

Overcoming hurdles for innovation in industrial biotechnology

Non-technological Roadmap



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1. Introduction

Despite being able to tackle some of today's global societal challenges including climate change, dwindling fossil fuel resources and the need for the development of a more sustainable and resource-efficient industry, several hurdles continue to hamper the full exploitation of Industrial Biotechnology's (IB) potential today.

The BIO-TIC project was a solutions-centred approach that comprehensively examined the innovation hurdles in IB across Europe and formulated action plans and recommendations to overcome them.

Three roadmaps have been developed, based on literature study, more than 85 interviews with experts and on the information collected through several regional and business case workshops.

The three roadmaps are:

- The *market roadmap* relates to current markets for five IB business cases across Europe, and market projections extending to 2030. It aims to obtain a comprehensive overview of the market potential for industrial biotechnology, the current and potential future value chain composition and stakeholders, including segmented market opportunity assessment and projections. The “market roadmap” provides an important focus for the other two roadmaps.
- The *technology roadmap* revolves around the setting of R&D priorities and identifying needs for research, pilot and demonstration plant activities. This is centred on obtaining a clear overview of R&D related hurdles for realising Europe's IB market potential. The analysis focuses on the identification of R&D bottlenecks and required breakthroughs across a broad range of technological domains. It seeks to identify key areas of research to focus on, and to selectively highlight those areas that can be best aligned with current and foreseen end user market requirements. The technology roadmap also seeks to identify the relative strength of research areas in different European countries and gathers evidence where a duplication of resources exists.
- The *non-technological roadmap* identifies regulatory and non-technological hurdles that may prevent IB innovation from taking advantage of market opportunities. The roadmap proposes solutions for key market entry barriers, going beyond recommendations already formulated by other initiatives and projects on biobased products.

The BIO-TIC roadmaps show how the various stakeholders can work together to overcome the major issues that hamper the huge potential of IB in Europe. The integrated roadmap entitled ‘The bioeconomy enabled: A roadmap to a thriving industrial biotechnology sector in Europe’ shows the relationship between potential market developments, R&D needs, regulatory and non-technological aspects impacting on IB innovation. All BIO-TIC roadmaps can be downloaded from the project website at <http://www.industrialbiotech-europe.eu/>.

2. Scope of the roadmap

The scope of the BIO-TIC-project is the industrial biotechnology (IB) value chain. While BIO-TIC aims to develop roadmaps with a scope that covers the wider IB market and value chains, it takes a focused approach in analysing the main hurdles, enablers and required actions towards realising IB's potential for Europe. It has been decided to focus the analyses on a limited number of five complementary "business cases for Europe", each of which represent different products and application areas, such that they enable the project partners to discover the widest possible hurdles and enablers that are relevant for the European IB market.

The business cases were selected based on a product group-specific rating carried out by an expert panel comprised of BIO-TIC partners and validated by the Project Coordination Committee and the Advisory Committee of the project. The 5 business cases represent product groups that can make a major contribution to an accelerated take-up of industrial biotechnology into the market place. The selected business cases are:

- Advanced biofuels: bioethanol and biobased jet fuels;
- Chemical building blocks¹;
- Biobased polymers²;
- Biosurfactants;
- CO₂ as a feedstock: Using IB as tool for reducing CO₂ generated from processes using fossil or biobased raw materials (Carbon Capture and Utilization).

The BIO-TIC roadmaps were developed in three steps as shown in Figure 1. More information can be found on www.industrial-biotechnology.eu.

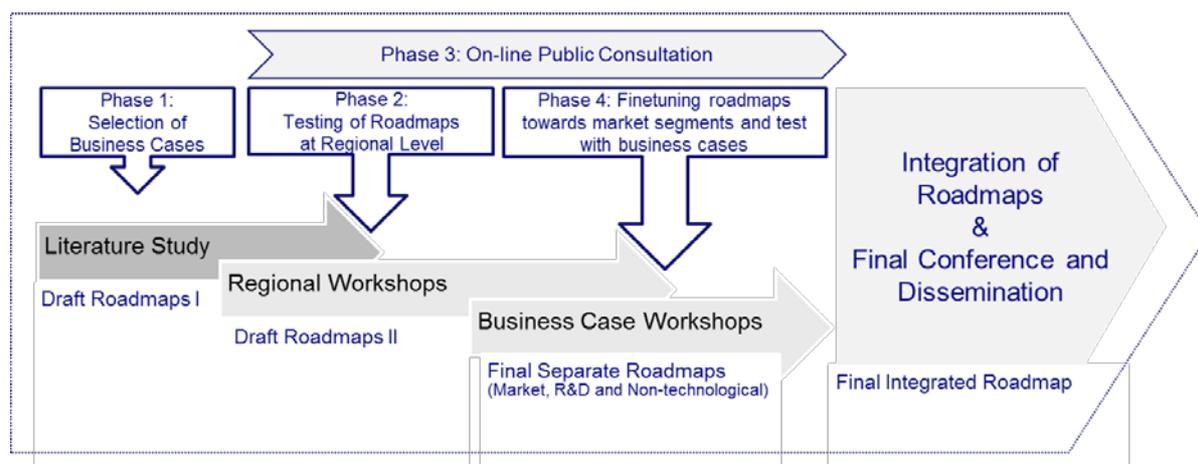


Figure 1. Roadmapping process

¹ A decision was made to have a closer look at 5 platform chemicals and these were later defined as Succinic acid; Isoprene; 3-hydroxypropionic acid (3-HPA); 1,3-propanediol (1,3-PDO); and Furfural.

² For bioplastics the decision was made to focus on PHA (polyhydroxyalkanoate) and PLA (polylactic acid)

3. Vision

This chapter describes the vision on Industrial Biotechnology for 2030 and the five selected business cases. Detailed information on the market development of industrial biotechnology and the business cases can be found in the market roadmap available at www.industrial-biotechnology.eu

3.1. General IB Vision

Industrial biotechnology has the potential to save energy in production processes and can lead to significant reductions in GHG emissions. Furthermore, it can lead to improved performance and sustainability for industry and higher value products. And also via IB – compared to fossil processes – capital investment can be reduced and more employment realized.

BIO-TIC looks at a world where Industrial Biotechnology plays a significant role in realizing the biobased economy through biorefineries, but also through novel IB processes for the production of valuable substances (chemicals, surfactants, fuels etc.) through e.g. cell-factories, direct enzymatic transformation as well as using novel feedstock streams such as CO₂ from flue gas or directly from the atmosphere.

The development of organisms as optimized biotechnological production systems cannot only replace petro-based products and processes, but also lead to new products and processes, for instance through bio-catalysts, which opens up the market for technology providers.

These developments will lead to new feedstock demands and related new technology developments. Synergies between different research fields are expected, as the combination of biotechnology, nanotechnology, process engineering and information & computing technologies can open new technological paradigms.

Overall, BIO-TIC's vision is that Industrial Biotechnology will play a major role in transforming our world, contributing to drastically lower CO₂ footprints of our society, and generating significant economic value and jobs for Europe.

According to the updated projections, the IB market is estimated to develop from 28 billion EUR in 2013 to 40 billion EUR in 2020, and up to 50 billion EUR in 2030 (Figure 2). This development represents an annual compound average growth rate (CAGR) of 7%³ between 2013 and 2030.

³ Excluding antibiotics and biogas

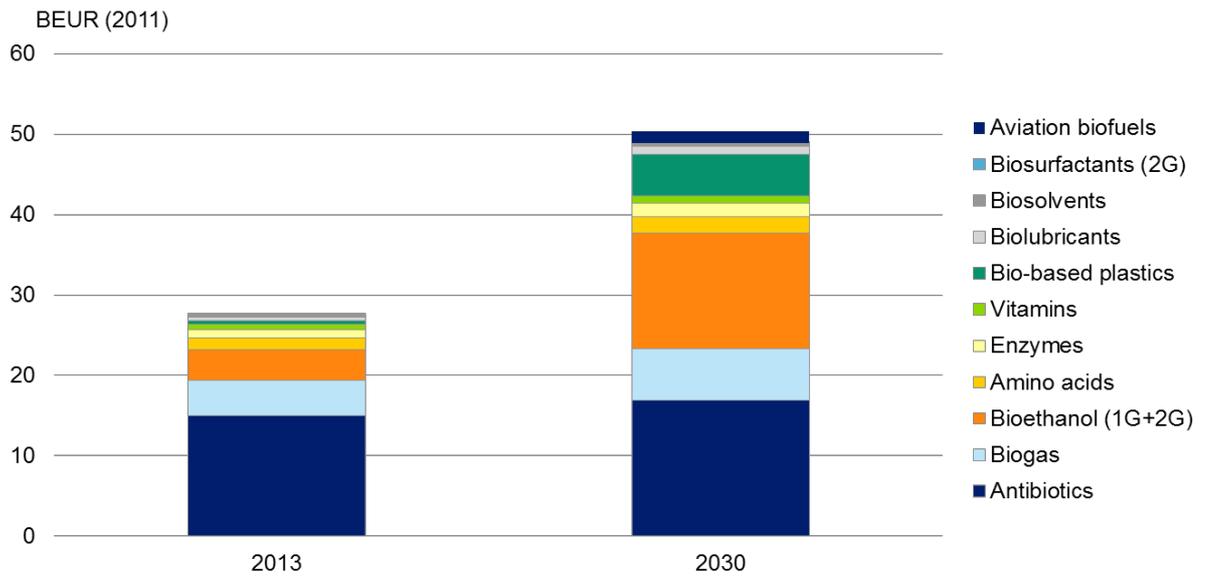


Figure 2. Estimated IB market demand in the EU up to 2030

3.2. Advanced biofuels

In 2030, diverse sustainable feedstocks will be available on a large scale and there will be a performing biofuels supply chain in Europe and globally.

3.2.1. Ligno-cellulosic ethanol

Ambitious greenhouse gas emission reduction targets for 2030 will continue to drive the consumption of renewable fuels, with or without separate biofuel quotas. The use of biofuel feedstocks that compete with the food or feed chain will no longer be politically supported. The demand for 2G ethanol is therefore expected to increase rapidly through to 2030.

According to the updated market projections, the 2G ethanol market is estimated to reach a demand of 2.7 million ton in 2020 valued at approximately 2.2 BEUR. In 2030, the market value would reach 14.4 BEUR.

3.2.2. Aviation fuel

The EU governments will have supported the scaling-up of biojet production capacity. Thanks to major efforts on reducing the price for feedstocks and the concurrent rising cost for fossil kerosene, the biofuel cost disadvantage will have diminished but will not be fully covered. Therefore, it will be difficult for the market to grow except on a voluntary basis, relying on air passengers' willingness to pay for additional biofuel costs in their ticket prices. The energy demand in aviation is expected to grow from current 52 Mtoe to 59 Mtoe in 2030, but the potential of biofuels is very unclear.

3.3. Bioplastics Vision (PHA & PLA)

In 2030, there will be both biodegradable and non-biodegradable bio-based plastics in the market. Biodegradable plastics will be widely used in disposable products whereas non-biodegradable bioplastics will be aimed at durable applications and recycling.

Both 1st and 2nd generation raw materials will be used in bioplastics production in 2030. Consumers are widely aware of the environmental benefits of bioplastics and familiar with EU-wide labels indicating bio-based content, biodegradability and recyclability of bioplastics. The bioplastics market value is expected to reach approx. 5.2 BEUR in 2030.

3.4. Chemical Building Blocks Vision

In 2030, the cost and security of supply will still be the dominant sourcing criteria in commodity chemicals, making biobased production more feasible in the value-added fine and specialty chemical markets than in commodity building blocks. An increasing number of chemicals and materials will be produced using biotechnology in one or more of the processing steps, leveraging on a number of intermediate enabling biobased platform chemicals produced from first and second generation biobased feedstock. This will allow European manufacturers in chemistry and material sciences to produce biobased versions of a wide range of their existing products currently produced with petrochemical feedstock. The market value in 2030 is expected to reach 9.2 BEUR.

3.5. Biosurfactants Vision

In 2030, bio-based surfactants will be available for a wide range of applications, however, still as niche products due to limited cost competitiveness compared to conventional surfactants. On a global scale, Europe will remain as the largest consumer of biobased surfactants. The European bio-based surfactant demand is expected to follow the growth of the overall surfactant market through to 2030. Bio-based surfactants will be produced from a variety of feedstocks including traditional plant oils, fats and sugar biomass but also algae and waste streams. The bio-based surfactants market is estimated at nearly 1.3 BEUR.

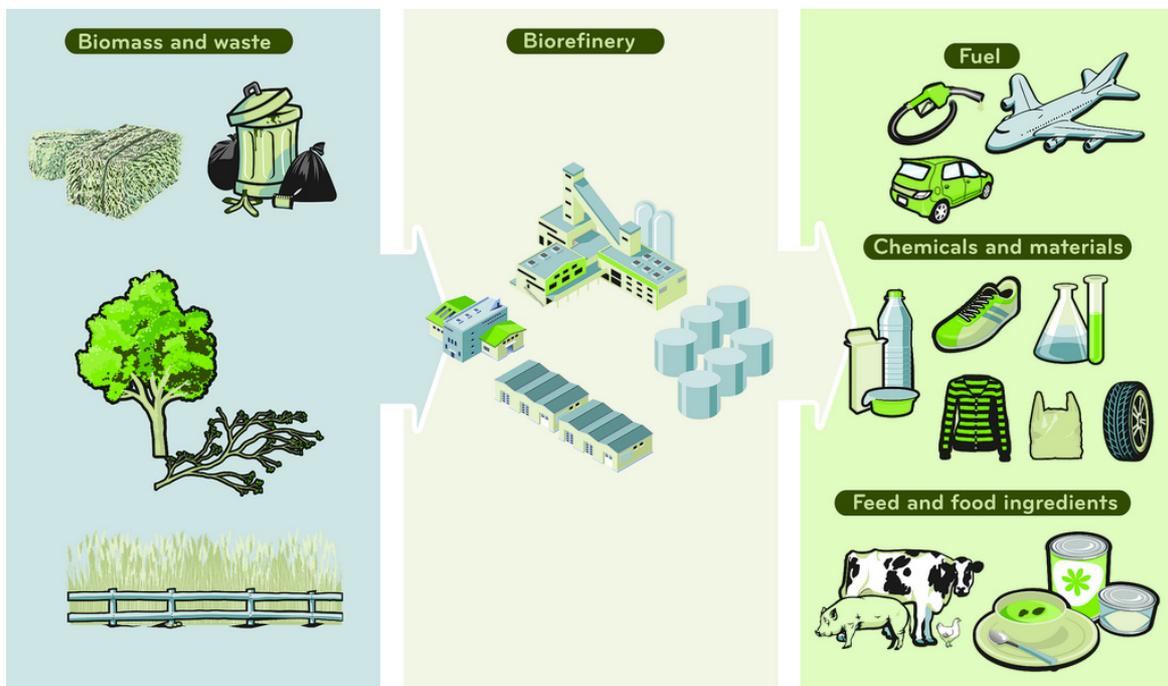
3.6. CO₂ as a feedstock

In 2030, CO₂ is no longer seen as a waste product with dangerous environmental effects but increasingly as a feedstock for chemicals, fuels or polymers. Carbon dioxide offers opportunities for new cost competitive chemical processes and applications, allowing complex chemical production chains to be reduced to one or two step microbiological conversions and opening windows for completely new chemical compounds. Realisation of industrial scale facilities will depend strongly on the cost of CO₂ capture, on the future political climate, and on the development of energy prices and hydrogen in particular.

4. Horizontal hurdles, enablers and solutions

4.1. Introduction

In this document, possible hurdles for IB and biobased products were first identified via literature study (see annex 1). The list was completed via stakeholder interviews and during the regional workshops. During the regional workshops, hurdles were also prioritised and the participants started to identify possible actions to overcome the hurdles. These actions were further developed during interviews and 5 business case workshops organised second half of 2014. Section 4.2. gives an overview of the hurdles with the biggest impact including actions to overcome them. Section 4.3. gives an overview of the other possible horizontal hurdles.



4.2. Main hurdles and solutions

4.2.1. Overview

HURDLES		SOLUTIONS
Feedstock related barriers	Need for continuous feedstock supply	<ul style="list-style-type: none"> • Continue to fund research and demonstration programmes on non-food biomass sources • Reinvigorate sugar beet production and processing capacity in the EU • Promote the availability of feedstock-related information. • Investigate routes for using multi-feedstock processing capability
	Inefficient transport and distribution of biomass	<ul style="list-style-type: none"> • Develop infrastructure for biomass collection, storage and transportation. • Development of decentralised pre-treatment facilities
	Inefficient recovery systems for (bio)waste	<ul style="list-style-type: none"> • Ensure that producers can make informed decisions on the use of their residues/wastes. • Ensure producers are given a fair-price for collecting their wastes/residues. • Amend the Waste Hierarchy in the Waste Framework Directive to facilitate the use of wastes for higher value applications.
	Costs of feedstock produced in Europe are too high and too variable	<ul style="list-style-type: none"> • Facilitate the appropriate use of wastes and residues for IB processes • Lower (high) import costs for certain types of feedstock
	No commonly accepted “sustainability” certification system	<ul style="list-style-type: none"> • Reduce the complexity of sustainability reporting schemes • Promote the cascading use of biomass.
Investment barriers and financial hurdles	Limited availability of public R&D funding	<ul style="list-style-type: none"> • Increase R&D funding
	Limited public support for scale-up activities	<ul style="list-style-type: none"> • Ascertain capacity, capability, funding models and client geography for European IB pilot and demo plants • Invest in infrastructure at pilot and demonstration scale to bring innovative European ideas to market • Promote development of predictive scale-up models • Promote funding support for trials at dedicated pilot plant facilities

	Limited access to finance for spin-offs and start-ups and SMEs	<ul style="list-style-type: none"> • Setting up funding programmes and innovation awards for bio-entrepreneurship • Implementation of funding for feasibility studies • Development of demonstration projects as proof of concept • Setting up of specific funding programmes targeted to innovative SME's
	Limited financial support for new production facilities	<ul style="list-style-type: none"> • Increase awareness about grants and funding opportunities • Speed up integration of public grants from EU H2020, EU ESIF and National grants • Create a European BioEconomy Strategic Investment Fund (EESIF)
Public perception and communication	Advantages of biobased products are not visible enough	<ul style="list-style-type: none"> • Develop an EU wide campaign to improve public awareness and perception of IB and IB-derived products • Develop a campaign aimed at improving awareness of how IB products can aid industry.
	Public acceptance for IB products can be improved	<ul style="list-style-type: none"> • Ascertain the public's acceptance level for IB and biobased products
Demand side policy barriers	No dedicated framework to promote biobased products	<ul style="list-style-type: none"> • Introduce financial incentives for biobased products
	Lack of a "green public procurement" policy promoting biobased products	<ul style="list-style-type: none"> • Support biobased products development through public procurement
	No uniform standard and label for sustainable and biobased products	<ul style="list-style-type: none"> • Develop clear European standards • Branding of biobased through an ecolabel and/or "Biobased" label • Set up a harmonization strategy for ecolabels in Europe

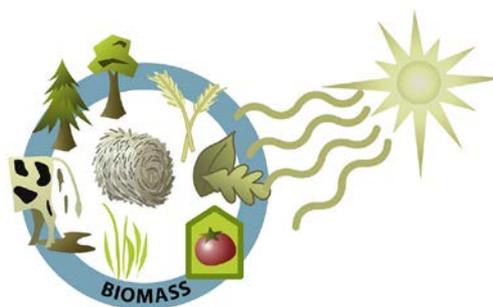
Table 1 Overview of the main non-technological hurdles

4.2.2. Feedstock related barriers

4.2.2.1. Need for continuous feedstock supply

Many of the products manufactured with IB processes will be produced in biorefineries⁴. To maximise the return on investment, biorefineries should operate all year round, so the seasonality of biomass cropping poses a particular challenge. Enough biomass should be available, but diversified and integrated logistics systems are needed to supply different types of biomass out of season at both a local and regional scale. The supply chain up to the factory gate has to ensure that the feedstock is suitable for the subsequent biorefinery processes, so that the final products meet relevant specifications. So the seasonability of biomass cropping poses a logistic and/or organisational challenge for agriculture and a R&D challenge.

Today, most of the feedstock used for conversion consist of raw materials with C6 sugars (sugar and starch crops). The use of woody biomass is still in its infancy. So there is also a R&D challenge to develop processes that are robust enough to deal with different kinds of feedstock during the year.



Future development of the European biomass sector will be subject to a high degree of uncertainty, mainly depending on crop yields and land availability. The uneven geographical development of agricultural production and demand for both food and feed will influence patterns of global trade in general and the demand for European agricultural exports in particular.

Solution: continue to fund research and demonstration programmes on non-food biomass sources.

A wide range of novel biomass sources exist which could be used as feedstocks for IB, including micro- and macroalgae, Miscanthus and Arundo donax. Their adaptability and resilience to marginal conditions could be improved to extend cultivation area beyond current limits and requires the input of plant breeders and research bodies from industry and academia using conventional and new technologies. A thorough assessment of the sustainability and LCA associated with novel biomass sources should be a necessity in any pilot and demonstration project utilising these resources at each stage of the project lifecycle.

⁴ Not all IB products need to be produced in biorefineries, e.g. PHA don't need a large scale biorefinery, and also other Biobased building blocks can be produced at a lower scale.

Solution: reinvigorate sugar beet production and processing capacity in the EU

Sugar beet is an excellent and sustainable feedstock for IB, with abundant and easily accessible fermentable sugars⁵. Since the mid-2000s, there has been a reduction in sugar beet processing capacity in the EU. While in some countries production has been scaled-back, in other countries production has been lost entirely. The sugar reforms due in 2017 present an opportunity for reinstating this capacity at least in some areas of Europe, but farmers to be assured that a market exists and they will get a fair price for their goods. Two approaches are proposed:

- Improve sugarbeet IB-readiness. Competitiveness of production for IB markets may be boosted through targeted research into how beet can be processed in a minimal way, so that sugars are available in a pure enough form for fermentation, but without the expense of being fully refined as for food grade sugar. Research is needed to ascertain whether this is possible and can be improved. A Horizon 2020 project on this, bringing together the sugar beet processing chain and fermentation capability is encouraged.
- Deploy integrated sugarbeet cultivations. On a local level, processors should work with potential growers to promote the opportunities for sugar beet cultivation in a specific locality, and agricultural extension services should ensure that best practices are deployed.

Solution: promote the availability of feedstock-related information.

Future feedstock availability should be promoted by taking advance of IT and by developing methods and tools for managing, refining and utilising feedstock related data so that necessary logistics and supply chains for biomass and waste streams can be established. Examples of such development include opening up previously exclusive feedstock statistics and inventory data and the utilisation of so-called big data (mining of large datasets to create business opportunities and to improve operations planning and decision making). Better information on e.g. the quality and utility value of feedstocks will benefit not only the producer but also other stakeholders of the value chain. A good example is the S2BIOM project⁶ (Delivery of sustainable supply of non-food biomass to support a “resource-efficient” Bio-economy in Europe).

Solution: investigate routes for using multi-feedstock processing capability

The European IB industry is hampered in securing sufficient amounts of any one type of feedstock, on a consistent and economic basis throughout the year. It has been suggested that the development of facilities able to process multiple feedstocks (including food, non-food and waste biomass according to availability and cost) would help overcome some of the issues surrounding the variability of biomass supply. Significant research and development is

⁵ Deloitte (2014) - Opportunities for the fermentation-based chemical industry

E4Tech (2015) - From the Sugar Platform to biofuels and biochemicals

⁶ www.s2biom.eu

needed to realise such facilities and their implementation is likely to be a longer term prospect. Nevertheless, funding should be allocated for R&D activities in this field now to ensure post-2020 plants have flexible processing capacity.

4.2.2.2. Logistics: inefficient transport and distribution of biomass

As biomass is a bulky material, the costs of biomass transportation very much depends on the distance between the biomass location and the processing facility. The most important driver in the forest feedstock supply chain is to determine whether a long-term supply of material can be delivered to a conversion facility at an acceptable cost and quality.

Because of the costs inherent to the transport of low density biomass over long distances, logistics systems have a significant influence on the efficiency and competitiveness of the entire biorefinery value-chain.

Another major challenge in the logistics chain is the quality management of perishable, wet material. The ability to store feedstock reduces the seasonality of biomass availability and bridges the gap between harvest and processing.

Solution: develop infrastructure for biomass collection, storage and transportation.

The ways in which wastes and residues are mobilised and who is responsible for this will be important in determining a fair price for producers. However, infrastructure and routes for mobilisation of waste and residues is currently lacking across much of Europe and there is a need to understand how this could be optimised. This is an active area of research in the EU, for example the BBI-JU or some Horizon2020 projects aim to address feedstock mobilisation and logistics by 2020 through a series of research, demonstration and flagship projects. There is no obvious solution to this problem and different solutions may need to be deployed in different regions. Financial incentives, cooperatives, obligations (or a combination thereof) may all be feasible options. Regional development funding should be used to explore which options best fit within different regions.

Solution: development of decentralised pre-treatment facilities

Wherever possible, integrate biomass procurement to existing efficient processes and/or make use of decentralised pre-treatment facilities to overcome the effects of high water content and fragmented availability of many biomass feedstocks on collection and transportation costs.

4.2.2.3. Inefficient recovery systems for (bio)waste

Waste may be cheaper as a feedstock right now, but the processing of waste is technologically more difficult. In addition, the regulation for waste is relatively complex.

Biomass waste streams are often disposed of without consideration for energy recovery. Energy-from-waste systems that utilize organic wastes as biomass energy feedstock could be designed.

The potential for using the residues of existing feedstocks, such as straws, forestry residues and wastes is immense, offering the possibility to develop biobased products without impacting upon land use whilst bringing in an additional income stream for farmers and landowners. In theory, wastes and residues are “cheap” feedstocks, however, many wastes and residues have existing uses, and care should be taken to ensure that the use of these materials do not adversely impact upon existing markets or uses and cause unintentional ‘negative displacement’ effects.

Solution: ensure that producers can make informed decisions on the use of their residues/wastes.

Farmers should know what options are available to them, and how they can be exploited, whilst still being able to manage cross-compliance measures stipulated in the CAP and any sustainability standards required by processors. There is currently a lack of guidance for farmers on the optimal use of straw as a soil improver. In this respect, EIP-Agri Farm Advice Service⁷ would appear to be the logical coordination point for this role, in collaboration with its national and regional advisors. Furthermore, bio-waste producers may not necessarily be aware of the opportunities they have for using their product for bioprocessing. As a result, there is a distinct need to raise awareness of IB amongst bio-waste producers to ensure that such synergies develop.

Solution: ensure producers are given a fair-price for collecting their wastes/residues.

The IB industry requires access to competitive sugars as feedstock prices are a major determinant of the final product price. However, wastes and residues are rarely ‘wasted’ and may have valuable uses in other markets. Producers need to be able to cover the costs of harvesting, collecting and storing the biomass and any inherent value that the feedstock brings. For example, for straw, the nutrients contained within the straw can be valuable depending upon the relative prices of nutrients, particularly phosphate and potash. The cost of biomass can vary significantly both in different areas and across the season. This variability in pricing can contribute to biomass producers deciding to sell on the open market rather than commit to forward contracts where the price may be held for several years. This can hamper the secure supply of biomass for processing. Options by which this could be facilitated need consideration. Regional development funding provides financial support to support this action, for example establishing producer groups, knowledge transfer and capacity building, but the administrative burden associated with applying is thought to be disproportionate to the funding available. Routes to reduce the complexity associated with accessing such funding would be welcomed by farmers and landowners.

⁷ <http://ec.europa.eu/eip/agriculture/en/content/EIPAGRISP>

Solution: amend the Waste Hierarchy in the Waste Framework Directive to facilitate the use of wastes for higher value applications.

Under the current waste hierarchy, as laid out in Article 4 of the revised Waste Framework Directive, the use of gasification, pyrolysis and other processes to produce new chemical materials from waste is not counted as being recycling. Instead, these technologies are counted as energy from waste applications and do not reflect the higher value applications that chemical production brings. This provides a barrier to companies wishing to invest in such technologies. In the UK at least, local authorities are measured on meeting their recycling targets are therefore not encouraged to divert waste processing away from lower value applications.

4.2.2.4. Costs of feedstock is too high and too variable

Feedstock costs are the most important driver of their market attractiveness and a key risk for the development of the IB markets. Supply of sufficient quantities of good quality renewable raw materials at a competitive price is critical for the success of biorefineries.

Costs in Europe for biomass are in general higher than in other regions of the world due to climate conditions, higher labour price, etc. In addition, there is a competing use of agricultural residues between several alternative uses. Especially the increasing demand for biomass for bioenergy is causing problems, as there is not enough area available for the cultivation of industrial crops dedicated to bio-energy. In addition, in some areas there is a limited availability for nutrients and water. According to the availability and demand, the price of raw materials is too much fluctuating, which has a direct effect on the rate of profit.

Pellets are heavily subsidized (bio-energy subsidies) which may contribute to price fluctuations. The market for chips and pellets is still immature and sensitive to short term supply side shortages or periods of high demand. This could lead to sudden increases in demand and prices, at least in the short term that affect the whole market in Europe.

Prices vary considerably depending on the time of the year, the growth in demand for fuel and bioenergy, and the amount of biomass purchased. Thus, there is no such thing as “one biomass price”, but a range of prices, complicating calculations of the cost of biobased products.

Future biomass prices are likely to move more in line with the prices of other energy sources than they have in the past. However, some differences will continue to be observed as biomass prices will be influenced by factors that are unlikely to impact other energy prices.

The difference in ability to access feedstock at different prices means that different sectors will be faced with different costs. In a future market economy, the most likely scenario for biomass supply for the industry and especially for industrial biotechnology will be a mixed one, involving a diverse and variable mixture of feedstocks. In this way, simple feedstock (agricultural products such as sugar from sugar beet and sugar cane, starch from wheat and corn, plant oils etc.) and more complex feedstock (sugars from lignocellulosic materials such as straw, short rotation coppice, residues or even algae and wastes) as well as advanced

“non-biological” sources such as wastewaters, flue gases and direct air captured carbon dioxide will coexist in the future.

Simple feedstocks are globally available at affordable prices for the bioeconomy of today, especially when oil prices are above 75 EUR/barrel. This is especially true for sugar from sugar beet, whose potential in Europe is set to increase after 2017 when the sugar quota regime will. After such date, it is expected that sugar will be produced in the EU at even lower prices than today. Nevertheless, ongoing policy debates, together with well-established economic and supply chain security considerations from the industry, are driving intensive investments and development in the use of non-food based biomass sources.

Solution: facilitate the appropriate use of wastes and residues for IB processes

Wastes and residues could be used for the production of biofuels and biobased chemicals. However, there are multiple barriers preventing their use that need to be addressed in order to become a viable feedstock option for the IB industry in Europe.

- 1) ***Identify what are truly wastes and residues.*** The fact that a material or industrial stream is classified as a waste it does not necessarily mean that such item has no potential application or (hidden) added value. In some cases, wastes may have valuable applications, for example, tall oil from wood processing, once considered a waste, is currently a valuable chemical feedstock. At the same, there is little reliable information on the existing uses of wastes and residue feedstocks and, consequently, to what extent their use for IB processes could result in unforeseen impacts. Therefore, there is a need to assess the waste biomass resources available. Differences in availability may occur on a regional and temporal level. As a result, an assessment of resources on a local scale would be useful in determining the sustainable supply of novel biomass types. Moreover, there is a need to ensure that any policy promoting the use of waste and residue biomass is cognisant of the subtleties associated with their use. Ideally, safeguards would be introduced to ensure that no negative, unintended consequences occurred through their use. A better classification supported by updated policies would give confidence to project developers that they were using sustainable biomass sources.
- 2) ***Invest in research and development on the use of waste materials.*** The use of wastes, residues or other side streams brings a series of technical challenges for IB processes. These include issues over the variability and availability of the material, the influence of inhibitory compounds and non-desirable competing microbes. Focussed R&D is needed on the use of waste and residue feedstocks within a range of IB processes (either dedicated IB or hybrid thermochemical/bioconversion based systems) to expand the variety of biomass sources available for the IB sector, for example, identifying robust processing technologies to deal with the inherent variability of wastes. Moreover, this should include research into the logistics associated with the collection, storage and transportation of different waste materials and the identification of any

regulatory barriers associated with the shipment of wastes for IB purposes within Europe.

- 3) ***Invest in research and development on processing of wastes and residues.*** The use of waste and residue materials for the production of chemical products will require significant R&D to overcome the issues of impurities present within the biomass. Given the early stage of development of technologies for using waste and residue materials, the problems associated with their use are not yet fully understood. It is therefore necessary to invest in targeted R&D into the best routes to optimise the bioconversion and downstream processing step in the face of these impurities.

Solution: lower (high) import costs for certain types of feedstock

Biobased raw materials for industrial use should be readily available at competitive market prices. However in Europe, this can only be achieved in a sustainable way by removing some trade barriers on agricultural products for industrial applications. Import tariffs are a reason explaining why certain feedstocks (e.g. ethanol) are more expensive in Europe.

4.2.2.5. No commonly accepted “sustainability” certification system

Significant issues that are so far unresolved and which require further research are the development of an agreed methodology for the evaluation of emissions from direct and indirect land use change (IUC and ILUC) and the quantification of the impacts of biomass production on regional biodiversity. Such assessments should be complemented by further approaches like Environmental Risk assessment (ERa), or certification approaches for good and sustainable agricultural practices like Eco-Management and audit Schemes (EMaS). Currently, no single approach gives a complete and balanced picture.

The methodology for calculating iLUC emissions is still quite controversial. Mostly these calculations base their reference on a status-quo of other policy, like a poor agricultural policy in developing countries, lack of protection of valuable nature areas, inefficient use of food and feed products while in the meantime world population and economies are growing.

Solution: reduce the complexity of sustainability reporting schemes

Ensuring that biomass is produced in an environmentally and socially sound manner is a prerequisite for the development of a sustainable bioeconomy. However, there are a multitude of different schemes which biomass producers (especially in the agricultural and forestry sectors) must comply with. Not only do farmers need to ensure environmentally sound production to qualify for support payments as part of cross compliance measures under the CAP, but there are a plethora of schemes to certify sustainable production chain from biomass to final product including several directly related to IB and the bioeconomy including ISSC+ and Round Table on Sustainable Biomaterials (RSB). The multitude of different schemes

and their different compliance criteria creates an extra complexity for landowners, especially given that demonstrating compliance is time consuming and costly.

Solution: promote the cascading use of biomass.

With cascading use – the sequential use of biomass in products and finally as energy -- more biomass will be available for the bio-based economy and therefore also for industrial biotechnology processes. This means that the cascading principle closes the gap between biomass utilisation and the waste hierarchy and helps improve resource efficiency. There are differing opinions on to what extent cascading should be promoted.

- Biomass as a raw material should be used in bioproducts (biochemical or biofuel) application as much as possible. Biomass which is used for bioenergy (burned) is lost for the cascade. This means for example incentives for bioenergy (such as pellets, as opposed to biofuels or other bioproducts) may hinder the most efficient use of biomass in higher-value material use and a cascading system that should be promoted by a level-playing field. The market, left to its own devices, will ensure the maximum value use of biomass alone. Where subsidies distort the market to the extent that this becomes a problem for other industries wishing to use the same biomass, the problem should be tackled on the regional or national level
- Standard and norms should be developed for the classification and separation of heterogeneous bio-waste and its fractions to make it available in high amounts and for reasonable prices for the industry. The use of wastes is subject to complex regulations like the Renewable Energy Directive (RED) that should be revised to give access to these resources in a level-playing field.

4.2.3. Investment barriers and financial hurdles

4.2.3.1. Limited availability of public R&D funding

European expenditure on R&D is rather low compared to other regions of the world. The latest Eurostat data shows that the 3% of GDP target of the Lisbon strategy was missed by a considerable margin: Europe dedicated 1.5% of its GDP to R&D in 2010, which was way below the US rate of 2.4%. Projects also often stop before patenting, so not leading to commercialization⁸.

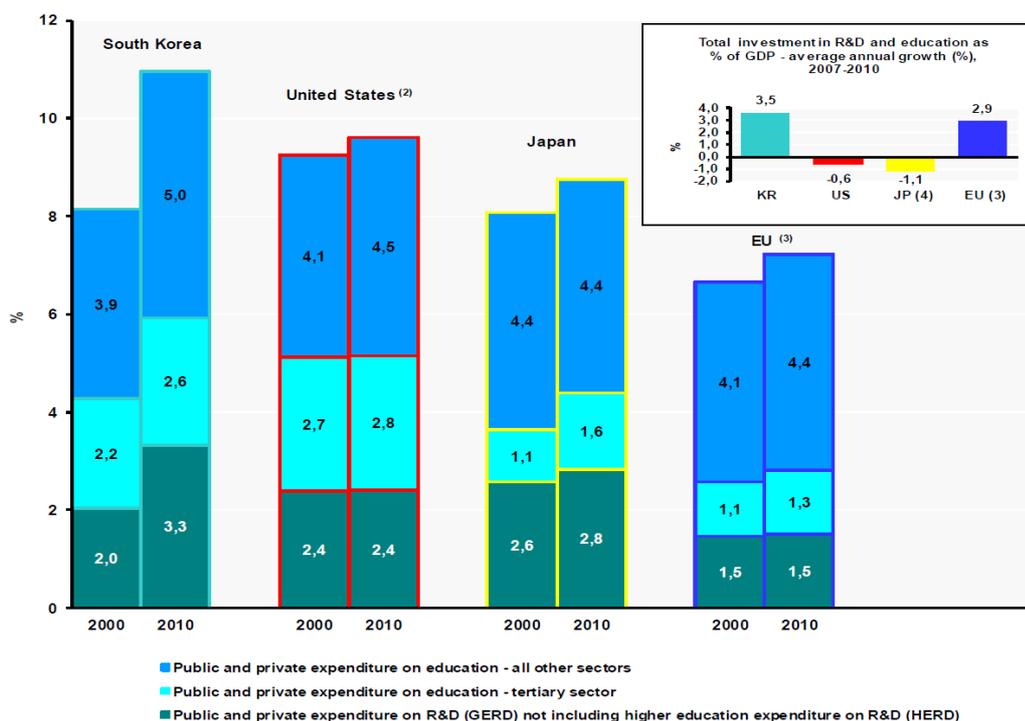


Figure 3. Overall investment in knowledge. Investment in R&D and education as % of GDP, 2000. and 2010

Solution: increase R&D funding

Increasing R&D funding at EU, national and regional level is necessary in order to pioneer public research in collaboration with the industrial sector in a co-funding scheme.

⁸ Innovation Union Competitiveness report 2013 - http://ec.europa.eu/research/innovation-union/pdf/competitiveness_report_2013.pdf

4.2.3.2. Limited public support for scale-up activities

In order to enhance the competitiveness and growth and maintain the leading role of European industries in the sector of biorefineries, it will be necessary to support pilot and demonstration activities for up-scaling of products and processes.



The development of a new product requires several steps to take it from the lab scale to a commercial product. These steps are needed to test that the technology is scalable and reproducible outside of the laboratory environment and to provide data to prove to investors that an idea is commercially viable. Access to scale-up equipment is commonly cited as a barrier to development of IB processes. Such equipment is costly and requires specialist staff to operate it. SME find it a particular challenge to finance trials at a large enough scale and to develop suitable data for investment decisions to be made whilst not compromising on IP rights. This results in the infamous ‘valley of death’ whereby innovative products at the lab scale fail to be commercialised. The risks and large capital outlay associated with scale-up mean that it is difficult to find private investors for these kinds of plants. Public funding therefore has a crucial role to play in helping bridge this gap.

Solution: ascertain capacity, capability, funding models and client geography for European IB pilot and demo plants

A study of the IB pilot and demo plants in Europe to ascertain capacity/equipment, capability, funding models, utilisation and client geography would be useful in terms of helping identify the current capabilities for IB scale-up in Europe. This should include plants which are currently used as well as those which are currently idle. This study, which could potentially be funded through the BBI-JU, would in turn help to:

- Signpost potential users and technology developers to appropriate facilities. An online information portal could act as a useful tool to provide information on location, capabilities, and the availability of the facilities, outlining for example whether the facility is operational or idle and if the latter case, why and whether it can be used for other purposes. Pilot plant owners should be able to update the information on their plant to ensure it is kept up to date and useful. This tool should be advertised widely as the IB community is currently unaware of the facilities available within the EU.
- Identify existing capability gaps/vulnerabilities which need to be filled by investment in pilot scale equipment to help promote specific emerging technologies both now and in the future. This should take into account the needs of the industry. As the IB sector is highly dynamic, this review should occur regularly to ensure that capability meets emerging needs.

Many SME are concerned that a host pilot/demo facility will claim IP rights over their results should the facility be used. As a result, it will be important to highlight the terms on which access is provided in such a study as it may be a crucial factor in determining whether a company chooses to use a particular facility or not.

Solution: invest in infrastructure at pilot and demonstration scale to bring innovative European ideas to market

As a preference, funding instruments should seek to use existing facilities before new ones are created to ensure multiple, redundant platforms are not created in parallel. In particular, regional pilots should be avoided, unless they offer unique capabilities not matched elsewhere in Europe.

- Europe has several excellent open access pilot facilities, such as the Bio Base Europe Pilot Plant in Belgium, the Centre for Process Innovation (CPI) in the UK, the Delft Bioprocess Facility in the Netherlands, and the ARD Bio demo facility in France. They could play a key role in technology development within the IB sector. These plants have significant knowledge on process development, flexible equipment and highly skilled, knowledgeable workers offering full support and capability therefore. Ideally, should any additional infrastructure/equipment be required, this should be deployed at such open-access facilities where the investment cost and risk can be shared across multiple projects. This would allow capability to be developed and retained in niche, highly technical areas whilst ensuring maximum value for money from the initial investment.
- In some cases, it may make sense to use idle facilities and retrofit them to a specific need. The impacts associated with their re-commissioning would need to be thoroughly assessed prior to funding to ensure that the specificities of different technologies are taken into account and that cost savings and environmental benefits are feasible. In particular, funders should seek to ensure that studies could not be performed at existing open access facilities before such ideas are funded.
- New facilities/equipment should only be funded so long as existing facilities and infrastructure are proven to be insufficient. End of life options should be outlined in funding proposals to ensure that large amounts of funding are not wasted. End of life options should be included at the design stage and give the possibility for the infrastructure to be disassembled and used by others at a later stage.

Anecdotal evidence suggests that funding for pilot and demonstration facilities is very fragmented, with several funding streams often needed to create a viable facility. In some cases, funding comes with significant barriers to access, either with use being restricted to companies from specific geographical areas, or limited to use for specific projects. Interreg funding can help bring regions together to develop joint facilities, helping to mobilise other regional funding resources. Simplification of funding streams and ensuring that fewer conditions are attached to such funding would be positive moves in ensuring that pilot and demonstration facilities are open to those who need it.

Solution: promote development of predictive scale-up models

Predictive modelling and techno-economic assessment approaches of the production process and realistic models of reactor types could help identify potential bottlenecks prior to expensive piloting operations. Such models could greatly aid the extrapolation of lab results to large scale processes and could leverage the development of computer-based systems already used in other engineering fields. Such a multi-KET approach could be of interest under the Commission's KET funding scheme.

Solution: promote funding support for trials at dedicated pilot plant facilities

Piloting trials can be financially challenging, especially for start-ups and SME. In order to ensure that promising IB ideas do not fail due to the inability to trial processes, an appropriate level of financial support is needed. Support could take many forms and it is likely that no "one-size-fits-all" solution will apply. Such support could include competitively awarded innovation vouchers for a specific value or in terms of substantial tax credits for companies. The scale of funding will depend upon the nature of the work being carried out, but should ideally be between 30-50 kEUR for a small pre-pilot study, to around 250K EUR for piloting and around 1 MEUR for advanced pilot scale tests. Alternatively, substantial tax credits for companies piloting at recognised facilities could be granted.

In order to ensure value for money, support should be provided to potential users of recognised centres of IB pilot/demonstration competence. Most of these facilities are based in Northern and North Western Europe due to the historical focus of these areas on IB and while many IB SME wishing to utilise such facilities may also be based in these regions, they should also be accessible to companies from Eastern and Southern Europe too, taking different travel costs into account. Structural funds may provide an option here, helping to support the training and education of people to develop the necessary 'know-how' for application in the host region. The application of structural funds for such uses is not well known about, and as a result, should be more widely publicised amongst the public. At a smaller scale, and for small duration visits, a dedicated programme for encouraging the use of recognised pilot facilities and exchanging information could be funded through H2020. The model developed by the FP7 project Biofuels Research Infrastructure for Sharing Knowledge (BRISK), where competitively awarded grants for EU researchers to attend laboratories with specialised thermochemical processing technologies could be a useful model to follow.

4.2.3.3. Limited access to finance for spin-offs, start-ups and SMEs

The use of friends, family and relatively unsophisticated local angel investors to provide seed money may be a way to get a company started. But a myriad of small shareholders diffuses control, making it difficult to raise significant further VC funding to expand the business.

Seed-/Start-up financing of potential start-ups <ul style="list-style-type: none"> • Approx. 60 new start-ups in Europe • Approx. 2 million Euro per start-up 	120 million Euro	1.370 million Euro
Growth financing of existing start-ups <ul style="list-style-type: none"> • Approx. 80 established start-ups in Europe • Approx. 50% of start-ups need financing • Approx. 5 million Euro per start-up 	200 million Euro	
Growth financing of existing SMEs <ul style="list-style-type: none"> • Approx. 70 established SMEs Europe • Approx. 50% of start-ups need financing • Approx. 60 million Euro per SME 	1.050 million Euro	

Source: Market Study on Financing Strategies in White Biotechnology of FESTEL CAPITAL from April 2005 / Market Study on Financing and Investment Trends in Industrial Biotechnology of FESTEL CAPITAL from February 2009

Grants are vital for funding young start-up companies and continue to be very important through the seed and VC rounds. Relative to early-stage equity funding, IB start-ups report that grant funding is more abundant, easier to access, easier to manage and highly attractive because it is non-dilutive. Grants from a respected agency provide reputational as well as financial leverage, which can combine into a virtuous circle. EU funding, which tends to be directed at more established companies, has been much less so.

Venture capital generally requires a foreseeable exit within a relatively short period of time – often within three to seven years, depending on the development stage of the potential portfolio company and the time it takes to push products through. There is a clear tendency towards funding later-stage companies. The reasons for this are simple: the time to exit is shorter, the technology risk and market risk are reduced.

VCs are reluctant to invest because historic returns on early-stage funds have been poor. For IB, production requires industrial plants often manufacturing hundreds of thousands of tonnes of product per year. The capital required to build and operate such plants is too high and the time it takes to develop them to the point when they become commercial (four to eight years) is too long for most investors to take the risk at the time such investment are needed.

In general, banks are extremely reluctant to lend to early-stage IB companies even if they are trading profitably, thus restricting their growth.

High-tech SMEs are key for technology and knowledge development, and investing in research and innovation is the only way for these enterprises to survive. It is of critical importance for the success of these SMEs, and hence for the innovation potential of the sector as a whole, to improve their access to finance. However, without larger scale validation, it remains very hard for SMEs to attract the large industrial partners or other private investors that they need to become sustainable.

Solutions:

- **Setting up funding programmes and innovation awards for bio-entrepreneurship** oriented to academia in order to stimulate spin-off of promising results.

- **Implementation of funding for feasibility studies** for start-ups and special grants for product development and commercialisation such as the Small Business Investment Company Program (SBIC) in the US⁹.
- **Development of demonstration** projects as proof of concept and flagship projects that cover the whole product value chain will minimize the risk and install confidence.
- **Setting up of specific funding programmes targeted to innovative SME's** in the field of biobased products at national and regional, comparable to the European Investment Fund (InnovFin).

4.2.3.4. Limited financial support for new production facilities

Producing (second generation) biofuels and chemicals through bio-chemical routes is in many cases still more expensive compared to traditional conventional routes. In addition, existing production facilities for chemical syntheses cannot be converted to biotechnological production without massive new investments, and in many cases there are clear economic restrictions in biotechnological production processes due to higher operating, R&D and investment costs.

Investments required for building a new bio-industrial facility - especially if it competes with conventional ones – might present a significant barrier. In addition, as result of the worldwide credit crunch, it has become even more difficult to obtain bank loans and funding for investing into building new, full-scale commercial plants and infrastructure. Governments too tend only to provide financial support and incentives on a relatively short-term basis, while pathway to success for many enterprises is a long term process.

The costs and the risks perceived and associated with the market entry of biobased products are high. The main limiting factors to launch products on the market are the time and scale available for the production (production facilities). The cost of the conversion process of some biobased products is often not competitive with their non-renewable counterparts (e.g. hydrocarbons). Poor process performance is often the reason for lack of cost-competitiveness (see “Technology Roadmap” for more details). Shale gas production could also slow down the development of industrial biotechnology due to its impact on the fossil raw materials prices.

Several public funding facilities are available for biobased industries in Europe, including amongst others: European level Horizon 2020 and BBI-JU, LIFE 2014-2020, Connecting Europe Facility (CEF), Interreg V; Transnational level EUREKA, ESIF, ERA-NET and National, Regional and Local Grants, etc.

While basic and fundamental research in Europe are mostly supported by EU and national/regional grants, certain countries have an increasing role in regional funding of flagship initiatives. Nevertheless, first of a kind and commercial scale biorefinery grants are

⁹ <https://www.sba.gov/content/sbic-program-seeking-financing-your-small-business>

not a sufficient instrument per se. Currently, for a flagship and commercial scale investment the most important contribution comes from bank loans and investors

The new Biobased Industries PPP (BBI-JU) is bridging some of the funding gap but cannot support all commercial scale projects. Although several instruments exist in Europe, accessibility to funding remains an issue. Financing is fragmented and the procedures involved from one institution to the next, or from one region to another, are different, and the process of applying for funds can also be very long-winded and complex.

Solution: increase awareness about grants and funding opportunities

At EU Level, Funding opportunities and public grants should be better highlighted. The JRC BioEconomy Observatory may create an EU-wide portal for EU, transnational and national bioeconomy-relevant funding opportunities and grants within a European Commission embedded website. Here all bioeconomy funding opportunities should appear in a searchable and sortable way for example by opening and closing date, funding amount, funding %, topic, eligible sectors, eligible locations, and eligible parties, under the responsibility of the JRC BioEconomy Observatory.

Solution: speed up integration of public grants from EU H2020, EU ESIF and national grants

At EU Level, different public grants may be better complemented by the European Commission and Regions. A step forward would be to set up dedicated H2020/ESIF Task Force with the objective of producing guidelines on how to better integrate H2020/BBI-JU and ESIF funding. This can be built upon the BIC Guiding principles document¹⁰.

Solution: create a European BioEconomy Strategic Investment Fund (EBESIF)

At EU Level, a strategic fund may be created by BBI-JU and EIB, including a novel synergy of public and private sources. The European BioEconomy Strategic Investment Fund's (EBISIF) mission should be to produce loans and loan guarantees (leverage 1-to-5) for large scale bioeconomy investments, learning from successful national investment funds such as the High-Tech Gründerfonds¹¹ and have the goal to be economically sustainable. Biorefinery projects with a concrete business perspective are actively seeking loans. The main hurdle is risk-acceptance from the investing and loaning side. With the contribution of several other stakeholders the EBISIF could establish a portfolio of projects, including 20 to 30 new biorefineries to be awarded loan guarantee or loans. A quarter of them may fail, 75% will succeed, and, following an "insurance" approach, Europe may kick start dozens of new biorefineries in less than a decade, corresponding to around 10% of the biorefinery required to keep up with the demand projected for Europe by 2030. Doing so Europe would equip the market with clear European biorefineries benchmarks and strong business cases to follow. The envisaged EBESIF may be funded via any combination of the following items:

¹⁰ http://biconsortium.eu/sites/biconsortium.eu/files/downloads/Guidelines_BBI-ESIF-Final.pdf

¹¹ <http://high-tech-gruenderfonds.de/en/>

- Stimulate Private Foundations Charities and Families to donate money for the development of bioeconomy projects with high social return on investment. A particular focus may be given to the rural development side of the bioeconomy, since this is part of the mission of many local and global foundations.
- Stimulate EIB's InnovFin focus on the bioeconomy. Stimulate the inclusion and allocation of minimum share of InnovFin Large Projects for topics related to the current H2020 societal priorities, in particular to the bioeconomy, to improve access to risk finance for R&I projects with Loans and guarantees from EUR 25m to EUR 300m to be delivered directly by the EIB. 500 MEUR will suffice to mobilize 20 to 30 Biorefinery Projects with a total value of around 4 BEUR value, with a capital leverage of 5x, and an interest rate able to cope with a failure rate of 10%. EIB may be further encouraged to co-invest in the envisaged European BioEconomy Strategic Investment Fund (EBESIF).
- Involve Public Pension Funds in the Bioeconomy. Develop an EU Directive or Communication to inspire Member States in order to enable, encourage and discount pension system investments in strategic innovation sectors such as the bio-economy. Pension funds have the timeframe and long term interest to invest in the bioeconomy, for longer term return on investment and social return on investment. Such a directive should learn from the experience of the Danish Pensiondanmark. Such pension funds may be further encouraged to co-invest in the envisaged European BioEconomy Strategic Investment Fund (EBESIF).

While specific fundraising milestones may be reached, the promoters should bind the European Commission to match the private donations on a 1-to-2 basis.

4.2.4. Public perception and communication

4.2.4.1. Public awareness: advantages of biobased products are not visible enough

The average citizen's relatively low level of understanding and acquaintance with IB and IB-derived products can be misinterpreted as a lack of acceptance of IB by the public. However, this lack of awareness arises from the fact that IB is a technology which is difficult to explain and thoroughly comprehend, despite being commonly used to produce e.g. beer, cheese or bread. Moreover, it seems that the challenge extends beyond the complexity of the very subject of IB and touches upon people's general awareness of the origins of everyday products that originate from fossil carbon. Subsequently, it is all the more difficult for the public to picture how these very commonplace products could be replaced by biobased ones, enabled by IB.

To be successful on the market biobased products should have a clear advantage over their traditional counterparts. Producers are concerned about consumer backlash for biobased products based on the negative public perception and the lack of willingness to pay the premium for biobased products.

There is a general appreciation for sustainability amongst many EU consumers and biobased products are increasingly being sold for the same cost as fossil ones with similar or even improved performance. Nevertheless, the combined lack of awareness of the existence of biobased products, produced using industrial biotech, coupled with a lack of understanding of their benefits still presents a significant barrier to the creation of new markets for these beneficial and resource efficient products and processes. More transparent communication is needed in particular to the public at large and toward consumers and consumer organisations. Consumers should be informed in a straight-forward manner based on fact findings about the sustainability and challenges and benefits of biobased products as well as the societal innovation benefits to shift to the bio-economy.

It appears that education in terms of sustainability and life cycle thinking is required for companies, authorities and the general public.

Solution: develop an EU wide campaign to improve public awareness and perception of IB and IB-derived products

Based on the results of the Eurobarometer study, it will be possible to design an informed and effective communications campaign to (further) improve public perception and awareness of IB and biobased products. The risk perception indicators of the study will establish the most relevant entities for supplementing the EU campaign nationally, and pinpoint if there is a need to create separate dialogues on more challenging subjects related to IB. The overall EU campaign could include:

- A website outlining all there is to know about IB, building upon the input and structure provided by the BIO-TIC website. It could include:

- An accurate scientific and agreed definition of IB, mentioning both biocatalysis and fermentation, and explaining the resulting processes with visuals rather than text
 - The policy context (IB as a key enabling technology, bioeconomy strategy, etc.) and directives which apply (contained use directive, food and feed directives, etc.)
 - A showcase of examples by means of infographics to illustrate how IB acts as an enabler for the bioeconomy, the circular economy, carbon neutral processes, improving industrial processes and the array of available products etc.
- Promotional videos illustrating the benefits of IB products, to be made available on websites and circulated amongst social media, possibly with “open licence”, as well as on TV. The videos should be application-oriented and focus on the sustainability, performance and environment-friendly aspects of biobased products. In order to increase familiarity with the word IB, the videos should indicate that a product is made using IB by means of a recurring visual effect (e.g. a label or stamp saying “thanks to IB”).
 - Educational material and tools for all age categories about IB and the bioeconomy. All IB players should provide the opportunity to live the ‘biobased experience’ by organizing open access days. The SusChem ‘Innovate to Educate’ programme mentioned in Recommendation 3.3 may be a useful model to replicate here.

Solution: develop a campaign aimed at improving awareness of how IB products can aid industry.

Within the larger aim of improving public perception and awareness of IB, it is also crucial to ensure that businesses are aware of IB solutions. The BIO-TIC project tools (e.g. the partnering platform and BIO-TIC website) can provide useful platforms and a sound basis to foster awareness of the IB alternative for businesses. The existing tools could be complemented and improved by:

- Gathering European IB success stories as separate case studies which are accessible to IB companies throughout Europe for their communications towards brand owners. A starting pool of examples for IB success stories could be found in the Bioeconomy Panel market group report¹². However, this work should be updated on an ongoing basis, possibly in the framework of the JRC’s Bioeconomy Observatory and should include national and regional examples in member state languages.
- Set up an online brokerage tool based on properties and corresponding functionality of certain molecules produced with IB pathways, e.g. an online

¹² http://ec.europa.eu/research/bioeconomy/pdf/where-next-for-european-bioeconomy-case-studies-0809102014_en.pdf

database where European technology providers who are looking for customers could list their services' and products' specificities. An existing similar tool is IAR's Agrobiobase¹³.

- Set up, for each Member State, a directory for IB and biobased companies, as well as chemicals companies. The information could be gathered by national knowledge transfer organisations. They could simultaneously act as "matchmakers" and raise awareness about the existence of IB solutions for many types of industries, as from the recent UK-Norway action (UK-NO Directory 2014). These activities could be complemented by concrete help to find the suitable customer or partner, identify the corresponding funding (e.g. structural funds, European Investment Bank loans), etc.

4.2.4.2. Public acceptance for IB products can be improved

The main barrier to public acceptance of IB is fear of the unknown, based on a limited knowledge of science in general and a fundamental lack of understanding of IB specifically. This vacuum of information is currently being filled with stories about the more controversial developments, namely GM and biofuels, synthetic biology, thus creating immediate emotive associations that will need to be overcome. Negative messages in the public domain about these issues could have a dramatic impact on public acceptance and on the development of the industrial biotech industry in the future.

Solution: ascertain the public's acceptance level for IB and biobased products

Special Eurobarometer surveys from 2006 and 2010 have established that a large majority of Europeans have a positive opinion of IB. Yet, BIO-TIC stakeholders have found that the public acceptance of IB and biobased products could be further improved. We recommend introducing a public opinion study across Europe with regards to: 1) Industrial biotechnology in general, including its technical aspects and 2) Applications of industrial biotechnology: via e.g. a Eurobarometer survey. Such a survey could be funded via Horizon 2020.

¹³ <http://www.agrobiobase.com/>

4.2.5. Demand side policy barriers

4.2.5.1. Lack of dedicated framework to promote biobased products

Whilst in February 2012 the European Commission adopted a strategy on the bioeconomy, a number of sectorial policies and funding mechanisms that have been put in place to support the development of industrial biotechnology and the bioeconomy still exist, to an extent, in isolation from one another.

At EU level, the European Commission promotes research and innovation in the field of industrial biotechnology and the bioeconomy through Horizon 2020 and the Biobased Industries Joint Undertaking. The Common Agricultural Policy (CAP) allows Member States and regions to support initiatives that facilitate the collection and storage of biomass. Industrial biotechnology has also been identified as a key enabling technology and biobased products were selected as one of the six priority areas, which should be supported by the new industrial policy. Several European Member States have also developed national or regional bioeconomy strategies. However, like the EU strategy, none are legally binding.

The European Union, its Member States and Regions need a holistic framework which weaves the bioeconomy into the fabric of policy making across many sectors. To be successful, it is essential that the regulatory fragmentation across the range of policy areas that can enhance the bioeconomy is addressed. More innovation-friendly market framework conditions and incentives are therefore necessary in Europe to reduce the time-to-market of new goods and services and to enable emerging sectors to grow faster. When adopted, legislation should also be stable in the long term to secure investments (secure “a business case”).

Markets have long been recognised as important drivers of innovation and, more recently, as a target for innovation policy. More innovation-friendly market framework conditions are necessary in Europe to reduce the time-to-market of new goods and services and to enable emerging sectors to grow faster. The improvement of market framework conditions is done by demand-side policies. As a result, companies will see a quicker return on their R&D and innovation investments.

A range of emerging non-fuel technology areas fall outside the scope of the legislation supporting renewable energy. For example, there are no incentives to support the case for investment in biobased chemicals or plastics. The absence of incentives makes these technology areas less attractive for investment.

The major production plants are nowadays out of Europe. Amongst the reasons are low incentives and subsidies and high taxes. There is also a significant imbalance in subsidies for energy and material use.

Solution: introduce financial incentives for biobased products

Direct financial incentives or tax reductions could be granted to biobased industries that produce renewable chemicals in Europe from European renewable biomass. Renewable chemicals produced should include a minimum % of biobased content as calculated by the

standard for biobased products (CEN TC/411). The financial incentives or the tax reductions could also be granted to industries buying renewable chemicals for the production of polymers, plastics or formulated products, or to industries buying renewable chemicals as polymers, plastics or formulated products. Given the national competence over taxation affairs, such framework should be agreed at European level and implemented by the Member States.

Alternatively, direct financial incentives or tax reductions could be granted to biobased industries that produce renewable chemicals in Europe from European renewable biomass based on a selection of sustainability indicators (e.g. GHG emissions, energy use, etc.). In order to set up such framework, standardized, comparative life cycle assessments between renewable and non-renewable products should be developed. Optimisation steps of products should be included for new materials which are at their early stage of development.

Targets and incentives, mandates and bans can successfully support the introduction of sustainable and innovative alternatives on markets, although excessive market distortion should be avoided. Binding targets, such as the one adopted for renewable energy in transport in the Renewable Energy Directive, help to ensure market development and create some long-term predictability for investors, hence securing “a business case”. Similar targets could be adopted for certain product categories or applications. Progressive substitution schemes on less sustainable products are also effective in reassuring investors when it comes to investing in innovative products and technologies. In a similar way to the progressive ban on incandescent lamps which led to the LED revolution, substitution could be adopted on certain products where more environmentally sustainable, cost-effective biobased alternatives are being introduced to the market.

4.2.5.2. Lack of a “green public procurement” policy promoting biobased products

Public procurement can shape production and consumption trends and a significant demand from public authorities for “greener” goods will create or enlarge markets for environmentally friendly products and services. By doing so, it will also provide incentives for companies to develop environmental technologies. Studies have confirmed that there is considerable scope for cost-effective green public procurement (GPP) - in particular in sectors where green products are not more expensive than the non-green alternatives (taking into account the life cycle cost of the product). As “greener” goods are defined on a life cycle basis, GPP will affect the whole supply chain and will also stimulate the use of green standards in private procurement.

One has to be sure that the biobased product is similar or more sustainable than the alternative.

Solution: support biobased products development through public procurement

The potential for increasing demand for biobased products through public procurement is huge, as European public authorities spend between 15% and 20% of GDP on goods and services yearly. Almost all product areas could potentially feature products made entirely or partly from renewable raw materials. Likewise, the production of almost all types of services could potentially benefit from bio-based inputs.

A public procurement system for biobased products requires

- biobased products to be available;
- information on products and products to be classified and compiled in database;
- products to meet defined criteria and standards and to be recognisable through labels;
- public procurers at European, national and regional level to be aware, convinced and trained to buy biobased products
- mandates, political support and legislation.

In Europe, products are available and have begun to be classified and compiled in databases. These activities are currently being undertaken and should be coordinated. While several environmental labels exist (EU EcoLabel, national and regional labels), none recognise biobased as an indicator. Discussion should be pursued within the CEN TC 411 on biobased products and with labelling stakeholders to assess the relevance of developing a specific biobased label. Two European directives address public procurement. However, neither mentions renewability of feedstock as a criterion. While public procurement for biobased products is one of the priorities of the DG GROW biobased products expert group, most of the policy initiatives taken are modest and recent. Several upcoming policy initiatives such as the circular economy package and the new investment package launched by the European Commission in Autumn 2014 could be used to introduce ambitious legislation supporting innovative biobased products through public procurement.

Example from the USA: the USDA BioPreferred programme

USDA's BioPreferred programme was created by the Farm Security and Rural Investment Act of 2002 (Farm Security and Rural Investment Act of 2002) and reauthorized by the Food, Conservation, and Energy Act of 2008 (the so called 2008 Farm Bill) to increase the purchase and use of biobased products. USDA manages the BioPreferred programme, which comprises two elements:

1. Preferred procurement programme for federal agencies and their contractors;
2. Voluntary labelling programme for the broad scale consumer marketing of biobased products.

Under the procurement programme, BioPreferred designates categories of biobased products that are required for purchase by Federal agencies and their contractors. As a part of this process, the minimum biobased content is specified, and information on the technical, health and environmental characteristics of these products are made available on the BioPreferred website.

A biobased product is composed wholly or significantly of biological ingredients. To be designated by the BioPreferred Programme, a product must meet or exceed USDA guidelines for its product category. The biobased content is determined by testing to American Society for Testing and Materials (ASTM) Method D6866.

In addition, the BioPreferred Programme developed a voluntary labelling programme for the marketing of biobased products. Under the voluntary labelling programme, biobased products that meet the BioPreferred programme requirements carry a distinctive label for easier identification by the consumer.

4.2.5.3. No uniform standard and label for sustainable and biobased products

Standards are guidelines, based on various degrees of consensus (industry wide, national, regional or international), which lay out rules, practices, metrics or conventions used in technology, trade and society at large. Standards are seen as tools for building trade capacity, transferring technology and disseminating good business practices.

To be comparable and reliable, sustainability assessments for biobased products need to be standardised and be certifiable. And not only standardising sustainability criteria is important, but also defining what is biobased, how the biobased carbon share or the biomass share can be measured, as well as complex compositions of materials.

Labelling can play an important role in the commercialisation of biobased products. They provide consumers with clear information on the environmental performance of the products and guide their purchasing behaviour towards sustainable choices. Labels can also be critical for the uptake of biobased products by green public procurement. However, today the market show to many and not reliable labels. Official definitions and standards are needed to give industry and consumers solid and trustable label that can really support their choices.

Solutions:

- **Develop clear European standards** for feedstock and product sustainability, biodegradability, biobased content, etc.
- **Branding of biobased through an ecolabel** (Green Product) and/or “Biobased” label linked to sustainability criteria
- Set up a harmonization strategy for ecolabels in Europe

4.3. Other hurdles

4.3.1. Overview

HURDLES		SOLUTIONS
Hurdles in human resources	Lack of HR with right skills and curricula	<ul style="list-style-type: none"> • Leverage education value from innovation projects • Encouraging the development of training and teaching activities in the industrial environment relevant to the needs of the IB industry • Providing “glue-money” to help develop IB-specific teaching programmes • Develop an EU “observatory”, supported by national bodies, to monitor skills needs from industry and monitor what skills are taught.
Hurdles for efficient collaboration	Insufficient cooperation and knowledge exchange between the parties in the value chain	<ul style="list-style-type: none"> • Set up or involve national and/or regional cluster organisations • Stimulate clusters to set up national/regional public-private partnerships • Support the creation of innovative value chains • Stimulate innovation across disciplines
	Difficulties to establish operational alliances between industry and academia	<ul style="list-style-type: none"> • Stimulate collaboration between industry and public institutes
	Regional funding conditions hinder establishment of international networks	<ul style="list-style-type: none"> • Setting up interregional platforms, coupled with a web-based portal database
Intellectual property related hurdles	High patent costs hinder start-ups and SME’s	<ul style="list-style-type: none"> • Lower the IPR cost for SMEs with public funding
	Lack of harmonised IP regulation	<ul style="list-style-type: none"> • Simplification and harmonisation of patent procedures
Other policy barriers	Difficulties in implementing the sustainability agenda and life cycle thinking in policies, and lack of coherent policy framework for sustainability	<ul style="list-style-type: none"> • Linking sustainable certification of biomass to certain incentives • Development of standardised systems to obtain feedstock corresponding to certain sustainability criteria
	Hampered implementation of strategic approach	<ul style="list-style-type: none"> • Full implementation of the EU Bioeconomy strategy

Table 2. Overview of the other horizontal hurdles

4.3.2. Hurdles in human resources

4.3.2.1. *Lack of HR with right skills and curricula*

It is generally acknowledged that while Europe excels at research, key competencies are needed to enable successful deployment of IB technologies. This entails an understanding of different scientific and technical skills, as well as business and personal skills that will allow professionals to easily adapt to new tasks, job functions or even different scientific areas. This will lead to efficient interdisciplinary work and effective collaboration with value chains partners. A greater focus on financial and business skills will also be required in scientific curricula in order to effectively turn ideas into business. A better balance between theory and practical training, more focus on cultural skills and cultural awareness (especially for emerging markets) and better project management skills are some of the other suggestions which should contribute towards enhanced innovation. It is clear that there will be no 'one-size-fits-all' approach here and innovative solutions will be needed to cover the complete value chain from farmers, forestry and landowners to end user and capitalise upon regional strengths. Industrial biotechnology is a rapidly developing sector, so there is a constant need to ensure that the skills and education provided to the sector are fit for purpose, take into account future skills needs and are adaptable to change. The EU has a world-leading academic sector, however, academia is often slow to react to specific skills needs of industry, and such inertia can lead to mismatches in the skills taught compared to those needed by industry. Facilitating the timely and effective collaboration between industry and academia for skills development will be the key to maintain European competitiveness.

Important prerequisites for successfully implementing the bioeconomy strategy is the availability of a well-trained workforce with the necessary knowledge and skills, from academia, industry or the primary-production sector, across public and private domains, and encompassing different skill levels.

Given the strong potential mismatch between the European workforce and labour market demands in the bioeconomy in the future, actions are needed to ensure that the EU workforce has the right mix of skills, including diversified curricula that are adapted to these needs and more attractive for the younger generation.

Improvements in skills are required at every level. In particular, Masters level training is needed to deliver appropriate interdisciplinary IB skills, to transcend traditional disciplinary boundaries and enable shared strategies and collaborative thinking at each stage of the product or process development lifecycle. In addition, skills are needed to scale up production ('from genes to tonnes') to generate wealth from IB.

In addition, there is a lack of qualified CEOs and sales representatives with entrepreneurial vision and the right marketing and strategic skills to successfully develop and launch new biobased and value added products on the market.

Solution: leverage education value from innovation projects

Using selected results from EU projects could effectively contribute to enhance skills for innovation in the short-medium term, at EU, national and regional levels. Through better exploitation of the innovation outputs from successful projects, initiatives such as SusChem “Educate to Innovate¹⁴” may support the systematic development of innovative learning resources. In this way such education programmes would become enriched in content with particular regard to case studies and real world examples. This would enable students to learn through failure as well as success, understanding how and why decision were made, with documented methodologies for problem-based studies, while at the same time being flexible in their implementation. It should also be possible to integrate these into existing modules and curricula, adaptable by teaching staff at undergraduate and master degree levels as well for their use within lifelong learning courses. The effective implementation of such initiatives would require engagement of teaching academics at appropriate stages in the innovation project.

Solution: encouraging the development of training and teaching activities in the industrial environment relevant to the needs of the IB industry

This industry-academia educational collaboration can be achieved at regional, national or European level and will include, for example, industrial masters and PhD studentships, industry placements for students, courses at pilot plants, and staff exchanges (both industry-academia and academia-industry). The skills developed through such learning activities should be recognisable and transferable. At European level, such activities could also be supported in the framework of Horizon2020 or the BBI-JU which could be used as a route for developing specialised training schools focussing on very specific elements of the bioeconomy, including IB, as well as in the framework of a future bioeconomy/IB focus at the European Institute of Innovation and Technology, to bring industry, research and teaching communities together at a pan-EU level.

The need for developing and maintaining specialised technical staff cannot be overstated, especially in the technically challenging and innovative IB sector. As people in such specialised roles ‘learn by doing’, such skills are not easily replaced.

Furthermore, innovative methods for delivering IB courses should be explored; for SME especially, since the time and cost associated with training can be discouraging. Massive Open Online Courses (MOOCs) offer considerable potential for broadening participation and knowledge exchange across borders and disciplines, allowing the transfer of European knowledge to less knowledge-intensive economies, and, similarly, helping improve European knowledge of applications worldwide. Evening courses are also a possibility.

Solution: providing “glue-money” to help develop IB-specific teaching programmes

Funding for IB-specific education action may initially be achieved by integrating such educational outputs into prospective project exploitation plans in the short term. In the

¹⁴ <http://www.suschem.org/priorities/education/educate-to-innovate.aspx>

longer term, an appropriate framework of project funding mechanisms should be spotted or built to enable such courses. Significant expertise already exists in many cases; although it may be necessary to join these up, either within a single university/institution or by bringing several centres together. The administration associated with establishing and maintaining such multi-centre, multi-focussed programmes should not be underestimated, and ‘glue money’ to develop and support such programmes for long periods should be provided to ensure continued impact and collaboration. DG Education and Culture has some relevant programmes under ERASMUS+ (Knowledge Alliances), but they follow a bottom-up approach. Therefore, no sector or technology-specific calls can be envisaged, and the success rate is extremely low. Signposting of relevant funding sources would be beneficial here. ESIF can also support cross regional knowledge sharing by using the new opportunity to use part of ESIF funding (up to 15% of ESIF funding) outside of their region (e.g. for education, skills and know-how, ...) and accelerate development of the biobased economy within and across regions throughout Europe.

Solution: develop an EU “observatory”, supported by national bodies, to monitor skills needs from industry and monitor what skills are taught.

IB is a dynamic sector so the skill sets required may be expected to change quickly. Such an observatory, perhaps established through the European Sector Skills Alliance¹⁵ scheme under Erasmus+, or through the Bioeconomy Observatory, could identify current skills gaps and forecast future skills gaps. In this way, academic and training programmes can be designed to best meet the needs of industrial players both now and in the future and provide the crucial skills needed to maintain European competitiveness in this nascent, but highly promising area. Long-term support of such an initiative is essential. In order to ensure the successful implementation, the input and opinion of university and other teaching personnel as well as from organisations active in the field of setting educational recommendations should be sought, and they should be involved in the set-up and the development of an implementation concept for the results of the “observatory”. The results of this observatory could then be used to develop a coherent education and skills plan for Industrial Biotechnology in Europe, thus helping to guide European activities for IB funding, incorporating academic training, skills retention and apprenticeships.

4.3.3. Hurdles for efficient collaboration

4.3.3.1. Insufficient cooperation and knowledge exchange between disciplines and parties in a value chain

The eventual success of the biorefinery concept depends largely on the extent of integration that can be achieved. This has to take place at various levels. Cooperation between farmers or forest owners with processing industries is a very simple example and shows the

¹⁵ http://ec.europa.eu/education/policy/vocational-policy/sector-skills_en.htm

importance of the integration of the biomass supply sector with all downstream industries. At the processing sites, integration of different technologies and processes is an absolute must for the site to be able to work efficiently. Integration can also take place between two or more processing sites, where, for instance, sharing of utilities and waste treatment are common modes of cooperation, exploiting synergies for mutual advantage.

However, currently there is not enough cooperation and knowledge exchange between different players in the value chain. The lack of cooperation between the different stakeholders horizontally and vertically along the value chain is slowing down the R&D and innovation process. One of the primary causes is that the players in the different sectors are not used to cooperate. Industrial policies can support the players in the value chain to cooperate across sectoral borders to overcome the barriers between processing, the feedstock supply and the food chain.

Solution: set up or involve national and/or regional cluster organisations

Already today, many countries host a number of “biobased” regional clusters, regrouping companies, research institutes, funding agencies, investors, etc. In some cases, these clusters are real public-private partnerships (PPP) funding research and innovation projects. In other cases, the focus is more on networking or financing specific studies of common interest. These clusters can play a crucial role as they can stimulate - at national or regional level - networking, cooperation, partnering and knowledge exchange. Member states not having such cluster organisations should be stimulated to do so. It is advised that a project is set up by e.g. the “Bioeconomy Panel” to map the European clusters, their activities and best practices, and to support the regions or member states that do not yet have such cluster organisation.

Solution: stimulate clusters to set up national/regional public-private partnerships

As most of the clusters are a mixture of associations, regional authorities, companies, universities and research organizations, the formation of a Public-Private Partnership where all parties commit to invest from their own resources, could strengthen cooperation resulting in targeted research and actions towards development and commercialisation of innovative biobased products. In addition, PPPs that stimulate the participation of companies and SMEs, are more attractive for external funding and are also eligible for European funding. Clusters can facilitate access to investors and venture capital, which is beneficial to SME participation. Therefore, funding by local and regional governments should be strongly encouraged.

Solution: support the creation of innovative value chains

In order to stimulate the collaboration between different industrial sectors (e.g. agriculture and forestry, food industry, chemical industry), projects should be set up (funded by the EU

through, for example, Horizon2020 or BBI-JU, or by the member states and the Regions) in order to study and communicate synergies and complementarities between technologies, feedstock and waste (availability and quality), and to bring representatives from the different sectors together in specific workshops or partnering events.

Research and innovation programmes (be they European, national or regional) should cover the entire value chain (including feedstock supply, processing, logistics, pre-treatment, processing, compounding, side-product valorisation and product recovery, etc.) in order to obtain funding. By supporting research covering the entire value chain – from feedstock to end-product – these programmes will stimulate integration of the individual bioeconomy sectors, facilitate innovation and encourage the uptake of its results by the industrial partners involved. In the longer term, we can expect not only a closer integration of the different sectors of the bioeconomy, but also between the different research areas across food as well as non-food commercial applications.

Solution: stimulate innovation across disciplines

It is often stated that innovation happens across traditional disciplinary boundaries. Industrial biotechnology innovation could also benefit from such interdisciplinary thinking. Innovations within the ICT sector are already helping to create tools which can improve processes within the bioeconomy, for example the application of expertise in telecommunications in helping to assess forestry productivity and microbial fuel cells can be used to power remote monitoring devices such as the ones monitoring water quality . Such cross-disciplinary thinking can bring new ideas to the IB industry, stimulating innovation and competitiveness. Routes to promote such interdisciplinary thinking are needed, such as cross disciplinary partnering events or focussed workshops. The BBI-JU and H2020 could prove potential routes by which such thinking could be promoted.

4.3.3.2. Difficulties to establish operational alliances between industry and academia

A strong disconnection between the industry and academic research institutions is slowing down the knowledge transfer process and thus innovation. In order to better align academic knowledge to industry needs, industry will need to develop an earlier understanding of the application potential of new technologies provided by academia. Similarly, academic researchers will need a sharper focus on industry's needs and specifications. To overcome the gap between applied and basic research a joint IB agenda between both stakeholder groups is urgently needed. Industrial associations could have an important role in catalysing collaborations between SMEs and academic research institutions.

Stakeholders in France mentioned that there are several small “clubs” working on the same ideas for a long time. In addition large companies often have long-term collaborations with the same laboratories.

Solution: stimulate collaboration between industry and public institutes

In order to better align academic knowledge to industry needs, industry will need to continue to develop an earlier understanding of the application potential of new technologies provided by academia. Similarly, academic researchers will need a sharper focus on industry's needs and specifications. Therefore, initiating specific bioeconomy networks at European and national level, building on existing sectorial networks such as European Technology Platforms (ETPs), industry associations etc. and involving funding authorities, industry and academia could be the key to overcome the knowledge gap and competence hurdle that currently exists. Similarly to and in connection with ETPs, the bioeconomy networks could develop research and innovation roadmaps, organise matchmaking events and any other type of activity to supporting closer relations between industry and academia/RTOs.

4.3.3.3. Regional funding conditions hinder establishment of international networks

Given the ever-increasing international linkage between science, business and society, the relevance of international collaborations and of the cross-border exchange of knowledge is rising. This also applies to the field of the bio-economy and accompanying research. There are diverse arguments in favour of establishing a stronger (bilateral and multinational) network within the bio-economy, corresponding to the broad nature of the sector, which transcends national borders and economic areas. The funding rules are also often specific to regions, which makes it difficult to collaborate with surrounding areas.

To develop a competitive biobased economy, it is important to create sustainable value chains (from feedstock production or supply, collection and logistics, conversion, production to market), and these do not necessary have to be developed within one single region.

Solution: setting up interregional platforms, coupled with a web-based portal database

Often one region has a surplus of a certain feedstock and another region the technological know-how or the industrial expertise. An interregional platform, coupled with a web-based portal database would be very useful to stimulate co-operation between all stakeholders in the biobased field. Such an open web portal could be helpful in finding partners for new and innovative value chains. But it can also give an overview of all research and demo biobased activities in the different regions and existing interregional cooperation, calls for partners etc. In addition, the web-based portal could contain a search engine for funding resources, including calls launched by government agencies, European funding programs and an overview of all business angels and potential investors.

4.3.4. Intellectual property related hurdles

4.3.4.1. High patent costs hinder start-ups and SME's

In the absence of a global IP system and strategy, the costs for acquiring IP rights are extremely high. Start-ups, spin-offs, and innovative SMEs that are crucial in the development of IB products, cannot only easily secure patents but also not afford to bear infringement costs.

Solutions: lower the IPR cost for SMEs with public funding

The "Framework for state aid for research and development and innovation¹⁶" clearly indicate that member states or regions can financially support the costs for "obtaining, validating and defending patents and other intangible assets" for SMEs. However today only a few member states have implemented this opportunity.

4.3.4.2. Lack of harmonised IP regulation

The lack of an international governance capacity for regulations and efficient IP mechanisms for innovative technologies has created an international field of uncertainty. Intellectual property (IP) and the role of patents in innovative research have increasingly become barriers to technology development and transfer.

As intellectual property continues to grow as a component of global trade, the costs of worldwide protection and enforcement have soared. Accordingly, patent holders continue to seek ways to acquire and maintain their exclusive rights more efficiently in an integrated world marketplace. They also bear increasing frustration because of the need to pursue multiple actions for infringement in cross-border disputes. Under the bedrock principle of territoriality, successive litigations can trigger different applications of domestic and international patent norms to the same set of facts, which can lead to conflicting judgments and arguably irreconcilable outcomes.

Solution: simplification and harmonisation of patent procedures

Although some progress has been made the last years, a simplification and harmonisation of patent procedures is urgently needed in Europe.

¹⁶ http://ec.europa.eu/competition/state_aid/modernisation/rdi_framework_en.pdf

4.3.5. Other policy barriers

4.3.5.1. Difficulties in implementing the sustainability agenda and life cycle thinking in policies, and lack of coherent policy framework for sustainability

The sustainability agenda is an important driver for many of the European policies. Several demand-side policies include sustainability aspects such as 'green' public procurement. However, addressing sustainability issues through all segments of the value chain of biobased products (from biomass production to end-use) in a fair, evidence-based regulatory framework, represents an enormous policy challenge.

Addressing these sustainability concerns is a major challenge for the biobased industry, as the sector has to demonstrate that it possesses sustainability credentials in order to gain a strong “license to operate” from governments and consumers, especially if supporting policies have to be developed. A standardised method for proving sustainability would be welcomed.

In addition, life cycle thinking is still not an intrinsic part of any product development, while an integrated sustainability assessment of the whole chain addressing local as well as global effects, people and planet aspects, including nutrient cycles, water management and food-feed-fuel-competition will be needed.

The regulation for waste is also very complicated and represents a major bottleneck for using waste as feedstock for biobased products.

In order to avoid unequal or unfair sustainability comparisons between different uses of biomass, appropriate, commonly-agreed and practical assessment tools for an integrated sustainability evaluation are needed.

Solution: linking sustainable certification of biomass to certain incentives

Requests for sustainable certification of biomass have to be linked to certain incentives (like in the RED) to avoid further market distortion: if all sectors have to fulfil sustainability criteria for biomass, while only some sectors receive incentives, the other sectors will suffer from additional hurdles.

Solution: development of standardised systems to obtain feedstock corresponding to certain sustainability criteria

There is a need to develop standardised systems to obtain feedstock that correspond to certain sustainability criteria, e.g. drying technologies, physic-thermical processes. A good example has been worked out by the “Biobased Raw Materials Platform¹⁷” in the Netherlands.

¹⁷ <http://www.groenegrondstoffen.nl/Rapporten.html>

4.3.5.2. Hampered implementation of strategic approach

The main barriers perceived at both EU and national levels are the insufficient links between decision makers and stakeholders from the bioeconomy (76%), and the insufficient links between policies related to the bioeconomy (73%) (European Commission, 2012). Poor coherence between decision-makers and stakeholders are often at the origin of regulatory failures, as is the lack coherent approaches between Member States and across sectors. The incompatibility of market regulation with environmental and social regulation can sometimes cause conflicts, such as the European targets on renewable energy in the Renewable Energy Directive that distort the market for biomass for industrial material use, such as chemicals and polymers. Subsidies or trade can also be an issue due to irreconcilable international obligations or policy objectives.

Discrepancies at national and EU level in policies and priority setting for the bio-economy is also hindering interregional cooperation and knowledge transfer.

Solutions: full implementation of the EU Bioeconomy strategy

Implementation of the EU Bioeconomy strategy (by EC and Member States) in order to develop a harmonized, integrated and straightforward strategic policy framework at EU and national level that facilitates the production and commercialisation of biobased products taking into account environmental, social, and marketing aspects, e.g. harmonization and simplification of transport regulations, revision of the waste regulation etc.

4.4. Enablers

Well-developed knowledge base & infrastructure

The infrastructure in Europe is well developed. The density of research infrastructures, pilot facilities and logistic infrastructures is high in some areas in Europe compared to other parts of the world. There are also several important bio-clusters, some of which are offering educational programmes in the field of the bio-economy. Europe has also built on a strong knowledge base in chemical industry and industrial biotechnology with centres of excellence, leading research organisations and internationally renowned experts in the field.

Price fluctuations

As an average, the crude oil price will continue rising. In the long term this could be of benefit to the market share of biobased products as they will relatively become less expensive than their fossil-based competitors.

Value added products

The technological and market potential of the next generation of biobased products will be the key to success for the future. Specialties and high value chemicals will be more competitive because of their functionality, which will contribute to unlocking the market potential of biobased-products. There is also a great interest in co-product production.

Environmental benefits

Environmental considerations have become important drivers for decision-making at governments, companies and research institutions. Biobased products are often more sustainable.

Government policies

Many EU-countries have recently put into place a consistent policy for the bio-economy including biobased products.

NGOs lobbying for biobased

Some non-Governmental Organisations (NGOs) are also active in the field of IB and supportive of biobased products. They are an important stakeholder in the debate between society, policymakers and the industry. The World Wide Fund (WWF) for example has reported on the environmental benefits (reduction of CO₂ emission¹⁸) the application of IB can bring.

Premium paid by industry

In the B2B environment some companies are willing to the premium for biobased products (e.g. Danone for biobased PLA, Coca-Cola for the plant bottle).

¹⁸ <http://wwf.panda.org/?174201/Biotechnology-could-cut-CO2-sharply-help-build-green-economy>

5. Business case specific hurdles + solutions

5.1. Biofuel (second generation ethanol and aviation fuel)

5.1.1. Summary

HURDLE	SOLUTIONS
Too high production costs	<ul style="list-style-type: none"> • Use all possible value streams • Set up demonstration projects utilizing lignin from existing biorefinery • Production of additional product streams • Continue top fund R&D
A need for a stable financial and regulatory support from governments	<ul style="list-style-type: none"> • Introducing a minimum aviation biofuel mandate • Support aviation biofuels under EC's Renewable Fuel objectives • Encouraging voluntary agreements such as the Dutch aviation sector agreement • More funding for advanced biofuel innovation, with focus on output • De-risk investments into bio-jetfuel production plants through loan guarantees and by relaxing rules on State Aid
Food versus fuel utilization of biomass	<ul style="list-style-type: none"> • Joint fact finding with NGOs and researchers
Insufficient infrastructure for collection of agricultural residues	<ul style="list-style-type: none"> • Implement complex logistics systems with specialized equipment for harvest and transport of agri-residues • Develop specific incentives for farmers and the forestry industry to collect material, and incentives to support biomass production on non-agricultural land
Lack of public acceptance for biofuels	<ul style="list-style-type: none"> • Organise communication campaigns and dissemination activities to the public at large on the benefits biofuels • Labeling of fuel pumps

5.1.2. Specific hurdles

Currently there is a low profitability of larger unit operations. Raw material sourced from large areas may increase logistic costs, and it is economically still more interesting to burn forestry residues than to use it as a feedstock for biofuels or other biobased products.

National and EU targets are perceived as being the greatest drivers for lignocellulosic ethanol production. However, unstable policies, investments and prices can hinder the development of the sector. Many stakeholders in Europe are doubtful that the EU will reach a 10% ethanol (in gasoline) target by 2020 as many do not believe that there is sufficient lignocellulosic ethanol capacity in the development pipeline today. In addition, producing lignocellulosic ethanol at a cost which is competitive compared to existing first generation production before 2020 is seen as a huge challenge. Finally it is unlikely that first generation plants can easily be retrofitted for lignocellulosic ethanol production as technological challenges need to be overcome.

With regard to biobased aviation fuels, international agreements, backed up with national policies are seen as the most effective drivers for aviation biofuels. The sector is hindered by concerns over feedstock availability, cost competitiveness and policies, but nevertheless, stakeholders are confident that the aviation biofuels industry will show significant growth to 2030, principally driven by GHG reduction targets.

As a conclusion, the top hurdles to the production of lignocellulosic ethanol and aviation fuels in Europe were identified as too high production costs, a lack of incentives and legislation promoting advanced biofuels, and a lack of a long term policy framework.

5.1.3. Too high production costs

In order to develop cost-effective routes to advanced biofuels using sugars from lignocellulosic sources, it will be crucial to utilise all possible value streams. These can bring in additional revenues and potentially reduce the cost of the biofuel. Lignin, for example, is currently used in a number of low value applications, but there is significant potential to use lignin in higher value applications such as the production of biobased aromatic chemicals whilst additionally improving the efficiency of biofuel production. Lignin use has been studied for many years, but has principally focused on those derived from paper production which may differ from those produced for biofuels production. A demonstration project, utilising lignin from an existing biorefinery, would help to provide sufficient quantities for testing commercial applications, and could be developed for an estimated 10-15 MEUR, potentially having synergies with several BBI-JI¹⁹ work streams. Similarly, the processes used for the production of aviation biofuels can produce several additional product streams, which could be marketed if appropriate incentives would be in place. It was stressed that regardless of the technology-readiness level of biofuels production technologies, R&D should continue to be funded from basic to applied levels to allow continuous improvements in technologies over time.

5.1.4. A need for a stable financial and regulatory support from governments

There are multiple ways to reduce CO₂ emission in road transport (multiple liquid biofuels, biogas, electric cars, increase in rail transport etc.) but the alternatives are much more limited in the aviation sector. Aviation biofuels have the potential for major reductions in

¹⁹ <http://bbi-europe.eu/>

GHG emission in a relatively short time-frame, whereas the road transport sector takes a long time to change.

There is an existing technology base able to supply significant quantities of aviation biofuels, but without international agreements, there will be no large-scale demand. In the current policy framework, aviation biofuels are simply not as attractive to produce as diesel or gasoline components.

Mandates

Introducing drop-in biofuels is a relatively straight-forward method to reach significant CO₂ savings in relatively short time-frame, however there is a need for mandates, incentives, policies, subsidies and levelling the playing field International agreements on emission reductions.

At EU Level, the Energy & Climate package for 2030 targets for CO₂ emissions reductions must be consistent across all transport sectors to ensure regulatory certainty for investors and a coordinated approach among Member States. Regarding EU ETS, a separate cap currently applies to the aviation sector. If this was consistent with other sectors, airlines would invest in renewable fuels. So, aviation fuels should be supported under the EC's Renewable Fuel objectives.

Introducing a minimum aviation biofuel mandate of, for example, an initial 2% leading to an increase to 4% by 2020/25 and allowing individual Member States to increase this mandate internally (such as for all domestic flights) would ensure commitment from all airlines to buy biofuels to meet targets. All airlines would have the same requirements and so costs would increase across the board. This price increase should be shared across the supply chain or added to end-user/consumer costs. If this is in line with inflation, customers would pay the difference, especially if supported by appropriate PR on the greening of aviation transport. In addition, the EU could regulate the airports, this might be easier for local governments to implement to ensure a specific target for biofuel use is set.

Voluntary agreements

National governments could also help stimulate the aviation biofuels sector, for example by providing subsidies for plans, or by encouraging off-take agreements such as the Dutch aviation sector agreement.

Case study: the Dutch aviation sector agreement.

The Dutch initiative aimed at ensuring the deployment of sustainable biofuels in the aviation sector is a good model for all other Member States to adopt, demonstrating the commitment of the public and private sectors in the aviation and biofuel industry. The signatories of this initiative include KLM, SkyNRG, Schiphol Airport, the Port of Rotterdam, the State Secretary of Infrastructure and the Environment, and the Minister of Economic Affairs. This provides market support which aids commercial production investments due to demand guarantees.

This open obligation from the airlines/aviation industry could be made more specific to guarantee support/technology development and up-scaling to commercial scale. Member States and EU need also to be more specific when it comes to the definition of advanced aviation biofuels, what could improve industry confidence on cost and on price stability.

Some airline companies have already tried to introduce voluntary environmental programmes but without much success. A simple scheme coupled with effective marketing could stimulate small scale demand for aviation biofuels.

Subsidies and funding

Governments need to invest in advanced biofuel. More needs to be done on reviewing all funding programme outputs (at a Member State and EU level) on advanced biofuels over recent years – this should focus on successes, and future calls need to be changed to support these specific technologies.

Although Europe needs additional production plants, high risks hinder investments. These could be underwritten by Governments (local or EU) in order to de-risk the investments into biojet production plants. This could be done through loan guarantees on investments provided by governments for plant development (e.g. 60-70% guarantees). The EU and Member States also need to relax their rules on State Aid like the United States of America has.

The biojet production kit can produce other biofuels and biochemicals, however, there are no incentives across the supply chain. If incentives were in place, producers would have additional revenue streams and therefore costs would be reduced.

Finally, the combination of conventional crude oil refineries with biorefineries (co-processing) could lower the investment costs, is technical feasible (in some cases), and would have less environmental impact.

5.1.5. Food versus fuel utilization of biomass

A strong ongoing societal debate is questioning the ethics of occupying arable land for fuel crops instead of food crops. Indirect land use change may be the consequence, or the food security might be at risk. The cultivation of fuel crops is also challenging the current agricultural production scheme as a whole.

There is an urgent need for Joint fact finding with NGOs and researchers in order to contribute positively to the food versus fuel debate

Example: Food-Fuel debate signed by 32 organizations in The Netherlands

In the Netherlands, a total of 32 companies, NGOs and institutions have endorsed the final document²⁰ of the food-fuel debate.

In the problem analysis there is consensus that the use of biofuels can offer opportunities but also threats to food security. Biofuels are not inherently positive or negative related to food security. So the ultimate effect strongly depends on how biofuels are produced. In addition, food security is influenced by a number of other factors. Making a distinction between first and second-generation fuels is not enough; both can be sustainable and not sustainable.

The parties agree that biofuels should not be at the expense of food security. Stronger still, the ambition should be for biofuels to contribute to food security. Ultimately, the solution for the food issue lies in the global fight against food waste, in sustainable land use and higher agriculture productivity levels. Biofuels may contribute to this, but the contrary may also be true. The key question is: which crops and production methods make the most efficient and sustainable use of scarce land? More sustainably produced biofuels are still being developed. The policy should be aimed at the continued development of these fuels and the phasing out of less sustainably produced biofuels.

Transparency and certification are vital in order to guarantee the sustainable production of biofuels. The dialogue with suppliers of biomass should become more important. The biofuels market is a result of government policy and this policy should be adjusted as this market develops and intended and unintended effects become visible, partially on the instigation of NGOs and businesses. At the same time, the invasive and continuously changing government policy disrupts the market and it slows down the development of sustainable biofuel chains. There is a fear that the lack of a joint vision among the governments in the EU may result in sustainable, innovative production of biobased products and fuels will predominantly take place outside Europe.

Furthermore, the parties continue to disagree. This is due to inherent uncertainties, but also because of conflicting perspectives and interests. The disagreement relates to the need of first-generation fuels as condition for the development of more sustainable second-generation fuels, the climate effects of biofuels, the effect on food prices and food security and whether or not first-generation biofuels should be promoted at all as a precaution and due to the immense challenges in the agricultural sector. Although the consensus is that hunger is not primarily caused by biofuels, opinions differ about whether the food-fuel discussion is one of the relevant discussions or if it distracts from more important issues with regard to food supply.

Parties agree more about the following problem-solving approaches:

- The parties involved agree on fighting waste of food, sustainable land use and higher agriculture productivity levels. The parties also largely agree on stimulating biofuels that result in improved agriculture practices, on a comprehensive approach to food, materials and energy production and on the need to invest in farmers, local biomass chains, the local community and the local market.

²⁰ Food - Fuel, Competition or Synergy?- Instituut voor Maatschappelijke Innovatie (March,2014)

- In addition, transparency regarding the biomass chain and effective supervision and control mechanisms is regarded as vital. One particular item that is deemed highly important is the safeguarding of local land rights through free prior and informed consent.
- The cascade principle needs closer consideration and detailing for the various applications and their economic and social values. A level playing field in terms of requirements and encouragement is desirable. A level playing field for green chemicals in relation to biofuels is desirable, for instance by expanding the RED with materials and chemicals, or by including CO₂ gains in the biochemical and biobased industry in the Renewable Energy Directive. A level playing field is also desirable in relation to other sources as fossil fuels, or other applications as food.

5.1.6. Insufficient infrastructure for collection of agricultural residues

To stimulate the production of commercial advanced biofuel or aviation fuel, there is an urgent need for the implementation of complex logistics systems with specialized equipment for harvest and transport of agri-residues. In some parts of the EU, efficient on-farm machinery and infrastructure for straw handling and baling is not yet available. There is also a need for large-scale facilities. In addition, financial incentives to collect and transport agri-residues are missing (Renewable Transport Fuel Certificates; incentives for farmers and the forestry industry to collect material; incentives to support biomass production on non-agricultural land e.g. willow, etc.)

The Rural Development Funds could be used to support access to machinery and infrastructure, and public private partnerships could be developed to upscale biorefineries. By-products and waste from (second generation) ethanol production can be used for the production of secondary and potentially high value added products. This would solve part of the logistics problem (feedstock and use of waste).

5.1.7. Lack of public acceptance for biofuels

There is a general lack of public acceptance and sufficient awareness of biofuels, due to inefficient communication, a lack of communication, the discussions in the media on food versus fuel and possible indirect land use changes, higher cost of cars, etc.

It is proposed to organise communication campaigns and dissemination activities to the public at large on the benefits biofuels and disadvantages of fossil fuels to raise awareness and to change the opinion and the cultural behavior. Labeling of fuel pumps (e.g. 5% blended with bio-ethanol) could be a first step. Finally, educational programmes and specific educational activities targeted at the secondary school level should be set up.

5.2. Chemical building blocks

5.2.1. Summary

HURDLE	SOLUTIONS
Raw material price and availability	<ul style="list-style-type: none"> • Removing import tariffs for industrial sugar • Using fiscal incentives to reinvigorate EU sugar production • Reinstall the local sugar processing capacity that has been lost in the EU over the last decade via government grants or fiscal incentives • Stimulate collaboration between the sugar industry and the chemical/fermentation industry to develop a “minimum processing route” • Improve feedstock availability, by educating farmers, foresters and other land owners on the value of their products to the bioeconomy • Ensure that a variety of feedstocks could be processed efficiently at a single facility
Improve process efficiency and reduce production costs	<ul style="list-style-type: none"> • focus on high value-added products and high quality applications such as specialty chemicals rather than bulk applications • Processing beet in a minimal way so that the sugars could be used for IB without being completely refined • Developing multiple feedstock facilities so that the EU IB industry is not dependent upon one single feedstock • Research projects should be built around full value chains focusing on solutions
Lack of market incentives for biobased chemicals	<ul style="list-style-type: none"> • Develop a fairer playing field between biobased alternatives (e.g. bioenergy – biofuels – biobased products)
Lack of investments	<ul style="list-style-type: none"> • Develop economic incentives helping companies in converting chemical plants to biotech ones • Develop mobile or smaller decentralised biorefineries

5.2.2. Specific hurdles

Market opportunities for biobased chemical building blocks are being driven by new properties for existing products, opportunities for product differentiation and by increasing customer awareness.

The top hurdles to the production of biobased chemical building blocks in Europe were identified as raw material availability, quality and price, cost-competitiveness of final products, and uncompetitive production processes. Taxes, regulation and regulation

volatility are also perceived as hurdles. Issues over incentives, funding and investments for scale up were less important in comparison.

Some mechanisms are needed in the EU to develop an industry based on the production of high value-added products, e.g. the development of advanced or aviation biofuels could be a stepping stone for high value added chemicals production, similar to the USA where the focus on ethanol production was then able to stimulate the development of other chemical building block products. A strategic focus on products which cannot easily be made from fossil products, or which have new functionalities may bring a competitive advantage to the EU, but it is questionable whether this can be achieved with high feedstock prices as the extent to which feedstock prices can be reduced for both farmers and industry is unclear.

5.2.3. Raw material price and availability

Biobased industries are competing in an international environment, but due to import tariffs and quotas the EU market for feedstock is non-globalised which creates high prices for sugars from biomass. There is an urgent need for a level playing field for feedstock access for technical (non-food) use. Mechanisms to improve feedstock availability focussed on reducing the cost of sugar by removing import tariffs for industrial sugar, and on using fiscal incentives to reinvigorate EU sugar production, reversing the decline over the past decade, are seen to be important.

Today, glucose price is controlled by sugar beet quotas. Since 1996, EU sugar producers have been encouraged by the EC to reduce production capacity due to fears over prices. Large scale single crop production is currently not possible in Europe, although is practiced in an efficient manner outside Europe. This causes supply chain issues for sugar processing plants in the EU (who need a large enough processing facility to achieve economies of scale with enough feedstock to produce sugars at a competitive price).

The local sugar processing capacity that has been lost in the EU over the last decade should be reinstalled, perhaps encouraged by government grants or fiscal incentives. This would also reduce costs associated with the transportation of biomass.

While import tariffs protected EU farmers, it had a negative impact on the IB industry as sugar prices are inflated compared to world prices. Import tariffs on world sugars could be removed as these are high and a disadvantage for EU processors. The playing field between different uses of sugars should be levelled. The proposed impact of these changes is still unclear: although the removal of import tariffs could help bring cheaper sugars to the EU, this may also have a negative impact upon the EU sugar producers, and it could also be argued that EU-produced sugars would still be more expensive than world sugar prices. The maintenance of quotas for food production, but the absence of quotas for industrial use would potentially be one way to mitigate this issue.

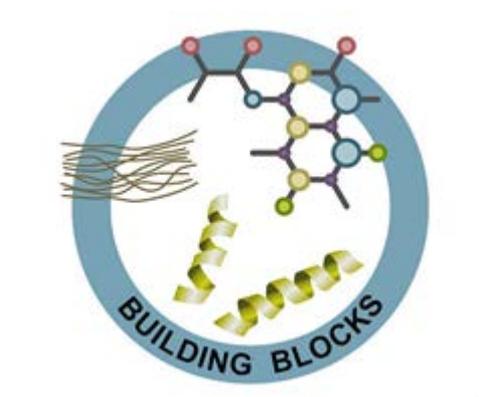
Sugars do not need to be pure refined glucose to be used in IB processes, and a 'minimal' processing route could be developed to isolate sugars in a more cost effective manner. R&D and collaboration between the sugar industry and the chemical/fermentation industry is needed in this area.

More widely, actions should be undertaken to improve feedstock availability, by educating farmers, foresters and other land owners on the value of their products to the bioeconomy and by stimulating cross-sectorial collaborations, for example between the chemical and forestry industry.

Moreover, the need to ensure that a variety of feedstocks could be processed efficiently at a single facility could help overcome the potential seasonal changes in feedstock availability in the EU. This should be combined with R&D on how to cost effectively, and remove efficiently, C5 and C6 sugars from a variety of biomass sources and identifying which other products could be produced, preferably those with a high added value.

5.2.4. Improve process efficiency and reduce production costs

The EU has considerable technological strengths but is disadvantaged by costs. As such, the sector should focus on high value-added products and high quality applications such as specialty chemicals rather than bulk applications.



R&D is crucial to improving process efficiency and reducing costs. Two possible routes to reducing feedstock costs were identified: processing beet in a minimal way so that the sugars could be used for IB without being completely refined; and the development of multiple feedstock facilities so that the EU IB industry is not dependent upon one single feedstock. Although consolidated bioprocessing was suggested as an efficient route for processing lignocellulosic feedstocks, integrating pre-treatment and fermentation steps, its operational expenditure (opex) benefits were questioned. Increasing fermentation selectivity or developing downstream processing steps to be more tolerant of the different contaminants produced by microorganisms was deemed important to improving product yields. Industrial symbioses between the IB industry and other industries should be explored both through exchanges of information and through practical measures such as heat integration. These aspects are further elaborated in the “technological roadmap”.

The conversion of a chemical to a biotechnological plant is very expensive, and will only be done if the cost of the production process is much lower. As the prices of the new biotechnological processes are today, in most cases, not economically sustainable, the technologies need to be improved to lower the price while improving environmental sustainability of biotechnological products. However there is low level of public funding

available for non-academical organisations such as industry, the current funding schemes are unstable, and there is poor willingness of investors to take risk for investment in demonstrations.

Research projects should be built around full value chains focusing on solutions that can make production chain simpler, shorter and more efficient.

5.2.5. Lack of market incentives for biobased chemicals

Different, internationally agreed policies are required for biobased chemicals and polymers, while the current EU regulation shows too much volatility and is too complex. Furthermore, the definition of “green chemicals” is unclear.

Consumers drive pricing strategies: all biochemicals currently sold are either at same price level or more expensive than their fossil counterparts. Competition without incentives is difficult because of expensive production costs (e.g. due to high energy and feedstock price). Industrial inertia is a problem: the mind set of traditional companies coupled with public perception is not stimulating the development of the sector. There are currently also no incentives for biobased chemicals, although feedstock diverted for bioenergy and biofuels skews prices. There needs to be a fairer playing field between biobased alternatives.

As an example, the revised US farm bill foresees that all incentives for biofuels should also become available for biobased chemicals.

5.2.6. Lack of investments

Today, the market is dominated by large players. However, the current financial and economic situation delays large investment, and there is a lack of VC. The cost of production makes EU as a location not ideal. The current price of sugar, high scale-up costs, and the no-willingness to pay a bio-premium are limiting factors.

Europe should focus on products where there is a limited market, where it is not feasible to transfer knowledge elsewhere, and/or where 1-3 production facilities can fulfil global demand. Economic incentives could help companies in converting chemical plants to biotech ones. Finally, major infrastructure costs will be required and will only be feasible if existing refineries are converted. Mobile or smaller, decentralised biorefineries could contribute significantly to achieving these growth targets.

5.3. Biobased plastics (PLA, PHA)

5.3.1. Summary

HURDLE	SOLUTIONS
New biobased plastics are often more expensive than the conventional ones	<ul style="list-style-type: none"> • Funding for innovations in order to reduce production costs (e.g. conversion technologies and down-stream processing) • Explain better the benefits of bioplastics, so consumers accept to pay a (bio-)premium
New value chains still have to be developed to obtain critical mass	<ul style="list-style-type: none"> • Develop infrastructure for effective composting or recycling • Development of policy tools to stimulate demand
Need for clear standards and a regulatory framework promoting market uptake	<ul style="list-style-type: none"> • Defining in a transparent way the characteristics ‘green’, “bio-degradable”, “biobased”, “bioplastics”, etc • Develop clear standards • Improve communication and education • Developing a good programme to stimulate market uptake in Europe (e.g. public procurement)
Lack of financial incentives	<ul style="list-style-type: none"> • Implementing a tax and/or subsidies for certain applications to close the price gap between biobased and fossil based plastics

5.3.2. Specific hurdles

There are several drivers for the use of biobased polymers. These range from rising and increasingly volatile fossil oil prices, the potential for net environmental benefits compared to fossil plastics, and local and national regulatory actions such as bans on plastic bags. Increasingly, positive consumer attitudes towards biobased and biodegradable or compostable materials are helping to develop the market.

There is currently a definite lack of an appropriate framework to promote biobased as opposed to fossil-based plastics. A series of regulatory incentives such as green public procurement, targets for bioplastics use, coherent EU labeling schemes, tax exemptions and other market pull measures would most certainly contribute to a more positive environment for biobased plastics. To accompany these measures, the public perception and awareness of biobased products and the benefits which they can bring will need to be improved. Currently, there is a strong discrepancy between regulations at the national and EU level, too many national level policies and badly defined terms such as ‘green’, ‘biobased’, ‘biodegradable’, ‘compostable’ and ‘bioplastics create confusion. Common terminologies and targets would help create a more coherent market opportunity in the EU. Although though Europe has a strong R&D base, there is a need for a true industrial policy which is less risk averse and helps start-ups to scale-up and overcome heavy initial expenditures.

The full exploitation of the potential of bioplastics will also depend on several technological improvements and breakthroughs. Production costs need to be lowered by, amongst others, improving yields, which not only requires the use of specific raw materials but also developing more efficient biocatalytic systems and improving downstream processing.

5.3.3. New biobased plastics are often more expensive than the conventional ones

In general, the production costs should be reduced. As for many biobased plastics the fermentation costs and process energy requirements are quite high. In many cases, the conversion technologies and down-stream processing in biopolymer production could still be improved. Often, the feedstock price plays an important role (e.g. sugar price).

However, many plants producing conventional mass commodities such as PE and PET could easily be used to produce bio-PE and bio-PET, which are the plastics with the already today highest volume amongst all bioplastics.

In addition, consumers may only accept to pay a (bio-)premium if they know the benefits of bioplastics.

5.3.4. New value chains still have to be developed to obtain critical mass

Fermentation based plastics require the integration of a new value chain. So far bioplastics have to fit into the processing equipment used for 'standard' plastics, and companies do sometimes not have the required material for bioplastics pellet production. There is also a lack of critical mass to guarantee investment return and profit.

Expectations for biopolymers are tempered through high prices (compared to their petrochemical counterparts), limited production capacity, lack of certain mechanical and thermal properties (bioplastics cannot replace all petroleum derived products in all applications) and the lack of infrastructure for effective composting or recycling. In addition, several major players on the market are reluctant to shift to bioplastic. Finally, policy tools to stimulate demand are much weaker in Europe than in other regions. We also need a strong political commitment at EU and national level to secure the supply of 'home-made' bioplastics.

5.3.5. Need for clear standards and a regulatory framework promoting market uptake

The characteristics 'green', "bio-degradable", "biobased", "bioplastics", etc are not well defined, so there is an urgent need for clear standards, and more coherent regulations are needed on biodegradable versus non-biodegradable. There is also a strong discrepancy between the regulation at EU level and at national level, and the national policies between the Member States can be quite different.

The public at large is not well aware of the technical properties of bioplastics, and consumers/customers are not informed about potential benefits. There is a lot of misleading communication of environmental aspects. In addition, the public is concerned about the

amount of biomass needed for the production of bioplastics. Finally, it is not an advantage for the public perception (in Europe) that some bioplastics such as PLA are made from genetically modified corn in the US.

A good programme to stimulate market uptake is missing in Europe. Implementation of an efficient public procurement programmes such as the Biopreferred Programme in the US could be helpful, as well as setting (binding) targets for the use of bioplastics in certain sectors or applications could stimulate the uptake (e.g. fast food restaurants, public building, sport and music events).

Adding a specific functionality will create an extra added value to biobased plastics and open certain markets (e.g. many chemical companies are shifting from promoting biobased to promoting additional functionality such as engineered PLA grades).

5.3.6. Lack of financial incentives

The investment climate in Europe falls short compared to other parts of the world, and more incentives are needed at national and EU level. More government support is needed for start-ups to scale up (on demand or supply side) in order to overcome initial cost disadvantages. Such support should only be given for projects that were proven to be cost-competitive. Although Europe has a strong knowledge and R&D base, there is need for an ‘industrial policy’ in Europe which is more focused on the applications and less risk averse.

Another (temporary) solution could be the implementation of a tax and subsidies for certain applications to close the price gap between biobased and fossil based plastics (e.g. implementing a carbon tax for consumers to move faster to a carbon low environment).

5.4. Biosurfactants

5.4.1. Summary

HURDLE	SOLUTIONS
Unclear definition of biosurfactants	<ul style="list-style-type: none"> Develop a clear definition of biosurfactants, easy to communicate
Customers are unwilling to pay a premium	<ul style="list-style-type: none"> Increase the actions towards product improvement and differentiation as superior properties and differentiation is seen as reason to justify a higher price Better communicating performance and sustainability of biosurfactants in marketing Raising consumer awareness about the benefits of bio-based products in general and biosurfactants more specifically via lectures and advertising
Absence of incentives or efficient policies	<ul style="list-style-type: none"> Reducing cost and complexity via modification of REACH legislation Harmonization of regulations between different member

	states to reduce cost and complexity
Poor public perception and awareness	<ul style="list-style-type: none"> • Make people aware of how much biobased products are already used, starting at school level • Develop positive and consistent labelling and language (“EU-wide regulation”)

5.4.2. Specific hurdles

According to the stakeholders from the sector, the most critical hurdles that prevent or slow down the development of biosurfactants are the (unclear) definition of biosurfactants, the cost-competitiveness, the absence of incentives and the poor public perception. Feedstock availability is not seen as an issue for biosurfactants as this is a low volume market (in terms of mass, not value).

5.4.3. Unclear definition of biosurfactants

The definition of biosurfactants is unclear which makes it hard to communicate. Several types of definitions are used for bio-surfactants: bio-based surfactants derived from biomass (partly or whole), bio-degradable surfactants, or surfactants based on industrial biotechnology.

Standards and official definitions are needed and have to be discussed and explained to the stakeholders in academia, industry and the public. Maybe an additional positive list of named compounds can be useful. There is a committee CEN TC 276 working on this topic which will publish results in 2015. A standardization on a global level would be crucial for the future.

5.4.4. Customers are unwilling to pay a premium

Cost competitiveness is seen crucial in a price-driven market such as surfactants, and customers are generally unwilling to pay a premium for new products or pay a bio-premium for IB-based biosurfactants. However, this applies to the “commodities” market only and higher prices may be accepted in specific high value applications. As such, it is recommended to increase the actions towards product improvement and differentiation as superior properties and differentiation is seen as reason to justify a higher price.

More attention should be paid to communicating performance and sustainability of biosurfactants in marketing. Ecolabels and certification can be used as tools, and the actions could be aimed at companies with announced targets / a strategy on increasing the use of renewable resources. In addition to the idea of improving B2B marketing, there is a need to raise consumer awareness about the benefits of bio-based products in general and biosurfactants more specifically. This could be done by means of lectures and advertising. Marketing actions should be carried out by producers and formulators themselves. Ideally,

consumers would be in a position to make informed choices and the role of governments would be to support labeling and certification schemes.

Because of the vicious circle where there are no economies of scale without market demand and vice versa, a policy/legislative framework to support bio-based products can play an important role.

5.4.5. Absence of incentives or efficient policies

Expensive and complex permits and approvals, and long procedures make it difficult to introduce new biobased products such as biosurfactants. In addition, existing regulations (e.g. REACH) do not favour the introduction of new products in general and this applies certainly to bio-based products

Companies management need to be convinced to push for biobased products, and reducing cost and complexity could be done via modification of REACH legislation. Also a better harmonization of regulations between different member states would reduce cost and complexity. To change the regulation such as REACH, both EC and member states should be involved, which need to be persuaded by biobased industry stakeholders. And although implementation could take 5-10 years, actions should be started now.

However, reducing complexity and harmonization will lead to cheaper legislation and hence cheaper registration of new products.

5.4.6. Poor public perception and awareness

There is a need to bring facts to address the legitimate questions that the general public may have regarding biosurfactants: why are biobased surfactants better (e.g. sustainability, performance, environment). There is also a need to overcome objections about GMM (Genetically Modified Microorganisms) which are used to optimize process performance and the range of accessible products.

The first focus should be on education based on the following topics:

- Make people aware of how much biobased products are already used
- Start at school level with positive messages
- Develop positive and consistent labelling and language ("EU-wide regulation")

In addition, promotion efforts of biobased surfactants should be consistent at the EU level and will be supported by consistent labelling mentioned above.

Actions such as developing tools, approach and common language, should be started as soon as possible, as well as seeking buy-in from NGOs and Governments. While industry can provide the necessary tools and should develop training plans, public authorities (EC and Member States) as well as NGOs should be part of the effort. In any case, the already existing channels should be used to promote action (Bioeconomy Panel, DG Sanco, panels on bio-based products ...). This could lead to a better acceptance of biosurfactants and will create a

larger interested customer base. A better awareness will create a market for industry. However the full impact will only arise in 10-15 years from now.

5.5. CO₂

5.5.1. Summary

HURDLE	SOLUTIONS
CO ₂ preparation and energy costs are too high	<ul style="list-style-type: none"> • Optimize selective conversion routes and avoid co-products that may be difficult to separate • Focus on the competitive production of high-value products (specialty chemicals) • Develop technical solutions to enable cost-effective CO₂ capture, pre-treatment and direct in-situ conversion, at a single point CO₂ source, to a higher value product
Absence of standards, incentives and supporting policies	<ul style="list-style-type: none"> • Develop recognized standards enabling the measurement and certification of the amount of CO₂ utilized for making CO₂-based products • Developing tax schemes whereby CO₂-based products (with a net reduction of CO₂ emission compared to fossil-based counterparts) could be promoted for instance through the EU ETS system
Lack of R&D funding	<ul style="list-style-type: none"> • Increase funding for R&D programs, including demonstration projects

5.5.2. Specific hurdles

The main hurdles for CO₂ conversion based chemicals seem to be technological ones, evenly distributed over CO₂ supply, bioconversion and downstream processing issues. CO₂ capture and purification (as sub-topics of CO₂ supply) appear to be a significant concern.

The major non-technological hurdle is the absence or efficient policies.

The CO₂ business case is different from all other business cases reviewed in this BIO-TIC study, since CO₂ is a possible feedstock to industrial biotechnology processes whilst all other business cases deal with products from such processes.

For the conversion of CO₂, the objective is to optimize selective conversion routes and avoid co-products that may be difficult to separate. So a possible solution could be to focus on the competitive production of high-value products (specialty chemicals) as this could be a way to make this process competitive against production of similar products from fossil feedstock, and be a way to lower the carbon footprint of the chemicals produced.

Another solution could be to develop technical solutions to enable cost-effective CO₂ capture, pre-treatment and direct in-situ conversion, at a single point CO₂ source, to a higher value product using Industrial Biotechnology. This solution will reduce costs of transportation of low value CO₂, by allowing direct production of a high value product, which will improve the ratio of value/costs. It will also avoid the need for new transportation infrastructure, where the CO₂ would otherwise be shipped to a conversion site before going further to become an end-product.

These solutions will be further developed in the Technological Roadmap.

5.5.3. Absence of standards, incentives and supporting policies

CO₂ as a feedstock is widely available from point sources (e.g. flue gas from coal, natural gas and crude oil power production, industrial processes, syngas production, natural gas sweetening, coal power production), which will require capture, compression and potentially an additional processing step to increase the degree of purification. This will create significant capital cost.

Today, CO₂ bioconversions are generally at low TRL levels, with more R&D work and demonstrations needed to demonstrate their viability in the long run and cost competitiveness. There are also no economic triggers to use CO₂ as feedstock.

There is indeed a need to develop recognized standards enabling the measurement and certification of the amount of CO₂ utilized for making CO₂-based products. This would be the starting point for tax schemes whereby CO₂-based products (with a net reduction of CO₂ emission compared to fossil-based counterparts) could be promoted for instance through the EU ETS system.

Products made from captured CO₂ (CCU) are not eligible for credits under the EU-ETS, but capturing CO₂ and burying it in the ground (CCS) is. This means that a valuable source of carbon for chemicals production is going to waste.

Fossil-derived CO₂ and biomass are both acknowledged to be renewable sources of carbon. Chemicals produced from CO₂ derived from fossil fuels need a standard to help market them effectively against those derived from biomass. Existing standards for measuring the renewable component of renewable feedstocks are based upon C14 measurements. These methods are ideal for biomass (C14 measures biogenic carbon content) but do not work for fossil derived products where C12 is the predominant carbon isotope.

A few methods could be employed. A carbon footprint, stating that there was at least X% carbon from fossil sources could be a possible label for CCU derived products. On the other hand, an LCA certifying the carbon balance of the entire supply chain would be the best method for developing a standard, but clear system boundaries need to be in place. In addition, an LCA covering the feedstock and production process would be the most feasible method as all downstream uses will be covered under existing LCAs. The LCAs report the amount of avoided CO₂ in both the process under investigation and in conventional supply chains.

The development of a clear standard for products derived from fossil CO₂ could be a useful step-stone towards the implementation of tax credits, whereby companies using CO₂ for chemicals and products could offset some of their plant costs against tax, as demonstrated by the tax reduction for bio-based chemicals in the USA.

It will take around 2-3 years to develop a standard, and a label will take an additional 2-3 years. However, before considering the development of EU standards or labels, there need to be some pilot facilities to demonstrate the feasibility of different technologies.

It was highlighted that the European Emissions Trading Scheme (EUETS) will be entering its final phase in 2020-2025 and that campaigning for inclusion of CCU technologies within any possible following scheme is crucial.

In terms of creating market pull for CO₂ derived products, some 'Champions' for CO₂ use for chemicals should be identified in different end-sectors (i.e. cosmetics). Case studies of successful use of CO₂ in products should be developed.

Finally, the development of a standard for products derived from CO₂ would help make the case for a tax reduction for plants producing fossil-fuel derived CO₂ products. This tax reduction could be used to reduce product prices, and help create market pull.

5.5.4. Lack of R&D funding

Although governments do not yet recognise the potential of this 'forerunner' research and technology, the current technological problems can be overcome. The research projects are still generally at small scale and there are currently only few examples of investments in prototypes. There is a problem to get into current regular funding programs, and there is currently no funding for demonstration projects.

Stakeholders could be brought together through, for example, a SPIRE-funded CSA, to bring together information in support of CO₂ labelling.

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