

## A REVIEW ON THE BIOREFINERY OPTIONS UNDER RESEARCH IN EUROPE: MARKET STUDY OF POTENTIAL PRODUCTS, TECHNOLOGY TRLS AND RESEARCH INFRASTRUCTURES

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**ABSTRACT:** The primary objective of the present work, as part of the BRISK2 project (funded by Horizon 2020, Grant Agreement Number 731101), is to identify the most promising bio-based products, clearly linked to the inherent capabilities of the infrastructures offer in BRISK II. The relation of these research infrastructure capabilities to actual processes in biorefinery operations are given extensively for each partner in the Appendix I and offers an overview of the project's contribution to bioenergy and biorefinery operations. Thus, different pathways are explored towards the conversion of multiple feedstock types into valuable products that can replace materials and energy from fossil refineries. When taken as a unity, the links can be combined in a variety of cascade processes, capable of supplying a wide range of energy vectors and high-added value chemicals. In more detail, several biogenic feedstock classes (i.e., lignocellulosic biomass, agricultural wastes, municipal and industrial wastes, algae biomass, residues) are linked with bioproducts (such as, methanol, ethanol, butanol, hydrocarbons, oils, dimethyl-ether) via 2 major pathways, based on relevant thermal and biological conversion technologies. It is expected that the offered processes and technologies will identify potential chemicals and novel biofuels (as well as their blends) of high value. For each identified group of 10 final bio-products, a short market study includes the product description, an overview of the production process, elements of the current trading situation and price examples at EU and international level.

**Keywords:** Biorefinery, market, biobased products

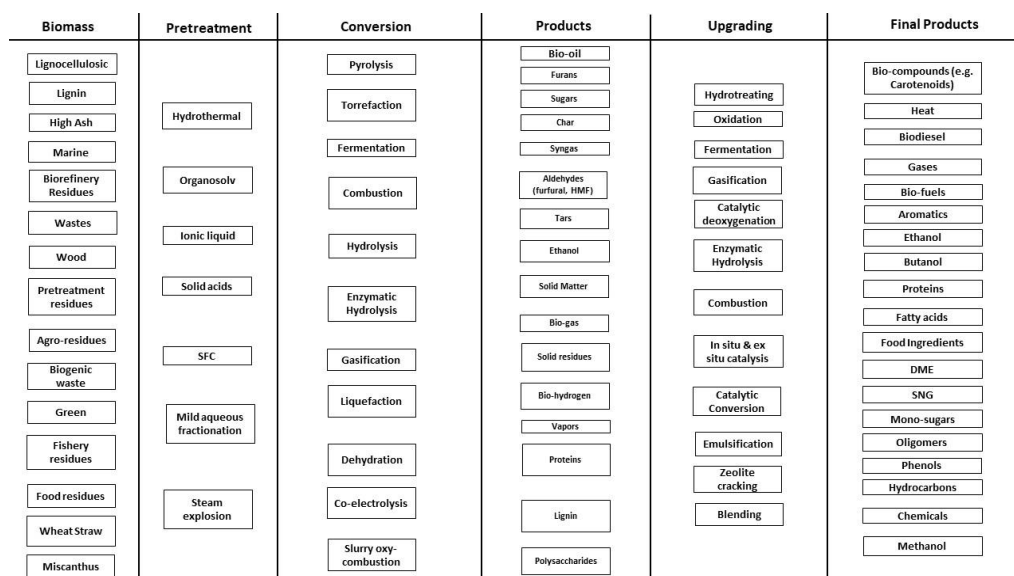
### 1 INTRODUCTION

The overarching objective and vision of BRISK2 is to establish a centre of excellence in the field of 2<sup>nd</sup> and 3<sup>rd</sup> generation biofuels via uniting leading European research infrastructures. Through an integrated approach the entire value chain is represented: from the first preparation of the biomass feedstock, to its conversion and treatment and finally through efficient utilization. Traditional and novel biogenic sources, including marine biomass, are in focus for user driven investigations with a wide spectrum of powerful and, in many cases, unique laboratory based and pilot scale equipment. Activities serve to strengthen academia and industry cooperation, spurring innovation

towards the advancement of fundamental and applied research in thermo- and bio-chemical biomass conversion and biorefinery.

The biorefinery concepts include a vast variety of potential processes and products that basically aim to replace the products we get from a petrochemical refinery (Figure 1).

Partners offering and opening their infrastructures to the European community are: Kungliga Tekniska Hogskolan Kth Sweden, Aston University Aston United Kingdom, Bioenergy 2020+ Gmbh Be2020 Austria, Fundacion Cener-Ciemat CENER Spain, ETHNIKO Kentro Erevnas Kai



**Figure 1:** A general representation of potential feedstock, pre-treatment methods, intermediate products and final upgrading towards final products.

**Table 1:** Market study Conclusions and global assessment.

Product	Market situation	Risks	Research to be accomplished
Methanol	Developed Fossil	Strong competition from fossil (NG)	Reduce costs / Lower Capex & Opex, Diversification of the feedstock basis
Bio-DME	Few examples - Average	Strong competition from fossil (NG)	Reduce costs / Lower Capex & Opex, Diversification of the feedstock basis
Bio-ethanol	Developed both fossil and bio	Strong competition many bio processes	Reduce costs / Lower Capex & Opex, Diversification of the feedstock basis
BioButanol	Developed fossil	Some but significant competition – Currently on a high trend	Increasing of selectivity and productivity, Diversification of the feedstock basis
HDO/HDT oil	Under development	Little developed market / uptake from oil refineries critical	Create option for drop in fuels, Diversification of the feedstock basis
Bio-char	Under development	Steadily developing / Competition from Asia / Americas	Deploy market / Improve product properties, Diversification of the feedstock basis
Furfurals	Under development	Average / little competition / Biobased material	Increase yields / quality, Diversification of the feedstock basis
Proteins	Under development	Nutrition market update crucial for success.	Assess products and potential high-end users
Heat	Developed	Little / Developed market	Lower emissions
Electricity	Developed	Future retrieve of feed in tariffs could create economic proem	Intensification / automation / cost reduction

Technogikis Anaptyxis Certh Greece, Stichting Dienst Landbouwkundig Onderzoek Dlo Netherlands, Stichting Energieonderzoek Centrum Nederland Ecn Netherlands, Agenzia Nazionale Per Le Nuove Tecnologie, L'energia E Lo Sviluppo Economico Sostenibile Enea Italy, Karlsruher Institut Fuer Technologie Kit Germany, Laboratorio Nacional De Energia E Geologia i.p. Lneg Portugal, Politecnico Di Torino Polito Italy, Stiftelsen Sintef Sintef Norway, Technische Universiteit Delft Tud Netherlands, Technische Universitaet Graz Tug Austria And The Teknologian Tutkimuskeskus Vtt Oy In Finland.

## 2 MARKET STUDY OF PRODUCTS & PROCESSES OFFERED FOR TRANSNATIONAL ACCESS

The strategic objectives of the BRISK2 project are centered on leveraging existing research infrastructures for the consolidation and sharing of knowledge with the European and international biofuels research communities. In this way, national and regional initiatives can be channeled for achieving joint goals as described in the SET-Plan and other strategic roadmaps. Strong links and outreach with European-based universities, research institutes, and companies/SMEs ensure complete coverage of the knowledge triangle – education, research, and innovation – promoting economic growth and job creation in biofuels.

Generated data will be openly available for exploitation, and existing system-level modelling tools will be improved for analyses in techno-economic, environmental, and policy aspects of advanced biofuels and their applications.

BRISK2 focuses of specific biobased products. The results of the corresponding market study is summarized in the table 1.

## 3 CONVERSION AND PRICES

Ten biomass to products value chains are developed and demonstrated based on different biomass types.

### 1 tn of solid biomass of relevant quality can deliver: 0.19-0.40 tn Bio-methanol

One of the most flexible bulk chemicals; raw material for large volume chemicals and fuel blending.

Produced from both fossil fuels (methane, coal) and non-fossil-fuel sources (biomass, residues, CO<sub>2</sub>).

The conversion of biomass to methanol is simpler and cheaper than for the other BTL processes.

Price range: 0.250-0.500 \$/kg.

### 0.18-0.38 tn Bio-DME

Used as alternative fuel for diesel engines and power generation; also, as propellant and chemical intermediate. Primarily produced via syngas production, conversion to methanol and its dehydration to DME.

Every raw material that can be gasified can be used for DME production.

### 0.12-0.36 tn Bio-ethanol

Applications as intermediate, fuel, solvent and in alcoholic beverages.

Numerous existing synthetic production routes; hydration of ethylene is the major one.

Produced from lignocellulosic materials via pretreatment, hydrolysis and fermentation, with high selectivity and yield.

Main producers: USA, Brazil and EU.

Price: 1.5 \$/gal = 0.396 \$/lt = 0.502 \$/kg (2018).

### 0.19-0.40 tn Bio-butanol

Used as chemical and solvent.

Can be blended with gasoline at higher concentrations than ethanol.

Currently produced by the Oxo- and ABE-fermentation processes.

Existing ethanol plants can be retrofitted to produce bio-butanol.

Price: 1.074 €/kg.

### 0.16-0.24 tn Upgraded oil

Biomass pyrolysis to bio-oil and upgrade to HDO oil.

Many upgrading methods exist but hydrotreating is the most suitable to produce drop-in fuels and biofuels. No existing market; need for market creation and development.

#### Heat

Biomass can provide space heating, hot water and high-grade heat for industrial processes.

In general, more heat is wasted than consumed; there are good prospects for CHP plants.

Small-scale plants suffer from bad economics.

Cost: 10-40 \$/MWh

#### 500-700 kWh Electricity

Existing electricity sources: hard coal, lignite, natural gas, nuclear, renewables (wind, solar, biomass, hydro, etc.).

Lately, electricity consumption increased all over Europe. Across the EU, biomass driven power generation is given the opportunity to feed in tariff.

Cost: 30-50 \$/MWh

#### 0.12-0.25 tn Biochar

Solid carbonaceous pyrolysis and gasification by-product.

Yield based on the pyrolysis type.

Used as soil amendment, for carbon sequestration and as chemical reduction agent.

Relatively new market; lack of accurate data and information.

Price: 3.4 \$/kg (2013) in Germany.

#### 0.10-0.20 tn Proteins

Proteins can be found in agro-materials, plants and animals.

Used for food and feed applications; secondary used are as concentrates and bio-based applications.

Market price of animal-based proteins are twice as much as plant based.

Price: 0.12-25 €/kg.

#### 0.03-0.31 tn Furfurals

5-carbon heterocyclic aldehyde.

Used as intermediate chemical; has also diverse applications in plastics, pharmaceuticals and agrochemicals industries.

Solely produced from lignocellulosic biomass; no existing fossil-based production route.

Average price: 1.874 \$/kg (2002).

## 4 CONCLUSIONS

The BRISK2 project offers research opportunities in the form of Transnational Access with an emphasis on objectivity, transparency, quality and flexibility on the above-mentioned products and technologies. More information is available on the web site of the project:

<https://www.brisk2.eu>

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