The IEA Bioenergy Task 42 "Biorefining" with its 11 member countries (A, AUS, CA, DK, G, I, IR, J, NL, NZ, USA) has the following definition on biorefining: "Biorefining is the sustainable processing of biomass into a spectrum of bio-based products (food, feed, chemicals, and materials) and bioenergy (biofuels, power and/or heat)".

IEA Bioenergy

# Biorefinery Fact Sheets

To make clear the development status and the perspectives for implementation and development of biorefineries the IEA Bioenergy Task 42 "Biorefining" developed a "Biorefinery Fact Sheet" for the uniform description of the key facts of a biorefinery. Based on a technical description and the classification scheme the mass and energy balance is calculated for the most reasonable production capacity for each of the selected biorefineries. Then the three dimensions – economic, environmental and social - of sustainability are assessed for each biorefinery and documented in a compact form in the "Biorefinery Fact Sheet" by using the following methodologies

- Economic assessment with Life Cycle Costing (LCC),
- Environmental assessment with Life Cycle Assessment (LCA),
- Social assessment with Social Life Cycle Assessment (sLCA) and
- Overall assessment with Life Cycle Sustainability Assessment (LCSA)

The "Biorefinery Fact Sheets" consist of three parts:

1. Part A: Biorefinery plant
2. Part B: Value chain assessment and
3. Annex: Methodology of sustainability assessment and data (available on the webpage)

In Part A the key characteristics of the biorefinery plant are described by giving compact information on

- classification scheme
- description of the biorefinery
- mass and energy balance
- share of costs and revenues.

In Part B the sustainability assessment based on the whole value chain of the biorefinery plant is described by giving compact information on

- system boundaries
- reference system
- cumulated primary energy demand
- greenhouse gas emissions
- costs and revenues.

In the Annex of the "Biorefinery Fact Sheet" (only available on the Task webpage) the main data for the sustainability assessment are documented.

## Biorefinery Classification System

Austria, as part of IEA Bioenergy Task 42 activities, has developed a classification and naming scheme to describe different biorefineries obviously. The classification of a biorefinery consists of the following four features:

1. platforms,
2. products,
3. feedstocks and
4. processes.

With the combination of these four features, different biorefinery configurations can be described in a consistent manner.

The most important feature is the platform. Platforms might be:

- intermediate products from biomass feedstocks towards biorefinery´s products or
- linkages between different biorefinery concepts or
- final products of a biorefinery.

The platforms might represent mixtures of compounds (C6&lignin, C5&C6 sugars) or more isolated compounds. For the platform "electricity and heat" in the different biorefinery concepts it is important to define, if electricity and heat are produced from

- process residues or
- directly from biomass feedstock or
- fossil fuels or
- other form of renewable energy, e.g. wind, solar.

Electricity and heat can be produced within the biorefinery plant e.g. from process residues or can be covered by external supply.

The naming of a biorefinery system consists of the following four elements:

1. number and name of the platform(s),
2. feedstock(s),
3. product(s) and
4. processes.

The first three elements in the naming are always necessary, whereas the inclusion of processes is optional.

Here is an example: "1-platform (oil) biorefinery using oilseed crops for biodiesel, glycerin and feed via pressing, esterification and distillation".

The classification scheme and the naming are used for the description of the biorefinery systems in the Fact Sheets.

## Conventional Reference System

For the definition of the conventional reference system the following relevant framework is agreed in Task 42:

1. The biorefinery system and the conventional systems provide the same amount of products with the same service, e.g. same amount of transportation service, same amount of materials or chemicals.
2. The same amount and type of biomass is considered in both systems.
3. The same amount of agricultural and/or forestry area use is considered in both systems.
4. The whole ("value") chain approach – from resource to products – is considered.

The comparison is done for the following aspects:

- production costs and revenues for the products,
- amount of greenhouse gas saving by substituting products from conventional systems with products from biorefinery and
- amount of fossil energy saving by substituting products from conventional systems with products from biorefinery.

## Biorefinery Complexity Index

Based on the classification system of biorefineries and the "Nelson´s complexity index" for oil refineries a Biorefinery Complexity Index (BCI) was developed. For each of the four features of a biorefinery the Technology Readiness Level (TRL) is assessed using level description between 1 ("basic research") to 9 ("system proven and ready for full commercial deployment"). Based on the TRL the Feature Complexity (FC) for each single feature of a biorefinery is calculated. With the number of features and the FC of each single feature the Feature Complexity Index (FCI) for each of the four features (platforms, feedstocks, products and processes) is calculated. The BCI is the sum of the four FCIs. The Biorefinery Complexity Profile (BCP) is a compact format to present the complexity of a biorefinery by giving the BCI and the four FCIs of each feature.

The BCP, which includes the BCI and the four FCI has the following format:

BCP: BCI (FCIplatforms/FCIFeedstocks/FCIProducts/ FCIProcesses),

with an example 8 (1/1/3/3).

The basic assumptions on the complexity of a biorefinery are:

- The number of different features of a biorefinery influences the complexity. The complexity increases by the number of features in a biorefinery.
- The state of technology of a single feature influences the complexity. The complexity decreases the closer a technology is to a commercial application. This means a high "Technology Readiness Level" of a feature has lower technical and economic risks and a lower complexity.
- This leads to the basic assumption for the calculation procedure of the Biorefinery Complexity Index that the complexity is directly linked to the number of features and the Technology Readiness Level of each single feature involved.

The following conclusions on the BCI and BCP are drawn:

1. They give an indication for the relative comparison of different biorefinery concepts and their development potential.
2. They present a benchmark of the "complexity" of a biorefinery in terms of involved platforms, feedstocks, processes and products, and their specific and overall "Technology Readiness Level".
3. The higher the BCI the more beyond "state of the art" is the biorefinery.
4. The BCI of a biorefinery producing biodiesel from vegetable oil which is fully deployed, with 8 (1/1/3/3) is a benchmark to compare the complexity of other current and future biorefinery systems.
5. The BCI will change in the future if the Technology Readiness Level has changed, e.g. if a demonstration plant for FT-Biofuels will go into operation.
6. The BCP show the most relevant features contributing to the complexity of a biorefinery
7. The BCP of a biorefinery gives an indication on the technological and economic risks.
8. The first results and conclusions of a critical review by the country representatives in IEA Bioenergy Task 42 show that the "Biorefinery Complexity Index" adds additional relevant information on the assessment and comparison of different biorefinery systems

## Further information

is available on Task 42 webpage and

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# IEA Bioenergy

IEA Bioenergy is an international collaboration set-up in 1978 by the International Energy Agency (IEA) to improve international co-operation and information exchange between national bioenergy RD&D programmes.
IEA Bioenergy's vision is to achieve a substantial bioenergy contribution to future global energy demands by accelerating the production and use of environmentally sound, socially accepted, and cost-competitive bioenergy on a sustainable basis, thus providing the increased security of supply whilst reducing greenhouse gas emissions from energy use. Currently, IEA Bioenergy has 24 Members and is operating on the basis of 12 Tasks covering all aspects of the bioenergy chain, from resource to the supply of energy services to the consumer.

## IEA Bioenergy | Task 42 Biorefining

IEA Bioenergy Task42 Biorefining deals with knowledge building and exchange within the area of biorefining, i.e. the sustainable processing of biomass into a spectrum of marketable Food and Feed Ingredients, Bio-based Products (Chemicals, Materials) and Bioenergy (Fuels, Power, Heat). The Task was started in 2007, and is now very successfully in operation involving Australia, Austria, Canada, Denmark, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, and the United States of America. Within the first triennium (2007-2009) the main focus of activities was on setting a common international framework on biorefining (i.e. definition, classification system, state-of-the-art in participating countries). In the second triennium (2010-2012) the focus of the activities was on the integral technical, economic and environmental assessments of full biofuel-driven biorefineries; the analysis of the types of Bio-based Chemicals that potentially could be co-produced with secondary energy carriers to maximise full biomass valorisation chain economics, and to minimise the overall environmental impact, to study overall sustainability aspects of integrated biorefineries, and to organise a Biorefining Summer School to get both industrial stakeholders, policy makers and students acquainted with the principles, current state-of-the-art, and future possibilities of applying the biorefining approach as base for a Bio-based Economy. This triennium (2013-2015) Task42 focused on tackling market deployment aspects for integrated biorefineries, supporting stakeholders in the energy sector finding their position within a future Bio-based Economy, assessing optimal sustainable use of biomass for Food and Non-food applications, and dissemination & training activities.

## Further Information

**IEA Bioenergy Task42 Website**
www.iea-bioenergy.task42-biorefineries.com

**IEA Bioenergy Website**
www.ieabioenergy.com

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