SAFETY OF COMMERCIALLY VIABLE BIO-BASED PRODUCTS: LABELLING AND STANDARDIZATION

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Abstract: Bio-based products can make the economy more sustainable and lower its dependence on fossil fuels. For this reason, the EU has declared the bio-based products sector to be a priority area with high potential for future growth, reindustrialization, and addressing societal challenges. An assessment made by the European Commission has indicated that bio-based products and biofuels represent approximately EUR 57 billion in annual revenue and involve 300,000 jobs. According to forecasts, the bio-based share of all chemical sales will rise to 22% by 2020, with a compounded annual growth rate of close to 20%. Taking into account that bio-based products represent an important part of the circular and bio-economy as a major source of the economic growth and employment in Europe of 21st Century some basic information on bio-based products is presented in this paper. In this paper particular attention has been paid to standardization process of bio-based products and to their labelling in order to promote the uptake of these products by consumers and to implement "green procurement policies".

Keywords: bio-based products, bioeconomy, standardization, labelling.

1. Introduction

The bioeconomy encompasses the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy via innovative and efficient technologies provided by industrial biotechnology which is now in a rapid development phase, driven by cooperation between technology providers, research institutes and raw material suppliers. Biotechnology and green chemistry are important drivers in this process. Bioeconomy describes a concept that acknowledges the full potential of biotechnological research and innovation for the both economy and society. In 2009, the OECD presented an influential report on "The Bioeconomy to 2030: designing a policy agenda". In 2012, the European Commission presented the first European Bioeconomy Strategy (European

Commission 2012). According to the documents, the countries realize a vision of a sustainable bio-based economy by 2030 – one which produces sufficient healthy food to feed the world and supplies quality products made from renewable resources. It is already a reality and one that offers great opportunities and solutions to a growing number of major societal, environmental and economic challenges, including climate change mitigation, energy, food security and resource efficiency.

The aim of the bioeconomy is to develop competitive, innovative and prosperous technologies by providing sustainable growth and by protecting the environment and resources. The bioeconomy will be to help keeping Europe competitive, innovative and prosperous by providing sustainable, smart and inclusive economic growth and jobs, and by meeting the needs of a growing population whilst protecting our environment and resources. This means an economy based, besides food and feed, increasingly on biomass-derived fuels (i.e., wood waste, solid municipal waste, sewage sludge and others), chemicals, and materials, sustainably sourced and produced, as an alternative to fossil fuel resources.

Bioeconomy has three major properties (European Commission, 2017, p. 16-18):

- it is a key in the transition from fossil/petroleum- based resources towards bioresources in industrial production. Bioeconomy refers to an economy that relies on renewable natural resources rather than on fossil resources and petroleum based materials to produce energy, products and services. In this sense, bioeconomy proposes a new industrial revolution/wave. Bioeconomy as a new wave of economic development;
- it is a crucial element of the circular economy based on the ‘cascading use’, reuse and recycling of resources (including waste) and the contemplation of complete lifecycles of resources and materials. In a circular economy, materials that can be reused and recycled are injected back into consumption cycle as new (raw) materials. This converts what is waste for some economic actors into "secondary raw materials" for others;
- it offers a potential to modernise traditional economic sectors and to generate new sustainable economic growth through enabling new technologies such as biotechnology and nanotechnology.

The bioeconomy is defined in different ways. The 13 definitions of bioeconomy are presented in the paper of Maciejczak and Hofreiter (Maciejczak, Hofreiter, 2013, p. 243-248).

At 2012 it was released by the U.S. Biotechnology Industry Organization that the bio-based products placed the national value of the bioeconomy at $1.25 trillion. The European Commission has estimated that the bioeconomy is worth over $2.7 trillion annually, providing 20 million jobs and accounting for 9% of total employment in 2009 often in rural or coastal areas and in small and medium sized enterprises (SMEs) (Golden, Handfield, 2014, p. 23-30).

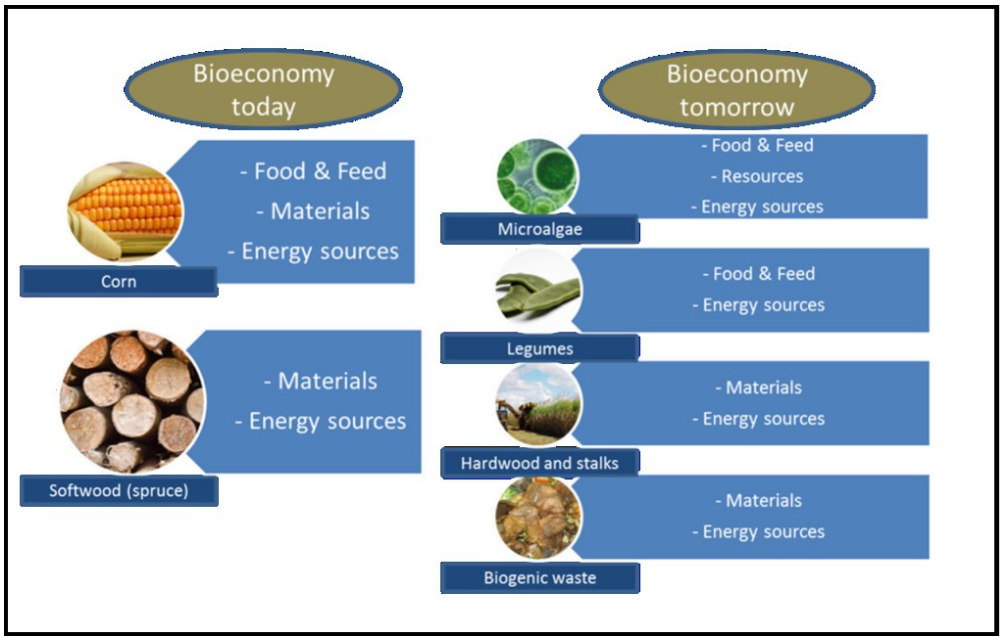


Figure 1. Raw materials and bio-based products used in the bioeconomy, now and in the future. Source: http://bioeconomie-bw.uni-hohenheim.de/en/bioeconomy.

According to the Organization for Economic Co-operation and Development (OECD), the bioeconomy will contribute 1–14 new drugs per year, and will be responsible for 10 % of chemical production by 2030 (www.biotech.ca/…). Worldwide demand for industrial enzymes is expected to reach U.S. $4.4 billion by 2015, with a compound annual growth rate of 6 %.

It involves a large number of industries including agriculture and forestry, horticulture, fishery and aquacultures, plant breeding, the food and drinks industry, as well as the wood, paper, leather, textile, chemical, and pharmaceuticals industries, and even parts of the energy industry. Bio-based innovations also drive growth in other traditional sectors, such as the commodity and food trade, the IT and automotive industries, and environmental technology.

The Bio-based Industries Joint Undertaking (BBI JU) has just published report entitled *Current situation and trends of the bio-based industries in Europe (2017).* This report, carried out by Nova-Institute for BBI JU, provides a non-exhaustive analysis of the main relevant studies on the current situation and trends of the bio-based economy in Europe, including an analysis of their conclusions and the identification the gaps in the existing research. The study addresses different industrial sectors and markets, i.g.: automotive, textiles, medical, healthcare and pharmaceuticals, home and personal care, food and feed additives, construction and furniture, packaging, pulp and paper, bioenergy, and biofuels. The study also covers other relevant subjects, such as the impact of bio-based industries in climate change, socio-economic and environmental aspects, national and regional policies and regulations, research and technologies, EU and global trends and social benefits, consumer acceptance and engagement of actors of the civil society.

The analysis of the Eurostat shows that the turnover of the total bioeconomy (including food and beverages and the primary sectors agriculture and forestry) in the European countries increased continuously from 2.11 trillion EUR to 2.26 trillion EUR.

Currently, out of the 536 products, the 110 are fully or partly bio-based. From these 110 products, 39% are 100% bio-based (e.g. tanning extracts of vegetable origin, sorbitol, tall oil), 25% products with a bio-based share of at least 10% (e.g., ethylene glycol, carboxylic acid, adipic acid) and 36% products of lower bio-based shares (e.g., acetic acid, methanol, epoxy resins). The majority of the products (426) is therefore currently non-bio-based (Dammer, Carus, Iffland, Piotrowski, Sarmento, Chinthapalli, Raschka, 2017).

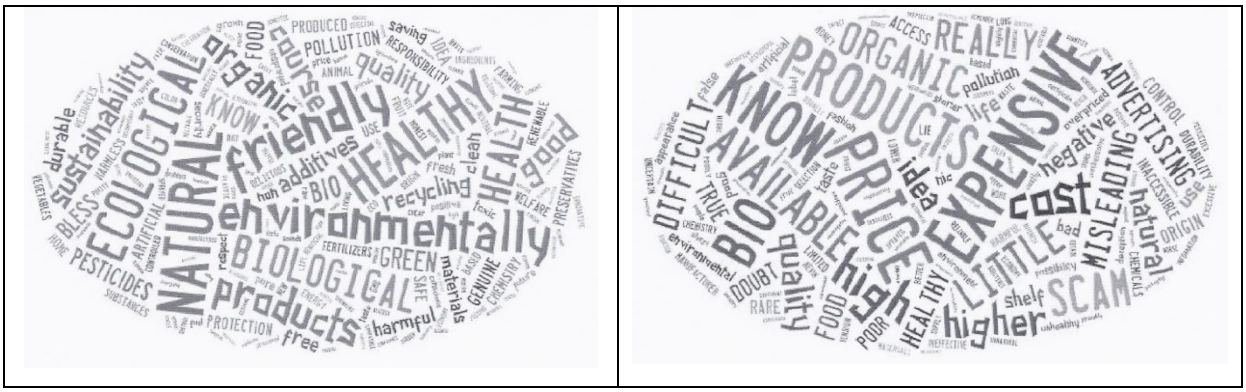


Figure 2. Positive and negative words associated with the properties of bio-based products. Source: Dammer et al., 2017.

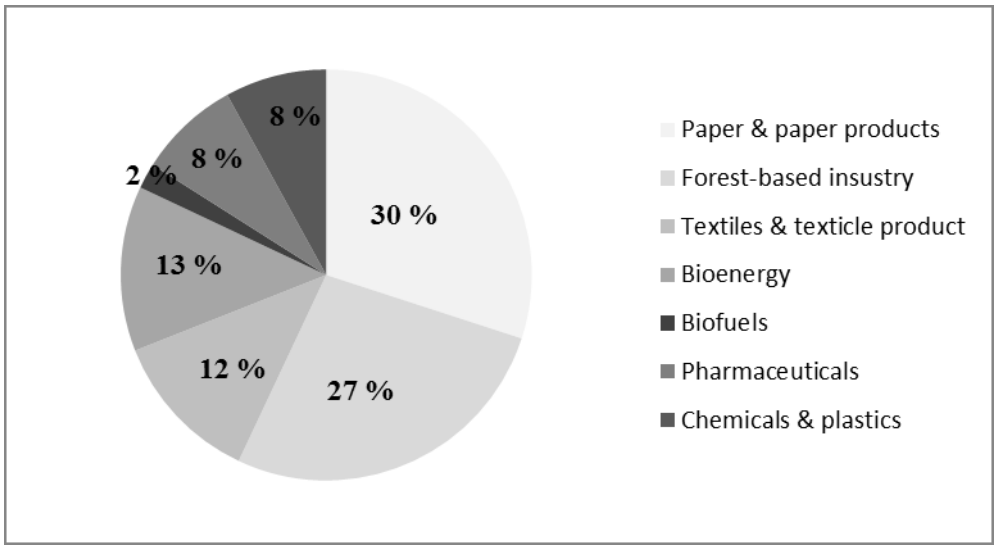


Figure 3. Turnover in the EU bio-based economy (2013 total: € 600 billion). Source: Piotrowski et al., 2016.

The analysis shows that biofuels and bioenergy together accounted for roughly 13-14% of the turnover of the EU industrial sectors that are referred to as 'bio-based economy', which corresponds to a total amount of approximately 90 billion €. The sectors paper and paper products (27%) and forest-based industry (wood products and furniture, 25%) make up for the largest shares of turnover, together this amounts to roughly 250 billion €. Bio-based

chemicals accounted for 45 billion €. The total turnover of the bio-based industries reached 660 billion EUR in 2013 and 674 billion EUR in 2014. The slight decrease in the turnover of bio-based chemicals and plastics from 2013 to 2014 is explained by a decrease in the overall sector or by potential lack of data.

2. Definition of bio-based products

The fundamental attribute of a bio-based product is the proportion of renewable material actually contained within it. The European specifications for some bio-based products require 25% bio-based content for example in bio-based solvents (CEN/TS 16766:2015) and bio-based lubricants (EN 16807:2016) in particular. In other instances, a minimum requirement is not even in place, meaning even lower proportions of bio-based content are acceptable.

The vocabulary of bio-based products has been defined in the European standard EN 16575:2014, and it is:

bio-based product wholly or partly derived from biomass

Note 1 to entry: The bio-based product is normally characterized by the bio-based carbon content or the bio-based content. For the determination and declaration of the bio-based content and the bio-based carbon content, see the relevant standards of CEN/TC 411.

This terminology must build a basis for product design criteria in a bio-based economy, and also complement the aspiration of a circular economy.

The term ‘bio-based’ means 'derived from biomass'. Bio-based products (bottles, insulation materials, wood and wood products, paper, solvents, chemical intermediates, composite materials, etc.) are products which are wholly or partly derived from biomass. It is essential to characterize the amount of biomass contained in the product by, for instance, its bio-based content or bio-based carbon content.

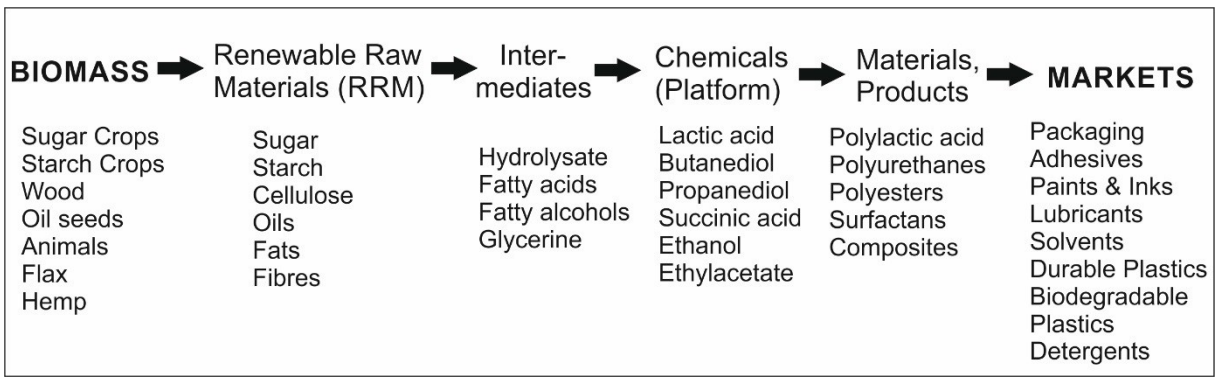


Figure 4. Bio-based products’ value chain. Source: adopted from the Presentation at the RRM-Group Meeting, 13th Nov. 2013, Brussels, Belgium.

In Table 1 some definitions emphasized end-of-life of products are presented.

Table 1.
Definitions of end-of-life of bio-based products

Term	Definition
Recirculated	Returned to use within a certain timeframe by an anthropogenic process and/or a natural process
Reusable	Returned to use within a certain timeframe without modification to the parent article or loss of performance
Recyclable	Returned to use within a certain timeframe by an anthropogenic process
Renewable	Comes from renewable resources and is returned to use within a certain timeframe by a natural process

Source: from Sherwood et al., 2017.

The report "D2.3 Assessment of the Bio-based Products Market Potential for Innovation", which has been prepared by Pöyry Management Consulting provides insight into the market structure and stakeholders, including risks and barriers related to the development of the European bio-based industries. This report focuses on four product groups, namely: (i) bioplastics, (ii) biolubricants, (iii) biosolvents and (iv) biosurfactants.

The volume of the European bioplastics market totaled 0.13 Mt in 2008 and is estimated to grow to 0.9 Mt in 2020 (growth rate 16% pa). At the current state of technology, 5-10% of the plastics market could theoretically be bioplastics and the long-term potential (2030 onwards) is significantly higher (70-100%). Annual biolubricant consumption in the EU totaled 0,15 Mt in 2008 and is estimated to grow to 0.23 Mt in 2020 (growth rate 3.6% pa). The current market penetration of biolubricants varies considerably within the EU, and not all biolubricants are completely vegetable oil-based. Theoretically around 90% of lubricants currently used could be replaced by plant-derived chemicals. The EU biosolvent consumption totaled 0.63 Mt in 2008 and is estimated to grow annually by 4.8%, reaching 1.1 Mt in 2020.

The consumption of biosurfactants totaled 1.52 Mt in the EU in 2008. Annual growth potential is estimated to be 3.5%, and biosurfactant potential 2.3 Mt in 2020.

Bioplastics are plastics made in whole or in part of renewable resources. They include starch plastics, cellulosic polymers, PLA, polytrimethylene terephthalate (PTT) from biobased 1,3-propanediol (PDO), polyamides (nylon), polyhydroxyalkanoates (PHAs), polyethylene (PE), polyvinyl chloride (PVC) from biobased PE, other biobased thermoplastics (polybutylene terephthalate (PBT)), polybutylene succinate (PBS), polyethylene terephthalate (PET), polyethylene-co-isosorbide terephthalate polymer (PEIT), polyesters based on PDO, polyurethane (PUR) from biobased polyols, and biobased thermosets. Globally, bioplastics make up nearly 300,000 metric tons of the plastics market. While this is a significant quantity, bioplastics account for less than 1% of the 181 million metric tons of synthetic plastics produced worldwide each year (Golden, Handfield, 2014, p. 56-60).

Biopolymers are partial replacements for petrochemical-derived materials and these natural raw materials are abundant, renewable, and biodegradable, making them attractive feedstocks for bioplastics, a new generation of environmentally friendly plastics. Biopolymers

are macromolecules derived from plants, trees, bacteria, algae, or other sources, and they are long chains of molecules linked together by chemical bonds. The most commercially available biopolymer, polylactic acid (PLA), is produced from lactic acid through the fermentation of dextrose, which is extracted from a starch source material.

Biobased polymers may be divided into three main categories based on their origin and production (Mukherjee, Kao, 2011, p. 714-725), i.g.:

1. **category 1** includes those derived from polysaccharides, such as starch or chitin,
2. **category 2** includes those produced from classical chemical synthesis using renewable, biobased monomers (which includes PLA),
3. **category 3** includes those produced by microorganisms or genetically-modified bacteria, such as polyhydroxyalkanoates (PHAs).

The term **biolubricant** refers to plant-derived lubricants, they are biodegradable and they are blended with biodegradable mineral oils. Formulations are very complex and they are blends of different types of oils. The biolubricants group therefore covers a very broad commercial range, and is not limited to 100% plant-derived lubricants. Plant-based lubricants are commonly used in cutting fluids, chainsaw lubricants, metal working fluids, hydraulic oils, 2-stroke engine oils, marine oils and drilling fluids. They have some properties and environmental benefits, i.g. biodegradability, lower toxicity, which enable their use in sensitive environments and contributes to pollution prevention.

Biosolvents are liquids that dissolve, dilute or extract other substances without modifying the chemical composition of the extracted substances. There are eight main solvent groups: aromatic hydrocarbons, petroleum-based solvents, alcohols, ketones, esters, ethers, glycol ethers, halogenated hydrocarbons and so-called special solvents. Base on their properties, solvents are used as degreasing agents (cleaning of metals, textiles), additives and diluting compounds (paints, varnishes, inks, glues, pesticides), stripping agents (paint, varnish, glue removers) and extraction solvents (perfumes, pharmaceuticals). Biosolvents have applications in cleaning, plant-protection oils and wetting agents and biofluxing agents. Biosolvents do not emit volatile organic compounds (VOC) which are harmful to human health. Examples of biosolvents are soy methyl ester (soy oil esterified with methanol), lactate esters (fermentation derived lactic acid reacted with methanol or ethanol) and D-limonene (extracted from citrus rinds).

The **biosurfactants** (biological surface active compounds or microbial surface active agents) are surface-active biomolecules produced by living cell, mainly by microorganisms. They are amphiphilic biochemical compounds contained both hydrophobic and hydrophilic groups that allow them to exist at the interface between polar and nonpolar media. They are produced on microbial cell surfaces or are extracellularly secreted. The current market demand for industrially sustainable biosurfactants has grabbed the attention of many companies for commercial production of cost-effective and environment friendly substitutes to synthetic surfactants. Therefore, the global market of biosurfactants, growing of 3,5%, and

is expected to reach 2,210,5 mln dollars in 2018. The review of Shete et al. (Shete, Wadhawa, Banat, Chopade, 2006, p. 91-115) presents 255 patents related biosurfactants issued worldwide. The highest number of patents are issued for use biosurfactants in the petroleum industry (33%), followed by cosmetics (15%), as antimicrobial agents and medicine (12%) and for bioremediation (11%).

In Tables 2 and 3 the EU production and EU market value and employment opportunities of 4 categories of bio-based products are presented, respectively. In the review of Biddy et al. (Biddy, Scarlata, Kinchin, 2016), the 32 biomass-derived chemicals were identified. The goal was to identify the current market volumes, prices, and projected growth for each of these products in the United States and globally, as well as to evaluate the potential for a near-to midterm deployment of these bio-derived chemicals.

Table 2.
Estimated EU production of bio-based polymers, lubricants, solvents and surfactants

Categories of bio-based products	**Total consumption in 2008** (mln tonnes)	**Biobased consumption in 2008** (mln tonnes)	**Biobased potential in 2020** (mln tonnes)	**Growth potential** (% annualy)
Plastics	48	0.13	0.9	16
Lubricants	5.2	0.15	0.23	3.8
Solvents	5.0	0.63	1.1	4.8
Surfactants	2.7	1.52	2.3	3.5

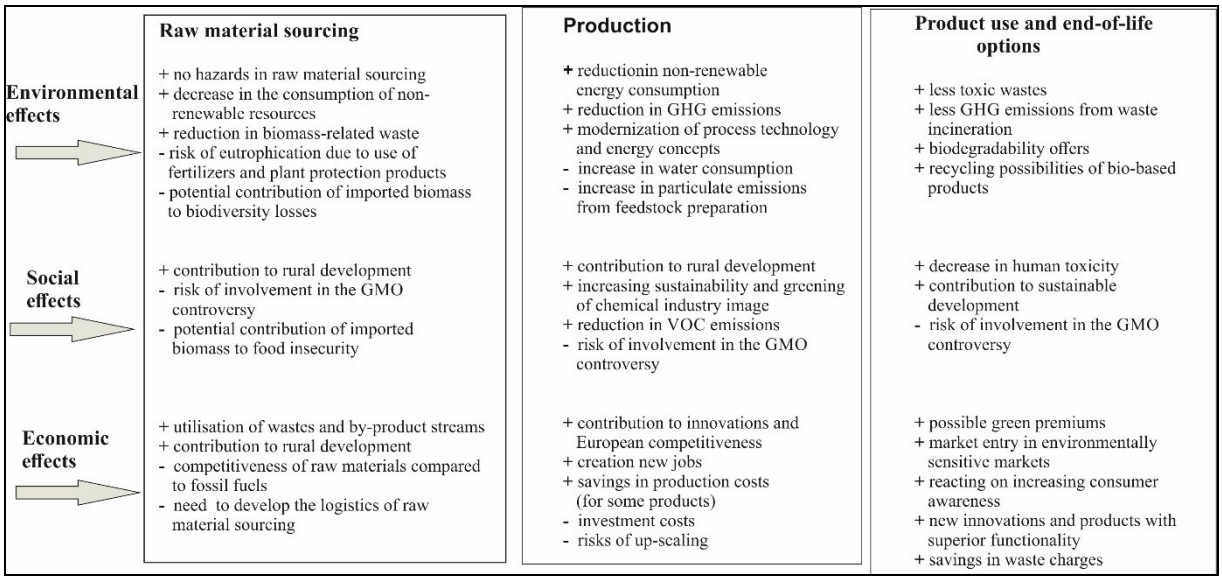
Source: Report D2.3 "Assessment of the Bio-based Products Market Potential for Innovation". Pöyry Management Consulting.

Table 3.
Estimated EU market value and employment opportunities of bio-based polymers, lubricants, solvents and surfactants

EU	**2008**	**2020**
Market Value (billion EUR)	21	40
Share of biochemical value of total chemical value	4.0	6.0
Employment in biochemical production	50.200	93.700

Source: Report D2.3 "Assessment of the Bio-based Products Market Potential for Innovation". Pöyry Management Consulting.

The results. mainly from the LCA studies. evaluating the environmental performance of bio-based products compared to petroleum-based products. indicates that bio-based products consume less energy and emit less carbon dioxide than products from fossil resources. The biosolvents emit few or no volatile organic compounds. The bio-based products offer the potential to reduce the generation of toxic wastes. On the other hand. there may be adverse environmental effects that are related to use of fertilizers and agricultural chemicals (excluding by-product streams) and particulate emissions from feedstock preparation. In conclusion. the overall environmental effects of bio-based production are seen as positive. In the Figure 5 the positive and negative impacts of bio-based value chain in the three aspects (environmental. social and economic) are presented.



"+" – positive impact; "-" – negative impact

Figure 5. Impacts of bio-based production in its various stages. Source: Report D2.3 "Assessment of the Bio-based Products Market Potential for Innovation". Pöyry Management Consulting.

According to Ademe (Ademe, 2004) bio-based products can create savings in non-renewable energy consumption of 40-80% and in GHG emissions. at least 50% lower CO_2 emission. Another attractive aspect of bio-based products is the potential to reduce the generation of hazardous and toxic wastes associated with the manufacture of fossil-based products. Many chemical processes require large quantities of aromatic solvents or strong inorganic acids and bases (e.g. sulphuric acid. sodium hydroxide) that can result in effluent streams that are harmful to the environment. These must be recycled or treated and disposed of. On the contrary, most biological processes require natural catalysts (e.g. enzymes) and solvents (water) and produce few or no toxic or hazardous by-products. In most cases. solid wastes and effluents from these processes are biodegradable or can be recycled or disposed of without excessive treatment processes.

The production of bio-based products can make a major contribution to agriculture and forestry by creating new markets for biomass. Over time. this could transform the farming and rural economies. The other transforming factor will be the need to develop bio-refineries in rural areas, to avoid transporting biomass for long distances. This would also provide work opportunities in rural areas. The bio-based sector contributes to the creation of knowledge driven and attractive jobs as well as to the greening of the chemical industry image. The total land use for bio-based chemical production is relatively low and land requirements are hence not likely to become a critical issue in the next few decades. Land use is, however, a delicate issue because of its close links to food insecurity and loss of biodiversity in developing countries. The value of the EU bio-based product market is forecast to grow from 21 to 40 billion EUR between 2008 and 2020 (Table 3). This growth implies significant employment opportunities and reduces dependency on imported fossil fuels. The sector will also facilitate

the creation of knowledge driven and attractive jobs and development of new innovations. Bio-based products will have the potential to utilise waste and by-product streams which currently have no value. This could transform the lives of farmers by making their business more profitable and creating new job opportunities.

4. EU policies related to bio-based products

Policies linked to bio-based products at the European level include the following:

- The EU's industrial policy which aims to raise industry's contribution to EU GDP to 20% by 2020 from the current level of 15%. The bio-based products sector. as a key enabling technology. is one of the priority areas with a high potential for future growth and addressing societal challenges.
- The Commission's bioeconomy strategy and action plan aims at shifting the European economy towards a greater and more sustainable use of renewable resources. The second pillar of the strategy focuses on the development of markets and competitiveness in bioeconomy sectors (such as the bio-based product sector) by sustainably increasing primary production. conversion of waste streams into value-added products (biorefineries). and mutual learning mechanisms for improved production and resource efficiency.
- The flagship initiative for a resource-efficient Europe under the Europe 2020 strategy supports the shift towards a resource-efficient low-carbon economy to achieve sustainable growth.
- The Circular Economy Package was created to help European businesses and consumers make the transition to a stronger and more circular economy where resources are used in a more sustainable way. The proposed actions contribute to 'closing the loop' of product lifecycles through greater recycling and re-use. and bring benefits for both the environment and the economy. This transition will be supported financially by ESIF funding. €650 million from Horizon 2020 (the EU funding programme for research and innovation). €5.5 billion from structural funds for waste management. and investments in the circular economy at national level.
- The European Innovation Partnerships (EIP) were launched under the Commission's Innovation Union flagship programme to accelerate the market take-up of innovations which address key challenges for Europe.
- The Commission's Lead Market Initiative between 2008 and 2011 fostered the development of the bio-based products sector by exploring demand-side innovation policy tools such as standardisation. labelling. and public procurement. The main outcomes of this initiative were an interim report "Taking Bio-based from Promise to

Market"; policy papers on financing and communications; and a list of priority recommendations for enabling the market uptake of bio-based products.

A Commission Expert Group for Bio-based Products was set up in mid-2013 for an initial period of four years. According to its Terms of Reference. the Expert Group's objective is to advise the Commission on the development of the bio-based products sector by:

- monitoring and supporting the development of the policy framework. and the implementation of the priority recommendations proposed by the Lead Market Initiative Ad-hoc Advisory Group for Bio-based Products.
- proposing demand-side industrial policy actions conducive to the market uptake of bio-based products and processes (standardization. public procurement. awareness raising. labelling. etc.).
- mapping of bio-based products and relevant bioeconomy related activities and exchanging of good practices at regional. national. international. and EU-level aimed at increasing the competitiveness of European industry.

The Group has 34 appointed members representing EU countries and state agencies. public procurers. non-governmental organizations (NGOs). academia. and businesses. 7 observers also follow the Group's work. The Expert Group has also set up several Working Groups:

- Assessment of the State of Play of the Implementation of the Lead Market Initiative Priority Recommendations.
- Public Procurement of Bio-based products.
- Awareness Raising on Bio-based products.
- Value added of Bio-based products.

The Working Group 'Assessment of the State of Play of the Implementation of the Lead Market Initiative Priority Recommendations' issued its paper in September 2015. The Working Group 'Awareness Raising' completed its general paper in February 2016.

The Working Group Public Procurement of Bio-based Products published its recommendations in April 2016 together with an annex containing additional information.

On 2 December 2016. the Expert Group hosted a workshop on "Bio-based Products in a Circular Bioeconomy: Functionality and Sustainability". Bio-based products have the potential to contribute to EU objectives of sustainable growth and addressing societal challenges. The workshop aimed at presenting an overview of what information. standards and measurements are already available in terms of sustainability. It also offered an opportunity for participants to highlight and discuss topics where further answers and information about bio-based products are still needed.

The final outcome of the Expert Group's work will be a report with policy advice for the sustainable development of a competitive bio-based products industry in Europe in the context of the current policy objectives.

5. Labelling of bio-based products

It is not always easy to communicate the benefits of bio-based and/or biodegradable materials to the market. Now. the Europe is working on standards and norms as one key area to promote bio-based materials. The certification and labelling help in promoting bio-based products because they inform businesses and consumers about the products' environmental benefits and therefore help them to choose the most sustainable products. Standards provide a reliable basis on which comparisons and claims can be made. Labels constitute a powerful tool to increase customers' confidence.

There are two labelling schemes. e.g. "OK bio-based" and "Bio-Preferred". focusing on bio-based products. Moreover. there are general ecolabels such as the EU Ecolabel that may be available for both bio- and fossil-based products. More information about international and national environmental labelling schemes can be found. e.g. in Ecolabels (http://ecolabelling.org/) or Global Ecolabelling Network (http://www.globalecolabelling.net/).

Under the new EU Public Procurement Directives (2014) there are possibilities to use labels as a source of information for defining technical specifications or award criteria.

The following is a (non-exhaustive) list of different labels. certification schemes and standards that may be considered when purchasing bio-based products or services.

ISO 14024 Type I Ecolabels specifying bio-based products:

- EU Ecolabel ("the Flower"): Lubricants: Lubricants receiving the EU Ecolabel need to prove a minimum content of bio-based carbon between >45% and >70% (depending on the type of lubricant). Examples of ecolabels:
- Nordic Ecolabel ("Nordic Swan") Sanitary products: This product group includes biobased materials in the form of fluffy pulp and bio-based polymers. Material composition must either include a share of 7% of all polymers from renewable raw materials. a share of 50% of all materials derived from renewable resources or the global warming potential of all the materials cannot be above 2.1 kg CO_2-equivalents/kilogramme of the product.
- Blue Angel ("Blauer Engel"): Office materials (writing utensils and stamps): A very recent revision of the criteria for these products has included the provision that they need to be produced either from 60% renewable raw materials or from 80% recycled materials.

Alphabetical index of 120 ecolabels is presented on the page: http://www.ecolabelindex.com/ecolabels/?st=category.building_products. In the Figure 6 some examples of ecolabels are presented.

Figure 6. The examples of EU ecolabels.

6. Standardization of bio-based products

The European Committee for Standardization (CEN) is responsible for delivering standards describing bio-based products within the European Union. Some European standards relevant to bio-based products are listed in the paper of Sherwood et al. (Sherwood, Clark, Farmer, Herrero-Davila, Moity, 2017, p. 1-17). One example of a European standard is EN 16785-1:2015. It is titled "Bio-based products: Bio-based content -Part 1: Determination of the bio-based content using the radiocarbon analysis and elemental analysis". It is a systematic method of assigning a value of total bio-based content to a bio-based product. EN 16785-1:2015 is an example of a verifiable test method that substantiates claims of bio-based content to the benefit of the market. The next draft European Standard on bio-based content is currently submitted to CEN members for formal vote. i.g. EN 16785-2 entitled "Bio-based products: Bio-based content – Part 2: Determination of the bio-based content using the material balance method". More European standards relevant to bio-based products are listed in Table 4. Most have been created by the CEN technical committee for bio-based products (CEN/TC 411). Standards are also essential to formally describe the attributes of the four key bio-based product types listed earlier (plastics. lubricants. solvents. and surfactants). The new trend report "Standards and labels for bio-based products" is available at www.bio-based.eu/reports.

Table 4.
European standards for bio-based products developed in CEN/TC411

Standard	Title	Stage of development
EN16575	Bio-based products: Vocabulary	Published 2014
CEN/TR 16721	Bio-based products: Overview of methods to determine the bio-based content	Published 2014
CEN/TS 16640	Bio-based products: Determination of the bio-based carbon content of products using the radiocarbon method	Published 2014
CEN/TR 16957	Bio-based products: Guidelines for life cycle inventory (LCI) for the end-of-life phase	Published 2016
FprEN 16640	Bio-based products: Bio-based content- Determination of the bio-based carbon content using the radiocarbon method	Waiting approval
EN 16785-1	Bio-based products: Bio-based content-Part 1: Determination of the bio-based content using the radiocarbon analysis and elemental analysis	Published 2015
prEN16785-2	Bio-based products: Bio-based content-Part 2: Determination of the bio-based content using the material balance method	Waiting approval
EN 16760	Bio-based products: Life cycle assessment	Publishing 2015
EN 16751	Bio-based products: Sustainability criteria	Published 2016
EN 16848	Bio-based products: Requirements for business to business communication of characteristics using a data sheet	Published 2016
FprEN 16935	Bio-based products:B2C reporting and communication-Requirements for claims	Waiting approval
CEN/TS 16766	Bio-based solvents: Requirements and test methods	Published 2015
EN 16807	Bio-lubricants: Criteria and requirements of bio-lubricants and bio-based lubricants	Published 2016
CEN/TS 16398	Plastics: Template for reporting and communication of bio-based carbon content and recovery options of biopolymers and bioplastics-Data sheet	Published 2012
FprCEN/TS 17035	Surface active agents: Bio-based surfactants-Requirements and test methods	Waiting approval

Source: listed by Sherwood et al., 2017.

There are four technical committees working in the area of bio-based products in European Committee for Standardisation (CEN):

- CEN/TC 19 – gaseous and liquid fuels. lubricants and related products of petroleum. synthetic and biological origin,
- CEN/TC 249 – plastics,
- CEN/TC 276 – surface active agents,
- CEN/TC 411 – bio-based products.

7. Conclusions

The market for bio-based products is constantly growing due to the efforts of producers, consumers and state offices. However, the promotion and acceptance of these products should be extended in order to increase their economic competitiveness. This is an important task; aiming at a more economical use of natural resources and creating a more sustainable

economy. One of the essential elements of the above mentioned policy is the standardization and labeling of bio-based products.

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