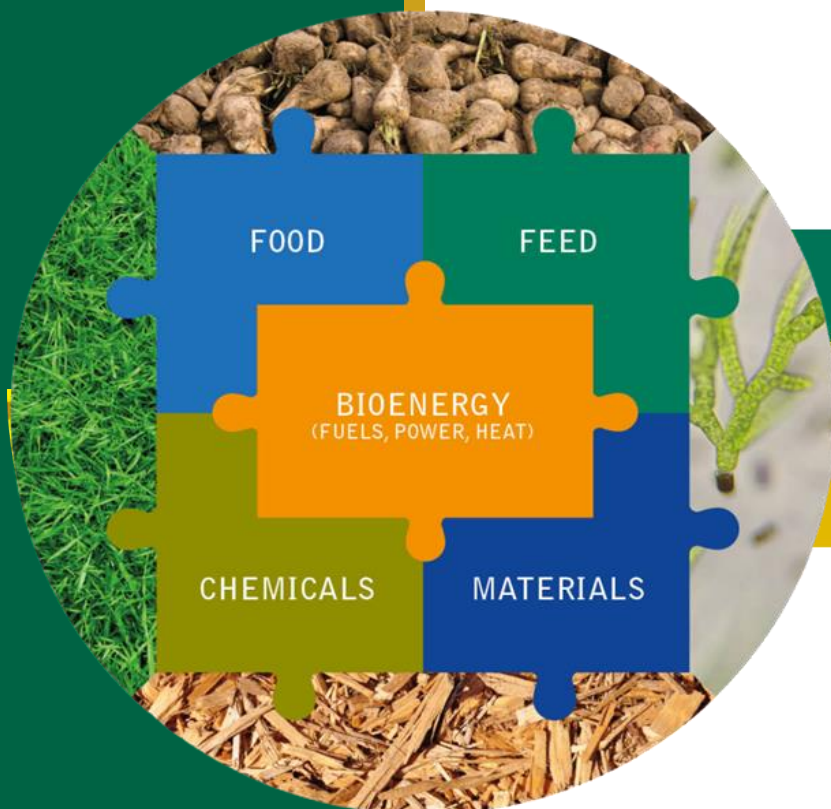


The Role of Biorefining and Bioenergy in the Circular Economy



René van Ree

Coordinator IEA Bioenergy Task42

Wageningen Food and Biobased Research

BIOECONOMY POLICY DAY, Brussels, Belgium,

16 November 2017 – Session DG ENER

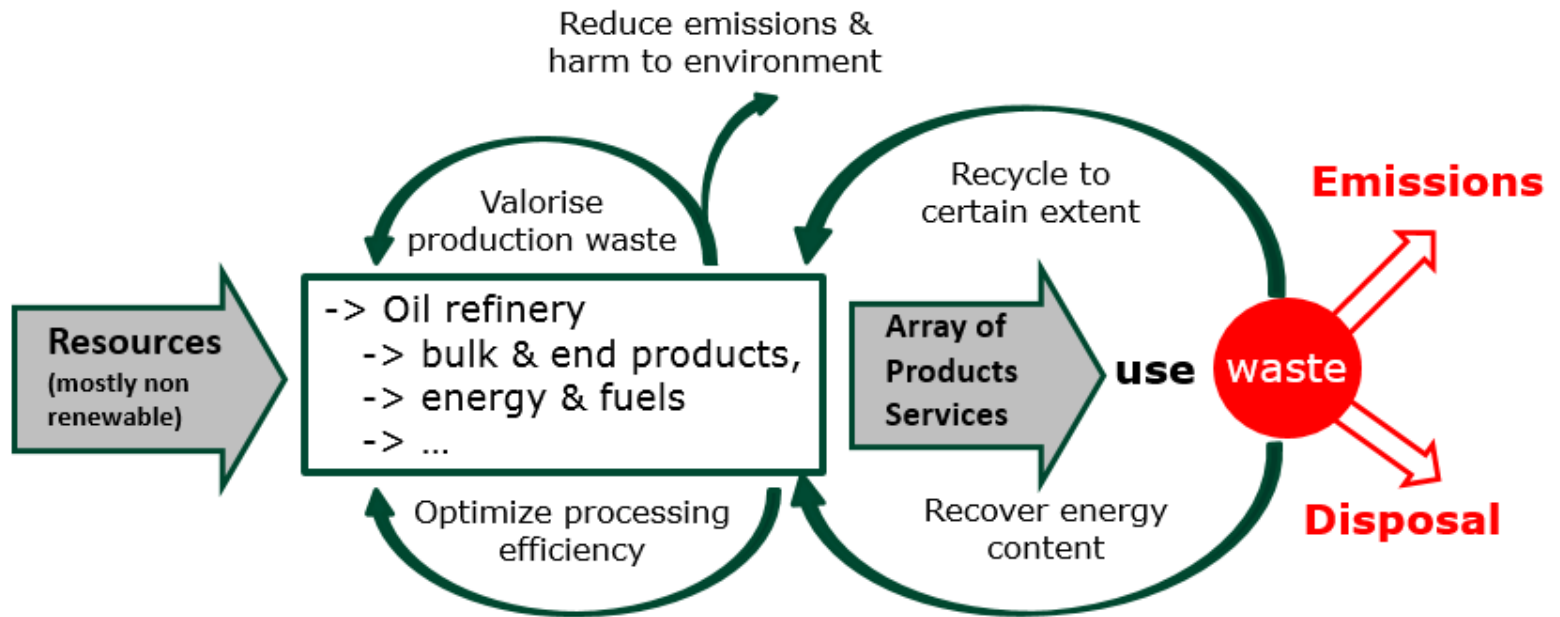
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Conventional Economy

Resources depletion !

Production system is not sustainable

Global Warming !



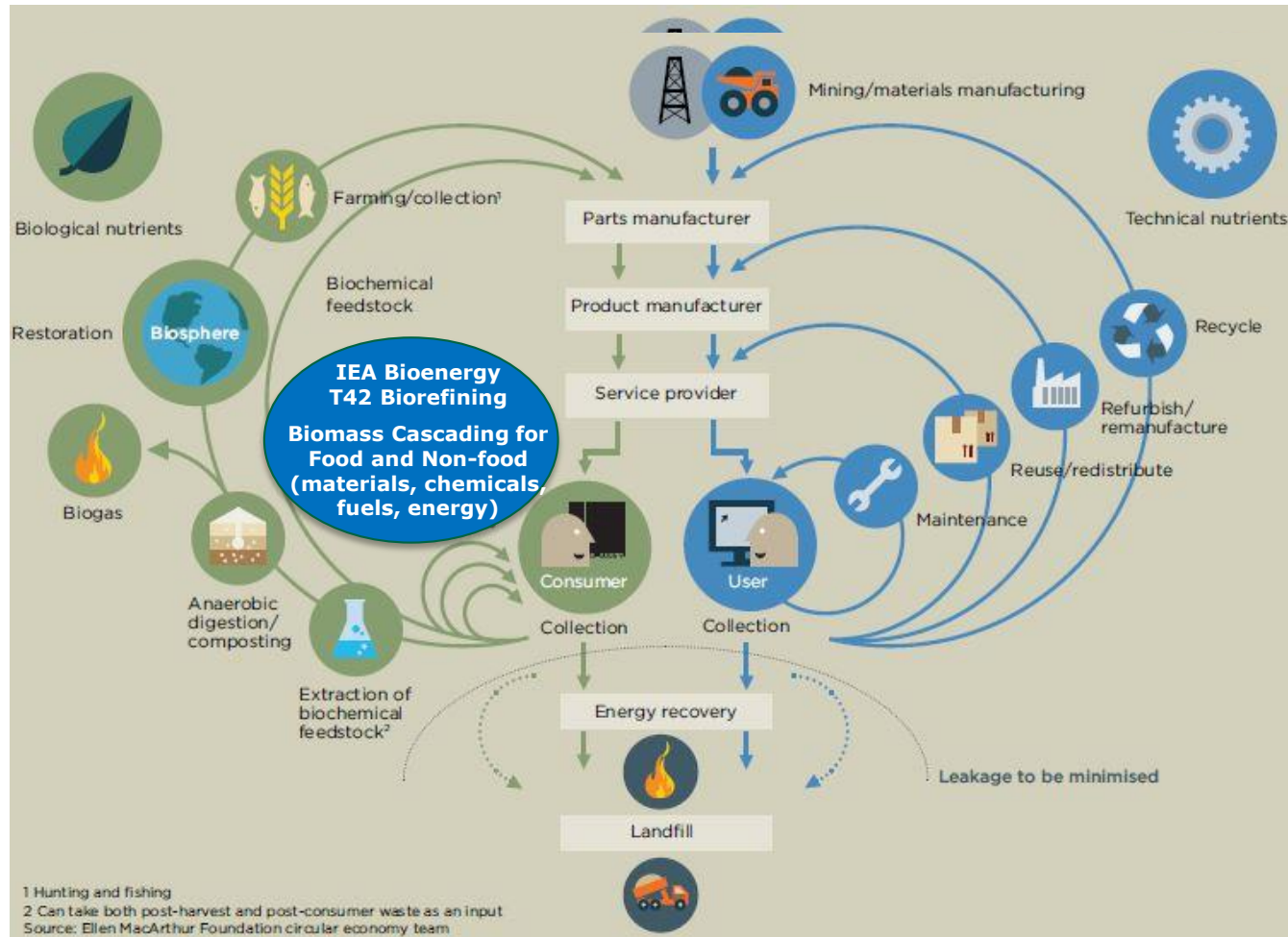
Reference: TbWResearch, Austria (2017)

Circular Economy (CE)

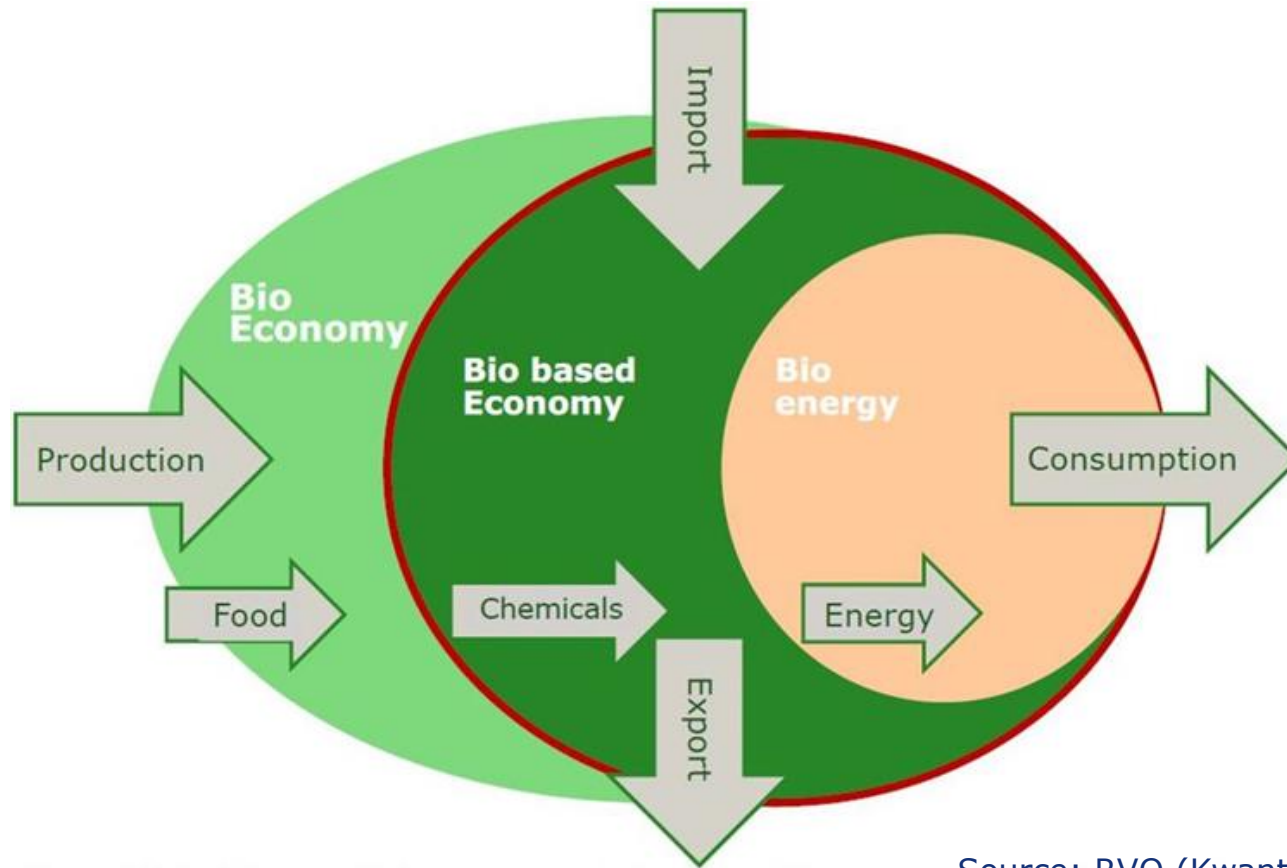
A Circular Economy is an industrial system that is restorative or regenerative by design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models.

Reference: Ellen MacArthur Foundation (2012)

Circular Economy (CE)

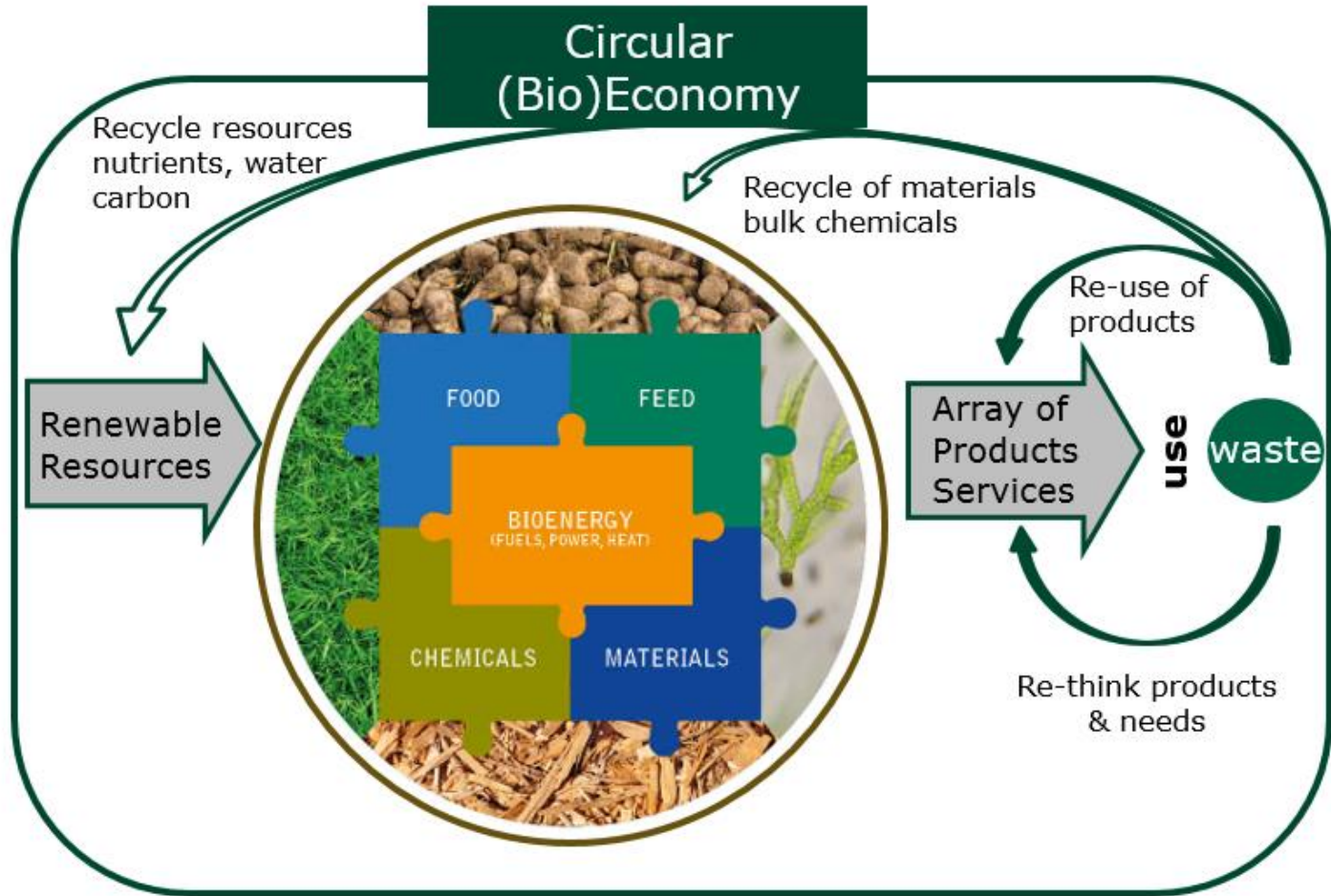


BioEconomy, Biobased Economy (BbE) and Bioenergy



Source: RVO (Kwant)

BbE & BioEnergy in the CE



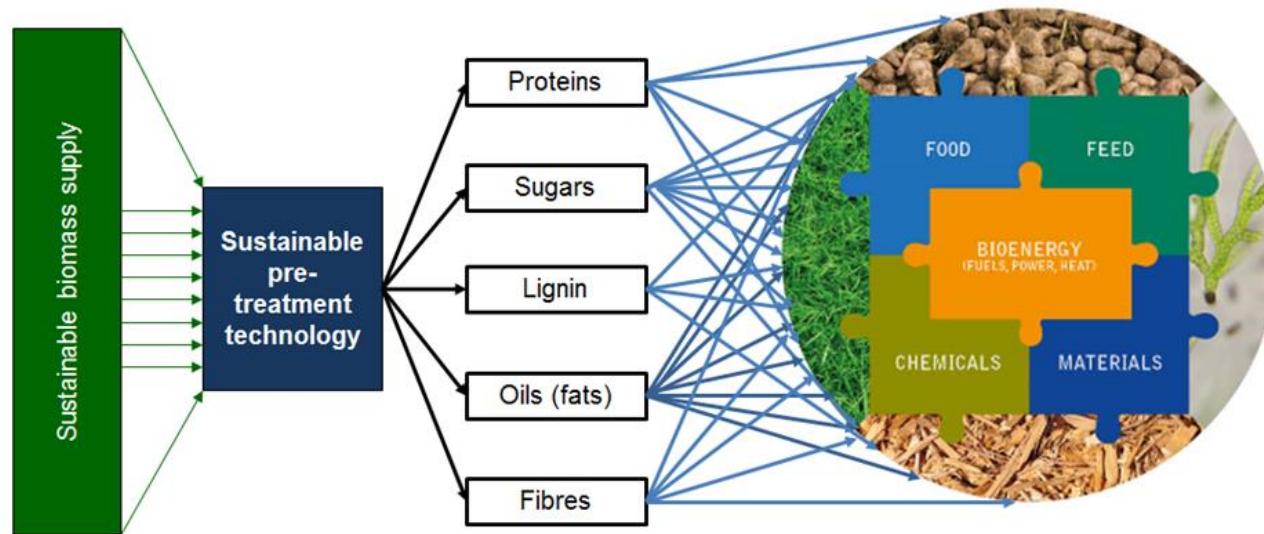
Bioenergy in the CE

- Bioenergy (power, heat/cold) is and will remain a very important renewable energy source necessary worldwide to meet global GHG emission reduction goals (a.o. use of residues, potential CO₂-sink combined with CCU/CCS)
- Bioenergy will provide advanced biofuels for aviation, shipping and heavy duty road transport; potentially in combination with RES-hybrids for energy storage
- Bioenergy will be a driver for the realisation of a Bio(based) Economy by
 - global sustainable mobilisation of the required biomass resources
 - the development of required standardisation/certification systems
 - providing (industrial) infrastructure as stepping stone for upgrading to biorefineries

Biorefining in the CE

Definition IEA Bioenergy Task42

Sustainable processing of biomass into a portfolio of marketable biobased products (food and feed ingredients, chemicals, materials, fuels, energy, minerals, CO₂) and bioenergy (fuels, power, heat)



Biorefining in the CE

Energy-based biorefineries

- Biofuel-based biorefineries
- Biopower-based biorefineries
- Bioheat/cold-based biorefineries
- Biogas-based biorefineries

Main focus on production secondary energy carriers from biomass; agro and process residues used for production added-value feed or biobased products to optimise full chain sustainability, incl. overall economic performance, reducing necessary financial governmental support

Product-based biorefineries

- Chemical-based biorefineries
- Material-based biorefineries

Main focus on production chemicals or materials from biomass; agro and process residues used for feed or energy to optimise full biomass-to-products chain sustainability

IEA Bioenergy Task42 has (co)organised two recent workshops to discuss

The role that industrial biorefineries can
play in a low-carbon economy

*Joint IEA Bioenergy/IEA IETS Workshop,
Gothenburg, Sweden, 16 May 2017*

The role that bioenergy and biorefining can
play in a Circular (BIO)Economy

*Joint IEA Bioenergy, ETIP Bioenergy, EERA Bioenergy,
EC DG JRC, IRENA, FAO, US DOE Workshop, Brussels,
Belgium, 27 September 2017*

IEA Bioenergy Task42

Joint Workshop with IEA-IETS



The role of industrial biorefineries in a low-carbon economy Gothenburg, Sweden, 16 May 2017

- Strategic biorefinery developments
- How to overcome deployment barriers



2 plenary lecture sessions
each followed by an interactive workshop with all
participants

IEA Bioenergy Task42

Joint Workshop with IEA-IETS



Interactive workshop focus

- Pulp and paper mills
- Chemical industries
- Food and feed industries
- Petroleum refineries
- Energy utilities



Examples of notes from the different brainstorm groups

Main deployment barriers

Social

Public perception on both BM sustainability and BBPs

Food habits, throw-away society

Resistance to change

Technological

TRL, complexity BRs, lack of qualified staff, etc.

Economic

Large investments, high risks, profitability?

BR business models, etc.

Markets

Conservative industry, need for cooperation

Opposition and competition, volatile markets

Policy

Lack of consistency and LT vision

Legislation (waste, food safety, etc.)

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Joint Workshop with IEA-IETS



Recommendations on

- Policy
- Business
- Research and education



Examples of notes from the different brainstorm groups



IEA Bioenergy

Task42 – Biorefining in a Future BioEconomy

Joint Thematic Workshop on Bioenergy and Biorefining in a Circular (BIO)Economy, Brussels, 27 September 2017



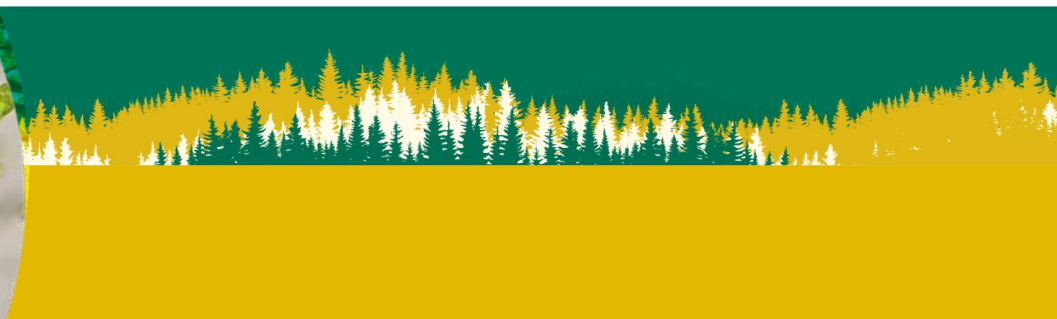
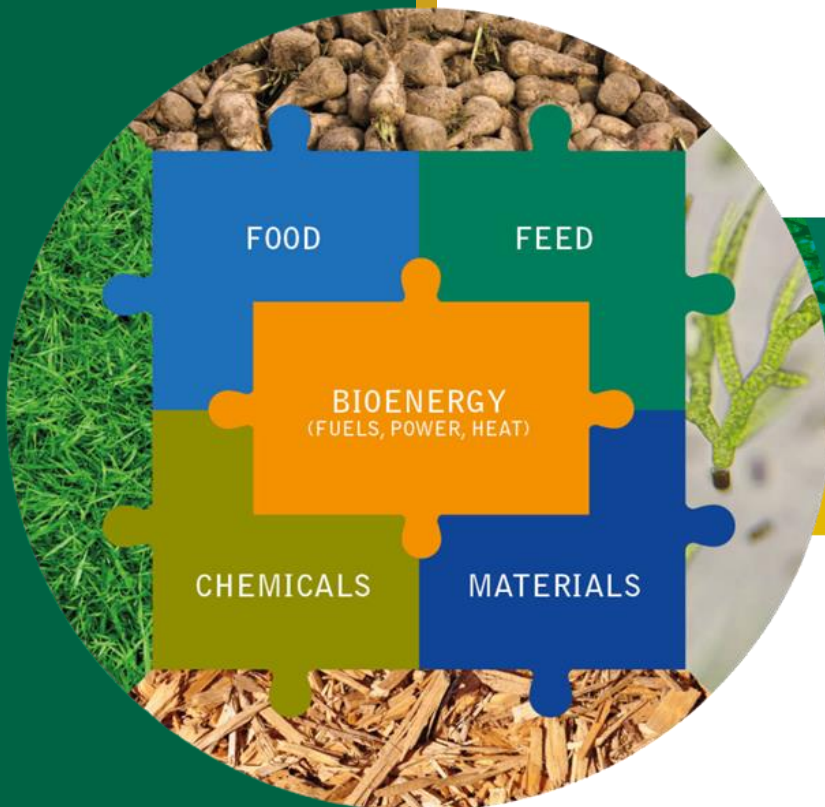
ETIP Bioenergy
European Technology and Innovation Platform



IEA Bioenergy



Food and Agriculture Organization
of the United Nations



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IEA Bioenergy, also known as the Implementing Agreement for a Programme of Research, Development and Demonstration on Bioenergy, functions within a Framework created by the International Energy Agency (IEA). Views, findings and publications of IEA Bioenergy do not necessarily represent the views or policies of the IEA Secretariat or of its individual Member countries.

Aim of this meeting

1. To inform each other on running and planned activities in the field of Bioenergy and Biorefining in a Circular (Bio)Economy;
2. To analyse cooperation opportunities to be able to use available (financial) resources as efficient as possible and to come-up with results that will have a broad support;
3. To define one/more joint activities to be performed in the coming year(s);
4. To organise (a) joint dissemination event(s) to communicate our views/results to a wider public (side event international conference, etc.).

Further cooperation

1. Continuation parallel activities and keeping each other actively informed on major achievements (reports, etc.)
2. Organising an annual joint dissemination event on Bioenergy and Biorefining in a Circular BioEconomy: success stories, lessons learned, innovation needs etc.
3. Joint database bioenergy/biorefinery facilities or coupling existing ones.
4. Contact other international organisations (OECD, BIC/BBI, etc.) and assess cooperation opportunities.
5. Identifying (2018) and final (2019 onward) execution of some joint projects



Attendees

Take home messages

The Food **OR** Fuel / Food **OR** Biobased discussion has to be replaced by a **Clear Vision on Sustainable Biomass Production and Use for combined Food and Non-food Applications**

Example: Applying flexible biorefineries that depending on market products requests (prices) are able to produce either food ingredients or non-food/energy products from various feedstocks might be a solution to optimise full chain sustainability, incl. guaranteeing a fixed farmers income necessary to make a living

Take home messages

Cooperation of international organisations and stakeholders by both exchange of best-practices and execution of joint activities to efficiently solve technical and non-technical deployment barriers **is of utmost importance to accelerate the market implementation of (energy/fuel-based) biorefineries in the Circular (Bio)Economy**

www.task42.ieabioenergy.com



Thank you for your
kind attention

IEA Bioenergy

Task42 - Biorefining in a Future BioEconomy



Contact Details

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Background Info

IEA Bioenergy

Task42 Biorefining

Task 42



Vision Biorefining is the optimal strategy for large-scale sustainable use of biomass in the BioEconomy resulting in cost-competitive co-production of food/feed ingredients, biobased products and bioenergy with optimal socio-economic and environmental impacts, viz.

- > efficient use of resources
- > reduced GHG emissions

Mission 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.

IEA Bioenergy Task42

WP 2016 - 2018

Countries involved: AT, AUS, CAN, DEN, GER, IRE, IT, NL, US

Scope involve 4 different Activity Areas (AAs)

- **AA1 - Biorefinery Systems** (AT et al)
Analysis and assessment of biorefining in the whole value chain
- **AA2 - Product Quality** (GER et al)
Reporting on related biobased products/bioenergy standardisation, certification and policy activities
- **AA3- Evolving BioEconomy** (IT et al)
Analysing and advising on perspectives biorefining in a Circular BioEconomy
- **AA4 - Communication, dissemination & training** (NL et al)
Knowledge exchange, stakeholder involvement, reports & lecturing

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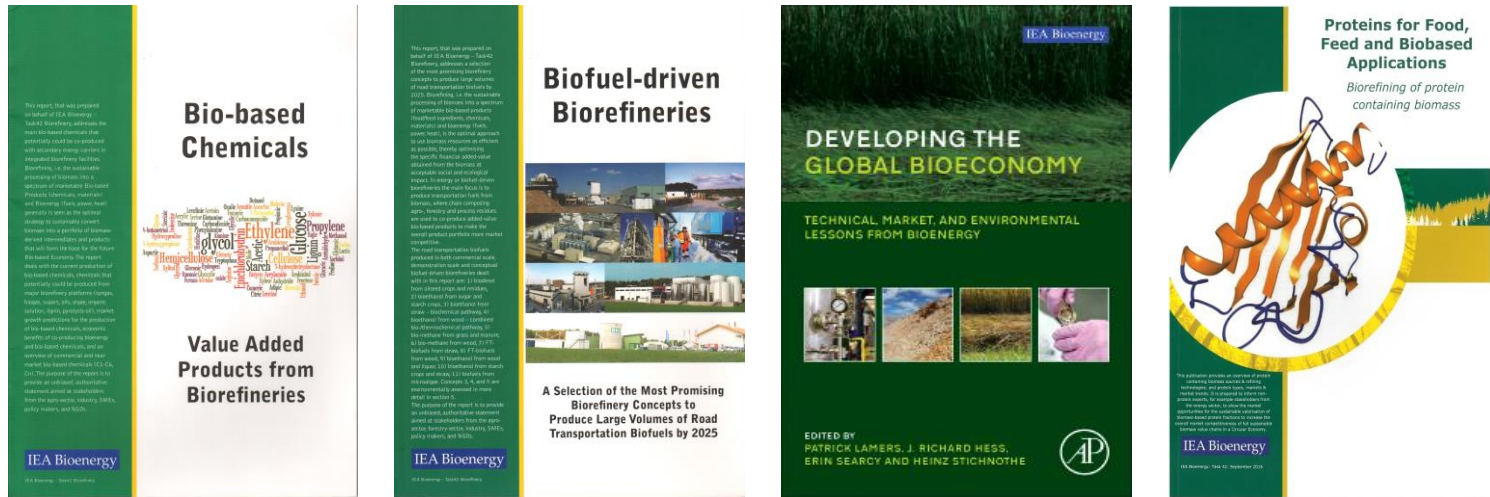
Deliverables 2016 - 2018

- Biorefinery Expert System (SA) / Factsheets
- Monitoring of international standardisation/certification activities BM-use
- Monitoring INT BioEconomy developments
- Joint Tasks Projects (bioenergy supply chains)
- Strategic Reports on
 - Proteins for Food and Non-food (2016)
 - Biobased Fibrous Materials (2017)
 - Biobased Chemicals (2018)
- Updates of National BR Country Reports
- (Thematic) Stakeholder Workshops
- Conference & training contributions, ...
- Biannual newsletters

IEA Bioenergy Task42

Results so far

Thematic Reports



- Biobased Fibrous Materials (AT) by end 2017
- Update Biobased Chemicals Report by end of 2018

Country Reports

AT, AUS, CAN, DEN, FRA, GER, IRE, IT, JAP, NL, NZ, TUR, UK, US



Task42 – Biorefining in a Future BioEconomy

IEA Bioenergy Task42

Results so far

Biorefinery definition, classification system and factsheet methodology

Part A: Biorefinery Plant

Part B: Value Chain Assessment

Biorefinery FACT SHEET

1-platform (oil) biorefinery using oilseed crops for biodiesel, glycerin and feed*

Part A: Biorefinery plant

The commercial scale energy driven biorefinery "1-platform (oil) biorefinery using oilseed crops for biodiesel, glycerin and feed" is shown in Figure 1. The oilseed crops in the "1-platform (oil) biorefinery using oilseed crops for biodiesel, glycerin and feed" are transported to the biorefinery, where the vegetable oil and the animal feed are produced in the greening step. The oil is considered as a platform, and it is esterified, producing FAME biodiesel and raw glycerin. To derive pure glycerin for pharmaceutical purposes the glycerin is subsequently distilled. The heat and electricity are typically supplied by fossil fuel energy carriers. The plant scheme of the "1-platform (oil) biorefinery using oilseed crops for biodiesel, glycerin and feed" is similar to the biorefinery using only oilseed crops, with the inclusion of an additional step for the filtration of the used cooking oil or animal fat.

This biorefinery is state of the art and commercial production facilities have an annual biodiesel production capacity between 50,000 up to 150,000 t per year. Many of the successful operating biorefineries operating today are multi feedstock plants that are able to use different oilseed crops, fat and oil based residues. The oil platform and the glycerin platform offer the possibilities for a wide range of biochemicals and biomaterials that are currently under development and partly at the beginning of commercialization. For example, the oil from certain oilseeds can be further processed via hydrolysis to long-chain fatty acids for lubricants; and the glycerin can be converted to softening agents such as propandiol by fermentation or to triacetin by chemical conversion.

Also, as new configurations are developed, the external energy sources can be partially or fully replaced by bioenergy produced within the process to reduce the GHG footprint.

Case study, example

Figure 1: 1-platform (oil) biorefinery using oilseed crops for biodiesel, glycerin and feed

Table 1: Key characteristics of biorefinery plant – generic example

Biorefinery plant		
Biorefinery Complexity Index (Products/Platform/Feedstock/Process)	8 (2/1/1/2)	
State of technology	commercial	
Products	biodiesel: 100 (Mtpa)	auxiliaries (external): electricity: 0.59 (PJ/tE)
	glycerin: 11 (Mtpa)	heat: 0.94 (PJ/tE)
	animal feed: 132 (Mtpa)	methane: 21 (Mtpa)
Feedstock	oilseed crops: 268 (Mtpa)	investment: 50 (Mio €)
	water content: 12% (wt)	feedstock: 414 (Mtpa)
Efficiencies	input to products: 84%	energy: 80%
	input to transportation fuel: 20%	CO ₂ : 52%

Figure 2: Mass balance of biorefinery plant

Figure 3: Energy balance of biorefinery plant

Figure 4: Share of costs

Figure 5: Share of revenues

Part B: Value Chain Sustainability Assessment

The method of the sustainability assessment - economic and environmental – is given in Annex 1. The main assumptions and modelling choices are documented in Annex 2.

In future the following improvements of the assessment might be possible:

- Reduction of investment costs
- Use of renewable energy for auxiliary energy
- Further products made from glycerine with higher revenues
- Lower area demand due to a yield increase
- Using of straw for various products

A 1-platform (oil) Biorefinery Using Oilseed Crops for Biodiesel, Glycerin and Feed

Conventional Reference System

Figure 6: Comparison of biorefinery with conventional reference system on whole value chain (incl. "end of life treatment")

Table 2: Key characteristics of biorefinery value chain – generic example

Whole value chain		
Greenhouse gas emissions (total)	biorefinery: 228 (210 to 245)	(in CO ₂ -eq/tE)
	reference system: 381 (360 to 402)	(in CO ₂ -eq/tE)
	saving: -45 (-27 to -63)	(%)
Comsumed energy demand (total)	biorefinery: 2.3 (2.1 to 2.6)	(PJ/tE)
	reference system: 3.9 (3.5 to 4.3)	(PJ/tE)
	saving: -45 (-42.7 to -48.1)	(%)
total	biorefinery: 8.8 (8.1 to 10.2)	(PJ/tE)
	reference system: 13.8 (13.1 to 15.2)	(PJ/tE)
	saving: 5 (-3.4 to 21.8)	(%)
Agricultural area demand (total)	biorefinery: 10 (10.0000 to 100000)	(ha/tE)
	reference system: 129 (120 to 135)	(ha/tE)
	annual saving: 119 (100 to 135)	(ha/tE)
	specific saving: 119 (100 to 135)	(ha/tE)
	annual saving: 127 (120 to 135)	(ha/tE)
	specific saving: 127 (100 to 135)	(ha/tE)

Figure 7: Estimated cumulated fossil energy demand of biorefinery and reference products

Figure 8: Estimated cumulated energy demand of biorefinery and reference products

Figure 9: Estimated greenhouse gas emissions of biorefinery and reference products

Figure 10: Estimated cost and revenues of biorefinery plant

Annex:

Methodology of sustainability assessment and data with references

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Results so far

Stakeholder Meetings, Excursions & Workshops

Between 30-40 over last 9 years



Knowledge & experience transfer

Lectures at international conferences

Publications in journals

Specific thematic workshops

Specific biorefinery education and training courses



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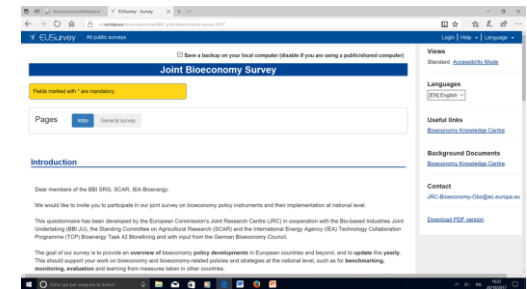
Task42 - Biorefining in a Future BioEconomy

To 3 recent deliverables

IEA Bioenergy Task42 BioEconomy Questionnaire

On-line Joint BioEconomy Survey 2017 JRC-SCAR-BBI-IEA Bioenergy

- Personal info (organisation or coordinated answer)
- National institutions
- National BioEconomy definition/scope
- National BioEconomy policy and strategy
- BioEconomy Infrastructure (funding, register, certification schemes, educational programmes)
- BBI SRG or IEA Bioenergy member
 - Questions for BBI SRG members
 - **Questions for IEA Bioenergy members:**
 - **commercial, flagship and demo/pilot biorefinery plants**
 - **R&D-projects**
 - **stakeholders involved**



<https://ec.europa.eu/eusurvey/runner/BKC-joint-bioeconomy-survey-2017>

Deadline EC countries: 29-10-2017