be stored, it is favourable to convert it to

energy carriers for which a storage and distribution infrastructure exists. As many of these energy carriers such as methane (Synthetic Natural Gas), methanol, diesel fuel or gasoline are hydrocarbons, their production from hydrogen needs a carbon source. Here, biomass can play a role by delivering this carbon either as bio-based product gas from gasification or similar processes, or as biogenic CO_2. Biogenic CO_2 is an inherent by-product of all fermentations, anaerobic digestions and biofuels production and can be recovered from flue gases from biomass combustion in CHPs or paper pulp plants (BECCU, Bio-Energy Carbon Capture and Utilisation). The same biogenic CO_2 can alternatively be used for negative emissions, when no renewable hydrogen is available, but the CO_2 can be transported to sequestration sites. This is then referred to as BECCS. A similar negative emission effect can be achieved when stable biocoal/biochar is produced as a (by-)product that then can be stored in the ground to improve soil quality. Synergies of biobased options with green hydrogen and BECCS will be discussed in more detail in Chapter 5.

Long term flexibility of bioenergy primarily refers to the option to store and transport biomass and to have several options how to use it, which could be steered according to market demand (e.g., more focus on heat and power production in colder seasons). The (seasonal) storability and transportability is proven for wood and some other types of relatively dry and highly dense materials (e.g. pellets from straw or grass, grain etc.). Some biomass, however, contains significant amounts of moisture and has the tendency to decay or to be converted to CO_2 or methane by microorganisms if left untreated. Examples for such non-stable biomass categories are municipal waste, sewage sludge, manure, food (processing) residues, green wastes, etc. In consequence, such feedstocks have to be converted to energy carriers with favourable properties for storage and transport, preferably using existing infrastructure. Energy carriers can be liquid, gaseous or solid; the most important feature is the often standardized quality, which simplifies transport, handling, storage and trading, and application for the different energy services.

In addition, bioenergy technologies also can have considerable input flexibility, i.e. the capacity of a digester, pyrolyser, gasifier etc. to convert different feedstocks (or liquid fuels and other energy carriers), maybe even in varying composition. With the increasing pressure on using woody feedstock in several applications, input flexibility has been under strong development over the past years.

As indicated in Figure 3, different (parts of) technology pathways are in different stages of development, which is sketched in more detail in the updated Task 44 technologies report (Schildhauer et al. 2025).

Best practice examples

To illustrate the progress of bioenergy integration into existing energy systems Task 44 has collected and documented best-practice examples. The goal is to make existing applications as well as ongoing demonstration and pilot projects in different countries visible and easily accessible. The collection is aimed at both laypeople and professionals from science, politics, and industry. It is designed to be easily understandable to facilitate knowledge transfer between research, practice, and policy. A dedicated subpage on the Task 44 website has been created (link). To ensure a consistent and comprehensible presentation, a specific template has been developed. This template includes technical and

economic details, and it provides a comparable structure for different examples and pdf-download options. Some best-practice examples can be seen in Figure 4.

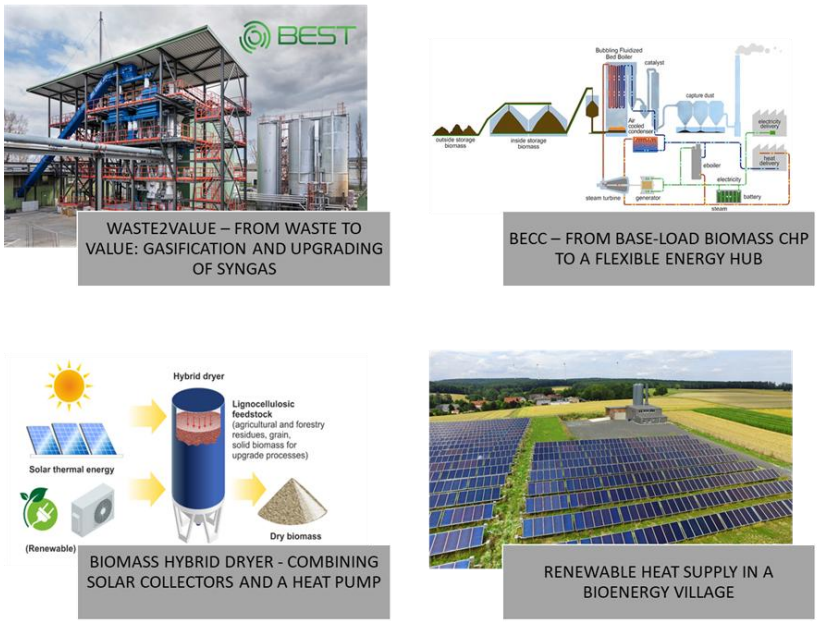

Figure 4. Some Best practise examples already published at Task 44 website.

The best-practice examples illustrate the diverse applications of flexible bioenergy and showcase innovative approaches from different countries (see Figure 4). These include e.g.:

- **Pilot plants** such as WASTE2VALUE – FROM WASTE TO VALUE: GASIFICATION AND UPGRADING OF SYNGAS in Vienna, Austria;
- **Technology adaptations** such as BECC – FROM BASE-LOAD BIOMASS CHP TO A FLEXIBLE ENERGY HUB in Land van Cuijk, Netherlands;
- **Simple but effective solutions** such as BIOMASS HYBRID DRYER in Jyväskylä, Finland; and
- **Municipal systems** such as RENEWABLE HEAT SUPPLY IN A BIOENERGY VILLAGE in Mengsberg, Germany.

These case studies provide valuable insights for advancing sustainable bioenergy concepts. The examples so far primarily come from European states, but contributions from Australia, Brazil and Thailand are also included. Despite efforts, no case studies from Asian or South American countries have been integrated so far. However, the involvement of a new Chinese observer in the 2025 triennium may help expand this scope. In addition to continuously collecting new best-practice examples, the categorization of these cases will help to make use of this valuable information basis.

The best-practice collection has contributed to further networking of Task 44. One example is the collaboration with the IEA Solar Heating and Cooling Technology Collaboration Programme (SHC TCP) (link) which led to the development of a best-practice document (see Figure 3: Example “Renewable heat supply in a bioenergy village”). This document was later included in their TCP’s newsletter. Additionally, synergies with other Tasks are being leveraged, for example, by integrating a case study (link) from the Task 33 database on gasification technology.

Flexible Bioenergy Policies – Implementation and Expectations

To well consider flexible bioenergy policies, over the last triennium in Task 44, their implementation and expectations were analysed for 14 countries, including several European countries, but also USA, Canada, Australia, Brazil, Türkiye, and the European Union. The investigation was mainly based on questionnaires completed by bioenergy experts in the countries, who were contacted through the IEA bioenergy network. Even though all surveyed countries are OECD members, the status, policy framework and examples are heterogeneous and give different priorities to short-term flexible bioenergy, multiproduct systems and longer-term flexibility services (Thrän et al. 2024, Thrän et al. 2025a, Thrän et al. 2025b).

Increasing attention on flexible bioenergy provision and/or the simultaneous production of electricity, heat, and fuels in the past three years are stated with adoption of strategies, investment support and also adjustment of energy legislation. Many of these efforts are linked to BECCU and BECCS, which have entered the policy field in almost all of the investigated countries. Concerning flexible power provision, countries largely differ in their focus and approach, e.g. emphasizing day-to-day flexibility or seasonal flexibility, poly-generation, combination with excess energy, hydrogen and/or power-to-X. Moreover, efforts mainly are in a research, development and pilot stage; implementation support for those flexibility options is rare (Figure 5).

Flexibility in the power sector is of increasing relevance due to rising share of variable renewable energy (VRE). Flexibility issues in the power provision field have entered the agenda during the last three years. Almost all of the investigated countries are expecting to invest or are already investing in flexibility. Statistics on and monitoring of flexible bioenergy are also of increasing interest. However, there are still very different approaches in describing flexible capacities between the countries, so that a clear definition and procedure could improve the comparability of the numbers. Advanced technologies to ensure reliability are expected in more than half of the investigated countries until 2030. In many countries different flexibility options are currently in implementation, mainly driven by research and development and pilot and demonstration plants, but also already in the market in some cases. The comparison of the different renewable flexibility options shows that, across the countries, an innovation and implementation pipeline for flexible power generation is visible. However, this is more prominent for hydrogen and hydropower than for biogas and solid biofuels.

Many support mechanisms for the implementation of renewable energy production are stated, where most of them only support flexible bioenergy and system integration indirectly. Direct policy support is stated from Austria, Denmark, Germany, Italy, Netherlands, Sweden, Switzerland, and Türkiye. Those mechanisms support the creation of flexible bioenergy capacities on biogas plants (in Germany), feed-in tariffs and premiums for flexible bioenergy (Austria and Denmark) or focus Capex and Opex contribution to biobased CHPs (Switzerland). However, the effect of those mechanisms also depends on the level of support. This is why indirect mechanisms, i.e. carbon pricing or emission trading, are not necessarily second-best options.

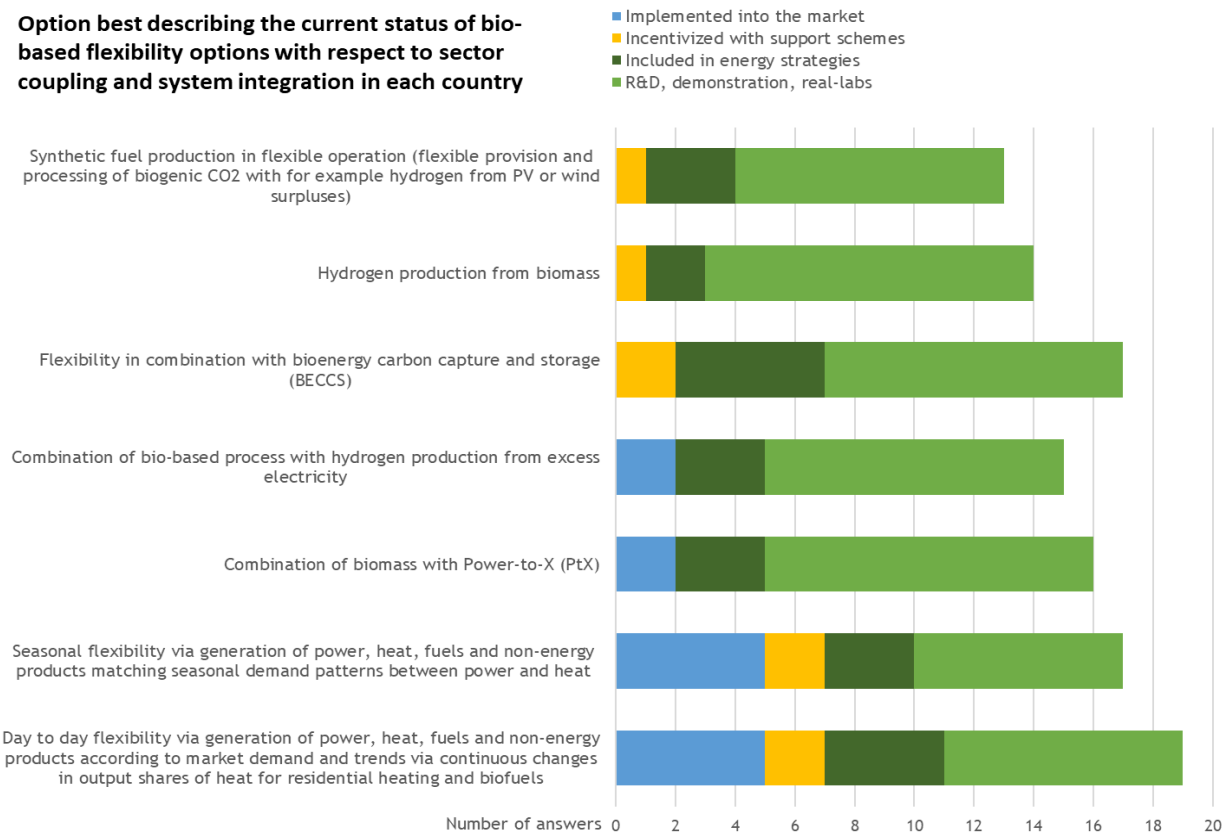

Figure 5: Current status of bio-based flexibility options with respect to sector coupling and system integration in 13 countries and EU; no data from Brazil. (Thrän et al. 2024)

Countries identified key opportunities for flexible bioenergy systems over two timeframes. For 2020–2030, priorities include utilizing biogenic residues, complementing renewables usage, and supporting industrial energy needs. For 2030–2050, the focus shifts to hydrogen synergies, CCUS, and e-fuels, highlighting their role in decarbonizing heavy industry and enhancing renewable energy storage. Providing sustainable fuels remains crucial across both periods, while biogenic residue valorisation diminishes in relevance by 2050. Overall, the shift reflects a move from short-term adoption to long-term integration within broader decarbonization strategies. However, uncertainties in biomass availability make its potential impact unclear in many countries. Also, differences in energy transition progress exist between countries, compounded by uncertainties around competing technologies such as electric mobility for heavy transport, bi-directional charging in the electric vehicle sector, and high-temperature heat pumps for industry.

To unlock the potential of flexible bioenergy, policy should take coordinated action at both national and international levels. This includes clarifying biomass potential, enhancing energy system modelling to better understand the need for flexibility in energy and material systems, determining how flexibility can be provided, developing supportive policies, and aligning technological advancements across sectors. In addition, policy strategies for flexible bioenergy need to be linked with green hydrogen strategies to unlock the synergies from flexible biomass and green hydrogen (Thrän et al. 2025b).

Synergies of flexible bioenergy with green hydrogen and negative emissions

Biobased value chains have multiple connections to renewable hydrogen and in providing negative emissions, such as BECCS (Mäki et al. 2024). One main aspect is how to integrate bioenergy, renewable hydrogen, and BECCUS value chains and where they bring opportunities for decarbonizing the energy system but also pose new challenges, e.g. in technology development in realizing this integration of the various chains. Starting from renewable hydrogen production and use, biobased value chains can be closely linked with renewable hydrogen industry by either providing renewable hydrogen from biomass resources (also referred to as biohydrogen) or adding renewable hydrogen from electrolysis to biobased value chains (Hennig et al. 2025):

Biohydrogen complements the well-known process via electrolysis, using renewable electricity. There are numerous production pathways to convert different types of biomass resources to biohydrogen, and they can be divided into two main groups, thermochemical and biological technologies (Lundgren et al. 2025):

- Thermochemical conversion processes include technologies as pyrolysis, hydro- and solvothermal liquefaction, and gasification followed by required downstream upgrading such as reforming, separation etc.
- Biological conversion processes include technologies such as water–gas shift reactions promoted by micro-organisms, photo-fermentation and dark fermentation, anaerobic digestion followed by biogas/biomethane reforming, fermentation to alcohols followed by reforming, and bio-photolysis with photosynthetic organisms.

The various technologies and concepts are of different technology readiness and the majority of concepts position at TRL 6 to 7. One concept which is in demonstration phase is based on the technology of thermo-catalytic decomposition or pyrolysis. Here a technology has been developed for (bio)methane splitting, producing renewable hydrogen when based on biogas, and solid carbon as a co-product. The carbon can be both used for carbon-neutral products or stored underground. The company Hycamite TCD Technologies is developing this concept and is currently testing it in a plant in Finland (Rahikka 2024).

Production of hydrogen from biomass offers CO_2 as a co-product, which potentially can be removed. This would allow to extract atmospheric CO_2, which is temporarily stored in the biomass, and its removal from the carbon cycle if carbon capture and storage is applied or biochar produced. As a result, hydrogen with a net negative carbon footprint becomes available, creating opportunities for financial benefits through Carbon Credits.

Adding renewable hydrogen to bio-based value chains is another strong link between hydrogen and biomass/bioenergy that can be considered. In principle, renewable hydrogen integration into biobased value chains can be done to 1) replace conventional, fossil-based hydrogen use, 2) to upgrade the quality of products, or 3) to produce (additional) products and by-products. The options vary in the level of technological and process adaptation needed. Incorporating renewable hydrogen highlights the strong synergies between renewable hydrogen and bio-based value chains, unlocking a range of potential benefits (see Figure 6) (Funke et al. 2025):

- **Improving existing fuel infrastructure**: The use of renewable hydrogen in carbon-based production to produce hydrogen-derived liquid fuels makes storage, transport, and utilization more convenient than gaseous or liquid hydrogen.

- **Synergies through process integration**: Combining electrolysis with biofuel production enhances infrastructure efficiency, lowers logistics costs, and improves heat flow management. This facilitates decentralized renewable energy use and provides local chemical energy storage, potentially reducing hydrogen costs.
- **Enhancing carbon efficiency**: Incorporating renewable hydrogen into biomass conversion processes significantly enhances carbon-to-fuel efficiency and, in some cases, improves the quality of the final products. Further on, renewable hydrogen can be used for upgrading product gas from gasification to liquid biofuels, biogas to biomethane, and pyrolysis oil to stabilized oil.
- **Facilitating liquid and gas co-production (BECCU)**: Using bioenergy with carbon capture (BECC) in heat and power generation, renewable hydrogen is essential for utilizing the captured CO_2. This enables the co-production of liquid and gaseous carbon products with heat and power generation.

When looking into the role of CO_2 capture in concepts of renewable hydrogen uptake in biomass conversion processes, capturing could be beneficial either through efficient process integration and/or due to high CO_2 concentrations in the offgases. This is for example relevant for biological methanation processes (also compare Funke et al. 2025). While these are general benefits from integration of CO_2 activation in bio-based value chains, the actual cost of available CO_2 will always be determined by additional factors such as cost of electricity, scale of realization, local infrastructure, contaminants in the offgas etc. (Funke et al. 2025).

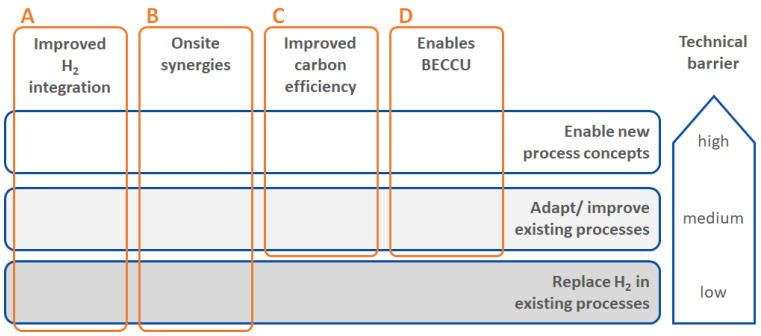

Figure 6: Overview of potential benefits (A-D) and level of technical barrier for integration of renewable hydrogen in bio-based value chains. (Funke et al. 2025)

This shows the multiple and strong connections of biobased value chains to renewable hydrogen and in providing negative emissions. The integration of renewable hydrogen with biobased value chains, along with the utilization of biogenic CO_2 to generate carbon-neutral products or negative emissions, can contribute to energy and climate system benefits (Mäki et al. 2024). By linking biobased value chains, renewable hydrogen, and BECCUS value chains, further opportunities for decarbonization may arise.

Energy system models and roadmaps, such as IEA Net Zero by 2050, consistently emphasize the role of bioenergy in achieving deep decarbonisation across sectors, especially in hard-to-abate sectors. Hydrogen is recognised for its cross-sectoral versatility and ability to support energy systems, particularly through seasonal storage. Several national and international modelling efforts, including IEA-ETSAP, explore a range of hydrogen and bioenergy value chains in net zero energy systems, where the use of biogenic CO_2 in e-fuel production is particularly highlighted. Their linkages and added value for the energy system ask for further consideration in modelling efforts (Hennig et al. 2025).

The value of flexible bioenergy

Increasing VRE generation potentially comes along with higher system costs: As wind and solar continue to grow as a proportion of generation, system level surpluses and periods of lower generation will eventually expand beyond hour-to-hour or daily variations to seasonal timescales. Addressing seasonal variability of renewables means that flexibility resources will be needed to varying extents throughout the year, even on a week-to-week or month-to-month basis. A mix of flexibility resources is expected to manage variability across all timescales and seasons, in particular in systems with very high level of VRE. We found that flexibility in the electricity sector is becoming increasingly important in many countries due to the growing share of intermittent renewable energy sources (VRES) (see Chapter 4). In energy systems' transition towards net zero emissions, all flexibility services will need to be fully decarbonised (IEA 2023).

Some components of the value of flexible bioenergy are reflected in the merit order of electricity prices. In an explorative study (Dotzauer & Thrän 2025), we figured out an approach to determine this value in certain countries as case studies.

shows a simplified merit order curve for different generation types as a bar chart. Starting on the left, generation technologies with no marginal costs start to build form the foundation of the merit-order, followed by increasingly expensive technologies. The ranking of bioenergy prior to fossil technologies is valid for electricity markets with a support scheme for electricity from bioenergy, which exists in many countries. In this case, bioenergy has no marginal costs at all, but generates revenue through the feed-in tariff and consequently acts as if there were no marginal costs. Demand is assumed to be highly price inelastic, as shown by the steep vertical line in Figure 7. The market clearing price for a single hour is determined by the price of the last unit needed to satisfy the demand from the cumulative bidding stack.

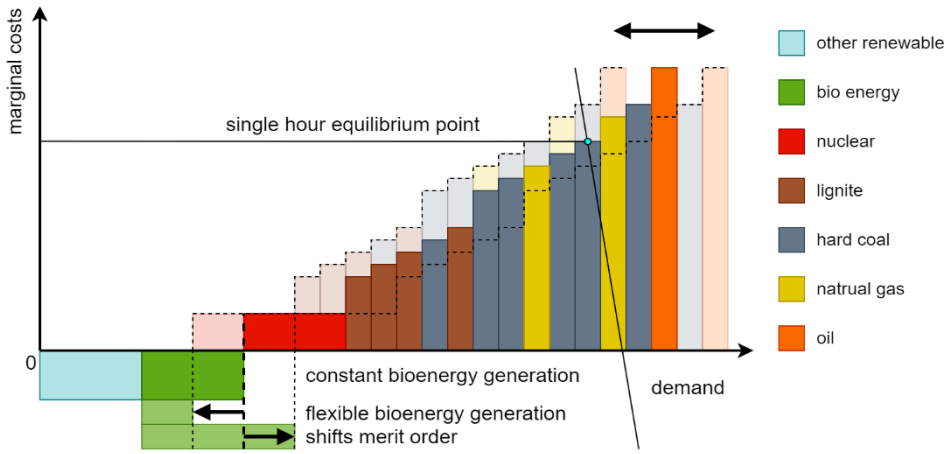

Figure 7: Basic concept of the merit order principle and the impact of flexible bioenergy. (Dotzauer & Thrän 2025)

To investigate the value of flexible bioenergy in explorative examples the effects on flexible bioenergy provision on the merit order is assessed by comparing existing data of electricity prices. The historical pattern of flexible operation is used as a reference and a baseload operation ("non-flexible" bioenergy provision) is simulated as a comparison scenario for selected European countries. The study is based on the Transparency Platform of the European Network of Transmission System Operators for Electricity (ENTSO-E) as main data source, which provides installed capacities and time series data for electricity wholesale prices and electricity generation. Under the consideration of bidding zone requirements and reasonable bioenergy contribution in the electricity sector three countries were selected as case studies: Austria, Germany and Finland. For the study a simplified merit order model was designed and applied for the case studies (Dotzauer & Thrän 2025).

For the German example the results are shown in Figure 8. Historical electricity generation from biomass for 2023 was characterised by seasonal and intraday flexibility. The level of generation was high until mid-April, and after the decline during the summer increased from October onwards. Intraday variability is more pronounced in the summer, and the range of variability is approximately 1.5 GW. The result of the scenario comparison using the merit order market model shows, that the flexible generation reduces the specific price by 0.58 €/MWh compared to the inflexible operation. Multiplying the grid-based electricity consumption of 458 TWh, the total cost difference on the spot market amounts to 266 million € in 2023. Even though Germany has a pronounced intraday variation pattern for the electricity generation from biomass, the specific price effect is the lowest in this collection of case studies. (Dotzauer & Thrän 2025). So, the critical question is how these cost savings translate into value for the flexible bioenergy operator.

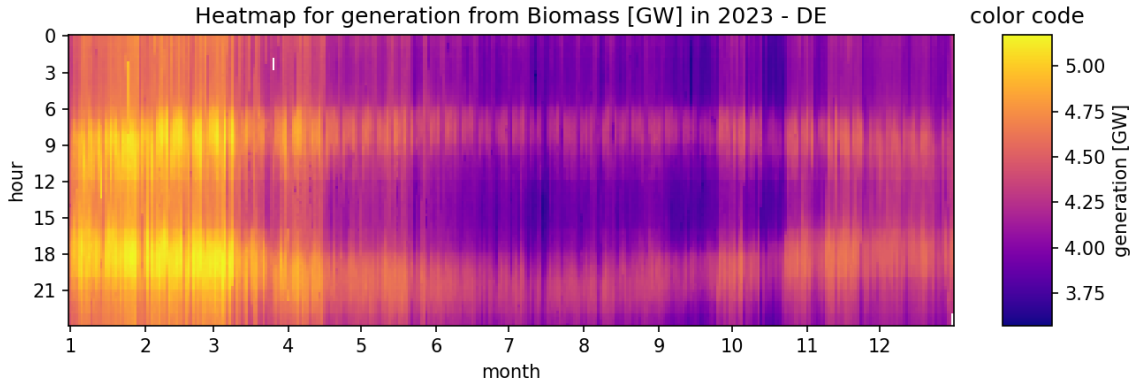

Figure 8: Heatmap for electricity generation from Biomass in Germany in 2023. (Dotzauer & Thrän 2025)

The main finding was that flexible electricity generation from biomass contributes to cost savings compared to an inflexible baseload operation. The price differences in Austria and Finland are mostly on a seasonal time scale, although there are also some intraday patterns that can be detected in the plots. Following this interpretation of the figures, the estimated value of flexibility is mostly based on the seasonal component of flexible electricity supply from bioenergy. In addition, the electricity generation from biomass in Germany, in contrast to Austria and Finland, shows significant amounts of intraday variability. One reason for this observation could be the specific German support scheme in for incentivising surplus capacity for biogas. Another reason could be the higher share of photovoltaic installations in Germany with 27% of the total installed capacity, compared to 17% in Austria and 9% in Finland. High share of PV installations can intensively cause intraday price variations, which provides a strong market signal for a price-driven

operation of dispatchable bioenergy plants. It can be assumed that seasonal flexibility is mainly provided by thermal power plants using solid biomass, and short-term flexibility is provided by CHP's running on biogas or biomethane (Dotzauer & Thrän 2025).

The presented study is a starting point capturing the systemic value of generated renewable electricity from biomass filling the gaps of PV and wind power generation. It does not attribute value to energy storage, neither on the short-term, for example through surplus PV-electricity to be converted to hydrogen for biomethane boosting, nor on the long-term through seasonal, solar-dried biomass reserves. Furthermore, contributions to energy security are only partially covered, with the focus on short-term variabilities, excluding extreme PV and wind generation short-falls or grid related challenges. But most importantly, the relevance of bioenergy technologies and bioeconomy practices stretches beyond the electricity system (see Chapter 2). Added value through flexible operation and planning can be expected not only regarding electricity generation, but also through heating and cooling, personal, public, and goods transportation, high-temperature and carbon intensive applications, negative emission strategies, and especially based on the integration between these energy vectors.

Working definitions are constantly challenged through collaborations with other IEA TCPs including on wind power (Wind), hydrogen economy (H_2), on energy system modelling (ETSAP), and since the spring 2025 in the IEA Energy System Flexibility Coordination Group representing TCPs and topics including, Smart electrical devices (4E), Buildings and communities (EBC), Energy storage (ES), Fluidized bed gasification (FBC), Hydropower (Hydro), Smart grids (ISGAN), Concentrated solar power (SolarPACES), social energy aspects (Users), Carbon management (GHG) and Heat pump technologies (HPT). The aim of this work is not to derive a universal definition and metric, but to explore, compare, and translate the different perspectives on flexibility and system integration.

Summary and conclusion for the next triennium

Bioenergy plays a crucial role where other renewable sources are difficult or costly to implement. It provides climate-efficient and cost-effective flexibility. Flexible bioenergy is defined as the deployment of sustainable biomass to offer multiple services under varying conditions, contributing to energy security, including using diverse biomass feedstocks, trading and storing bioenergy carriers, generating power for grid stability, and providing biogenic CO_2 for synthetic fuels and chemicals or storage. The potential of flexible bioenergy extends beyond the energy sector, contributing to carbon dioxide removal and integrated biorefineries. To unlock all this potential, favorable conditions and policies are necessary. The IEA Bioenergy Task 44 has been aiming to improve understanding and identify barriers to flexible bioenergy, with work packages addressing low-carbon energy systems, policy recommendations, and synergies with hydrogen and BECCS. The task's results include technology portfolios, best practices, and policy analysis, highlighting the importance of flexible bioenergy in the energy transition.

In the new triennium 2025-2027, Task 44 aims to broaden the scope even more beyond the power sector. The aim is to dive even deeper into system flexibilization through system integration and multi-sector coupling. New focuses of the task are related to exploring flexibility in fuels and chemicals production and assessing the systemic impacts of

flexibilization, e.g. from policy point of view, but also on a more detailed level, such as in modelling. The Task contributes with a broad perspective of energy vectors and their embeddedness in the food-water-materials-energy nexus to the trans-disciplinary exercise of defining and quantifying the multi-faceted values of designing and operating less rigid and more flexible systems. We will continue to find best practices and explore the important cross-cutting topics of BECCUS and hydrogen, via close collaboration with the intertask projects and key stakeholders.

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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 93rd ExCo meeting was held as a Virtual meeting in three separate sessions on the 13th, 15th and 16th May 2024. The 94th ExCo meeting was held in São Paulo (Brazil) on the 21st and 22nd October 2024.

Participants in the ExCo94 meeting, São Paulo (Brazil), 21-22 October 2024

Dina Bacovsky of BEST – Bioenergy and Sustainable Technologies (Austria) chaired both ExCo meetings in 2024, with Mark Brown of the University of the Sunshine Coast (Australia) and Birger Kerckow of FNR – Fachagentur Nachwachsende Rohstoffe (Germany) in the roles of Vice-chairs.

Ari Uguyama represented IEA Headquarters at these meetings.

At ExCo94, Mark Brown was elected as the new Chair. Two Vice-chairs were appointed to assist the Chair in his work: Birger Kerckow and Anna Malmström of the Swedish Energy Agency (Sweden).

The IEA Bioenergy Executive Committee also appointed Eric van den Heuvel of Studio Gear Up (The Netherlands) as the new Technical Coordinator. He follows Luc Pelkmans of Caprea Sustainable Solutions (Belgium).

Chair Dina Bacovsky and incoming Chair Mark Brown

Secretariat

The ExCo Secretariat is currently based in San Casciano in Val di Pesa, Florence (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 2024, is described below.

Extension of IEA Bioenergy to 2030

In line with the recommendation from IEA's Renewable Energy Working Party (REWP), in November 2024, the Committee on Energy Research and Technology (CERT) approved the extension of the IEA Bioenergy TCP until 2030. As part of the extension process, IEA Bioenergy developed a new Strategic Plan (for 2025-2030). For further details on this see below under 'Strategic Fund/Strategic Outputs'.

Contracting Parties/New Participants

A complete list of the Contracting Parties to IEA Bioenergy is included in Appendix 3. In addition, the U.S. Grains Council participated in Task 39 (Transport biofuels) as a Limited Sponsor in 2022-2024.

Supervision of Ongoing Tasks, New Triennium Proposals, Review and Evaluation

At the ExCo93 meeting in May 2024, the Tasks presented their Audited Accounts Reports for 2023. At the ExCo94 meeting in October 2024, the Tasks presented their Progress reports, updating ExCo on the completion of the projects and activities for the 2022-2024 triennium. In addition, at this meeting the Tasks presented their programmes of work for the 2025-2027 triennium, which were approved by ExCo.

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 2024 approved by the Executive Committee for the ExCo Secretariat Fund and for the Tasks are shown in Appendix 2. Total funds received in 2024 were US$2,032,100 comprising US$233,000 of ExCo funds and US$1,760,000 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

The Secretary manages the IEA Bioenergy ExCo Secretariat Fund, through a bank account that he uses 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.

Ernest & Young, Florence (Italy) were appointed as independent auditors for the ExCo Secretariat Fund to the end of 2024. The audited accounts for the ExCo Secretariat Fund for 2023 were approved at ExCo93.

The Tasks also produce audited accounts. These are prepared according to guidelines specified by the ExCo. The accounts for the Tasks for 2023 were approved at ExCo93.

The audited accounts for the ExCo Secretariat Fund for the period ended 31 December 2024 have been prepared and these will be presented for approval at the ExCo95 Virtual meeting.

Task Administration and Development

Task Participation

In 2024, there were 109 participations in 11 Tasks. Please see Appendix 1 for a summary of Task participation.

Two Inter-Task projects were implemented in the 2022-2024 triennium, one on 'Management of Biogenic CO2: BECCUS[1] Inter-task Phase 2' and one on 'Synergies of Green Hydrogen and Bio-Based Value Chains Deployment'. For further details on these see below under 'Strategic Fund/Strategic Outputs' and 'Communication Strategy'.

Strategic Planning and Strategic Initiatives

Strategic Plan

The objectives of the Strategic Plan for 2020-2025 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).

Following an extensive consultation process, IEA Bioenergy developed the Strategic Plan for 2025-2030, which was approved by the IEA Committee for Energy Research and Technology (CERT) in November 2024. The new Plan includes four Strategic Objectives that will guide the work of our TCP over the next five years, namely:

1. Providing science-based information to support technology innovation, policy development and deployment.

2. Improving understanding of key features of sustainability in bioenergy systems, including biomass resources, biodiversity linkages, climate effects, and socio-economic impacts, such as contribution to local energy security.

3. Exploring synergies of sustainable bioenergy systems with other clean energy technologies and bio-based sectors.

4. Demonstrating how sustainable bioenergy, within the broader circular economy, can contribute to international climate targets and other Sustainable Development Goals.

Technical Coordinator

In 2024, 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 preparation of the BBEST – IEA Bioenergy Conference 2024, leading the drafting of the summary and conclusions report from this event. Furthermore, he provided

[1] Bioenergy with Carbon Capture, Utilization and/or Storage.

guidance and support to the Tasks in the development of their programmes of work for the new triennium (2025-2027).

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 2024 Report and to an IEA study on carbon accounting of sustainable biofuels, and he coordinated IEA Bioenergy's contribution to selected TCP Coordination Groups. He also participated in selected meetings and discussions held by other organisations such as Biofuture Platform (particularly the Working Group on Sustainability) and Global Bioenergy Partnership (GBEP).

As mentioned above, at the end of 2024, Luc Pelkmans of Caprea Sustainable Solutions (Belgium) concluded his mandate as Technical Coordinator. Eric van den Heuvel of Studio Gear Up (The Netherlands) was appointed to this position.

Communication Strategy

The Communications Team has continued with regular online meetings to oversee communications' activities and review progress with the Comms Specialist ETA Florence.

Regarding the website, users were in the same range as last year (with an average of 7,000 to 9,000 users per month), indicating the need for continued efforts. The transfer of the Tasks' websites to the new IEA Bioenergy design has been completed. The use of social media to disseminate outputs from the TCP has expanded, with around 5,400 followers on X (former Twitter) and over 9,000 followers on LinkedIn.

The webinar programme has continued with six webinars being presented in 2024, with the following titles:

- 'Synergies of Renewable Hydrogen and Biobased Value Chains: Case Studies' (26 Sep).
- 'Utilization ad Storage of Captured Biogenic CO_2 – Deployment in Selected EU Countries' (17 Jun).
- 'Novel Opportunities for the Development of Biorefineries: Bio-carbon to Chemicals and Fuels by Integration of Biorefineries and Green Hydrogen' (16 May).
- 'Chemicals and Materials from Fast Pyrolysis of Biomass' (9 Apr).
- 'Treating and Valorising the Aqueous Phase from Hydrothermal Liquefaction' (19 Mar).
- 'Biohubs and the Role they Play in Biomass Supply Chains' (23 Jan).

In 2024, the Communications Team oversaw the development of a set factsheets to summarize the scientific evidence on the environmental and socioeconomic benefits of sustainable bioenergy production and use. These factsheets are being finalized and launched in 2025.

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 Inter-Task projects were implemented in the 2022-2024 triennium: one on 'Management of Biogenic CO_2: BECCUS Inter-task Phase 2' and one on 'Synergies of Green Hydrogen and Bio-Based Value Chains Deployment'.

Inter-Task Project: Management of Biogenic CO_2: 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 CO_2 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 by Q2 2025, will include four reports, two workshops and one webinar. Collaboration is taking place with various TCPs (ETSAP[2], GHG, IETS[3]), 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 is 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 by Q2 2025. Collaboration is taking place with the Hydrogen TCP and the ETSAP TCP, in addition to the BECCUS Phase 2 ITP.

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 39 organized a virtual workshop on 'Lowering Hinders for Maritime Biofuels – Identifying means to increase the use of biofuels in the marine sector' on 3 December 2024 – link.
- Task 36 organized a virtual workshop on 'Mixed plastic waste – Sustainable valorisation solutions for material and energy recovery' on 18 November 2024 - link.
- Task 39 organized a virtual workshop on 'Progress in Commercialization of Biojet /Sustainable Aviation Fuels (SAF): Technologies and policies' on 10 October 2024 – link.
- Task 43 organized a virtual workshop on 'Documenting sustainable biomass supplies – plans for quantification & interpretation of data' on 17 June 2024 - link.
- Task 45 organized a hybrid workshop on 'Quantifying biodiversity impacts in bioenergy systems' on 13 June 2024 in Stockholm (Sweden) and online - link.
- Task 33 organized a workshop on 'Gasification for production of biochemicals' on 12 June 2024 in Karlsruhe (Germany) – link.
- Task 34 organized a virtual workshop on 'Chemicals and Materials from Fast Pyrolysis of Biomass' on 9 April 2024 – link.
- Task 32 organized a side event on 'Sustainable low emission wood stoves – Recent developments and proper operation' on 29 February 2024 at the Progetto Fuoco Fair in Verona (Italy) – link.

[2] Energy Technology Systems Analysis Program.
[3] Industrial Energy-Related Technologies and Systems.

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

Under the Inter-task projects described above, exchanges were held with the Advanced Motor Fuels (AMF) TCP, the Hydrogen TCP, the Energy Technology Systems Analysis Program (ETSAP) TCP and the Industrial Energy-Related Technologies and Systems (IETS) TCP. IEA Bioenergy participates in and contributes to four TCP Coordination Groups, namely: Carbon Management; Energy System Flexibility; Thermal Networks; and Hydrogen.

Biofuture Platform

IEA Bioenergy and the Biofuture Platform continued to collaborate under the Memorandum of Understanding signed in 2021 to implement collaborative activities in the field of bioenergy, with a focus on biofuels and biorefineries. The Technical Coordinator participated in several meetings of the Technical Advisory Group to the Biofuture Platform Workstream on Biomass Quantification and Sustainability.

FAO and Global Bioenergy Partnership (GBEP)

Collaboration continued between IEA Bioenergy and FAO, under the MoU between the two organisations. In particular, IEA Bioenergy continues to collaborate with GBEP (whose Secretariat is based at FAO) on issues and methodologies related to biomass availability/quantification and sustainability, mainly through Tasks 43 and 45. IEA Bioenergy is also involved in the GBEP Activity Group 7 on 'Biogas' through Task 37 and in Activity Group 8 on 'Advanced Liquid Biofuels' through Task 39. IEA Bioenergy, GBEP and several other organisations collaborated on the development of a joint statement on sustainable bioenergy for climate and development goals, which was launched in June 2024. FAO/GBEP participated as an Observer in the ExCo94 meeting in October 2024 in São Paulo (Brazil).

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.

Mission Innovation

Synergies are being explored with Mission Innovation, particularly with the Integrated Biorefineries Mission, which is led by India and the Netherlands.

UNIDO

IEA Bioenergy has established an informal collaboration with the UNIDO-led Council on Ethanol-based Clean Cooking (CECC). UNIDO participated as an Observer in the ExCo94 meeting in October 2024 in São Paulo (Brazil).

Promotion and Communication

Effective communication of IEA Bioenergy activities to the broader stakeholder community is a priority for the Executive Committee of IEA Bioenergy. 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, the Communications Team identified a list of priority actions, which informed and guided the implementation of communication activities in 2023 and 2024.

The engagement of ETA Florence has been continued and their contract for communications support has been renewed, following a tendering process.

The 2023 Annual Report included the special colour section on 'Emissions from Biomass Combustion'. The Report was widely distributed through our website, distribution lists and social media channels.

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 2024. The first issue in 2024 featured an article by Task 45 on 'Future Visioning of Bioenergy within Multifunctional Landscapes and Value Chains'. The second issue in December 2024 featured an article by Task 36 on 'Food Losses & Waste: A Global Challenge'. The newsletter is available from the IEA Bioenergy website, and it is widely distributed outside of the normal IEA Bioenergy network.


Technology Collaboration Programme

Bioenergy News

Volume 38 Number 2 - December 2024

BBEST – IEA Bioenergy 2024 Conference: highlights


Technology Collaboration Programme

Bioenergy News

Volume 38 Number 1 - July 2024

Joint Statement on Sustainable Bioenergy for Climate and Development Goals

Two contributions under the banner 'IEA Bioenergy Update' were provided to the journal Biomass and Bioenergy in 2024, bringing the total to 77. 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 2024 IEA Bioenergy issued several press releases and bulletins to shed light on a few key topics related to bioenergy. These are available here.

In addition, the Technical Coordinator joined a number of key events, where he presented relevant IEA Bioenergy work and related key messages. These events included: 84th meeting of IEA Renewable Energy Working Party – REWP; IEA Sustainable Biofuels workshop; European Biomass Conference and Exhibition – EUBCE 2024; 2nd Annual Advanced Biofuels Forum; and PubAffairs event on Biofuels and Agriculture.

Interaction with IEA Headquarters

Interaction with IEA Headquarters in Paris is of high importance to IEA Bioenergy and has been facilitated in 2024 particularly through the Chair, Vice-chairs, Technical Coordinator, Secretary and a number of Task Leaders, at both technical and administrative level.

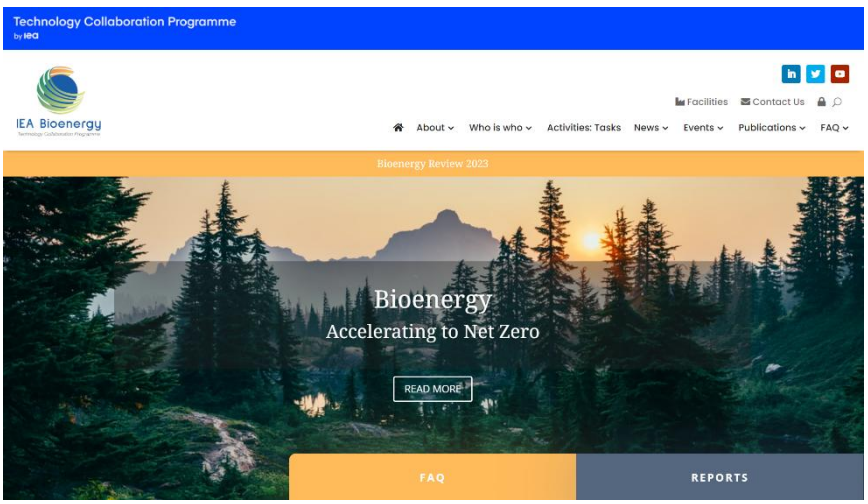
The Technical Coordinator of IEA Bioenergy, Luc Pelkmans, attended the REWP meetings in April 2024 (in person), where he presented the Strategic Communication from our TCP. The subsequent REWP meeting, which took place in October 2024, was attended (in person) by Chair Dina Bacovsky, who presented IEA Bioenergy's Request for Extension, for another five-year term starting in March 2025.

The Technical Coordinator provided input to the IEA Renewables 2024 Report and to an IEA study on carbon accounting of sustainable biofuels, and he coordinated IEA Bioenergy's contribution to relevant TCP Coordination Groups.

Ari Ugayama attended the ExCo93 and ExCo94 meetings on behalf of IEA Headquarters, and he made presentations to the IEA Bioenergy Executive Committee on relevant 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. The minutes of the ExCo93 and ExCo94 meetings were shared with the IEA's Desk Officer.

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 has been completed.



TASK 32: Combustion & Emissions[4]

Participating countries: Austria, Canada, Denmark, Germany, Japan, The Netherlands, New Zealand, Norway, Switzerland.

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

Prior to the triennium, Task 32 members identified challenges for deploying to biomass combustion:

- Emission reductions remain important - both in small and in larger scale applications.
- Transition away from fossil fuels in industry.
- Integration and flexibility of biomass combustion.
- Sustainability of biomass combustion.

Task 32 thus 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 topics that impede deployment of biomass combustion technologies.

[4] Official name: Biomass Combustion.

The 2022-2024 work programme condensed:

- WP1 Substituting fossil fuels in industry.
  - New case studies.
  - Searchable list of cases and references.
- WP2 Sustainable biomass combustion and negative emissions.
  - 2.1 Biomass combustion and BECCUS, technical options, cases, workshop (Task 40 ITP).
  - 2.2 Biomass combustion and synergies with hydrogen – tech options and case study (Task 44 ITP).
  - 2.3 Workshop on BECCUS and experiences with large-scale biomass combustion.
  - 2.4 CO_2-neutrality and sustainability.
- WP3 Innovative low emission biomass heating plants.
  - 3.1 Low emission biomass combustion boilers plants - recent development and cases.
  - 3.2 Study of the nitrogen cycle in biomass combustion plants (Phase II).
  - 3.3 Smooth operation and low emissions.
- WP4 Low emission residential appliances.
  - 4.1 State-of-the-art residential biomass boiler systems and workshop at biomass conference.
  - 4.2 Expert workshops on emission policy strategies - disseminate findings in inventory.
  - 4.3 Workshop on sustainable low emission wood stoves - recent developments.

Task 32 member countries are Austria, Canada, Denmark, Germany, Japan, Netherlands, New Zealand, Norway, Switzerland. The USDA Forest Service contributes as external expert.

Selected highlights from Task 32

In 2024, Task 32 has provided expert knowledge for a broader audience on:

- Low emission design, testing and operation of residential heating units (state of the art report, inventory of national strategies, workshop).
- Substitution of fossil fuels in industrial processes (Case studies, online database).
- Advanced combustion technology design (report, presentation).
- Plant operation with potentially negative emission of reactive nitrogen (report).
- The role of biomass combustion in energy systems with focus on net negative CO2 emissions and CCU/S (case reports, technology overview).
- How biomass combustion can help mitigating climate change (fact sheet).

Progress in R & D

Work programme and key deliverables

The 2022-2024 programme of work is referenced above. Deliverables that have been prepared and published in 2024 or in the first part of 2025 are listed below. Publications can be downloaded from the Task 32 website or the IEA Bioenergy website. Some of the publications reach the Linked-In account of IEA Bioenergy.

WP1 Substituting fossil fuels in industry.

1.1 New case studies on industries successfully changing from fossil energy supply to biomass-based process heat supply are being published.

1.2 Online database of cases studies, references and good examples being published.

WP2 Sustainable biomass combustion and negative emissions.

- 2.1 Manage and contribute to WP2 of the BECCUS 2.0 Inter-task project.
  - Case study of BECCUS on small scale biomass boiler plants in Canada. Report being published (part of inter-task project).
  - Overview of CCU Technology Types for Small Scale Biomass Combustion Systems. Report being published (part of inter-task project).
- 2.2 Contribute to WP3 of the Synergies with H2 Inter-task project.
  - Modelling case of implementation of full-scale BECCS/BECCU on an existing large-scale wood chip fuelled CHP plant in Denmark (part of inter-task projects). Results have been presented at more occasions, report is being published. [contributing to 2.1 as well]
- 2.3 Workshop on experiences with large-scale wood chip combustion.
  - Experiences with large scale wood chip combustion. Hybrid workshop being held.
- 2.4 CO_2-neutrality and sustainability - contribution to knowledge base.
  - IEA Bioenergy Fact Sheet: Residential solid biofuels combustion – continuous improvement over time. Published.

WP3 Innovative low emission biomass heating plants.

- 3.1 Low emission biomass combustion in automated boilers for heat and power. Report has been published and presented at more occasions.
- 3.2 Study of the nitrogen cycle in biomass combustion plants including cases with combustion of wood respectively straw (Part II). Report being published.
- 3.3 The report on low emission operation of automatic wood boilers operated in cascades has been finalised and published on the website.

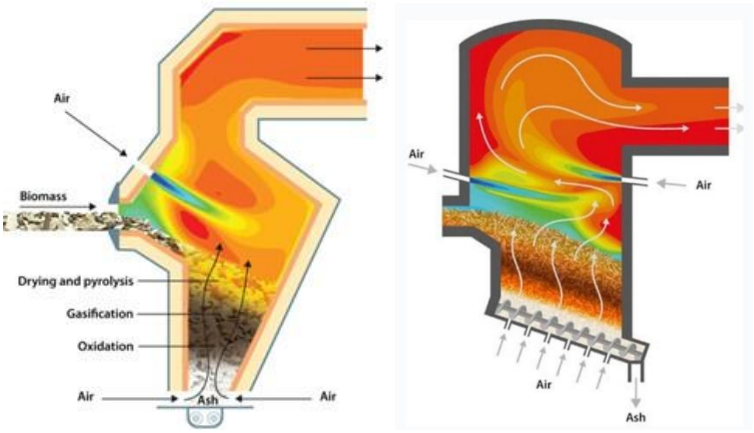


Figure 9. Schematic view of staged combustion design with one and two secondary air zones respectively. (Source: Nussbaumer, T., Low emission biomass combustion in automated boilers for heat and power, 2024)

WP4 Low emission residential appliances.

- 4.1 State-of-the-art residential biomass boiler systems. Results have been presented at more occasions, amongst others at a Task 32 session report is being published.
- 4.2 Updated inventory of national strategies to reduce impact on air quality from residential wood combustion. Report being published. Replacing a second round table discussion that did not materialise.
- 4.3 Workshop on sustainable low emission woodstoves. Held at Progetto Fuoco fair in Verona, Italy. Slides have been published. Short report being published.
- Colour feature: Emissions from biomass combustion. Published as part of the IEA Bioenergy annual report 2023.

Task 32 has experienced great interest from stakeholders as to the projects and workshops, not least around low emission design of residential heating systems and strategies and measures to reduce emissions and improve ambient air quality. Further, we have seen that the (deliberate) misconceptions about bioenergy continue and thus decided to contribute to misspelling these by taking part in the joint work in IEA Bioenergy on factsheets. Finally, It has proven challenging to finalise pending industry case studies due to hesitation at the hosts as well as to find new hosts for new case studies.

Task meetings, workshops and webinars

- Workshop: Sustainable low emission wood stoves - recent developments. Side event at the Progetto Fuoco 2024 fair, Verona, Italy (29 February 2024).
- Virtual task meeting sessions (14 and 21 March 2024).
- Annual physical task meeting and site visits, Straubing, Germany and surroundings (3-6 June 2024).
- TFZ Workshop, Task 32 session: Current projects in the area of biomass combustion. Straubing, Germany (5 June 2024).
- Monthly virtual task meetings (Last Tuesday of August, September, October, November 2024).
- Plus national meetings and workshops across the year.

Task 32 combustion experts discussing biomass gasifier concept in Neufahrn, Germany
(Photo: Morten Tony Hansen)

Collaboration with other Tasks and organizations
Internally:

- Task 40 and Task 44 on the inter-task projects on BECCUS respectively Synergies with H2. The work involves collaboration with Task 36.
- Task 43, Task 45, ExCo members in the fact sheet working group.
- Task 36 and 40 on collaborations 2025-27.

Externally:

- Boiler suppliers and plant owners on input to the projects.
- AIEL, Italy on the Task 32 workshop at the Progetto Fuoco 2024 where also Bioenergy Europe made a presentation.
- European Solar Thermal Electricity Association (ESTELA) and CST4ALL on hybrid biomass systems - presentation at E-workshop.
- Thermal Networks Coordination Group on highlighting benefits of district heating.
- ETIP Bioenergy meeting on RES technologies.
- World Bioenergy Association re. the campaigning against biomass.

Task 32 receives and responds to inquiries from around the world regarding biomass combustion and related topics. Task lead has also assisted ExCo members and other stakeholders with combustion related technical support.

Dissemination
The website has been updated with relevant events, recent publications, new bios and is continuously being updated. ETA Florence has assisted setting up a system to gather proper analytical data on the website visits.
Publication of Task 32 reports takes place on the task website as well as on the central IEA Bioenergy website. In most cases, corresponding posts have been made on LinkedIn by ETA.
Task 32 contributes to the IEA Bioenergy Newsletter. The National Team Leaders distribute newsletters and news from IEA Bioenergy and Task 32 to their national networks.
Task 32 promotes the project work at conferences and workshops.

Main activities in 2025

2025 is the first year of the triennium. Task 32 has focused on kicking of project activities to have deliverables early in the triennium. Focus is on:

- WP1: Sustainable residential heating – low emission design and operation and boilers.
  - Impact assessment based on the inventory.
  - Market surveillance.
- At the task meeting in the Netherlands in June, Task 32 plans a second expert round table discussion on emission from residential wood combustion - a public hybrid event with Dutch stakeholders present and audience online.
- WP2: Hybrid bioenergy heating systems.
  - 2.1 Case study on hybrid district heating system.
  - 2.2 Report summarizing different hybridization options and approaches in different scales.
- WP3: Decarbonizing industrial process heat with efficient and flexible bioenergy solutions.
- WP4: Biomass combustion with carbon capture and biochar production.
  - 4.1 Study biochar from biomass boilers.

(Commitments to Task 32 are pending and a member is withdrawing: No plans are fixed.)
Task 32 plans to hold a task meeting in Germany in June 2024, including a public workshop session on advanced boilers. The Task might also contribute to the BBEST – IEA Bioenergy 2024 Conference (São Paulo, Brazil, 22-24 October 2024).

TASK 33: Gasification[5]


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

Operating Agent: Bas Heukels, Ministry of Economic Affairs and Climate Policy.

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 waste gasification technologies. Thermal gasification is a versatile technology to convert various organic materials into valuable energy products such as electricity, heat, fuels, chemicals, hydrogen as well as biochar. With its ability to reduce greenhouse gas emissions and provide a reliable source of renewable energy, thermal gasification stands as a key enabler in the pursuit of a future towards net-zero carbon emissions.

Task 33 monitors the current status of existing and planned biomass and waste gasification plants, the critical unit operations and unit processes that constitute biomass and waste gasification processes, and identifies challenges to advance further development, operational reliability, and reducing the capital cost of biomass gasification systems. The Task meetings provide a forum to discuss the technological advances and issues critical to scale-up, system integration, and commercial implementation of gasification pathways.

The task is divided into six different subtasks focusing on end-products from gasification: CHP, SNG, Hydrogen, Biofuels, Biochemicals and GHG Balance.

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

Selected highlights from Task 33

In 2024, Task 33 continued its projects, with results to be published by the end of Q1/2025.

Reports:

- Gas Cleaning: Update on gas cleaning for catalytic processes, covering recent developments.
- Investment Opportunities in Biomass Gasification Systems: Update on economic conditions for investments in BMG plants in several parts of the world.
- Biomass Gasification for Hydrogen Production: Descriptions of biomass gasification technologies suitable for hydrogen production and information of on-going commercial activities.
- Gasification Status: Summary of gasification progress in member countries, highlighting SNG, hydrogen, biofuels, biochemicals, and CHP routes.

Fact sheets and leaflets as an output of five Subtasks (CHP, SNG, Biofuels, Biochemicals, Hydrogen) were published on the website as a part of an interactive graphics.

Progress in R & D

Work programme and key deliverables

In 2024, fact sheets and leaflets for key gasification products - CHP, SNG, Hydrogen, Biofuels, and Biochemicals - were completed and published on the Task 33 website. These were made available as part of interactive graphics featured prominently on the homepage, designed to provide easy access to the information.

Each fact sheet offers a detailed yet concise breakdown of these gasification products, starting with a brief introduction to the topic. The fact sheets also highlight the various production pathways for each product, outlining the technological processes involved in converting biomass or waste into valuable outputs. Additionally, they explore the opportunities these products present in the energy and chemical industries, emphasizing their potential role in the renewable energy transition. Furthermore, the fact sheets provide updates on current commercial developments, illustrating the real-world application and progress of these technologies.

The accompanying leaflets serve as 1-page summaries, providing a quick and simplified overview of each process. These leaflets are ideal for those looking for a brief snapshot of the essential information, making them useful for both experts and the general public interested in the advancements in gasification technologies.

Additionally the workshop report on Gasification for production of biochemicals was published on the website as a summary from workshop, which was held in June 2024 in Karlsruhe. The workshop report as well as all presentations can be found here.

Task meetings, workshops and webinars

- Meeting (Task meeting and Task workshop) was held in Karlsruhe, Germany. During the Task meeting country reports were presented, which can be found here. The workshop presentations and workshop report can be found here.
- Meeting (Task meeting) was held in São Paulo, Brasil. The presented country reports can be found here.
- Webinar: “Synergies of renewable hydrogen and biobased value chains – Case studies on biomass based hydrogen production”.

- TCBiomass Conference presentation: “Global gasification developments for RNG and advanced fuels”.

Collaboration with other Tasks and organisations

Strong collaboration with other IEA Bioenergy tasks in the ITP projects "Synergies of renewable hydrogen and biobased value chains" and "BECCUS". In the former, task 33 leads the work package on biomass-based hydrogen production, which was finalized in the end of 2024.

Task 33 is also involved in the increased collaboration with IEA Hydrogen TCP, primarily on biomass-based hydrogen production as well as hydrogen utilization in biomass gasification systems.

Dissemination

The Task 33 website features workshop presentations, country reports, and newsletters, which provide updates on the status and latest developments in gasification across member countries. The newsletters highlight key advancements and insights from each participating nation.

At the H2 and Mobility Conference in Berlin, Task 33 showcased how gasification offers a promising, cost-effective pathway for hydrogen production. Additionally, gasification presents a significant opportunity as a hydrogen sink in fuel production, such as methanol (MeOH) and other fuels. Furthermore, if CO_2 isn't repurposed, it can be utilized for negative emissions through carbon sequestration.

Main activities in 2025

- Task 33 is co-organizing the “Biomass and Hydrogen - Allies for Net Zero” workshop on May 15th at IEA HQ in Paris, where it will discuss hydrogen production through biomass gasification.
- An invitation-only workshop, “Make Gasification Great Again”, will be held on June 3rd in Luleå, Sweden, gathering key stakeholders from industry, technology companies, and authorities to address challenges in deploying biomass gasification commercially for fuels, chemicals, and other products.
- Task meetings will take place in June in Luleå, Sweden and in September in Xian, China.

TASK 34: Liquefaction[6]

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. 'Direct Thermochemical Liquefaction' is the controlled thermal degradation of biomass in any form to derive valuable energy and chemical products. It includes thermal and catalytic fast pyrolysis, hydrothermal and solvothermal liquefaction. Task 34 continues to follow the technology scope outlined by this definition of direct thermochemical liquefaction and in addition includes feedstock pre-treatment, bio-oil/biocrude upgrading and co-processing in petroleum refineries. Consequently, the Task scope includes all steps in a process of liquid fuels production from biomass extending from reception of biomass in a raw harvested form to delivery of a marketable product as liquid fuel, heat and/or power, chemicals and char by-product. The technology review may focus on the thermal conversion and applications steps, but implementation requires the complete process to be considered. Process components as well as the total process are therefore included in the scope of the Task, which will cover optimisation, alternatives, economics, and market assessment.

The Task contributes to standardisation efforts of these energy intermediates, the resolution of critical technical areas and disseminating relevant information particularly to

[6] Official name: Direct Thermochemical Liquefaction.

industry and policy makers. The scope of the Task is to monitor, review, and contribute to the advancement of issues that will permit more successful and more rapid implementation of biomass liquefaction technology, including identification of opportunities to provide a substantial contribution to bioenergy. 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 Inter-task Projects.
Industry is actively encouraged to be involved as Task participants, as contributors to Workshops or Seminars, as Consultants, or as technical reviewers of Task outputs to ensure that the orientation and activities of the Task match or meet their requirements.

Selected highlights from Task 34

- Fast pyrolysis can realize negative CO_2 emissions in various ways integrated in the production process of its main product fast pyrolysis bio-oil. Upon realizing these options, a bio-fuel with negative carbon emissions can be provided to the market. The extent to which this is possible and options to realize negative CO2 emissions have been quantified and the results are summarized in the contribution to the BECCUS 2.0 ITP.
- Two successful webinars with high participation and active discussions highlighted the importance of further strengthening the focus on the entirety of products obtained from direct thermochemical liquefaction and the variety of their uses, specifically also those not related to fuels. While for hydrothermal liquefaction treatment and valorisation of the aqueous phase seems to be a pressing issue, fast pyrolysis community is actively developing value added uses for fast pyrolysis bio-oil (fractions).

Progress in R & D

Work programme and key deliverables

- WP 1.1 (Pathways to) Transportation fuels from HTL and FP: The report has been finalized and will serve as knowledge basis for continuation in the upcoming triennium. It was observed that this field is very complex and not suitable for a broader audience in its current form, leading to a more tailored work package.
- WP 1.2 Production of chemicals and materials from HTL and FP oil: The report has been finalized and was published. This is a very important topic for the community and based on the feedback, work in this field will be continued and extended in the upcoming triennium.
- WP 2.2 DTL as BECCS/ BECCU technology: The contribution to the BECCUS 2.0 ITP has been finalized and submitted. Quantification of various possibilities to achieve negative CO2 emissions during the production of fast pyrolysis bio-oil was achieved. The results showcase the potential of producing a biofuel with carbon negative emissions attributed to it.
- WP2.3 Hydrogen use for DTL product upgrading: The draft report has been finalized; integration in the H2 synergies ITP is ongoing.
- WP3.1 Round Robin for validation of analytical method: The Round Robin has been finalized and the associated report has been drafted. It provides important hints on how to treat bio-oil samples and showcases gaps in important analytical methods. Tis relates specifically to analyses relevant for NOx and SOx emissions, which demand for the ability of reliably determining N/S trace compounds in bio-oils. This is obviously still an open issue for bio-oils produced from fast pyrolysis and hydrothermal liquefaction and hinders their use to produce e.g. marine fuels.
- WP3.4 TEE of DTL biorefinery: This work item has not been finalized, yet.

Task meetings, workshops and webinars

One face-to-face/ hybrid meeting was conducted in 2024. Task 34 met at BTG Biomass Technology Group BV in Enschede/ The Netherlands November 14th, 2024. This meeting was followed up by a hybrid workshop to gather and present stakeholders from The Netherlands and facilitate exchange. This included a site visit to the research labs of BTG Biomass Technology Group BV.
Monthly videoconference were conducted in 2024 to keep track on work packages and current developments. Detailed minutes of all meetings are available on the Task 34 website.

Collaboration with other Tasks and organisations

Task 34 participates in the IEA Bioenergy ITP ‘Synergies of green hydrogen and bio-based value chains deployment’ by contributing a case study around the use of H2 for the upgrading of HTL biocrude. Furthermore, Task 34 is WP lead for the use of H2 in biobased value chains (WP 3)
Task 34 also participates in the IEA Bioenergy ITP ‘Management of biogenic CO2: BECCUS inter-task phase 2’ by investigating carbon dioxide removal technologies in the context of DTL technologies. Furthermore, Task 34 is WP lead of the associated work package (WP 4). Also, a TEE study of a DTL based biorefinery is planned together with Task 42.

Dissemination

Two issues of the PyNe newsletter have been published. Moreover, country reports for Denmark and Finland have been created and published.

The Task 34 website was updated on a continuous basis regarding publications, events, participants, and the PyNe newsletter.
Website traffic is categorically up but improved in comparison to the previous year. Most page views are continuously highest pyrolysis reactors, bio-oil, and biocrude, i.e. those pages remain at the top list of accesses.
Two webinars have been conducted as a result of the report from WP 1.2 Production of chemicals and materials from HTL and FP oil. Attendance of the webinars was very high.

Main activities in 2025
There are three remaining activities to be wrapped up from the previous triennium; all of which are in a draft report stage:
- WP 2.3 Hydrogen use for DTL product upgrading.
- WP 3.1 Round Robin for validation of analytical method.
- WP 3.4 TEE of DTL biorefinery.

Due to unspent funds, there will be an additional activity that has been decided upon among Task 34 members to reduce carryover to the next triennium, which naturally is still in an initial stage:
- WP Add 1.1: Direct use of DTL liquids as fuels.

In the first year of the new triennium, Canada will host the in person Task 34 meeting in May 2025. Two work packages are planned to get finalized in 2025:
- WP 1.1 (DTL) pathways to (ASTM) SAF approval and marine fuels (industry and politics).
- WP 3.3 Technical notes to transfer knowledge/ expertise to a broader public (up to three).

TASK 36: Waste & Circular Economy[7]

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

Operating Agent: Anna Malmström, Swedish Energy Agency.

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

Task 36 website - link

Overview of the Task

Waste is a resource that plays an important role in supporting the bioenergy sector journey towards leading the renewable energy market. The amount of waste generated globally keeps increasing - biogenic waste, reject fractions from the recycling industry and contaminated streams from industrial processes are just some examples.

Task 36 Material and Energy Valorisation of Waste in a Circular Economy is an international working group 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 2022-2024, Task 36 seeks to understand what role energy from waste and material recycling can have in a circular economy and bioenergy deployment and identify technical and non-technical barriers and opportunities needed to achieve this vision.

Over the last years, the task has been following the development and deployment of technologies that support additional resource recovery: recovery of nutrients from composting, digestion, and combustion process; extraction of useful metals and salts from combustion residues; the beneficial re-use of ash from incineration; CCS/CCU or biological production of hydrogen from wastewater. An important part of the work has focused on highlighting social, environmental and economic aspects associated to these processes or the connection of the Sustainable Development Goals (SDGs) with waste management strategies. But the task has also dedicated efforts to explore the use of advanced waste sorting technologies (i.e. AI) and reviewed and compared waste-to-energy policies in an international context.

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

Those countries participating in the 2022-2024 triennium are Germany, Italy, Norway, Ireland, Sweden, South Africa and United States.

Selected highlights from Task 36

- During 2024, Task 36 has published 4 reports, arranged a webinar with more than 300 participants, and participated as speaker in conferences and webinars.
- The use of cutting-edge technology based on AI and digital tools applied to waste sorting is crucial for transforming the waste management sector into resource management; decrease its negative climate impact; and optimize processes. Read more.
- Pyrolysis, advance sorting, and thermal systems based on fluidized bed-steam cracking are technologies that have the impact on paving the way towards a circular handling of mixed plastic waste. Read more.
- Regarding food waste strategies, an avoidance strategy presents the best environmental performance, while AD results in the lowest environmental impact for unavoidable food residues and minimal food waste, among the strategies considered in one of our studies.
- Despite social acceptance remains a key barrier in the bioenergy deployment, social considerations are being the least addressed in LC), being environmental and economic aspects prioritized. Read more.

Progress in R & D

Work programme and key deliverables

- There are technical solutions that already have or might have the potential to impact on paving the way towards a circular handling of mixed plastic waste: pyrolysis, advance sorting and thermal systems based on fluidized bed-steam cracking combined with gas conditioning were identified during the webinar "*Mixed plastic waste. Sustainable valorisation solutions for material and energy recovery*" (link). Adopting sorting strategies that allow sorting mixed plastic fractions based on polymer content and/or degree of contamination rather than monomer (polymer) type fractions – as it is done nowadays - it is one step closer.
- Food waste is a promising feedstock for producing value-added chemicals and fuels. A recent work where we have considered the *environmental impacts of different waste management options for municipal food waste using LCA* (link), including avoidance, composting, anaerobic digestion (AD), showed that an avoidance strategy for wasted food had the best environmental performance, while AD resulted in the lowest environmental impact for unavoidable food residues and minimal food waste.
- One of our latest work, *Literature review on social LCA of bioenergy* (link), brought up that the fact that most Life cycle assessment (LCA) studies on bioenergy focus on environmental impacts, with economic factors receiving secondary attention, and social considerations being the least addressed. Social acceptance remains a key barrier to bioenergy expansion and thus ensuring that all key stakeholders are included in the social impact assessment is essential. Incorporating qualitative data and improving result interpretation are critical for advancing S-LCA.

Task meetings, workshops and webinars

TASK MEETINGS

- Five on-line Task meeting has been held in February, May, July, September and November 2024. All of them were follow-up meetings except the one in July that has as focus finalizing the Task programme for 2025-2027.
- Working meetings dedicated to specific deliverables were set when needed.

WORKSHOPS & WEBINARS

- Task 36 Webinar "Mixed plastic waste. Sustainable valorisation solutions for material and energy recovery", November 2024. 660 people registered and 310 attendees (link).
- Two Task 36 members participated as panelists in the webinar "System Dynamics: Decision Tool for Municipalities & Waste-to-Energy" organized by RISE (link).

Collaboration with other Tasks and organisations

INTERNAL INITIATIVES:

- Participation in the Working Group (WG) *Socio-economic benefits of bioenergy within the broader bioeconomy*. The Irish NTL is representing Task 36 in this context.
- Participation in *TCP Coordination Group Carbon Management*.
- Participation in the *Inter-task BECCUS 2.0 (phase 2)*.
- Participation in the *Inter-task Synergies of green Hydrogen and bio-based value chains deployment*.
- Task TL has joined the *WGs (1) Communications Team; (2) ExCo modalities; and (3) How to engage developing countries*.

OUTSIDE OF IEA BIOENERGY:

- Task 36 has invited speakers from industry, research institutes and academia (mainly in Europe) outside of IEA Bioenergy to the webinars arranged by the Task during 2024.
- Task 36 members were invited as speakers to a webinar organized by RISE in November 2024.
- Contact with ISWA (International Solid Waste Association - link) to investigate potential collaborations during 2025-2027.

Dissemination

WEBSITE: The website (link) has been updated during the year with new publications, news and events. Changes in the content have been made to make the website more attractive for the reader.

NEWSLETTERS:

- Task 36 Newsletter published in June 2023 and Task 36 Newsletter published in December 2024 (link).
- Contribution to IEA Bioenergy Newsletter published in July 2024.
- Contribution including Task focus article with title: "Food Losses & Waste: a global challenge" in IEA Bioenergy Newsletter December 2024 (link).

OTHER ACTIVITIES:

- Participation in the BBEST- IEA Bioenergy Conference (São Paulo, October 2024) and speaker in the session "Heat and power from biomass and waste", with the presentation "Towards a Dynamic Understanding of Waste-to-Energy Futures".
- The NTLs represent and promote actively Task 36 when attending different types of events.
- A Task 36 page has been created within the RISE (Research Institute of Sweden) as a way expand visibility in new networks (link).

Main activities in 2025

During Q1, the content of the task programme for 2025-2027 will be revised to adjust to the final number of countries participating. After that, we will have more cocreate activities for 2025.

MEETINGS:

- Task 36 kick-off meeting for the new triennium: on-line 25th of February.
- Task 36 physical meeting: Q2, place tbc.
- 3 Follow-up on-line meetings along the year.
- TL will be participating in ExCo 95 virtual in June and ExCo96 in November in Norway.

PUBLICATIONS:

- It is already scheduled that the following deliverables from the 2022-2025 triennium will be published during Q1:
  - Topic Report: *"Social and Environmental Sustainability of Municipal Solid Waste in the Context of the UN SDGs"*
  - Case Study Compilation. "*Environmental Impacts of Waste Management Strategies. Case study compilation*".

WORKSHOP/WEBINAR:

- Potential webinar connected to the Topic Report "*Social and Environmental Sustainability of Municipal Solid Waste in the Context of the UN SDGs*".

OTHER ACTIVITIES:

- Participation in the CEWEP conference in June in Poland.
- On-going discussions with ISWA about potential collaborations.

TASK 37: Anaerobic Digestion / Biogas[8]

Participating countries: Austria, Brazil, Canada, 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.
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.

[8] Official name: Energy from Biogas.

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

- Publication of monthly newsletter.
- Publication of country report summary “A perspective on the state of the biogas industry in 12 member countries of IEA Bioenergy Task 37”.
- Publication of case story “Renewable CO2 from food waste based Biogas – a case story from Switzerland”.
- Publication of report.
- Murphy, J.D., Rusmanis, D., Gray, N., O’Shea, R. (2024) Circular economy approaches to integration of anaerobic digestion with Power to X technologies.
- Publication of case story LIMECO Biological Power-2-Gas production from waste and wastewater - a Swiss Flagship Project; Hajo Nägele, Wolfgang Merkle, Thomas Di Lorenzo, Niclas Gündel.
- Publication of case story Upgrading Landfill Gas into Biomethane - Using the WAGABOX® technology in France by Emmanuel GIOVANNONI & David AGUDELO-ROMERO.
- Session during the RNG conference in Drummondville Canada.
- Task Meeting and presentations on conference during the end of Triennium conference in Brazil.

Progress in R & D

Work programme and key deliverables

In the second half of 2024, Task 37 published the country report summary "A perspective on the state of the biogas industry in 12 member countries of IEA Bioenergy Task 37". The country summary report series provides a regularly updated compilation of information about the biogas industry in the Task 37 member countries, including production of biogas and biomethane, utilization of biogas and other products from anaerobic digestion, policy and financial conditions and innovative projects.
The report shows that countries have different strategies accelerate the implementation of biogas industry which leads to a quite diverse picture in regards of type and amounts of substrates used, used technologies (e.g. preferred upgrading technology) and the type of gas utilization. Difficulties in the sector development are changing framework conditions – in the support schemes and the regulatory conditions. The 2024 report includes updates from 12 countries: Brazil, Canada, China, Denmark, Finland, France, Germany, Ireland, Norway, Sweden, Switzerland and United Kingdom.
Further the task published the case story "Renewable CO2 from food waste based Biogas – a case story from Switzerland". It deals with an upcoming technology within the biogas sector – the upgrading and liquification of the within the upgrading CO2 from the offgas of the biomethane upgrading process. The technology has been applied to several plants – the integration into existing plants comes with some challenges, but in general the process is reliable. For a implementation at more plants, a so to say across the board application a larger market for renewable CO2 with a matching price needs to be established. The case story shows that biogas based CO2 is ready to be implemented now.
Three case stories have been published:

- BIOGAS PRODUCTION – AN INTEGRAL PART OF AN EVOLVING INTEGRATED BIOREFINERY COMPLEX IN QUÉBEC; by Maria Wellisch and Sylvain Trépanier.
  The integrated Varennes biorefinery complex combines a anaerobic treatment of local municipal and industrial waste and a ethanol production site. Initially, SÉMECS Center for the treatment of organic waste was a source of renewable energy and recovered valuable nutrients from solid waste, the current planning extends this to supply of biogenic CO2 for methanol production. This biorefinery complex demonstrates how creative industrial design can generate income, create new permanent employment, produce renewable fuels, reduce greenhouse gases, extract value from waste and contribute to the circular economy.
- LIMECO Biological Power-2-Gas production from waste and wastewater - a Swiss Flagship Project by Hajo Nägele, Wolfgang Merkle, Thomas Di Lorenzo, Niclas Gündel.
  The case story describes a biological Power to gas unit which is integrated into a wastewater treatment plant and a waste incineration facility. As Power-to-Gas is a crucial technology for sector coupling—integrating electricity, gas, heat, and mobility within a sustainable energy system—the plant in Dietikon, Zurich, aims to advance and optimize the cost-effectiveness of Power-to-Gas technology in the Swiss energy landscape.
- Upgrading Landfill Gas into Biomethane - Using the WAGABOX® technology in France by Emmanuel GIOVANNONI & David AGUDELO-ROMERO.
  The case story deals with the upgrading of landfill gas to biomethane. Landfill gas is a source of GHG emissions for many years to come and the collection and utilization of the gas reduces not only these emissions, it also provides renewable gas. The case story updates information on the technology.

Task meetings, workshops and webinars

- Task 37 had a meeting in Montreal, Canada which was hosted by the National Research Council. The meeting included a session within the RNG Forum in Drummondville and an second event dedicated to scientific exchange at the NRC Montreal facility – the Clean Fuel Symposium.
- During the forum four members presented on current research, technology standards and future perspectives.
- Task 37 had in October 2024 a meeting in Foz de Iguazu in Brazil, followed by the participation of the End of Triennium conference in Sao Paulo. During the conference 6 presentations from members of the task where given.
- Lecture given by Jerry Murphy "Circular economy, energy and the environment" 1st February 2024.
- Session during the RNG conference in Drummondville, Canada.

Collaboration with other Tasks and organisations

- ECCUS 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 presented on the website and posted via LinkedIn.
- Set up of a LinkedIn account and several posts.
- News on the website, including the publication of above mentioned case stories and reports.
- Publication of report on Power to X on the website, including post via LinkedIn.

Main activities in 2025

- Meeting and conference participation in Norway.
- Second meeting likely in Netherlands.
- Publication of deliverables from last triennium.
- Two reports on biogas in the food and beverage industry.
- Report on manure utilization.
- Report on benefits of anaerobic digestion.
- Report on methane oxidation technologies.
- Case story on Biomass auction platform.
- Case story on Towards carbon neutrality in on-farm biomethane production - Apsley farm.

TASK 39: Transport Biofuels[9]

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

Operating Agent: Anna Malmström, 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 focused on promoting sustainable biofuels for transportation. Its goal is to provide Task members with comprehensive information to support the development and deployment of biofuels, including ethanol, biodiesel, sustainable aviation fuels, marine biofuels, and other advanced biofuels. The key objectives of the Task are:

1. Provide technical 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 fuels.
2. Catalyse cooperative research and development projects to help Task members develop improved, cost-effective processes to produce conventional and advanced liquid biofuels.

[9] Official name: Biofuels to Decarbonize Transport.

3. Provide information, engage in activities of dissemination, outreach to stakeholders, and coordinate with other related groups.

The vision of the Task is to accelerate the production and use of environmentally sound, socially accepted, and cost-competitive bioenergy on a sustainable basis. The goal is to ensure bioenergy makes a substantial contribution to global energy demands, enhancing energy security while reducing greenhouse gas emissions. The Task mission is to facilitate the commercialization and market deployment of sustainable bioenergy systems and technologies while advising policymakers and industry leaders. The key strategy behind this mission it to foster international collaboration and knowledge exchange in bioenergy research, development, demonstration, and policy analysis among Task members.
In 2024, the members of Task 39 comprised fifteen countries including Austria, Belgium, Brazil, Canada, China, Denmark, European Commission, Germany, Ireland, Japan, The Netherlands, New Zealand, South Korea, Sweden, and the USA. US Grains Council participates as a Limited Sponsor, with the same terms as other participating countries. Their participation was limited to one Task and one triennium and there was no ExCo representation.
In 2025, the task is initiating a new triennium welcoming the participation of France and Norway as new task members, consolidating its position as the largest Task in IEA Bioenergy TCP. In this triennium, the efforts of the Task will be split into five large projects: Implementation Agenda (including Emerging Markets), Advanced Biofuels Demonstration, Biofuels for Heavy Duty Transportation, Sustainable Aviation Fuels, and Marine Biofuels. Additionally, the task will contribute to projects with other Tasks of IEA Bioenergy.
New task members are welcome to participate in the Task so we can increase the outreach of our activities. With the collaboration among this number of countries, Task 39 is set to deliver cooperative research projects to address and assess policy, markets, and sustainable biofuel implementation issues fundamental for the energy transition.

Selected highlights from Task 39

- Task 39 finished 2024 with 17 participants confirmed for the 2025-2027 triennium, consolidating its position as the largest Task in IEA Bioenergy TCP. We welcome France and Norway and the new NTLs from EC and South Korea!
- The 2024 yearly in-person business meeting of Task 39 took place in São Paulo, Brazil as part of the BBEST & IEA Bioenergy Conference 2024. Three sessions were organized to bring attention to the work of Task 39: Biofuels in Transportation, Marine Biofuels, and Biofuels in Emerging Markets.
- At the end of the conference, participants of IEA Bioenergy TCP visited a sugarcane mill in the State of São Paulo.
- Task 39 published eight reports/factsheets/slide decks related to the conclusion of the projects and three issues of the Biofuels News Magazine.
- During the triennium concluded in 2024, the Biofuels News Magazine included country features that described policies and markets in Belgium, Austria, Japan, the European Union, China, New Zealand, the USA, and Can.

Progress in R & D

Work programme and key deliverables

• T39-T1 Ongoing progress in the commercialization of SAF/biojet fuel: The aviation sector aims for net-zero emissions by 2050, with sustainable aviation fuels (SAF) crucial for reducing emissions. Policies like ReFuelEU and the US Inflation Reduction Act are boosting SAF production, while technologies like HEFA advance. Challenges remain, including price gaps and jet fuel standards.

• T39-T2: Progress in the commercialization of drop-in biofuels and co-processing to produce low-CI transport fuels. Transport emissions are still rising, with fossil fuels meeting over 90% of demand. To meet net-zero goals, decarbonization is necessary, with electric vehicles and drop-in biofuels or e-fuels needed for sectors like aviation and shipping. New policies in the US and EU are driving growth in drop-in biofuel facilities.

• T39-T3: Extend assessment of decarbonization of the marine transport sector and evaluate the commercial production and use of biofuels. The report brings an up-to-date report on the status of marine biofuels technologies. The final report has been circulated among task members, and soon it will be made available on the Task's website.

• T39-T4: Assessment of demonstration plants and commercialization progress. Scaling up advanced biofuel production is essential for global decarbonization, particularly in hard-to-electrify sectors. International collaboration and knowledge exchange can accelerate this process. The report brings an up-to-date state of advanced biofuels demonstration plants around the world.

• T39-T6: Inter-Task project 'Synergies of green hydrogen and bio-based value chains deployment'. Report: "Synergies and Services from H2 and Bio-based Value Chains Deployment" presenting case studies on hydrogen.

• 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, within business meetings.

• T39-P2: Assessment of the Sustainability of Biofuels Pathways, Including Social and Environmental Aspects of Sustainability — A Case Study of Industrial Exhaust Gas-Bioethanol in China and Brazil. This policy brief examines bioethanol production using captured CO_2. The use of biogenic CO_2 from sugar fermentation produces biofuel with negative emissions (-8.5 gCO_2e/MJ). The study highlights sustainability benefits and techno-economic hurdles in integrating carbon capture with biofuel production.

• T39-P3: Improvement opportunities for policies and certification schemes promoting sustainable biofuels with low GHG emissions. Part 2: Robustness of GHG emission certification and verification – a case study of selected biofuel value chains and policies. The project found that robust certification and verification of GHG emissions provide a solid foundation for implementing sustainable aviation fuel (SAF) in the market, but further improvements are needed. Harmonizing SAF policy frameworks is essential to prevent potential misuse (e.g., double claims) and to reduce complexity in international supply chains.

• T39-P4: Biofuel's production and use status in emerging economies. Publication of a Report ("Biofuels in Emerging Markets of Africa and Asia") and a factsheet for the G20 meeting ("Biofuels in Emerging Markets Factsheet G20"). Results indicate the great potential of biofuels in countries of Latin America, Africa, and Asia, regions in which energy demand is set to increase in the coming years and their potential to contribute to global decarbonization efforts.

Task meetings, workshops and webinars

Business Meeting #8 took place on March 21st, 2024, online, and Business Meeting #9 took place on 22nd October 2024, in-person, in São Paulo. The goals were to discuss the current state of biofuel programs around the world, the current state of projects that were going to be finished with the end of the triennium in 2024, and propose and discuss the program of work for the 2025-2027 triennium. Many webinars were held (organized by IEA Bioenergy with the support of ETA Florence), related to the closure of projects of the 2022-2024 triennium.

As part of the activities of the in-person Business Meeting of October 2024, we organized a study tour of a Brazilian sugarcane mill. Members visited the sugarcane plantation and mill and observed its large scale. Iracema Mill has a sugarcane crushing capacity of 5.6 million tonnes per year, a share of 0.8% of the Brazilian sugarcane market. In 2024, Brazil produced 689 million tonnes of sugarcane cultivated in 1.1% of its total land area.

Collaboration with other Tasks and organisations

Task 39 strengthened its collaboration with national and international organizations, such as the IMO, to advance biofuel development. It also expanded engagement with other IEA TCPs through joint participation in meetings and conferences with AMF, IETS, and Hydrogen. Building on connections established during webinars and conferences, Task 39 fostered further collaboration with other tasks and organizations through active member participation and engagement.

The Inter-task project on "Synergies of green hydrogen and bio-based value chains deployment" involves all Task groups. In this project, Task 39 contributed by presenting case studies to WP2 and WP3. The objective was to identify and assess synergies in the deployment of green hydrogen and bio-based value chains.

Dissemination

During 2024, Task 39 made many successful dissemination efforts. The Task's magazine (Biofuel News, ISSN 2004-7002) published three issues with country feature articles: New Zealand (issue 64), the United States (issue 65), and Canada (issue 66). Country features bring an overview of the state of biofuel policy and technology development in these countries, with inputs from Task members. The magazine was uploaded on the website and distributed via email, with over 1,800 receivers/subscriptions.

Task 39 produced eight publications in 2024, including reports, slide decks, and factsheets. These are related to the deliverables of projects that were finished in 2024 with the last triennium coming to an end. Projects contributed scientific publications, newsletters, and dissemination on other media outlets. Task 39 members have also participated in webinars and conferences.

Main activities in 2025

In 2025, Task 39 plans to host five online meetings and one in-person meeting in Norway, with a workshop on Marine Biofuels. In meetings, task members give updates on the status of biofuels in their countries and projects. Online meetings will be duplicated so members in different time zones participate within or close to business hours. Projects for this triennium include, besides Inter-task projects:

1. Implementation Agenda of biofuel technologies and policies.
2. Database on Advanced Biofuels Demonstration Plants.
3. Biofuels for Heavy Duty Transportation.
4. Sustainable Aviation Fuels.
5. Marine Biofuels.
6. BioTRACE: Biofuels conversion Technologies: energy and carbon emissions Evaluation.
7. Members show increased interest in Sustainable Aviation Fuels and Marine Biofuels. Our Program of Work is very bold, especially in terms of content and dissemination, because we need to involve as many actors as possible in the energy transition. We are excited to share our work with the community!

TASK 40: Biobased Deployment[10]

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

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

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

Task Secretary: Nora Lange, 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 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 CO_2 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.

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

- 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 CO_2: 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

- Conference presentation Task 40 at ABLC in Washington DC, USA.
- Task 40 participates in two of five Coordination groups initiated by IEA Paris:
  - IEA TCP Coordination Group on Carbon Management.
  - IEA TCP Coordination Group on Hydrogen.
- Scientific journal publication: Schipfer, F., Burli, P., Fritsche, U., Hennig, C., Stricker, F., Wirth, M., Proskurina, S., Serna-Loaiza, S. (2024): The circular bioeconomy: a driver for system integration. Journal Energy, Sustainability, and Society.
- Task 40 Webinar "Utilisation and storage of captured biogenic CO2 – Deployment in selected EU countries".
- Conference presentation ITP BECCUS 2.0 "BECCUS applications" at DBFZ Annual conference.
- BBEST and IEA Bioenergy conference Sao Paulo, Brazil, 3 presentations: "BECCUS: From innovation to deployment", "Mobilizing feedstocks and setting up supply chains", "Biobased value chain networks enabling multi-sector coupling".
- Publication of final report of Task 40 Bioeconomy Synergies 2.0 project.

Progress in R & D

Work programme and key deliverables

- Bioeconomy Synergies (BioSyn) Initiative - Biorefineries as system integrators for improved resource efficiency and system reliability (by Fabian Schipfer, Sebastian Serna-Loaiza, Bettina Muster, Judith Buchmaier, and Pralhad Burli).

The IEA Bioenergy BioSyn Initiative showcased the potential of system integration in bioeconomy networks to enhance resource efficiency, resilience, and sustainability. By leveraging diverse biomass resources and advanced biorefinery technologies, the project highlighted pathways to reduce emissions, foster circular economies, and strengthen regional development. Key outcomes include recommendations for biomimicry-inspired frameworks, policy support, and international collaboration to align bioeconomy strategies with global sustainability goals. The final report is available on the Task 40 Homepage summarizing Task 40 Bioeconomy Synergies activities. Additional insights are provided by a

presentation “Bioeconomy Synergies 2.0 - Biobased Value Chain Networks Enabling Multi-Sector Coupling" (Fabian Schipfer, TU Wien) at the BBEST+IEA Bioenergy conference (video recording), and the scientific journal publication (see following).

- Summarizing Task 40 work over the past two years (by Schipfer et al.).
- Regional Transitions 2.0 (by Hoefnagels, Ric et. al.).

The project aims to demonstrate that regionalization and commoditization strategies can work together in the energy transition, with the regional context playing a key role in the sustainability performance of bioenergy supply chains. The project is divided into two tasks that both focus on the regional context but differ in terms of the supply chain length.
Task 1 explores the regionalization of biobased value chains. Case studies include the integration of bioenergy communities for renewable natural gas production in Austria (TU Wien), bio-based innovations in Central Germany (DBFZ), and the use of risk rating for bioeconomy development in the United States and Canada (INL).
Task 2 examines regional mobilization strategies for commoditized supply chains. This task includes case studies on the role of sugar depots for biorefinery supply (University Utrecht), location factors for advanced biorefineries in Europe (INL), and biofuels rollout in Sweden (RISE). Industry input, particularly from our industrial member RWE, will provide valuable perspectives on regional mobilization strategies for resilient supply chains linked to global markets.
The project timeline includes the completion of case study reports, followed by a synthesis report that combines the individual case studies and industrial partner perspectives to be published by March 2025.

Task meetings, workshops and webinars

- 5 online Task 40 meetings and 12.-14.03. hybrid physical meeting in Washington, DC.
- 24.02. Presentation at IEA IETS Workshop Circular Carbon.
- 15.03. Conference presentation Task 40 at ABLC in Washington DC, USA, physical.
- 22.04. IEA TCP Carbon Management Coordination Group Workshop, online.
- 02.05.&18.09. IEA Bioenergy Monitoring Panel for ITP BECCUS 2.0, online.
- 22.05. Workshop "ITP Synergies", hybrid at DBFZ in Leipzig.
- 17.06. IEAB Webinar BECCUS 2.0 “Utilisation and storage of captured biogenic CO2 – Deployment in selected EU countries”, online.
- 11.07. Webinar GBEP “Understanding the climate benefits of BECCS”, on BECCUS 2.0 ITP, online.
- 12.09. DBFZ annual conference, presentation of BECCUS 2.0 ITP, online.
- 23.10. BBEST and IEA Bioenergy conference in Sao Paulo, Brazil, 3 presentations: “BECCUS: From innovation to deployment”, “Mobilizing feedstocks and setting up supply chains”, “Biobased value chain networks enabling multi-sector coupling”, physical.

Collaboration with other Tasks and organisations

- Close cooperation with different IEA TCPs like IEA Hydrogen, IEA AMF, IEA IETS, IEA ETSAP
- Task 40 participates in two of five Coordination groups initiated by IEA Paris:
  - 22.04. Workshop IEA TCP Coordination Group on Carbon Management, online.
  - 18.07. IEA TCP Coordination Group on Hydrogen, online.
- Close cooperation with other IEA Bioenergy Tasks takes place within the two strategic ITPs “Management of biogenic CO2: BECCUS 2.0” and “Synergies of green hydrogen and bio-based value chains deployment”, in particular with Tasks 32, 33, 34, 36, 37, 39, 42, 44 and 45.
- Within BECCUS 2.0 ITP four Work Package Leader meetings took place and within Synergies ITP four.
- Cooperation with GBEP on BECCS (webinar).

Dissemination

- Publication of Task 40 Newsletter in December 2024 (link).
- Up-to-date information of the Task 40 website on activities, publications and the work programme of the current triennium.
- Contribution to IEA Bioenergy Newsletter.
- Overall Task 40 contributed to and presented at 6 workshops and 3 conferences.

Main activities in 2025

- 5 Task meetings, virtual.
- Physical/hybrid Kick off Triennium 2025-2027 Task meeting 9-10 April 2025 in Stockholm, Sweden.
- Participation in second webinar "ITP Synergies" to be scheduled Q1 2025.
- Participation in ExCo96 WS “Biomass and Hydrogen – Allies for Net Zero” 15 May 2025 in Paris.
- Finalisation of work on Task project Regional transitions 2.0 and publication of summary report.
- Finalisation of work on ITP BECCUS 2.0.
- Finalisation of work on ITP Synergies.
- Kick off 2025-2027 work package activities:
    - WP1.1 Roadmap for biogenic carbon value chains.
    - WP1.2 Case studies of defossilising carbon in industry.
    - WP2.1 Showcasing Task 40 BECCUS projects – BECCUS technologies, concepts and value chains.
    - WP2.2 Continued BECCUS Intertask Project (ITP) 3.0 – carbon management around BECCUS.
    - WP3.1 Analysis of resilience of new biogenic carbon value chains.
- Newsletter publication, new-biannual format with focus on selected thematic content.

TASK 42: Biorefining[11]

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

Operating Agent: Bas Heukels, Ministry of Economic Affairs and Climate Policy.

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 the IEA Bioenergy Task 42 'Biorefining in a Circular Economy' 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 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:

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

- 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).
- 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 'Biorefining in a Circular Economy' 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

- Significant advancements have been made in the assessment of biorefinery technologies, especially in finalizing four case studies that focus on various biorefinery pathways, including fast pyrolysis, bio-LNG production, and residual wood conversion to sustainable biofuels.
- The TEE assessment methodology has been continuously reviewed.
- New data sources have been analysed with the aim of updating the information on the biorefinery plants reported in the Global Biorefineries Atlas portal.
- Tools allowing registered users to propose changes/add new information or delete a plant have been created and added.
- Two biorefinery country reports have been delivered: US & The Netherlands. A webinar was held on the 'Novel opportunities for the development of biorefineries: bio-carbon to chemicals and fuels by Integration of biorefineries and green hydrogen'. A report 'Integration of biorefineries and green hydrogen' was published.

Progress in R & D

Work programme and key deliverables

• WP1. Techno Economic Environmental (TEE) assessment of biorefinery and dissemination of results.

Key achievements include successful *TEE assessments of four biorefinery pathways*, culminating in the development of a detailed documentation reports and factsheets. Furthermore, a short summary report was written on the major findings of the work in WP1 including aspects like Cost Efficiency Optimization, Carbon Efficiency Maximization, Integration of Renewable Energy and Utilization of By-products.

• WP2. Global Biorefineries Atlas portal.

A portal registration system was developed. The tool allows registered users to propose the modification, elimination or insertion of new plants in the database. An analysis of different data sources was conducted in order to increase the quality of the data reported in the database. With the aim of guiding users in using the new tools that will be added to the portal, a PDF flip book guide and a video guide were added to the test version of the portal in a specific tool called “Help for New Tools”. New sources are acquired with the purpose of updating and collecting new data. During the webinar titled “Novel opportunities for the development of biorefineries: bio-carbon to chemicals and fuels by Integration of biorefineries and green hydrogen” the portal was shown with the functions currently available and the new functions that will be implemented.

• WP3. Current status of biorefinery deployment and best practice identification.

At least one slide deck with a *biorefinery country report* has been published in this triennium for all countries. The goal of the activity *Barriers and incentives for market diffusion* was to specify specific barriers by surveying experts in green, algal and/or lignocellulosic biorefineries. A SWOT-Analytic Hierarchy Process analysis was conducted. As barriers are often related to insufficient transfer of knowledge and different stakeholders contribute to different elements of knowledge transfer, experts were asked to rate the role and quality of knowledge transfer between research organization and industry for the commercialization of biorefineries. The survey, analysis and slide deck were completed in December 2024.

• WP4. BIOCarbon-to-Chemicals by Integration of biorefineries and green hydrogen (BIOCCI).

The activities of WP4 concerned providing the techno-economic assessment of the integration of biorefinery systems with renewable electricity systems. The *third case study* was on the direct lignin hydrogenation to produce alkyl phenols and BTX. A plant size of about 10 t/h of lignin from a lignocellulosic biorefinery in Brazil. The main economic result highlighted the production cost (without considering the hydrogen cost) of alkyl phenols is in the range 1.40 - 3.80 €/kg depending by the lignin supply cost. Furthermore, a *fourth case study* was performed considering the production of SAF (Sustainable Aviation Fuels) by Alcohol-to-Jet (AtJ) process. Converting bioethanol by dehydration, oligomerization and hydrogenation to alkanes a production cost of 1.73 - 3.00 €/kg was found supposing a SAF production of 90,000 ton/y. Finally, for the four case studies selected a green hydrogen availability analysis and modelling was performed. Literature data and modelling were used to evaluate the green hydrogen supply cost depending on the hydrogen requirement and the distance between VRE (Variable Renewable Energy) farms and the biorefinery. All results are reported the IEA Bioenergy Task 42 report ‘Integration of biorefineries and green hydrogen’.

Task meetings, workshops and webinars

- Dutch IEA Bioenergy Task leader meeting, Utrecht, The Netherlands - 30 January 2024.
- Teams Task 42 progress meeting (47) - 12 March 2024.
- Dutch MI Integrated biorefineries meeting 'Biorefineries for Fuels and Biobased Chemicals and Materials, in international collaboration', Utrecht, The Netherlands - 30 April 2024.
- IETS Task XI meetings, online, Graz, Austria - 8 April 2024.
- IEA Bioenergy webinar - Novel opportunities for the development of biorefineries: bio-carbon to chemicals and fuels by Integration of biorefineries and green hydrogen - 16 May 2024.
- Teams Task 42 progress meeting (48) - 12 June 2024.
- National Networking Meeting: Biorefining meets circular economy! Focus I: More value creation from secondary raw materials. Linz, Austria - 20 June 2024.
- Teams Task 42 progress meeting (49) - 9 September 2024.
- Teams Task 42 progress meeting (50) - 6 & 11 November 2024.

Collaboration with other Tasks and organisations

- IETS Annex XI Industry-based biorefineries towards sustainability (link) is focusing on the system analysis of biorefineries, while Task 42 is also looking broader at characterization of biorefineries (technologies, products, overview of existing biorefineries, global status of BRs etc.). Task 42 is participating in the activity on 'Decision Support Systems (DSS) and Ex-ante Research'.
- Task 42 is closely cooperating with the MI - Integrated Biorefineries Mission (link). Their goal is to Develop & Demonstrate innovative solutions to accelerate the commercialization of integrated biorefineries. Together with Brazil, Canada, the European Commission, and UK, India and the Netherlands combine their innovative strength. At the Dutch MI Integrated biorefineries meeting 'Biorefineries for Fuels and Biobased Chemicals and Materials, in international collaboration' in Utrecht, The Netherlands, a presentation called 'Task 42 Biorefining in a circular Economy' was given.

Dissemination

Dissemination and communication are essential to achieve impact. This has been 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 got attention in this Triennium.

E.g., the activities of WP4 have led to a publication in the international journal Computer Aided Chemical Engineering: "Thermodynamic approach to simulate the HydroDeOxygenation process of Lignin". Furthermore, the work was presented with an oral presentation titled "Thermodynamic approach to simulate the HydroDeOxygenation process of Lignin" during the European Symposium on Computer Aided Process Engineering 2024 in Florence. Finally, an IEA Bioenergy webinar was presented "Novel opportunities for the development of biorefineries: bio-carbon to chemicals and fuels by Integration of biorefineries and green hydrogen" on 16th May 2024.

Main activities in 2025

- WP1 - Techno Economic Environmental (TEE) assessment of biorefineries.
- WP2 - Update and maintenance of the Global Biorefineries Atlas portal.
- WP3 - Current status of biorefinery deployment per country.
- WP4 - Develop a Social Life Cycle Assessment (SLCA) model for biorefinery technologies.
- WP5 - BioRefinery and Green-Hydrogen Integration Methodology (BRGHYM) - Optimization of the integration between biorefineries and green hydrogen.
- WP6 - Green biorefineries in combination with biogas production.
- WP7 - Building materials from biorefineries.
- WP8 - Systems perspective on biorefineries based on lignocellulosic waste and side streams in a circular economy.

TASK 43: Biomass Supply[12]

Participating countries: Australia, Canada, European Commission, Finland, Germany, New Zealand, Sweden, USA.

Operating Agent: Cathryn O'Sullivan, Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia.

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

The Task addressed challenges in sustainably-sourced biomass supply chains through three key work packages (WPs):

- WP1: Analyzed and quantified opportunities for biomass production and supply.
- WP2: Enhanced supply chain efficiencies through improved handling and recovery systems.
- WP3: Developed biohubs to integrate high-value biomass supply within sustainable and circular economies.

Each WP documented strategies to optimize biomass supply, supporting bioeconomies and contributing to multiple Sustainable Development Goals (SDGs) through improved land, forest, and materials management.
The Task fostered international collaboration to develop and deploy sustainably-sourced biomass for bio-based products, energy, and fuels.

Key activities included:

- Biomass Quantification & Integration: Leveraged global expertise to explore and promote innovative biomass quantification and utilization strategies aligned with climate action initiatives and sustainable land management.

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

- Supply Chain & Pre-Processing: Enhanced biomass supply and material handling strategies to maximize reuse, repurposing, and recycling within circular economies.
- International Collaboration: Strengthened cooperative efforts to enhance the quantity, quality, value, and reliability of biomass supply in bio-based economies.

The Task focused exclusively on terrestrial biomass sources, including:
- Residues, by-products, and co-products from forestry and agriculture.
- Residues and by-products from bio-based manufacturing.
- Cellulosic biomass from post-consumer waste.
- Dedicated biomass crop systems integrated into broader land management strategies.

By effectively capturing and integrating biomass resources from waste and residues, the Task ensured sufficient supply quality and quantity to meet the needs of expanding sustainable and circular bioeconomies.

Selected highlights from Task 43

In 2024, IEA Bioenergy Task 43 published several reports:

- Residual Biomass Fuel Projections for New Zealand (Oct 2024): This report provides indicative availability of residual biomass fuels by region and source in New Zealand for 2024.
- Wildfire Resilience and Biomass Supply (Aug 2024): This publication discusses strategies to enhance wildfire resilience through sustainable biomass supply chain management.
- Environmental Sustainability Studies of Biohub Archetypes (Jan 2024): A report for the IEA Bioenergy Intertask Project on Biohubs, focusing on the environmental sustainability of various biohub models.
- Identifying Key Quality Characteristics of Woody Biomass for Bioenergy Application: An International Review (Jan 2024): This review highlights essential quality attributes of woody biomass critical for efficient bioenergy production.

Progress in R & D

Work programme and key deliverables
Three key areas saw significant deliverables from the Task in addition to the collaborative report on socio-economic impacts.
A report was delivered that highlights the key drivers in biomass quality for sustainable bioenergy production. Of particular interest is that the most important characteristic, that impacts the quality and logistics is moisture content and is one that the Task and research more broadly has helped develop strategies to better manage moisture content through smart supply chains and more recently biohubs. In the biobubs space, we published a report that shows the significant role well designed biohubs, linking local resources with local demand, play in enabling emission reduction in energy production. The report shows biohubs playing an enabling role in 60% to 90% emission reductions.

There was also a series of workshops over the triennium in the context of record fire seasons in many countries around the world. The work explored what role biomass harvesting could play both in the mitigation of fire risk, by removing biomass fuel from forests, as well as what role biomass harvesting might play in providing added economic value to salvage harvests after a fire. The expert consultation showed a strong, economically viable role for biomass harvesting in both cases and ultimate success will rest in supportive policy that includes biomass recovery as part of the mitigation and recovery tools.

Task meetings, workshops and webinars

WEBINARS/WORKSHOPS

1. Inter-task collaboration workshop via video conference, January 2023.
2. Understanding Indirect Land-Use Change (ILUC) and Why Reality is a Special Case webinar via video conference, 28 June 2023.
3. Biohubs workshop via video conference, 27 July 2023.
4. Wildfire Resilience and Biomass Supply workshop, 5 October 2023.

TASK MEETINGS

- 01/2023 via video conference, 9 February 2023.
- 02/2023 via video conference, 21 March 2023.
- 03/2023 via video conference, 26 April 2023.
- 04/2023 via video conference, 1 June 2023.
- 05/2023 via video conference, 6 July 2023.
- 06/2023 via video conference, 24 August 2023.
- 07/2023 face-to-face, 2-6 October 2023.
- 08/2023 via video conference, 7 December 2023.

Collaboration with other Tasks and organisations

As is typically the case we have retained our close working relationship with Task 45 as well as collaborating with GBEP in the delivery of our sustainable biomass supply work. We have also lead a collaborative strategic project on the socio-economic impacts of bioenergy that captured input from a number of Tasks.

Dissemination

- The task relies on its website to disseminate and communicate key findings. Four new activity reports were posted on the website during 2024.
- In January 2025, the task engaged ETA Florence to upgrade and redesign the website. Additional work will be done to upgrade and refresh the website during the first quarter of 2025.
- In the last quarter of 2024, the Task also established its LinkedIn showcase page (link) which now has 439 followers.

Main activities in 2025

2025 will have a focus of wrapping up the previous triennium work and translating results and ongoing knowledge gaps into the new work plan. The Task has picked up some preliminary work started in 2024 by the Biofuture Platform collaborators to create greater consistency in how we understand sustainable biomass availability assessments around the world. Often described as a better understanding of global sustainable biomass supply, the project will actually seek to understand the range of methods in use, identify common threads in those methods and progress a suggested structure or framework of assessment that will ensure regional efforts can contribute meaningfully to global estimates. The Task will also seek to extend the early work on social and socio-economic implications of bioenergy looking at specific communities that have different needs and expectations of land management and the ultimate supply of natural resources and will start with first nations in CAN and AU.

TASK 44: Energy System / Flexibility[13]

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

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

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

Co-Task Leader: Miia Nevander, VTT - Technical Research Centre of Finland Ltd, Finland.

Task Secretary: Nora Lange, 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 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 either under demonstration or development, but policy frameworks and market mechanisms to valorise the benefits from flexible bioenergy are not yet in place. Thus, the focus of the Task is in showing the system services and value it can provide, and connecting flexible bioenergy to a 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 analyses the status of flexible bioenergy implementation in different countries. Potential synergies with green hydrogen and BECCU/S value chains are of special interest.

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

Key objectives of Task 44 are:
1. To identify and evaluate viable flexible bioenergy concepts for supporting low-carbon energy systems.
2. To accelerate the implementation of flexible bioenergy concepts.
3. 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

- Participation in two of five Coordination groups initiated by IEA Paris:
  - IEA TCP Coordination Group on Energy System Flexibility.
  - IEA TCP Coordination Group on Thermal networks.
- Workshop + work package leaders' meeting ITP Synergies of Green Hydrogen and Bio-Based Value Chains Deployment", physical.
- Publication of report "Implementation of flexible bioenergy in different countries".
- Open access article: Defining bioenergy system services for accelerating the integration of bioenergy into a low-carbon economy. Journal Biofuels, Bioproducts and Biorefining (BioFPR).
- Two Webinars together with World Bioenergy Association (WBA), online.
- Webinar of ITP Synergies: "Synergies of renewable hydrogen and biobased value chains: case studies", online.
- Conference presentation at BBEST and IEA Bioenergy conference in Sao Paulo, Brazil und participation in panel discussion, physical.
- Publication of four different Best practise examples at Task 44 website.

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.
Publication of four different Best practice examples during January and December 2024:
1. Pellet production linked to combined heat and power plant. The combined heat and power plant in Falun is linked to a wood pellet plant. This allows for longer running times and higher power production as the surplus heat can be used for the dryer in the pellet plant.
2. BECC – from base-load biomass CHP to a flexible energy hub.
3. EMPYRO - biomass to pyrolysis oil. This example highlights BTG Bioliquids' fast pyrolysis technology, demonstrated at a commercial scale of 25 MWth.
4. Flexibility through biomass gasification: Task 33 database and Nong Bua DFB gasifier example. Introduction to gasification database of IEA Bioenergy Task 33.

WP3 – Acceleration of flexible bioenergy concepts implementation.
- Report "Implementation of flexible bioenergy in different countries".

As part of this WP Task 44 published a report on "Implementation of flexible bioenergy in different countries" in May 2024. The publication involved 14 countries and the European Commission who responded to an extensive questionnaire on the status and development of flexible bioenergy. The results show that flexible bioenergy is being considered in many different applications and it is prioritized differently in countries. However, insufficient policy instruments and market mechanisms are seen as main barriers for accelerating flexible bioenergy in almost all countries surveyed. An report on expectations for flexible bioenergy in different countries and a summary report will follow.

Dissemination of Task 44.

- Open access article: Mäki, E., Hennig, C., Thrän, D., Lange, N., Schildhauer, T., Schipfer, F. (2024): Defining bioenergy system services for accelerating the integration of bioenergy into a low-carbon economy. Journal Biofuels, Bioproducts and Biorefining (BioFPR). https://doi.org/10.1002/bbb.2649

Interest in flexible operation of bioenergy value chains, bioenergy with carbon capture and utilization as well as synergies with renewable hydrogen-based value chains has increased recently. The objective of this paper is to present a holistic definition of flexible bioenergy as a system service based on the work conducted in Task 44, and to provide some practical examples. The paper also presents the different bioenergy system services and considers their definitions and interactions, as this is important in energy system design. The definition of flexible bioenergy shows that the flexibility provision from bioenergy goes far beyond the traditional definition of providing short-term flexibility in the power sector. Indicators to demonstrate the value of services as well as further quantitative assessment of synergies and trade-offs are needed to valorise the different services from bioenergy and create viable business cases.

Task meetings, workshops and webinars

- 7 days of online Task meetings and one hybrid meeting in Switzerland 11.-12.4.2024.
- IEA Coordination Group meeting Energy System Flexibility - led by CERT, Energy Storage TCP, physical.
- IEA Coordination Group meeting Thermal networks - led by DHC TCP, online.
- IEA Bioenergy Monitoring Panel for ITP Synergies, first joint meeting, online.
- IEA Bioenergy Monitoring Panel for ITP BECCUS Phase 2 | first joint meeting, online.
- Workshop + work package leaders' meeting ITP Synergies of Green Hydrogen and Bio-Based Value Chains Deployment", physical.
- Webinar: Bioenergy for Flexibility in Energy Systems; Task 44 together with World Bioenergy Association (WBA), online.
- Webinar: Bioenergy for Flexibility in Energy Systems – Part II: Heat Demand, World Bioenergy Association (WBA), online.
- Webinar of ITP Synergies: "Synergies of renewable hydrogen and biobased value chains: case studies", online.
- Presentation at BBEST and IEA Bioenergy Conference.

Collaboration with other Tasks and organisations

- Task 44 was working in close collaboration with different IEA TCPs, such as IEA Hydrogen, IEA AMF, IEA IETS, IEA ETSAP, IEA SHC, and IEA DHC:
  - 16.5.2024 IEA Coordination Group meeting Energy System Flexibility - led by CERT, Energy Storage TCP, physical in Rome.
  - IEA TCP Coordination Group meeting on Thermal networks- led by DHC TCP, online.
- Close cooperation with other IEA Bioenergy Tasks was maintained through the two strategic ITPs “Management of biogenic CO2: BECCUS 2.0” and “Synergies of green

hydrogen and bio-based value chains deployment". Collaboration was tight especially with Tasks 32, 33, 34, 36, 37, 39, 42, 44 and 45.
- BECCUS 2.0 ITP Work Package had four and Synergies ITP Work Package had four Lead Team meetings in which Task 44 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 at 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.
- Task 44 work was presented in 5 workshops/webinars and 1 conference.

Main activities in 2025
- Task 44 will have several virtual Task meetings, e.g., physical/hybrid Kick off Triennium 2025-2027 Task meeting 25-26 March 2025 in Laxenburg, Austria.
- Task 44 will deliver reports on 'Flexible Bioenergy Policies', Summary of both policy reports, 'Technologies for Flexible Bioenergy', Value report no1 and Value report n. 2 in Q1 2025.
- Task 44 will publish a 20 pages article in IEAB Annual report 2024.
- Best Practice examples will be added to our collection.
- Task 44 will participate in second webinar "ITP Synergies" to be scheduled Q1 2025.
- Task 44 will participate at EUBCE 2025 with a presentation.
- Conference participation at ExCo96 WS "Biomass and Hydrogen – Allies for Net Zero".
- ITP Management of Biogenic CO2: BECCUS Inter-task Phase 2 has ongoing work and the work in WP4 will be finalized.
- ITP Synergies of green hydrogen and bio-based value chains deployment has ongoing work and the project will be finalized.

TASK 45: Climate & Sustainability[14]

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

Operating Agent: Anna Malmström, 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.

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:

- 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

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

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

- Workshop - Forests, forestry and carbon balances - investigated how policies and forest sector responses can influence carbon storage in forests and forest products. Participants discussed global, regional and country-level studies, and issues related to methodology and data. Discussions concluded with some cautionary observations, including that 'leave alone' forest strategies do not take into account the lock-in effect for future generations, the issue of 'perfect foresight' and the assumption of perfectly rational agents in economic modelling, and the risks of inappropriate use of counterfactuals leading to misleading results.

- Workshop - Quantifying biodiversity impacts in bioenergy systems - provided an overview of the state-of-the-art in assessing biodiversity impacts in life cycle assessment to inform decisions affecting land use and land-use-change. A way forward was discussed to assist and accelerate the integration of biodiversity considerations into policy and businesses.

Progress in R & D

Work programme and key deliverables

- Multifunctional bioenergy and mitigating land use change emissions:
  - Future-oriented visioning of agri-food and land systems invites broader consideration of how these systems become integrated with, inter alia, future energy sources and bio-based value chains in a sustainable and resilient economy, operating within planetary boundaries.
  - There are a range of options for sustainably expanding bioenergy generation using organic residue and waste streams as well as agriculture and forestry systems that provide biomass while supporting biodiversity and a broad range of ecosystem services.
  - Policy measures and strategies for land and biomass use can be tailored to regional circumstances, balancing biomass production for bioenergy and other bio-based products with land carbon storage and other objectives.
  - Illustrative of this, increased use of grasses in crop rotations can support the development of biorefineries, providing protein feed, bioenergy and a range of other products, while improving soil carbon storage and productivity, and reducing deforestation pressures from increased global feed demand.

- Biomass, carbon balances and climate effects:
  - A review of the scientific literature on biomass, carbon balances and climate impacts inevitably leads to the conclusion that "it depends". Carbon storage in vegetation and soils may increase or decrease as landowners plan their land use in response to the expected increase in demand for biomass, and the portfolio of bio-based products determines the biogenic carbon storage in society and the GHG savings from substitution.
  - Emerging carbon capture and utilization/storage systems offer additional opportunities for effective mitigation. Biomass remains a critical resource, but the provision of biogenic carbon may in the future have a higher value than the provision of energy in a net zero energy system.

- Sustainability governance:
  - The development of the GHG Protocol Land Sector and Removals Guidance has been significantly delayed and some proposed inventory methodologies have been questioned. While continued engagement is essential to ensure sound guidance, we are concerned that the process has become less transparent and inclusive of critical voices.
  - There are diverging views on the treatment of temporary carbon storage in corporate inventories and project accounting, and in emissions trading. Further research is needed to inform decisions on approaches to recognizing the climate impacts of temporary carbon storage in accounting and economic transactions.
  - The increased awareness of the biodiversity crisis has resulted in an urge from businesses and decision makers to address biodiversity loss and contribute to a transformation towards sustainable use of natural resources
  - The lack of a single biodiversity indicator or the complexity of measurement can be perceived as barriers, quantitative tools such LCA brings undoubtedly an opportunity to companies and policy makers to better understand various biomass supply chains, when applied coherently.
  - Greater awareness and control enables for a realm of actions to reduce biodiversity impacts, and improved biodiversity impact models and collection of life cycle inventory data, e.g. based on appropriate biodiversity indicators and remote sensing methodologies, will open for increasingly applicable assessments.

Task meetings, workshops and webinars

Task meetings: during 2024 the task had nine virtual meetings and two physical (hybrid) meetings, placed back-to-back with (i) a joint workshop with GBEP and the University of Surrey in Guildford, UK; and (ii) the BBEST & IEA Bioenergy Conference in Sao Paulo, Brazil. The Task participated and took part in the organization of the following workshops/conferences:

- Workshop, 27 March: Forests, forestry and carbon balances. Organized together with Global Bioenergy Partnership (GBEP), and University of Surrey.
- Field visit to Drax power station, 28 March, including a meeting on sustainability issues with their global sustainability team.
- Hybrid workshop, 13 June: Quantifying biodiversity impacts in bioenergy systems. Organized together with the Royal Swedish Academy of Agriculture and Forestry, and Lund University.
- Two sessions, during the BBEST & IEA Bioenergy Conference in Sao Paulo, 22-24 October.

Collaboration with other Tasks and organisations

- Task 45 members contributed to the work in two inter-task projects:
  - Synergies of green hydrogen and bio-based value chains deployment.
  - Management of biogenic CO2: BECCUS phase 2.
- Task 45 continues to collaborate with other Tasks as well as the UNCCD secretariat, FAO, GBEP, UNEP, IRENA, and Biofuture Platform.
- Task 45 associates participated in expert groups and advisory committees connected to the development of standards and guidance documents within ISO, UNEP Life Cycle Initiative, and GHG Protocol.
- The Task works with universities and institutes to co-organise events. This year, the University of Surrey and the Royal Swedish Academy of Agriculture and Forestry helped to organise two workshops.

Dissemination

Dissemination is carried out in association with workshops, webinars, conferences, collaboration with organizations outside IEA Bioenergy, through publications, and our website (>2000 unique visitors during 2024).

- Reports & commentaries:
  - Evaluation of the Brazilian RenovaBio conversion-free criteria on land use change emissions.
  - The role of bioenergy in the energy transition, and implications on the global use of biomass.
  - Future visioning of bioenergy within multifunctional landscapes and value chains.
  - Biomass exclusion must be weighed against benefits of carbon supply in European
  - energy system.

- Scientific articles:
  - Diversity of biomass usage pathways to achieve emissions targets in the European energy system.
  - Evaluating metrics for quantifying climate-change effects of land-based carbon fluxes.
  - Defining national net zero goals is critical for food and land use policy.

The updated Task webpage was visited by over 2000 unique visitors during 2024.

Main activities in 2025

- Publishing while finalizing projects from previous triennium:
  - Forests, forestry and carbon balances: importance of policies and forest sector responses.
  - Timing of emissions and temperature impacts of biomass-based vs fossil systems.
  - New approaches to crediting temporary C storage.
  - LCA indicators relevant to sustainability of bioenergy.
  - Biochar systems: renewable energy and carbon dioxide removal.
  - Robustness of GHG emission information from the certification of biofuels.
  - What does 'Nature Positive' look like for the bioenergy sector.
  - Quantifying biodiversity impacts of bioenergy system.
  - Sustainability aspects of using of agricultural and forestry residues for bioenergy and BECCS.

- New projects:
  - Biomass production in multifunctional landscapes.
  - Land management and cascading biomass use for net zero.
  - Impacts of policy instruments on existing bioenergy value chains.
  - A comparison and evaluation of governance and verification instruments using voluntary sustainability.

APPENDIX 1: TASK PARTICIPATION IN 2024

	Aus	Aut	Bel	Bra	Can	Cn	Den	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			1				9
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			15
Task 39		1	1	1	1	1	1	1			1		1		1	1	1	1			**1**			1	1	16
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			1			1		8
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**	**7**	**4**	**5**	**3**	**11**	**3**	**5**	**4**	**2**	**1**	**9**	**3**	**4**	**1**	**8**	**3**	**3**	**9**	**1**	109

* Limited Sponsor

1 = Participating in Task
1 = Operating Agent

APPENDIX 2: BUDGET IN 2024: SUMMARY TABLES

Budget for 2024 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	9,700	45,000	54,700
Denmark	13,700	108,500	122,200
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	**268,800**	**1,652,500**	**1,921,300**

Budget for 2024 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	15	14,000	210,000
Task 39: Transport biofuels	16	15,000	240,000
Task 40: Biobased deployment	6	15,000	90,000
Task 42: Biorefining	7	17,500	122,500
Task 43: Biomass supply	8	15,000	120,000
Task 44: Energy system / flexibility	8	15,000	120,000
Task 45: Climate & sustainability	13	15,000	195,000
Total		**1,652,500**	**1,681,500**

APPENDIX 3: CONTRACTING PARTIES

University of the Sunshine Coast (Australia)

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 Ministry of Transport and Energy, Danish Energy Authority

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 for Energy Security and Net Zero (United Kingdom)

The United States Department of Energy

APPENDIX 4: LIST OF REPORTS

IEA Bioenergy: Countries' Report - update 2024

The updated IEA Bioenergy Country Reports show the trends of bioenergy in the IEA Bioenergy member countries up to 2022, highlighting the role of bioenergy in their energy mix. The analysis is based on data from the 2024 IEA World Energy Balances and Renewables Information, combined with input provided by the IEA Bioenergy Executive Committee members.

Read more

Factsheet: What is bioenergy?

Bioenergy is renewable energy derived from biomass. Biomass is defined as organic material derived from plants and animals. Examples of biomass used for bioenergy are woody biomass, multipurpose crops and dedicated biomass crops, and organic waste/ residues from industry, agriculture, forest and landscape management, and households.

Read more

Residual biomass fuel projections for New Zealand

The goal of this report and the accompanying tables is to describe the woody biomass residue resources in New Zealand by volume, type, energy content, and region over time for the coming 30 years (from 2024 to 2053). The focus is on existing resources derived from established forests, processing, residue streams etc. The report was produced by Scion in the frame of IEA Bioenergy Task 43 (biomass supply)..

Read more

Flexibility by fast pyrolysis in renewable energy systems

With the increasing contribution of variable renewable energy sources in primary power production, there is a clear need to provide additional flexibility to ensure supply and demand remain properly balanced.

Read more

Evaluation of the Brazilian RenovaBio 'conversion-free' criteria on land use change emissions related to biofuels

Dealing with Land Use Change (LUC) emissions is the most challenging aspect of any bioenergy program, and this has a central role in defining policy. Induced Land Use Change (ILUC) emissions cannot be measured, and there is no consensus on the best way to estimate a quantitative ILUC value

Read more

Biofuels in emerging markets of Africa and Asia - An overview of costs and greenhouse gas savings

This policy brief highlights the critical potential of biofuels in reducing greenhouse gas (GHG) emissions in the transportation sector in emerging markets of Africa and Asia.

Read more

BBEST & IEA Bioenergy Conference 2024

Every three years IEA Bioenergy organizes a conference to present the main developments in the bioenergy field. After successful events in 2012 (Vienna), 2015 (Berlin), 2018 (San Francisco) and 2021 (online), we now teamed up with BBEST – the Brazilian Bioenergy Science and Technology Conference – which is held every three years in Brazil.

Read more

Food Loss and Waste: Quantification, Impacts and Potential for Sustainable Management

This report provides an overview of food waste and its potential role as a feedstock for material and energy valorisation. It was prepared within the framework of IEA Bioenergy Task 36.

Read more

From base-load biomass CHP to a flexible energy hub

Bio-Energy Centrale Cuijk (BECC) is transforming from a base-load solid biomass power plant to a flexible renewable energy hub, which is steered on optimizing operational margin instead of maximizing MWh output.

Read more

State of the biogas industry in 12 member countries of IEA Bioenergy Task 37

This publication contains a compilation of country report summaries from the following member countries of IEA Bioenergy Task 37 (Energy from Biogas): Brazil, Canada, China, Denmark, Finland, France, Germany, Ireland, Norway

Read more

Renewable CO_2 from food waste based biogas - a case story from Switzerland

Biogenic CO_2 will be increasingly required in the future as substitute for fossil CO_2 for chemical and food industries, as CO_2 source for Carbon Capture and Storage (for negative emissions) and as renewable carbon source for carbon containing e-fuels or e-products.receiving much attention. In particular, the development of low carbon Aviation and Marine fuels are being demanded by international transportation. This creates a growing interest in biofuels for aviation and maritime transport.

Read more

Low emission biomass combustion in automated boilers for heat and power

IEA Bioenergy Task 44 (Flexible bioenergy and system integration) publishes good practice examples on flexible bioenergy to showcase the multiple benefits and services that flexible bioenergy can provide.

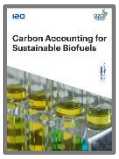
Read more

Commercialization of drop-in biofuels and coprocessing

Transport-related emissions are still growing, with fossil fuels contributing more than 90% of the energy demand required by this sector.

Read more

IEA: Carbon accounting is of increasing importance in biofuel policies around the world



Transport-related emissions are still growing, with fossil fuels contributing more than 90% of the energy demand required by this sector.

Read more

Priorities for the sustainability criteria of biomass supply chains for energy

This study aims to identify the criteria perceived to have the highest preference when evaluating the sustainability of biomass supply chains. The data includes the assessments of 122 international experts from 23 countries providing their evaluations through a questionnaire.

Read more

Evaluating Metrics for Quantifying the Climate-change Effects of Land-based Carbon Fluxes

New paper published in the International Journal of Life Cycle Assessment, based on a study carried out in the frame of IEA Bioenergy Task 45 (Sustainability).

Read more

Key quality characteristics of woody biomass for bioenergy application: an international review

This research was initiated by IEA Bioenergy Task 43 (Biomass Supply) with the aim to review and identify the top biomass characteristics as they relate to commercially viable biomaterial and bioenergy processes.

Read more

Environmental sustainability studies of biohub archetypes

Biohubs are increasingly seen as essential to the cost-effective deployment of bioenergy at scale for decarbonising hard-to-abate sectors like heavy-duty vehicles and heat.

Read more

Environmental sustainability studies of biohub archetypes

Biohubs are increasingly seen as essential to the cost-effective deployment of bioenergy at scale for decarbonising hard-to-abate sectors like heavy-duty vehicles and heat.

Read more

Case study about a MSW sorting facility in Italy – Eco+Eco Srl

This report is part of a series of reports to explore lessons on sorting technologies for waste in the field of material and energy valorisation of waste within the framework of IEA Bioenergy Task 36. The purpose 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

Gasification of liquids derived from Direct Thermochemical Liquefaction

In this report, produced in the frame of IEA Bioenergy Task 34 (Direct Thermochemical Liquefaction), an overview is presented on the status of DTL-oil gasification on pilot- and demo-scale (TRL ≥ 5). Moreover, potential alternatives such as the gasification of DTL by-products and hybrid gasification systems are briefly discussed.

Read more

Production of chemicals and materials from direct thermochemical liquefaction

Two prominent direct thermochemical liquefaction technologies, Pyrolysis and Hydrothermal Liquefaction (HTL), are pivotal in unlocking the potential of biomass. This report – produced by IEA Bioenergy Task 34 – delineates the principles, potential, and challenges inherent to these technologies, along with the outlook for deriving valuable products.

Read more

Integration of anaerobic digestion with Power-to-X technologies

There will be a future role for renewable power to produce other energy carriers and chemicals. A pathway to convert this hydrogen to a renewable hydrocarbon is to react with biogenic CO2. One of the most prominent sources of high concentration biogenic CO2 may be from biomethane systems. This IEA Bioenergy Task 37 report aims to provide an overview of the role that anaerobic digestion can play in Power to X technologies.

Read more

Energy from waste: Regional Sustainability Workshop Series

Between November 2022 and October 2023, IEA Bioenergy Task 36 organized three informative 'Regional Sustainability Workshops' on regionally relevant waste management systems with the participation of stakeholders to consider the most relevant sustainability indicators.

Read more

Overview of Thermochemical Liquefaction activities in Canada, Germany and the United States

This report provides an overview of research activities, demonstration activities and commercial applications of Direct Thermochemical Liquefaction of biomass in Canada, Germany and the United States.

Read more

Biofuels production and development in New Zealand

This is a feature article in IEA Bioenergy Task 39 Newsletter Issue n. 64, by Paul Bennett, Scion. With New Zealand's main sectors of GDP being exported products and Tourism, greening of international transportation is receiving much attention. In particular, the development of low carbon Aviation and Marine fuels are being demanded by international transportation. This creates a growing interest in biofuels for aviation and maritime transport.

Read more

Flexible Bioenergy and System Integration: Best Practices

IEA Bioenergy Task 44 (Flexible bioenergy and system integration) publishes good practice examples on flexible bioenergy to showcase the multiple benefits and services that flexible bioenergy can provide.

Read more

IEA Bioenergy Annual Report 2023

The IEA Bioenergy Annual Report 2023 includes a special feature article on 'Emissions from Biomass Combustion' prepared by Task 32.

Read more

Implementation of flexible bioenergy in different countries

In energy systems with rising shares of variable energy sources like solar and wind, bioenergy has an increasingly important role to play, particularly in fields where alternative renewable energy sources are difficult or costly to provide.

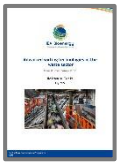
Read more

Progress in Commercialization of Biojet/Sustainable Aviation Fuels (SAF): Technologies and policies

IEA Bioenergy Task 39 has already published several SAF related reports, with the latest dedicated report in 2021 (on biojet/SAF commercialization). The current report has a dominant focus on technologies, key developments in commercialization and recent research-and-development trends.

Read more

Advanced Sorting Technologies in the Waste Sector – case studies compilation



This report is produced by IEA Bioenergy Task 36 (material and energy valorisation of waste in a circular economy), and includes two case studies highlighting the use of new technologies in the waste management industry for increasing material recovery of waste fractions that otherwise might go to energy recovery or be landfilled. The material recovered has a sufficient quality for being recycled contributing to reach the recycling targets.

Read more

The circular bioeconomy: a driver for system integration

New open-access paper published in the Journal Energy, Sustainability and Society, based on a work carried out by members of IEA Bioenergy Task 40 (deployment) and Task 44 (flexibility and system integration).

Read more

Defining bioenergy system services to accelerate the integration of bioenergy into a low-carbon economy

New open-access paper published in the Journal Biofuels, Bioproducts & Biorefining (BioFPR), developed in the frame of IEA Bioenergy Task 44 (flexible bioenergy and system integration).

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.

The Task is organised with 'National Teams' in the participating countries. These countries and the respective National Team Leaders for 2024 are listed below.

Country	National Team Leader	Institution
Austria	Christoph Schmidl	BEST – Bioenergy and Sustainable Technologies
Canada	Sebnem Madrali	National Resources Canada
Denmark	Morten Tony Hansen	Ea Energy Analyses
Germany	Hans Hartmann	Technologie- und Förderzentrum
Japan	Masayuki Mizuno	New Energy and Industrial Technology Development Organization (NEDO)
The Netherlands	Jaap Koppejan	Pro Biomass BV
Norway	Øyvind Skreiberg	SINTEF
Switzerland	Thomas Nussbaumer	Verenum

TASK 33 – Gasification

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

Task Leader: Berend Vreugdenhil, Ministry of Economic Affairs and Climate Policy, The Netherlands.

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

The Task is organised with 'National Teams' in the participating countries. These countries and the respective National Team Leaders for 2024 are listed below.

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Austria	Jitka Hrbek	University of Natural Resources and Life Sciences
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Canada	Travis Robinson	National Resources Canada
China	Guanyi Chen	Tianjin University
France	Chourouk Nait Saidi	Pyrogasification Club (ATEE)
Germany	Sabine Fleck	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.

The Task is organised with 'National Teams' in the participating countries. These countries and the respective National Team Leaders for 2024 are listed below.

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Denmark	Lasse Rosendahl	Aalborg University
Finland	Christian Lindfors	VTT (Technical Research Centre of Finland Ltd.)
Germany	Axel Funke	Karlsruhe Institute of Technology (KIT)
India	Pramod Kumar	HP Green R&D Centre
The Netherlands	Bert van de Beld	BTG (Biomass Technology Group)
New Zealand	Francois Collard	Scion
USA	Micheal Thorson	PNNL (Pacific Northwest National Laboratory)

TASK 36 – Waste & Circular Economy

Operating Agent: Anna Malmström, Swedish Energy Agency.

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

The Task is organised with 'National Teams' in the participating countries. These countries and the respective National Team Leaders for 2024 are listed below.

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Ireland	Fionnuala Murphy	University College Dublin (UCD)
Italy	Giovanni Ciceri	RSE - Research on Energy Systems
Norway	Michäel Becidan	SINTEF
South Africa	Cristina Trois	University of KwaZulu-Natal
Sweden	Mar Edo	RISE Research Institutes of Sweden
USA	Beau Hoffman	Department of Energy - Bioenergy Technology Office U.S

TASK 37 – Anaerobic Digestion / Biogas

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

Task Leader: Jan Liebetrau, Rytec Consulting, Germany.

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Finland	Saija Rasi	Natural Resources Institute Finland (Luke)
France	Julien Thual	ADEME
Germany	Jan Liebetrau	Rytec Consulting
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Ireland	Jerry D Murphy	University College Cork, MaREI Centre
Italy	Marco Pezzaglia	Consorzio Italiano Biogas (CIB)
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Norway	Kari-Anne Lyng	Norwegian Institute for Sustainability Research
Sweden	Jonas Ammenberg	Linköping University
Switzerland	Hajo Nägele	ZHAW Zürcher Hochschule für Angewandte Wissenschaften
United Kingdom	Sonia Heaven	University of Southampton

TASK 39 – Transport Biofuels

Operating Agent: Anna Malmström, Swedish Energy Agency.

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

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

The Task is organised with 'National Teams' in the participating countries. These countries and the respective National Team Leaders for 2024 are listed below.

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Denmark	Sune Tjalfe Thomsen	University of Copenhagen
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Ireland	Tom Walsh	Renetech
Japan	Yuta Shibahara	New Energy and Industry Technology Development Organization (NEDO)
Korea	Chan Hyun Ko	Korean Institute of Energy Research
The Netherlands	Paul Sinnige	Netherlands Enterprise Agency (RVO)
New Zealand	Paul Bennett	Scion
Sweden	Tomas Ekbom	Swedish Bioenergy Association (SVEBIO)
USA	Ling Tao	National Renewable Energy Laboratory (NREL)
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: Christiane Hennig, DBFZ- Deutsches Biomasse Forschungszentrum, Germany.

The Task is organised with 'National Teams' in the participating countries. These countries and the respective National Team Leaders for 2024 are listed below.

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Sweden	Karin Pettersson	RISE Research Institutes of Sweden
USA	Richard Hess	Idaho National Laboratory

TASK 42 – Biorefining

Operating Agent: Bas Heukels, Ministry of Economic Affairs and Climate Policy, The Netherlands.

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.

The Task is organised with 'National Teams' in the participating countries. These countries and the respective National Team Leaders for 2024 are listed below.

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Germany	Heinze Stichnote	Thünen-Institute of Agricultural Technology
Ireland	J.J. Leahy	University of Limerick
Italy	Isabella De Bari	ENEA
The Netherlands	Bert Annevelink	Bert Annevelink, Wageningen Food and Biobased Research (WFBR)
USA	Mark Shmorhun	U.S. Department of Energy - Office of Energy Efficiency and Renewable Energy

TASK 43 – Biomass Supply

Operating Agent: Mark Brown, University of the Sunshine Coast, Australia.

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.

The Task is organised with 'National Teams' in the participating countries. These countries and the respective National Team Leaders for 2024 are listed below.

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Germany	Jörg Schweinle	von Thünen-Institute (vTI)
New Zealand	Peter Hall	Scion
Sweden	Jannis Dimitriou	Swedish University of Agricultural Sciences
USA	Thomas M. Schuler	USDA Forest Service

TASK 44 - Energy Systems / Flexibility

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

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

Co-Task Leader: Miia Nevander, VTT - Technical Research Centre of Finland Ltd, Finland.

The Task is organised with 'National Teams' in the participating countries. These countries and the respective National Team Leaders for 2024 are listed below.

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Finland	Miia Nevander	VTT – Technical Research Centre of Finland Ltd
Germany	Daniela Thrän	UFZ/DBFZ
The Netherlands	Jaap Kiel	TNO
Sweden	Kjell Andersson	Swedish Bioenergy Association (SVEBIO)
Switzerland	Tilman Schildhauer	Paul Scherrer Institute
USA	Ian Rowe	U.S. Department of Energy

TASK 45 - Climate & Sustainability

Operating Agent: Anna Malmström, 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.

The Task is organised with 'National Teams' in the participating countries. These countries and the respective National Team Leaders for 2024 are listed below.

Country	National Team Leader	Institution
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China	Dou Kejun	China National Renewable Energy Centre, CNREC
Denmark	Niclas Scott Bentsen	University of Copenhagen
European Commission	Biljana Kulišić	European Commission – DG ENER
Finland	Kati Koponen	VTT (Technical Research Centre of Finland Ltd.)
France	Anne-Laure Dubilly	ADEME
Germany	Stefan Majer	Deutsches Biomasseforschungszentrum (DBFZ)
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Norway	Francesco Cherubini	Norwegian University of Science and Technology
Sweden	Göran Berndes	Swedish University of Agricultural Sciences
United Kingdom	Zoe Harris	University of Surrey
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APPENDIX 6: EXCO REPRESENTATIVES IN 2024

	Member	Alternate Member
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BELGIUM	**Dr Thibaut Masy** Centre wallon de Recherches agronomiques Bâtiment Francini Chaussée de Namur 146 5030 Gembloux Email: t.masy(at)cra.wallonie.be	**To be announced**
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