Bio-based Industries Consortium

SIRA

STRATEGIC INNOVATION & RESEARCH AGENDA

BIO-BASED INDUSTRIES
for Development & Growth in Europe

May 2017

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DISCLAIMER:

This document is the first update of the Strategic Innovation and Research Agenda, originally published in March 2013. It reflects the ambitions and objectives of the members of the Bio-based Industries Consortium (BIC) in December 2016, and is the basis for road mapping towards the BBI calls for proposals. The BBI SIRA will be adjusted as needed to reflect technology and market developments, results obtained and ambitions of new members entering the BIC.

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EXECUTIVE SUMMARY

This Strategic Innovation and Research Agenda, or SIRA, sets out the main technological and innovation challenges to developing sustainable and competitive bio-based industries in Europe at the time of writing. It reflects the industries' vision of a competitive, innovative and sustainable Europe leading the transition towards a bioeconomy, while decoupling economic growth from resource depletion and environmental impact.

The SIRA identifies research, demonstration and deployment activities to be carried out by the Joint Technology Initiative on Bio-based industries, or BBI Initiative.

This public-private partnership between the European Commission and the Bio-based Industries Consortium (BIC), aims to invest € 3.7 billion in bio-based innovation between 2014 and 2020. The BBI Joint Undertaking established by the Council Regulation (EU) No 560/2014 of 6 May 2014 will implement this initiative.

The bio-based industries in Europe have been evolving rapidly. Driven by business and consumer demand for greener products and by policy developments such as the European Bioeconomy Strategy and equivalent strategies in Member States, they have started to invest in technological advancements and deployment. They will receive a further boost from the increased efficiency of innovative technologies and their upscaling to commercial levels, and from the new policy focus on the circular economy and decarbonisation that initiatives such as the European circular economy package and COP21 have brought.

Dynamic and sustainable bio-based industries in Europe can deliver many environmental, economic and social benefits. They can help to meet EU objectives in areas ranging from economic growth, job creation, the circular economy and resource efficiency to climate change mitigation, security, agriculture modernisation and regional development. For instance:

- Bio-based industries are hugely important to Europe. The European bioeconomy taking in the food, feed, beverage and primary sectors, has an annual turnover of € 2.1 trillion. Bio-based industries (relevant chemicals, plastics, pharmaceuticals, paper and paper products, forest-based industries, textile sector, biofuels and bioenergy) account for € 600 billion of this total. Moreover, the European bioeconomy provides jobs for 18.3 million Europeans, over half of them in primary biomass production (agriculture, forestry and fisheries). Bio-based industries employ 3.2 million people[1].
- Industrial biotechnology – an important pillar of the bio-based industries – provides almost half a million jobs in the EU and over € 31 billion in added value. By 2030 it may account for between 900 000 and 1.5 million jobs and € 57 to 99 billion in added value[2].

- Bio-based industries make use of European biomass sources and sustainable European supply chains. As such, they lower our dependency on imports and contribute to our raw material security. With 90 % of Europe's chemical industry feedstocks for non-energy use coming from fossil resources[3], access to alternatives such as biomass (including bio-waste) or CO_2 is an important strategic issue.
  - Bio-based industries can create opportunities for local regeneration in rural and coastal areas, fostering cooperation between the different stakeholders along the value chain. For example, trade unions in Denmark have estimated that realising the country's biomass potential could create 23 700 jobs, of which nearly four in five would be in rural districts. Bio-based industries can also provide farmers with new sources of income[4].
  - Bio-based industries are important players in building the European circular economy. They are pioneering the processes to produce added-value products from feedstocks such as agricultural residues, urban bio-waste, side streams from food processing, and industrial emissions of greenhouse gases (GHG), including CO_2.
  - By replacing fossil-based products with bio-based products, which tend to have a smaller carbon footprint, bio-based industries can make a critical contribution to Europe's climate goals[5].

To unlock their full potential, Europe's bio-based industries will need to make sustainable, resource-efficient and largely waste-free use of Europe's renewable materials to play an important role in spurring sustainable growth and boosting Europe's competitiveness. They will re-industrialise and revitalise rural and coastal areas, providing tens of thousands of highly skilled research, development and production jobs over the next decade.

At the heart of this Agenda are the bio-based value chains and their composing pillars:

- foster supply of sustainable **biomass feedstock** to feed both existing and new value chains;
- optimise efficient **processing** for integrated biorefineries through research, development and innovation (R&D&I);
- develop **innovative bio-based products for identified market applications**; and
- create and accelerate the **market-uptake** of bio-based products and applications.

These pillars form the four strategic orientations of the bio-based industry in Europe.

This Agenda extends beyond the original, by explicitly incorporating new feedstock such as aquatic-based sources, bio-waste and CO_2. In addition, it more actively pursues the crossover between 'traditional' value chains. This 'multi-value-chain' approach increases opportunities to convert and valorise new feedstocks into a wide array of bio-based products:

- chemicals;
- materials;
- food ingredients and feed;
- transport fuels[6].

The BBI Initiative focuses on developing Europe-based value chains and accelerating the transition to advanced feedstock for biorefineries. It is aimed at:

- building new value chains: this will involve developing sustainable, highly productive biomass collection and supply systems and making better use of biomass feedstock, including co-products, side streams and residual streams from various sources;
- bringing existing value chains to new levels: this will involve optimising the use of biomass feedstock and offering innovative added-value products that respond to market needs; and
- bringing existing and new technologies to maturity: this will involve using R&I and upgrading and building demonstration and flagship biorefineries that convert a wide variety of biomass into a broad range of innovative bio-based products.

The Initiative builds on the strong performance of the agricultural, agro-food, forestry, pulp and paper, aquatic and bio-waste sectors, and of world-leading companies in the plant breeding, biotechnology, chemistry, energy and bioprocess engineering sectors. It capitalises on the vast amount of R&D investments and results to make Europe's existing pilot and demonstration facilities as used and useful as possible. And finally, it seeks to leverage the combined and complementary knowledge and skills of academia, research organisations, small and medium-sized enterprises (SMEs) and larger corporations to achieve its innovation objectives.

Endnotes chapter 1

1 *Bioeconomy in figures* (2013), BIC, 2016.

2 *Jobs and growth generated by industrial biotechnology in Europe*, EuropaBio (European Association for Bioindustries), 2016.

3 CEFIC, *Measuring Bio-Based raw materials use in the chemical industry*, 2014

4 *Geographical employment potentials from bioeconomy*, Copenhagen Economics, prepared for the United Federation of Danish Workers, 2015

5 *Bio-based economy and climate change: important links, pitfalls, and opportunities*, nova-Institut GmbH, 2017

6 The Agenda sets out the framework in which the bio-based industries in Europe operate, the aim being the integrated production of chemicals, materials, fuels, etc. The BBI joint undertaking work programmes will dovetail with other parts of Horizon 2020 and overlaps will be excluded. For example, standalone biofuel projects (including aviation) and energy-driven biorefinery projects are a focus of Horizon 2020 - Societal Challenge 3 (secure, clean and efficient energy) calls. The industries cover advanced biofuels in BBI through cascading biomass-driven biorefinery projects focused on high added-value products (materials, chemicals) and a limited number of advanced bioethanol activities conceived as a stepping stone to integrated biorefineries.

2

THE LONG-TERM OBJECTIVES OF THE BIO-BASED INDUSTRIES INITIATIVE

The BBI Initiative reflects the BIC's ambitions to contribute to society's long-term sustainability. It will trigger further developments with long-term benefits, including:

- full deployment of new value chains and products launched and demonstrated under the Initiative;
- operational, fully fledged new flagships and upgraded biorefineries;
- new bio-based product developments; and
- applications and dedicated policy measures.

The combination of research and innovation actions and associated supporting actions, spanning across Technology Readiness Levels 3 to 8, will ensure that the Initiative delivers long-lasting, forward-looking and widespread benefits. Public investments to help cross the innovation 'valley of death' (from research to market) will attract at least three times higher private investments for actions directly related to the Initiative. The leverage effect on the total European bioeconomy will be substantially higher.

The BBI Initiative will achieve significant, tangible results by 2020. However, the greatest leverage effect and commercial deployment will be felt from 2020 to 2030.

2.1 Overall strategic objectives for 2020 and 2030

The following list sets out the objectives as formulated in 2013, with that same year as the baseline (unless otherwise stated). This adjusted Agenda maintains these objectives and ambitions, adds some new objectives and provides updates ***as of 1 January 2016*** *where applicable.*

1. BBI activities will help guarantee a secure and sustainable supply of biomass feedstock for European biorefineries. They will do this through the development of integrated and sustainable value chains using agri-based, forestry-based, aquatic feedstock and their residues and side streams; and bio-waste and CO_2[1].

2. BBI activities will contribute to a 10 % increase in biomass supply in Europe by 2020 (rising to 20 % by 2030). They will do this by increasing productivity and mobilisation in a sustainable manner, while making best use of innovations in agriculture and forestry practices.

- EU biomass utilisation in 2011 was estimated at around 2 billion tonnes, of which 21 % was used for food, 44 % for feed, 19 % for processing (sugar, starch, vegetable oils and other foods) and for materials, and 12 % for energy production[2].

Grant-funded projects in the 2014 and 2015 BBI calls targeting this objective are EFFORTE (a research and innovation action (RIA) to boost the development of forest-based value chains by adopting novel technologies and procedures in the forestry sector) and TECH4EFFECT (an RIA to improve silvicultural operations and forest management). It is too early to state their impact on, and contribution to, this objective.

3. BBI activities will boost the mobilisation and utilisation of 15 % of currently unused sources per year by 2020 (25 % per annum by 2030)[3]. See also point 9.

- In 2014, unused by-products and waste from various bio-based sources[4] in the EU amounted to 2.8 billion tonnes[5].

Grant-funded projects in the 2014 and 2015 BBI calls targeting this objective are PROMINENT (an RIA to obtain proteins for food from side streams of the wheat and rice processing industry), NEWFERT (an RIA to recover nutrients from bio-waste for fertiliser production) and PULP2VALUE (an innovation action (IA) demonstration project to valorise underutilised, low-value sugar beet pulp). It is too early to state their impact on, and contribution to, this objective.

4. BBI results will help maintain and further develop a competitive and knowledge-intensive rural economy in Europe, based on biorefineries. These will result in new, higher and more diversified revenues for farmers and cooperatives and create up to 400 000 new highly skilled jobs by 2020. By 2030 the figure will be 700 000. At least four in five of these jobs will be in rural and currently underdeveloped areas.

Grant-funded projects in the 2014 and 2015 BBI calls targeting this objective are FIRST2RUN (an IA flagship project to establish a first-of-its-kind value chain based on the large-scale cultivation of dry crops on marginal land[6], with local farmers as key players in the value chain), LIBBIO (an RIA to maximise the yield and value, for farmers and biorefineries alike, of the cultivation of the lupinus mutabilis species of lupin grown on marginal land) and BIOSKOH (an IA flagship project to develop 'a novel European second-generation bioeconomy' by exploiting large amounts of currently unused crop residues or by growing dedicated crops on marginal land as a means of revitalising the local and regional economy). It is too early to state their impact on, and contribution to, this objective.

5. BBI activities will aim to utilise and valorise as much available biomass as possible, pursuing solutions towards 'zero-waste' bio-based operations with subsequent closure of the cycles. Integrated biorefineries will apply the cascading principle where feasible to maximise conversion of the biomass feedstock and its by-products, side streams and residual streams into higher added-value products[7].

> *Grant-funded projects in the 2014 and 2015 BBI calls targeting this objective are Zelcor (an RIA to preliminarily assess the feasibility and sustainability of an integrated biorefinery approach aiming to reduce or even avoid waste production), MACRO CASCADE (an RIA to pilot a marine macroalgal biorefinery by applying a cascading approach in which process residuals are used for fertilisers and bioenergy) and BIOFOREVER (an IA demonstration project focusing on up to four different cascading biorefinery approaches to valorise several lignocellulosic feedstocks into marketable products). It is too early to state their impact on, and contribution to, this objective.*

6. BBI activities will contribute to isolating and valorising protein through additional biomass processing, bringing down imports of protein (e.g. soy) for feed in Europe by 15 % by 2020 (and halving imports by 2030).

> *Grant-funded projects in the 2014 and 2015 BBI calls targeting this objective are PROMINENT (an RIA to obtain new plant-based protein ingredients from cereal processing side streams for use in a range of food products) and GreenProtein (an IA demonstration project to tackle issues related to protein requirements and food waste production by obtaining food-grade functional proteins and other ingredients from vegetable residues from salad processing). It is too early to state their impact on, and contribution to, this objective.*

7. BBI activities will trigger programmes to recover and reuse phosphate and potash that will lead to a 10 % reduction in imports of those components for fertilisers applied to feedstock production (with imports cut by a quarter by 2030).

- In 2013, fertiliser consumption in the EU amounted to around 2.4 billion tonnes of phosphate and 2.7 billion tonnes of potash[8]. An estimated 90 % of this was imported in the form of rock materials or processed rock (non-renewable resources)[9].

> *Grant-funded projects in the 2014 and 2015 BBI calls targeting this objective are NEWFERT (an RIA to recover NPK nutrients for fertiliser production from bio-based solid and liquid residues), MACRO CASCADE (an RIA) and LIGNOFLAG (an IA flagship project where some residual and side streams from the processing steps are further valorised to produce fertilisers).*

8. The BBI Initiative will contribute to and trigger industrial deployment of bio-based chemicals, biomaterials and advanced biofuels[10], so that:

- 20 % of the chemicals and materials produced in Europe will be bio-based by 2020 (rising to a quarter in 2030), compared to 10 % in 2010;
- by 2020 at least 2 %[11] of Europe's transport energy demand will be met by sustainable advanced biofuels (reaching 6 % in 2030, together with a 50 % overall improvement in road transport system efficiency[12]). This compares to zero advanced biofuels in the European fuel mix in 2010; and
- also by 2020 at least five first-of-their-kind flagship plants are up and running, demonstrating optimised technologies for biomass conversion into competitive added-value products. These will pave the way for a new wave of commercial production of bio-based products for various applications.

> *Most of the grant-funded BBI projects so far (2014 and 2015 calls) are developing a wide range of marketable products and materials for several sectors, including construction, transportation, packaging, textile, food and feed, nutraceutics, cosmetics, pharmaceuticals, the medical sector and energy. It is too early to state their impact on, and contribution to, this objective*
>
> *Among the grant-funded projects in the 2014 and 2015 BBI calls are four flagship projects: FIRST2RUN (designed to produce several bio-based products and materials from underutilised oil crops cultivated on marginal land), BIOSKOH (to obtain ethanol from agricultural residues in combination with dedicated energy crops to be grown on marginal land), LIGNOFLAG (to establish a large-scale bioethanol production route from lignocellulosic feedstock) and EXILVA (to produce microfibrillated cellulose (MFC) from forest-based raw materials).*
>
> *Flagship projects run for four years and so it is too early to state their impact on, and contribution to, this objective. Expectations are that five flagship plants will be up and running by 2020, while the number of grant-funded flagship proposals will approach 10.*

9. BBI activities will help create a new generation of bio-based materials and composites so that higher-performance components can be produced and used in several industries. In this way, the BBI Initiative will contribute to the desired increase in the market application of these materials by a factor of 5 by 2020, compared to 2010 (and by a factor of 10 by 2030).

- Increased consumer acceptance, concerted policy-making and labelling, awareness of bio-based products, recycling and reuse will do much to improve market penetration.

Many of the grant-funded projects from the 2014 and 2015 calls, especially the 11 demonstration projects and the four flagship projects, will deliver new bio-based products.

Coordination and support actions (CSAs) targeting this objective are: BIOCOM (aiming to increase awareness of bio-based products and their related applications and potential among different stakeholders, including the general public – and more especially students, scientists, the media and policy-makers) and BIOCANNDO (focusing on improving awareness and acceptance of bio-based products and bio-based value chains among end-users, other potential stakeholders and the public as a whole).

10. BBI activities will include valorising high added-value products from un- or underexploited sources of sustainable biomass, such as bio-waste and marine biomass.

- Bio-waste such as the organic fraction of municipal solid waste (OFMSW) or sludge from wastewater treatment is currently un- or underexploited for bio-based operations. BBI activities will assist in developing and deploying innovative technological and logistic solutions to efficiently set up new value chains based on bio-waste by making the best possible use of cascading and circular approaches.
- Marine living resources – such as seaweeds, microalgae, shellfish, molluscs, finfish and aquaculture residues and waste – represent a huge and almost untapped reservoir of new bio-based products. BBI activities will support R&I advancements and their upscaling into market-ready materials and products[13].

Grant-funded projects in the 2014 and 2015 BBI calls targeting this objective are MACRO CASCADE (an RIA to obtain nutraceutical and pharmaceutical ingredients as the main products from seaweeds), and projects involving the production of fertilisers and biofuels from the valorisation of waste streams.

11. BBI activities will support the better legislation and standardisation efforts needed for an effective, functioning bioeconomy in Europe. They will provide factual, state-of-the-art data, highlighting current hurdles and suggesting how the relevant authorities might remove them[14].

Most, if not all, of the grant-funded BBI projects so far address regulation and standardisation that may have an impact on their success. One grant-funded CSA specifically addresses these topics: STAR4BBI (2015 BBI call) seeks to establish an effective regulatory framework and adapt the relevant standards that will support and encourage full development of a bio-based economy and related value chains in Europe.

12. Efforts under the BBI Initiative will contribute to the European target of a 20 % reduction in GHG emissions by 2020 (compared to 1990 levels).

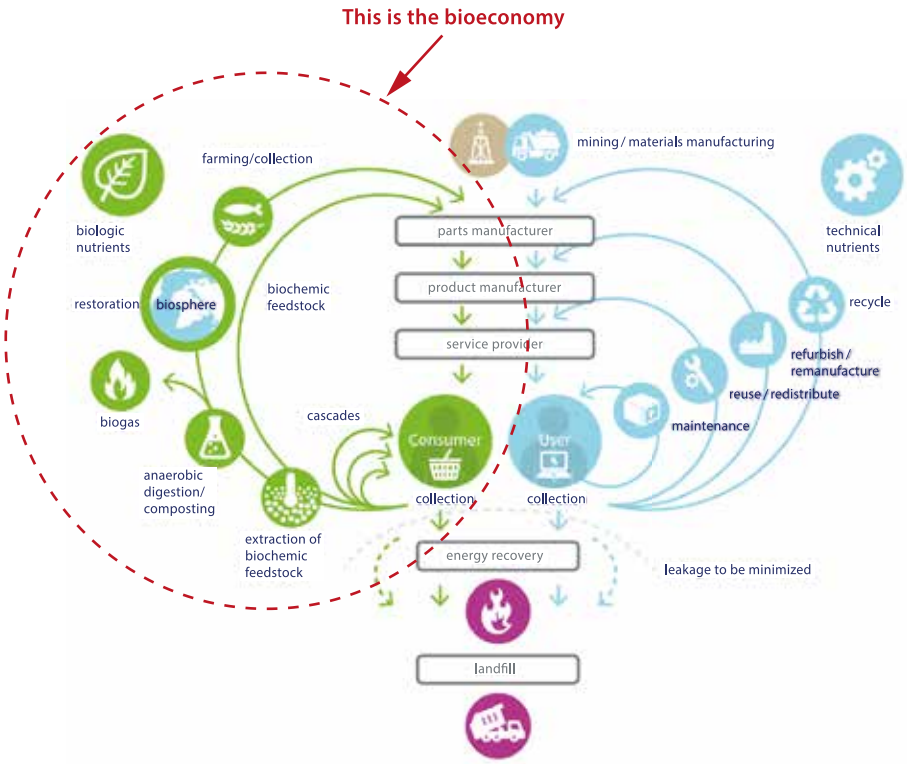
13. The BBI Initiative seeks to actively involve academia, research and technology organisations (RTOs) and SMEs in its work, applying the openness and excellence principles, so that the latter (i.e. SMEs) receive at least 20 % of Horizon 2020 funds allocated through the BBI joint undertaking.

- Significant additional industry funding will go to academia, RTOs and SMEs taking part in industry-driven demonstration and flagship projects.

> *The public funds allocated to SMEs in the grant-funded projects in the 2014 and 2015 BBI calls amount to 24 % of the total*[15].

2.2 Contribution to a sustainable and inclusive growth for Europe

As we pursue the overall strategic objectives for 2020 and 2030, the BBI Initiative actions and projects will help build a European circular economy and make its industrial sectors more competitive. In general terms, promoting the cascading use of biomass in integrated biorefineries and the innovative use of side and residual streams and bio-waste, the Initiative will support the measures outlined in the Circular Economy Package[16]. More specifically, it will contribute to the three pillars of the 2012 European Bioeconomy Strategy. The bioeconomy is integral to the circular economy, with resource efficiency and sustainability as core principles. It is circular by nature and can therefore help deliver a *renewable* circular economy[17]:



Source: Ellen MacArthur Foundation

The Circular Economy Package also covers topics related to the Waste Framework Directive, green public procurement, biomass guidance sustainability criteria, eco-design and food waste, all of which are pertinent to the BBI Initiative. This Agenda refers to these regulations where appropriate.

What is more, the BBI Initiative is helping address global challenges related to climate (COP21), food security (EU Food 2030) and agricultural and forest policies (the EU's common agricultural policy, or CAP, and its Forest Strategy).

Bio-based industries have the potential to decarbonise major industrial sectors such as chemicals and plastics by replacing fossil-based carbon with renewable carbon as raw materials. They could further reduce CO_2 emissions through carbon capture and use in bio-based operations. Bio-based plastics can save 26 kg of CO_2 equivalent per kilogram of plastic compared with petrochemical-based plastics[18].

Bio-based industries can provide the food industry with resource efficiency and food waste solutions that embrace circular economy principles. The biodegradable fraction of municipal solid waste, mainly consisting of food residues from households, caterers or large food retailers, could provide economical and sustainable feedstock for biorefining purposes[19].

The 2014 policy document *For a European Industrial Renaissance* states that 'granting access to sustainable raw materials at world market prices to production of bio-based products […] will require the application of the cascade principle in the use of biomass and eliminating any possible distortions in the allocation of biomass for alternative uses that might result from aid and other mechanisms that favour the use of biomass for other purposes (e.g. energy)'[20].

The current trend of automation and data exchange in manufacturing technologies (Industry 4.0) could significantly benefit the bio-based sector. ICT and related technologies (such as photonics and robotics) can make producing and managing bio-resources more efficient. For example, integrated systems for precision forestry and agriculture can decrease the use of fertilisers and pesticides and improve operations. ICT technologies will also improve information exchange along the value chain, leading to more efficient logistics and, possibly, higher biomass mobilisation. And using advanced sensors, monitoring and control paradigms at plant level will increase productivity and resource and energy efficiency.

Bio-based industries will work closely with regional platforms and networks when developing biorefineries that use local resources and can contribute to regional smart specialisation strategies. The European Commission provides various platforms to help regions formulate more joined-up bioeconomy, RTD and cohesion policies. These include the SP3 Agri-Food smart-specialisation platform, the RIS3 platform and the Knowledge Exchange Platform (KEP). In 2016, the selected KEP priority was the bioeconomy.

The BIC has issued guiding principles for *Combining BBI (H2020) funds and European Structural and Investment Funds (ESIF)* to deploy the European bioeconomy (2014). BBI- and ESIF-funded projects can feed into each other.

The BIC has signed memoranda of understanding with the European Regions Research and Innovation Network (ERRIN) and with the Vanguard Initiative (for new growth through smart specialisation). It is also involved in service provision to the six model demonstrator regions for sustainable chemicals (selected in January 2016).

The BBI Initiative embraces the 'three Os': open innovation, open science and open to the world[21].

It is committed to innovation and open to any legal entity that directly or indirectly supports R&I in an EU Member State or associated country[22]. This is in keeping with the open innovation focus that is so central to participation in Horizon 2020. This focus will lead, inter alia, to innovative bio-based products with novel functionalities. Being an industry-led initiative, the BBI programme is results- and competitiveness-driven; industry also steers work on the annual work plans.

The grant agreements for projects funded under the BBI programme are fully in line with the H2020 multi-beneficiary general model grant agreement. This means that the general H2020 legal and contractual provisions apply to the results (including Intellectual Property Rights). The BBI joint undertaking disseminates the results as broadly as possible, using press releases, presentations, social media and its website. In addition, it promotes open access to data sets and publications during its annual Info Days.

Even though the BBI Initiative focuses on European industrial competitiveness, the rules governing H2020 participation mean that its actions are open to all countries in the world. Indeed, more legal entities from countries other than the EU Member States and associated countries have been responding to BBI calls for proposals of late. This is probably because the BBI Initiative is becoming better known worldwide, and this is set to continue boosted by the International Bioeconomy Forum launched by the European Commission (in October 2016).

Endnotes chapter 2

1 This objective has been expanded as compared with the 2014 version to include aquatic feedstock, bio-waste and CO_2.

2 Nicolae Scarlat, Jean-François Dallemand, Fabio Monforti-Ferrario, Viorel Nita, ***The role of biomass and bioenergy in a future bioeconomy: policies and facts*** (2015). Data extracted from Eurostat, 2014.

3 The original objective (2013) aimed only at sources traditionally referred to as 'waste' and unused as feedstock for bio-based industries for valorisation into chemicals and materials.

4 Including by-products and waste from agriculture, forestry, aquaculture, wastewater treatment, sludge (such as semi-solid slurry from water treatment plants, or suspension from drinking water treatment processes), organic household waste, yard waste, food processing waste, debarking waste.

5 IEA Bioenergy Task 37. See also: http://www.iea-biogas.net/technical-brochures.html

6 'Marginal land' includes all land that is less favoured for various reasons, such as reduced fertility, limited access to infrastructure or adverse climate conditions. See for example: O.K. Shortall, ***'Marginal land' for energy crops: exploring definitions and embedded assumptions***, 2013.

7 This is a newly added objective to focus BBI activities as part of a renewable circular economy.

8 http://www.fertilizerseurope.com/fileadmin/user_upload/publications/statistics_publications/Stat_website.pdf (data from Fertilisers Europe)

9 This objective will receive additional impetus from the proposed new EU regulation on fertilising products. See: https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/1-2016-157-EN-F1-1.PDF

10 Advanced biofuels are defined by the European Industrial Bioenergy Initiative as those (1) produced from lignocellulosic feedstocks (i.e. agricultural and forestry residues, such as wheat straw, corn stover, bagasse or wood based biomass), non-food crops (i.e. grasses, miscanthus or algae), or industrial waste and residue streams, (2) having low CO_2 emission or high GHG emission reduction, and (3) reaching zero or low ILUC impact (reference: http://www.biofuelstp.eu/advancedbiofuels.htm).

11 A 2 % substitution of transport fuels in 2020 with advanced ethanol would require 45 million tonnes of biomass. See also: https://setis.ec.europa.eu/system/files/Bioenergy%20EII%202013-2017%20IP.pdf

12 ERTRAC SRA 2010

13 This is a newly added objective to include bio-waste and marine/aquatic sources into BBI activities.

14 This is a newly added objective to include the BBI contribution to legislation and standardisation.

15 Results from the 2014 and 2015 calls, with SME status based on 'self-declarations'.

16 http://ec.europa.eu/environment/circular-economy/index_en.htm

17 See ***Position of the Bio-based Industries Consortium on the European circular economy package***; http://biconsortium.eu/sites/biconsortium.eu/files/documents/Biobased_Industries_position_EU_CircularEconomyPackage_NOV2015.pdf

18 http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/the-new-plastics-economy-rethinking-the-future-of-plastics

19 ***Food wastage footprint***, FAO (2013) http://www.fao.org/docrep/018/i3347e/i3347e.pdf

20 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0014&from=EN, p. 10.

21 https://ec.europa.eu/digital-single-market/en/news/open-innovation-open-science-open-world-vision-europe

22 http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/3cpart/h2020-hi-list-ac_en.pdf

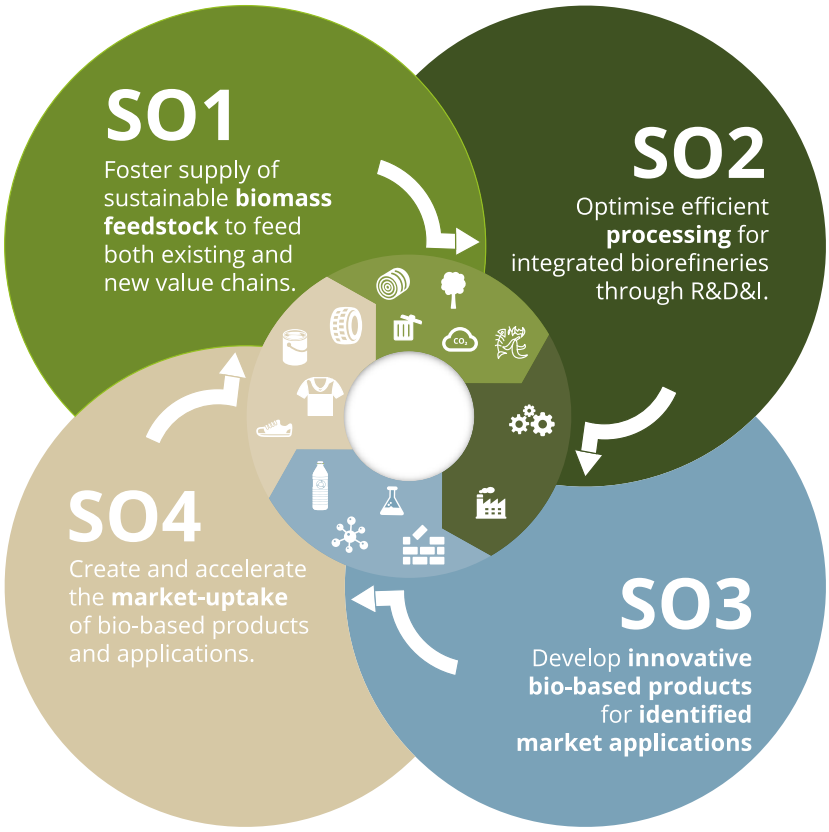
3

THE STRATEGIC ORIENTATIONS OF THE BIO-BASED INDUSTRIES

The strategic orientations of the bio-based industry focus on the steps of a value chain:

1. Foster supply of sustainable **biomass feedstock** to feed both existing and new value chains.
2. Optimise efficient **processing** for integrated biorefineries through R&D&I.
3. Develop **innovative bio-based products for identified market applications.**
4. Create and accelerate the **market-uptake** of bio-based products and applications.

The industries and their partners apply an open, 'multi-value-chain' approach. Rather than specifying a limited number of specific (feedstock-based) value chains, this approach enables the value chains to keep evolving, so that all possible biomass feedstock sources are included, there is crossover between existing value chains and new chains can emerge. It also encourages the use of all relevant technologies in producing, preparing and processing the biomass feedstock into added-value bio-based chemicals and materials for a specific market demand.



3.1 Supply of sustainable biomass feedstock

The bio-based industries in Europe are committed to a supply of feedstock that comes primarily from European sources and is produced and delivered sustainably. They will pursue the combined use of different feedstocks – for example, using marine-, agriculture- and forestry-based feedstock to make added-value products and possibly enabling year-round biorefinery operation.

The industries will also look at how best to manage core aspects such as logistics for biomass collection, storage and supply to the main processing sites. This will make for efficient and sustainable value chains on a large scale and will cut upstream biomass losses, costs and environmental impacts.

The following subsections describe the four main sources of biomass feedstock for bio-based industries in Europe. The industries and others in the sectors concerned will work closely together to make existing value chains more cost-competitive and create new, resource- and energy-efficient value chains. To pursue these aims they will together optimise cultivation and supply logistics, develop new processing steps, valorise residual and side streams, and make new products.

3.1.1 Agri-based feedstock: agriculture, agro-food sector and their residuals and side streams

The bio-based industry projects that use feedstock from agricultural activities for food, feed and other industrial production and from horticulture build on current sustainable practices in these sectors and their processing value chains. The ambition of the agriculture, horticulture and food processing industries is to broaden the product portfolio and create new bio-based markets. The bio-based industries will work with these sectors on the appropriate technologies and applications to make more use of residual and side streams from current and new raw materials. These partnerships will make existing agriculture, horticulture and food processing value chains more competitive, thereby securing the production of their primary products, adding value all along the chains and developing rural areas.

The bio-based industries therefore set out to add value to the current feedstock base by increasing feedstock production and flexibility and making better use of side streams and residues[1] for new innovative products. In addition, new and improved profitable crops, produced with higher efficiency (in terms of fertiliser and water use and logistics) will reduce industrial waste streams and lower the environmental impact. New and innovative plant protection products (such as biocides and biocontrol) and plant nutrition products (such as biostimulants and high-efficiency fertilisers) will become available to help increase

productivity while protecting the environment. The bio-based industries can help develop advanced bio-based fertilising products that comply with the EU regulatory framework currently under revision and could increase the sustainability of fertilising practices and the productivity of agriculture in Europe.

The industries will also pursue the application of multi-crop agronomic systems (such as agro-forestry, rotation, intercropping, etc.) to increase the supply of biomass feedstock. These could be fertilisers from low-value bio-based streams, fully biodegradable coatings for agricultural plastic mulches, controlled release fertilisers or the smart use of plant bio-stimulants, including microorganisms.

The bio-based industries are working on utilising more lignocellulosic biomass as feedstock. One of the planet's most abundant fixed renewable carbon resources, it is present in resources such as woody crops, agricultural residues, residues from agro-industrial processing and even residues from conventional biomass conversion plants.

The food supply chain provides a very wide variety of residues that can be valorised to make bio-based products. Agri-based residues include fruits and vegetables, eggshells, cereal bran, olive mill wastewater, red and white grape pomace, milk and dairy, protein by-products, wheat bran, agro-residues, and wastewater from agro-food production processes and food operations. A recent survey of stakeholders (on 'food supply chain to bio-based products') identified technologies available at the various technology readiness levels to convert these residues into innovative products. The BBI Initiative can incorporate excellent project proposals to improve, upscale and expand these value chains.

The bio-based industries will promote co-production of food and industry products through the sustainable intensification of land use. Efforts here include (re)activating unused, abandoned[2], underutilised and marginal land, applying sustainability principles in line with the CAP and biodiversity strategies. Activating these areas[3] could contribute to socio-economic

key performance indicators (KPIs), such as maintaining and creating jobs, furthering rural development and increasing primary producers' income, to landscape conservation and so on.

While using land to co-produce crops for the bio-based industries, the BBI Initiative will respect environmental biodiversity in line with the CAP and international agreements, and will maintain the social and recreational value of the land for the community. The same will apply when (partially) changing the intended use of an existing resource, for example using a traditionally non-food biomass such as lignocellulose as a source for new food products.

The main R&D&I challenges in expanding the utilisation of agri-based feedstock to chemicals and materials for added-value applications concern (numbers refer to table in Appendix 9.1):

1. fostering a sustainable biomass supply to feed existing and new value chains – see topics 1.1.1; 1.1.4; 1.2.2 and 1.2.7;
2. optimising efficient processing through R&D and pilot biorefineries – see topics 2.1.1; 2.1.2; 2.1.4; 2.1.5; 2.2.1; 2.2.2; 2.2.4 and 2.2.5; and
3. developing innovative products and speeding up the market uptake of bio-based products – see topics 3.1.2; 3.1.3; 3.1.4; 3.1.5; 3.1.8; 3.1.10; 3.1.12; 3.2.1; 3.3.1; 3.3.2; 3.3.3; 3.3.4 and 3.3.5.

3.1.2 Forest-based feedstock: forestry, forest-based sector and their residuals and side streams

The bio-based industry projects that use feedstock from forestry and forest-based industries[4] build on current sustainable practices in forestry and its processing value chain (for example the pulp and paper industry). These sectors would like to increase their product portfolio and create new markets. The bio-based industries will work with them on the appropriate technologies and applications to make more use of residual and side streams from current and new raw materials. These partnerships will make European forest-based value chains more competitive, securing the manufacturing of their primary products, adding value all along the chains and boosting rural livelihoods.

The bio-based industries will therefore engage in creating more added-value products from the current feedstock base. Further, they will make the biomass supply more cost-efficient through more feedstock mobilisation (forest residues), more innovation in wood harvesting

and logging, and better utilisation of side streams and residues. To this end, the industries will implement innovative and efficient technologies to develop new innovative products along with more productive, greener processes.

Cellulose is a well-known and widely exploited material. Besides its traditional uses, recent technological developments have opened up new applications with more added value. This not only boosts the competitiveness of the industrial sectors concerned, but also significantly improves their environmental performance.

Along with cellulose conversion, valorising lignin into commercial products and materials is increasingly seen as a viable solution for using lignocellulosic biomass more efficiently and making the related processes more sustainable.

Moreover, polymers contained in hemicellulose, such as xylans, and other fractions of woody biomass such as terpenes, can be put to a wide range of uses, both before and after depolymerisation.

The main R&D&I challenges in expanding the utilisation of forest-based feedstock to chemicals and materials for added-value applications concern (numbers refer to table in Appendix 9.1):

1. fostering a sustainable biomass supply to feed existing and new value chains – see topics 1.1.1; 1.1.4; 1.2.2 and 1.2.7;

2. optimising efficient processing through R&D and pilot biorefineries – see topics 2.1.1; 2.1.2; 2.1.4; 2.1.5; 2.2.1; 2.2.2; 2.2.4 and 2.2.5; and

3. developing innovative products and speeding up market uptake of bio-based products – see topics 3.1.2; 3.1.3; 3.1.4; 3.1.5; 3.1.8; 3.1.10; 3.1.12; 3.2.1; 3.3.1; 3.3.2; 3.3.3; 3.3.4 and 3.3.5.

3.1.3 Aquatic feedstock: aquatic organisms, fisheries and aquaculture sectors and their residues

The bio-based industry projects that use feedstock from marine and freshwater environments (marine and freshwater aquaculture, the fish/aquatic processing industry and marine biotechnology biorefineries) set out to draw on the enormous potential of the aquatic ecosystems and organisms for the bio-based industries. Aquatic living resources represent a huge and largely untapped reservoir of genes, microorganisms and new bio-based products with the potential to offer unique solutions for industrial and biotechnological applications in the bio-based industry. This will mean creating suitable incentives for new discoveries and the development of innovative processes and technologies to convert co-products, side streams and residues[5] into bio-based products.

The bio-based industries will work with these sectors on the appropriate technologies and applications to make more use of residual and side streams from new and existing raw materials. These partnerships will make the existing fishing, aquaculture and aquatic processing value chains more competitive, thereby securing the production of their primary products, adding value all along the chains and developing coastal and rural areas.

Cultivated micro- and macroalgae (seaweeds) are a great potential source of aquatic biomass with various applications, while at the same time requiring little or no land on which to grow. With global demand for resources and competition for land use both on the increase, harnessing the potential of seas and oceans sustainably is critical for Europe.

Micro- and macroalgae hold enormous potential for extracting high added-value natural biomolecules (such as pigments, lipids and fatty acids, proteins, polysaccharides, phenolics and phytosterols) for use in industries such as cosmetics, pharmaceuticals, polymers, food and feed ingredients and energy[6].

Shellfish (crustaceans, molluscs and echinoderms) are sources of calcium carbonate, chitin, chitosan and protein-derived peptides with multiple properties that can be used in various bio-based industries, mostly in the pharmaceutical and cosmeceutical industries. Finfish are a source of minerals, lipids and fatty acids, carbohydrates and protein. Sponges, skeletons of calcareous algae, shellfish or collagen from finfish can be used for bone or tissue repair.

The main R&D&I challenges in expanding the utilisation of aquatic feedstock to chemicals and materials for added-value applications concern (numbers refer to table in Appendix 9.1):

1. fostering a sustainable biomass supply to feed existing and new value chains – see topics 1.1.1; 1.1.4; 1.2.2 and 1.2.7;
2. optimising efficient processing through R&D and pilot biorefineries – see topics 2.1.1; 2.1.2; 2.1.4; 2.1.5; 2.2.1; 2.2.2; 2.2.4 and 2.2.5; and
3. developing innovative products and speeding up market uptake of bio-based products – see topics 3.1.2; 3.1.3; 3.1.4; 3.1.5; 3.1.8; 3.1.10; 3.1.12; 3.2.1; 3.3.1; 3.3.2; 3.3.3; 3.3.4 and 3.3.5.

3.1.4 Bio-waste and CO_2

The bio-based industry projects that use bio-waste and CO_2 build on the drive in industry and society at large towards a renewable circular economy. The aim is to move away from linear economic models and, by optimally utilising 'waste' as feedstock, contribute to resource and energy efficiency while lowering environmental impacts.

The bio-based industries will work with cities, municipalities and other relevant parties on the appropriate technologies and applications to valorise household and other urban bio-waste, sludge from wastewater treatment plants and discarded bio-based plastics and products (including post-consumer wood-based bio-waste)[7].

Significant fractions of urban bio-waste are composed of OFMSW and the sewage sludge from urban wastewater treatment plants. Converting these fractions into bio-based products can provide environmental, economic and social benefits. These include reduced GHG emissions from landfills, a boost for local economies and a lower waste management burden in urban areas. Composting and anaerobic digestion are mature technologies; on the other hand, processes to derive higher value products from urban bio-waste streams are still in the developmental stages. There is a need for a broad policy effort to overcome technical obstacles, market weaknesses, regulatory hurdles and cultural barriers.

Urban bio-waste is available throughout the year as a feedstock for bio-based industries, and does not interfere with food production and land use. Working together in this way will add value to waste from households and urban activities supporting social and economic development in urban areas, and will facilitate the industrial symbiosis contributing to a circular economy.

CO_2 is a very promising feedstock. The bio-based industries set out to capture and use CO_2 for agriculture applications or conversion into added-value products. Exhaust gases (containing mainly CO_2) can serve as feedstock for different types of processing into commercially viable products. Capturing and utilising CO_2 in bio-based processes will reduce process efficiency losses and convert this GHG into chemical building blocks for added-value products while improving process economics. The bio-based industries will work closely with the SPIRE public-private partnership[8], which deals with CO_2 from all kinds of sources, to draw and build on each other's strengths. While SPIRE will focus on various chemical and other conversion technologies to valorise CO_2, the bio-based industries will use biotechnological conversion.

The main R&D&I challenges in expanding the utilisation of bio-waste and CO_2 from bio-based operations to chemicals and materials for added-value applications concern (numbers refer to table in Appendix 9.1):

1. fostering a sustainable biomass supply to feed existing and new value chains – see topics 1.1.1; 1.1.4; 1.2.2 and 1.2.7;
2. optimising efficient processing through R&D and pilot biorefineries – see topics 2.1.1; 2.1.2; 2.1.4; 2.1.5; 2.2.1; 2.2.2; 2.2.4 and 2.2.5; and
3. developing innovative products and speeding up market uptake of bio-based products – see topics 3.1.2; 3.1.3; 3.1.4; 3.1.5; 3.1.8; 3.1.10; 3.1.12; 3.2.1; 3.3.1; 3.3.2; 3.3.3; 3.3.4 and 3.3.5

3.2 Innovative processing

The bio-based industries' strategy for processing is to expand and improve pre-treatment, conversion and downstream processing steps to valorise a broad range of biomass feedstock into an array of added-value products. The key aim here is the innovative processing of biomass, making the best possible use of feedstock and energy resources, while linking all processing steps into an integrated biorefinery setting. The BBI Initiative will be based on the results of the BIO-TIC[9] and Star-Colibri[10] roadmaps. The bio-based industries will also pursue added value by combining central and decentralised operations, including on-site and stand-alone biorefining operations.

3.2.1 Pre-treatment

The bio-based industries are looking for pre-treatment steps – the processing steps after biomass harvesting – that efficiently prepare the biomass feedstock for the conversion process without significantly sacrificing its characteristics. To achieve this, BBI projects will build on the Star-Colibri roadmap and recommendations. The roadmap presents two major strategic recommendations for 2020 regarding biomass pre-treatment:

1. to develop and tailor new, flexible biomass pre-treatment processes to suit sustainably produced biomass feedstocks, to obtain fully functional fractions (such as lignin and carbohydrates from lignocellulose); and

2. to speed up research on lignocellulose breakdown through better technologies to develop efficient and cost-effective enzyme cocktails.

The bio-based industries have been addressing some of the main challenges to making these recommendations a reality. Sections 2.1 (primary conversion processes) and 2.2 (secondary conversion processes) of Appendix 9.1 contain some of the specific challenges that BBI projects are addressing. The main challenges are as follows:

- developing processes (chemical and mechanical) to cope with variable feedstock quality;
- developing technologies to separate the components without reducing the value of any as a raw material;
- developing chemical or biological technologies to process individual components of the biomass without degrading other components;

- developing mechanical processing methods that require less energy;
- developing processing technologies that require significantly less water;
- improving the extraction of materials to simplify their conversion to high added-value products;
- integrating process intensification into these challenges to improve efficiency and allow for the deployment of smaller-scale processing technologies that can be distributed more easily;
- defining added-value uses for the inorganic components of biomass that can be readily isolated; and
- developing/using computational approaches for better prediction of upscaling.

The bio-based industries will continue to address these challenges up to 2020. In so doing, they will consider several routes for pre-treating the biomass feedstock.

3.2.2 Conversion of pre-treated feedstocks to bio-based chemicals and materials

The bio-based industries want to surpass the leading existing conversion processes for biomass, take innovative and promising technologies to industrial levels and incorporate them into new and existing production systems.

The strategy path will differ from one applicable technology to another[11]:

- for (thermo)chemical processes, research and demonstration activities should focus on upscaling and integration;
- for chemical catalysis, research should focus on developing new catalysts, tailor-made for specific components in the biomass feedstock, which can function in various media and conditions; and
- for industrial biotechnology, research should focus on new and improved bio-catalysts that can perform at industrial levels.

The bio-based industries will also work towards integrating key conversion processes and avoid their development in isolation. This should lead to an operational cascading process whereby biorefineries can convert not only the main input of biomass feedstock, but also the primary and subsequent side streams. Understanding how best to integrate

various processing technologies will also help with industrial symbiosis, in terms of linking operational sites and different industrial sectors.

The bio-based industries have been addressing some of the main challenges for (thermo-) chemical processes, chemical catalysis and industrial biotechnology. Sections 2.1 (primary conversion processing) and 2.2 (secondary conversion processing) of Appendix 9.1 contain some of the specific challenges that BBI projects are addressing.

The main challenges for (thermo-) chemical processes are:

- upscaling;
- better, stable product quality;
- higher energy and carbon efficiency for more cost-effective and resource-efficient processes; and
- integrating concepts and processes into existing and new facilities.

The main challenges for chemical catalysis processes are:

- retrofitting existing chemical technologies to deal with oxygen-rich (highly functionalised) biomass: from a 'hydrocarbon-based petrochemical approach' to an 'oxygen-rich, biomass-derived feedstock approach';
- designing robust catalysts to deal with reactive biomass-derived molecules and function effectively in aqueous environments, while remaining highly selective;
- dealing with impurities and variety in biomass feedstock; and
- developing new reactor technologies based on thorough knowledge of the kinetics of biomass-based reactions and catalyst deactivation.

The main challenges for industrial biotechnology processes are:

- developing biochemical processes for high concentrations of raw material and products;
- increasing the yield and productivity of biochemical processes; limiting material losses to increase sustainability and economic viability;
- developing enzyme cocktails that can efficiently breakdown lignocellulosic raw material into fermentable sugars and oligosaccharides;
- dealing with the sensitivity of biochemical reactions to impurities;
- developing microorganisms to effectively metabolise pentose (C5) sugars;
- developing new and innovative enzyme activities to convert lignocellulosic biomass;
- drawing on developments in microbiology and metagenomics, systems biology and

synthetic biology to benefit biomass conversion. These developments include new microorganisms such as extremophiles and biocatalysts such as extremozymes;

- developing new bioreactors; and
- developing new water management systems for biocatalytic processes.

3.2.3 Downstream processing

The bio-based industries will focus on developing recovery, separation and purification steps beyond the state of the art to benefit from developments in pre-treatment and conversion processes for biomass feedstock (see 3.2.1 and 3.2.2). To achieve these goals BBI projects will build on the Star-Colibri roadmap and recommendations.

The large amounts of water being used in the biomass pre-treatment and conversion processes are a hurdle. Work is needed to improve product recovery from the aqueous reaction medium to make it more economical. Contaminants in the water present an additional challenge since they prevent the water from being reused in the process. Hence the need to develop generic and specific separation technologies to help overcome the product recovery, contaminant removal and water reuse hurdles. Alternatively, processes and organisms requiring minimal or even no water should be developed.

Selective purification techniques for high-value products or in-situ product recovery are possible alternatives to separate the product from the bioconversion aqueous medium efficiently.

The bio-based industries have been addressing some of the main challenges for downstream processing in bio-based value chains. Sections 2.1 (primary conversion processing) and 2.2 (secondary conversion processing) of Appendix 9.1 contain some of the specific challenges that BBI projects are addressing.

The main challenges for downstream processing are:

- separation of the products from the medium of the reaction (e.g. aqueous solution);
- purification of the target products by separating them from undesired by- and co-products or other impurities and contaminants resulting from the process;
- processing of dilute solutions – large volumes;
- filtration methods that may not be robust enough for large volume production (fouling, clogging);
- high energy needs;
- end-product concentration and quality; and
- utilisation and/or treatment of residual streams.

It is crucial to work with technologies that are scalable and consume less energy and water, to make the bio-based business viable. Moreover, it is important that we attract the relevant developers and enablers for these technologies.

A major hurdle to upscaling is that pre-treatment, bioconversion, product recovery and downstream processing are now often developed and optimised independently of each other. This leads to difficulties in integration of these processes during upscaling. Furthermore, these various production steps often take place in batches. Integrating these processes into continuous systems should bring production costs down considerably. This would require the integrated optimisation of process intensification, in-situ product recovery, continuous fermentation, downstream processing systems and use of computational methods for faster, high-precision upscaling. In addition to bringing processes together, new industrial physicochemical processes should be developed and tested in a variety of conditions, for example making use of other solvents and processing conditions[12].

3.2.4 System modelling

The bio-based industries will strive to define the pathways for 'making the best possible use of feedstock and energy resources, while linking all processing steps into an integrated biorefinery setting' (see introduction to section 3.2). This may mean designing tailor-made paths for each specific feedstock – from its intake and preparation, through the processing steps to the end product(s). Modelling the entire system from intake of feedstock and energy to output of products, could assist in designing these pathways, as could incorporating relevant sequential and/or parallel processing steps, and the chemical composition of input and output streams. Such models should also make it possible to assess the potential for the further valorisation of all side and residual streams. The models should be capable of simulating and subsequently assisting in designing pathways that will ensure the best possible utilisation of the various feedstocks, through the required chemical, physical and biotechnological processes to the desired products. As such, they will help the bio-based industries meet the aims outlined in this Agenda more quickly.

The development of the models will make use of numerous sources such as data-mining of literature/patents, additional laboratory benchmarking of processes in terms of material and energy input/output, contaminants in downstream effluents, etc.

The modelling approach must specify the 'optimal use' of a feedstock, in terms of the environmental, economic and social sustainability of the value chain and the effects of its processes and products. For this, adequate metrics will be needed to assess feasible techniques from different perspectives. The definition of 'optimal use' must include the end-of-life optimisation of the products, where innovative bio-based products may be designed for reuse or recycling.

3.3 Innovative bio-based products for specific applications

The bio-based industries seek to generate products for specific, added-value applications. In existing applications, they compete with fossil-based products. The bio-based products may be replicas of their fossil-based counterparts (drop-in products), they may differ from them in terms of formulation, performance and functionality, or they may be new, innovative products based on novel, breakthrough molecules.

3.3.1 Drop-in bio-based products

Currently the main drop-in bio-based products are plastics. Among the major bio-based plastics on the market are bio-based polyethylene (bio-PE) and bio-based polyethylene terephthalate (bio-PET). They are used in large market applications such as packaging, textiles, fibres and composites, where producers can claim a 'green image'.

The bio-based industries will continue to improve the value chains that deliver these bio-based alternatives to meet the main challenge of being cost-competitive with their fossil-based counterparts.

Other developments will seek further market penetration and broader application opportunities for drop-in bio-based products in other sectors where fossil-based products dominate at present. To effectively address this challenge, partnership with brand owners (at project and/or industry level) and an understanding of societal needs and consumer behaviours will be crucial.

3.3.2 Bio-based products that outperform fossil-based counterparts

The bio-based industries are increasingly focusing on low-volume, high-value products for specific application areas. The ongoing prolonged spell of low crude oil prices has served to speed up this process. Bio-based adhesives, bio-based binders, speciality bio-based polymers, bio-based lubricants, and high added-value components for food, feed, cosmetics, nutraceuticals or pharmaceuticals with new functionalities are just some of the products with the potential to deliver high revenues for the bio-based industries, provided they meet all quality and safety requirements.

The main challenges are to develop, test and demonstrate bio-based materials that outperform fossil-based materials in terms of resource efficiency, production cost, environmental impact or social benefits in comparable applications.

New functionalities and better performance are key if bio-based materials are to avoid cost-competition with fossil-based materials. A better performance in terms of sustainability includes better handling opportunities during a product's end-of-life phase. European standards and standardisation documents should be used to demonstrate a higher sustainability score.

Partnership with brand owners (at project and/or industry level) and an understanding of societal needs and consumer behaviour will be crucial to tackling this priority in the most effective way. This will help the bio-based industries set up the appropriate value chain, starting from the biomass feedstock suppliers. Involving all interested parties in identifying the best feedstock and associated processing steps that will ultimately deliver the right product for market needs can help de-risk investments and boost market acceptance of the new products.

3.3.3 'New' breakthrough chemicals as the foundation for tomorrow's markets

The bio-based industries are also prioritising the development of new, high added-value products that have no fossil-based counterpart and no industrial scale production as yet. This will require small-scale testing and evidence-gathering at first, preserving as much as possible the characteristics and functionalities of bio-based materials for exploitation in applications. Biotechnological processes could be effective for this purpose as they are highly selective and work in relatively mild conditions, maintaining complex structures while preserving existing functionalities.

This development process must involve creating completely new value chains – from the starting biomass feedstock, through pre-treatment and conversion processes, including intermediate compounds, to the end products. These value chains may be the result of a new family of chemical compounds and building blocks (a chemical 'tree').

Again, partnership with brand owners (at project and/or industry level) and an understanding of societal needs and consumer behaviour will play a crucial role in paving the way for the future market deployment of such breakthrough bio-based chemicals. This will help the bio-based industries set up the appropriate value chain, starting from the biomass feedstock suppliers.

3.3.4 Proteins and active ingredients for feed/food, pharmaceuticals and cosmetics

The bio-based industries will continue to prioritise work on extracting proteins and other bioactive compounds from underexploited and new sources.

The strategy for tackling the protein gap has two aims: on the one hand, sourcing, extracting and purifying high-grade proteins and developing new protein derivative solutions for food and feed applications; and on the other, unlocking lower-grade protein streams and refining these for industrial and food/feed applications.

Bioactive ingredients, including proteins and protein derivatives, carotenoids, polyphenols and prebiotics, are widely used as additives in the food, feed, flavouring, fragrance, cosmetics, chemicals, textile, nutraceutical and pharmaceutical industries. Global demand for bioactive compounds and proteins in 2030 is expected to outstrip current production capacities[13].

3.4 Market uptake of bio-based products and applications

The bio-based industries seek to convert a broad range of biomass into bio-based chemicals and materials for further processing into high added-value products for specific applications.

Market sectors that are already using high added-value bio-based products include[14]:

- packaging;
- agriculture;
- medical; healthcare; home and personal care;
- pharmaceuticals;
- food and feed additives;
- paper and pulp;
- textiles;
- construction;
- automotive; and
- transportation.

'Drop-in' bio-based products should be price-competitive to allow for market uptake. A life-cycle analysis (LCA) comparison with a fossil-based counterpart would be needed to demonstrate a higher sustainability score – the premise being that the bio-based products are produced from sustainable, renewable sources along a sustainable value chain from feedstock to market.

Bio-based products that outperform their fossil-based counterparts should be able to command a premium reflecting the impact of the higher performance. This will only happen if end-users see a product's value and are willing to pay the premium. Product premiums will offset (expected) higher production costs and unblock investments.

There are potential hurdles involved in deploying different or new products (or new product functionalities). These may stem from policy and regulatory requirements, a lack of consumer awareness and acceptance, low public and private (industrial) demand (in terms of procurement and application), resistance from established industrial sectors or unfavourable public perception of bio-based products and applications.

Policy and regulatory requirements may relate for example to standards, safety aspects, labels and certification and REACH legislation. In addressing these requirements, actors in the value chains and policy-makers need to interact closely to understand and align the options and needs in play. Bio-based products that meet all policy and regulatory requirements will be attractive products for the markets.

Consumer awareness and acceptance of the benefits of bio-based products should be addressed through dialogue and communication with consumer representatives. Understanding and responding to consumers' needs, concerns and perceptions about bio-based products and applications will make for ever better awareness and acceptance campaigns.

Establishing a high level of transparency through, say, databases that record certified (positive) impacts of bio-based products, information on the full value chains from feedstock cultivation to application, and their benefits in terms of sustainability, etc., will help boost consumer confidence in bio-based products.

Innovation actions (demonstration and flagship projects) should include steps to make sure there is market uptake for the targeted products. In addition, coordination and support actions should address strategic aspects (knowledge-gathering, networking, etc.) and non-technological barriers to enable bio-based industries to grow as a sector and to stimulate the market uptake for bio-based products.

Including bio-based products in public, 'green', pre-commercial innovation procurement is key to creating market uptake for bio-based products. The BBI Initiative supports the '15 recommendations for an increased uptake of bio-based products in public procurement', which the Public Procurement Working Group of the European Commission's Expert Group for Bio-based Products issued on 12 April 2016[15].

Industrial procurement of bio-based intermediate products for their subsequent processing into end products can also be a major driver for market uptake. Increasingly, companies and brand owners are responding to consumer and market needs for sustainable products and applications. They are demanding sustainable intermediate products from their suppliers and pursuing high sustainability index scores to maintain or improve their future market position.

Endnotes chapter 3

1 Including manure and other residues from farming and other activities based on land-grown feedstock.

2 The abandonment of forest and rural productive areas is increasing; see Agri-environmental indicator – risk of land abandonment, Institute for European Environmental Policy, 2013.

3 In addressing the marginal land issue the BBI Initiative will avoid duplicating the work done in other parts of Horizon 2020 Societal Challenge 2.

4 These include 'woody and non-woody forest feedstock' such as medicinal plants, resins, tannin, etc.

5 These include innards and bycatch.

6 Report on the experts' workshop on the potential of 'new marine to bio-based products value chains' for the next BBI joint undertaking work programme; European Commission, 20 April 2016; http://ec.europa.eu

7 The Waste Framework Directive (2008/98/EC) defines bio-waste as biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants. This Agenda also includes urban wastewater as bio-waste. It excludes the by-products of food production that never become 'waste'. It covers residual streams from agriculture and forestry, including manure and sewage sludge, together with other side streams from these industrial sectors, in sections 3.1.1 and 3.1.2.

8 Sustainable Process Industry through Resource and Energy Efficiency; http://www.spire2030.eu

9 See BIO-TIC research and development roadmap at http://www.industrialbiotech-europe.eu/

10 European biorefinery joint strategic research roadmap: strategic targets for 2020 – collaboration initiative on biorefineries, 2011; http://www.forestplatform.org/files/Star_COLIBRI/Roadmap_document_-_FINAL.pdf

11 See also the Star-Colibri roadmap and recommendations.

12 See BIO-TIC research and development roadmap at http://www.industrialbiotech-europe.eu/

13 http://www.who.int/nutrition/topics/3_foodconsumption/en/index4.html

14 See also Bioeconomy in everyday life, booklet by BioSTEP; www.bio-step.eu

15 http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8767&lang=en&title=15-recommendations-for-an-increased-uptake-of-bio-based-products-in-public-procurement

4

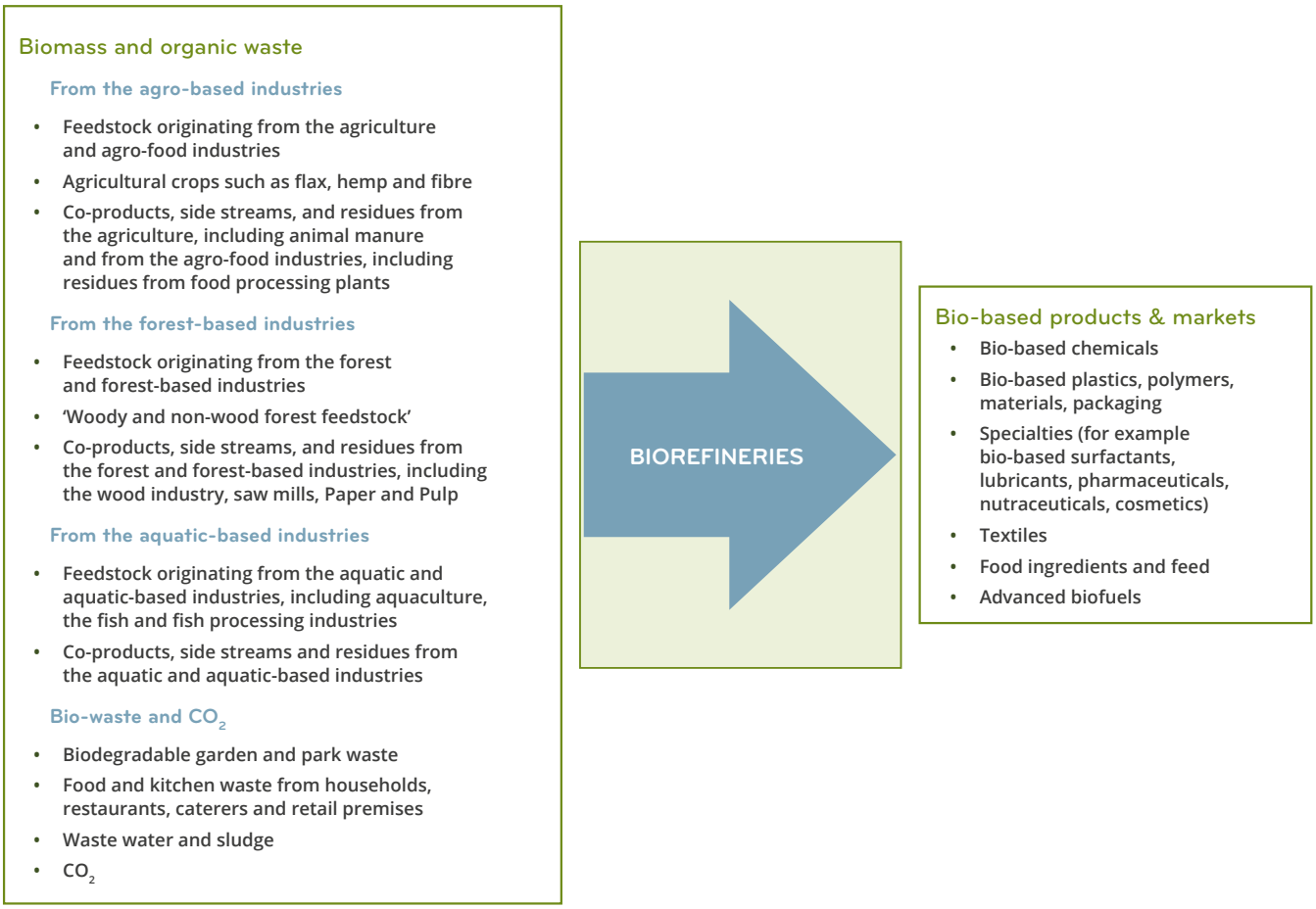
THE PROGRAMME AND ACTIONS OF THE BIO-BASED INDUSTRIES INITIATIVE

Meeting the long-term strategic objectives for the BBI Initiative (see chapter 2) will mean establishing new value chains and manufacturing and demonstrating new bio-based products for the market.

4.1 Value chains connect feedstock via processing to market

The BBI's programme seeks to speed up the creation of bio-based value chains, from sustainable feedstock production and mobilisation to conversion into bio-based materials and products for specific market applications (see Figure 1). Building on cooperation through the chain and across traditional boundaries, these value chains will often produce new and unconventional partnerships that could well extend beyond the bio-based sector. In turn, as they cross into other industrial, manufacturing and servicing sectors, these partnerships could provide significant mutual opportunities and benefits.

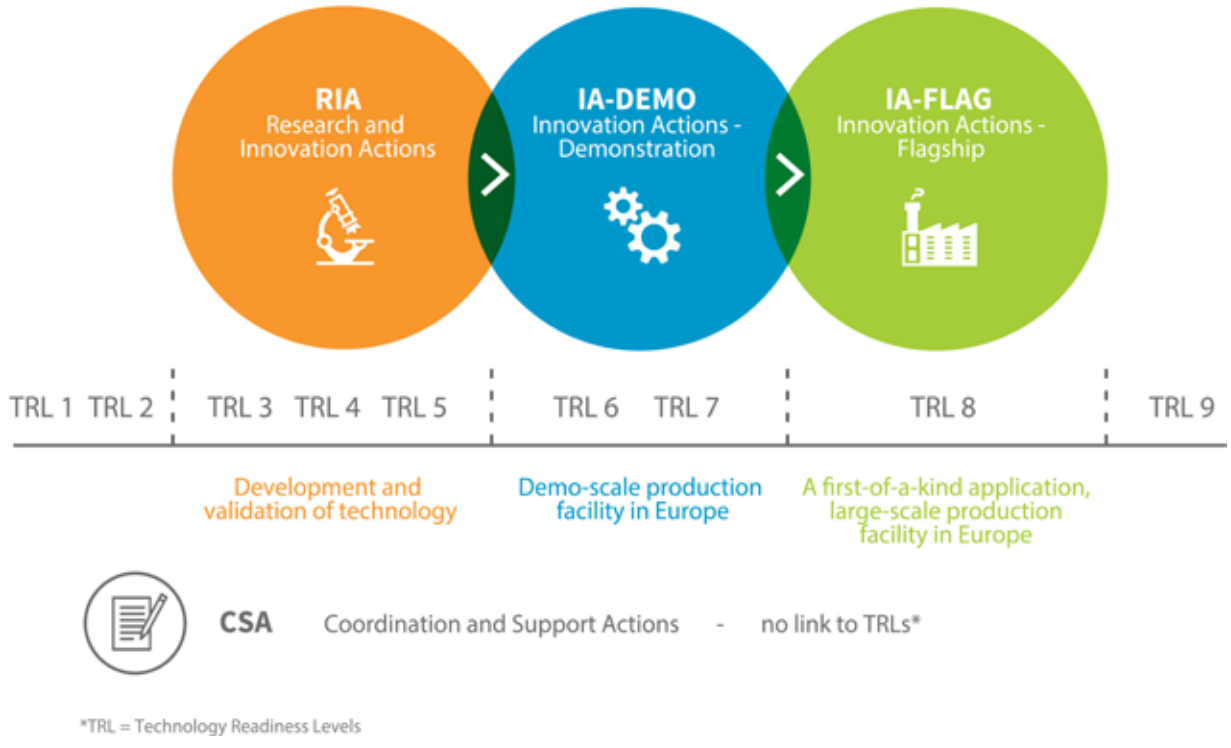
Figure 1: Bio-based value chains envisioned in the BBI Initiative[1]



4.2 Actions to realise value chains

The sustainable establishment and growth of bio-based value chains require a dedicated and balanced approach. This approach will address specific R&I and societal challenges to upscale bio-based processes to industrial levels successfully and quickly. It will also bring stakeholders from different disciplines and industrial sectors together around clear aims. It recognises three types of action[2]:

- **innovation actions** (**IAs**) to integrate and deploy the technologies and results of research and innovation actions within actual value chains, bringing technology close to the commercial scale through upscaling in **demonstration** and **flagship** projects. IAs consider the **whole value chain**;
- **research and innovation actions** (**RIAs**) to focus on filling the gaps in technological innovation: dedicated projects on the development of specific technologies and concepts needed to make the value chains work, and demonstrating the principles in pilot installations. RIAs will also be instrumental in allowing the establishment of new value chains; and
- **coordination and support actions** (**CSAs**) to address cross-cutting challenges and support the creation of value chains.



Industry participation is crucial if the actions are to succeed. It is therefore generally expected that, from industry, both large enterprises and SMEs will participate in BBI projects. The BBI Initiative provides incentives for high SME take-up. These include the standard Horizon 2020 incentive of funding all the direct costs and a quarter of the indirect costs that SMEs incur (and submit for funding). This incentive is also available for universities and RTOs[3].

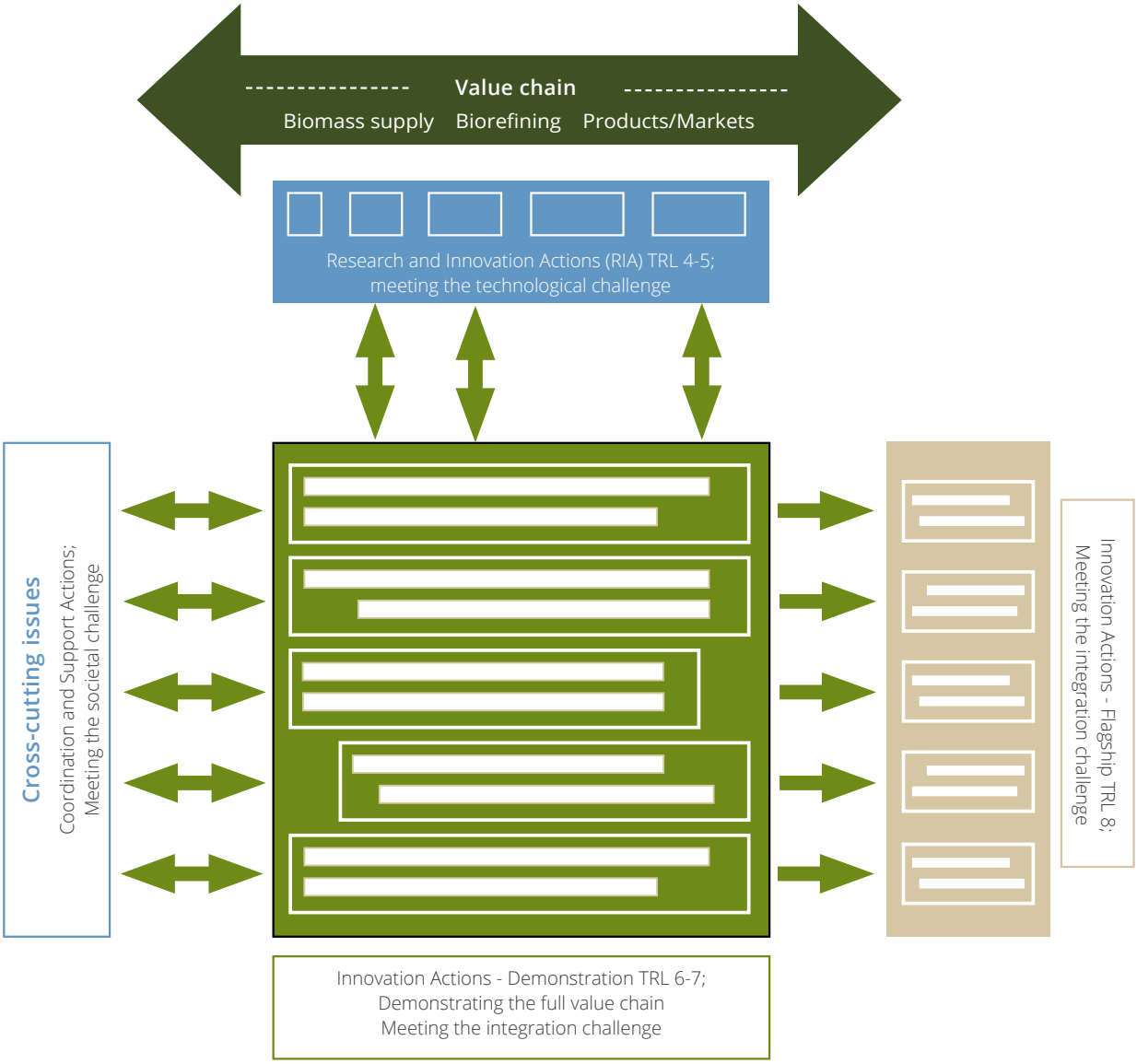
Any industry body can (partially) provide in-kind and cash contributions to take part in all types of projects. Large enterprises do not receive public funding for RIA and CSA projects; their participation in these actions is fully covered by in-kind and cash contributions. Any costs they incur in implementing these projects are considered as 'in-kind' contributions: these costs are eligible for funding under Horizon 2020 rules but are not reimbursed[4].

The industry contribution should match the public contribution from Horizon 2020 within the BBI joint undertaking, in line with its public-private nature and aims.

The financial contribution to the operational costs by BIC and its members in the years 2014 and 2015 amounts to 1,6 % of the total commitment[5]. Based on the current Regulation, BIC finds it difficult to deliver the total financial contribution but remains committed to meet its obligation. A procedure to amend the BBI JU Council Regulation, Annex 1 (Statutes), Article 12, is currently ongoing. This amendment would allow contributions by BIC members to indirect actions funded by the BBI JU (meaning 'at project level') to be reported to the BBI JU and be counted as financial contribution to the operational costs. This delivery mode at project level will encourage BIC members' financial contribution (i.e. cash payments) because they would have access to the project results in which they participate. Such amendment to the Regulation would facilitate BIC and its members to deliver the financial contribution[6].

Figure 2 shows the above described relationship between the projects in the various actions, centred around the IA – demonstration projects that span the whole value chain: from biomass feedstock supply, via biorefineries to products for the markets.

Figure 2: Overview of BBI projects



4.2.1 Value chains Innovation Actions – addressing the integration challenge

4.2.1.1 Innovation actions – 'demonstration' projects

IAs for demonstration aim to provide the final proof that a process, product manufacture and necessary supply chain are technologically and economically feasible before the commercial phase commences. For instance, a demonstration project makes it possible to scale up a process to industrial or near-industrial scale. Each step in the process has previously been

tested and validated individually as a pilot. The demonstration projects focus on proving how different sub-processes can be combined using industrial-scale equipment. Research activities within the demonstration projects thus focus on optimising flows and bringing down costs. They might, for instance, test the operational conditions identified during the lab and pilot phases to maximise productivity or reduce costs. Monitoring, data collection and analysis are critical during this phase. Demonstration projects are also aimed at fine-tuning the process to ensure that the product(s) can be reproduced and quality maintained.

Wherever possible, the value-chain demonstration projects will make use of the existing infrastructure and demonstration facilities available for the bio-based economy (industry and SME sites, and open shared facilities)[7]. For some of the new innovative value chains new and near-industrial-scale facilities will be required.

The IAs for demonstration have **technology readiness level (TRL) 6 or 7 on completion**. TRL 6 is technology demonstration in a relevant environment, TRL 7 in an operational environment. These activities are considered the last non-commercial step in demonstrating the performance and reliability of all critical steps in a value chain, so that the first commercial unit can be designed and performance guaranteed from the outcome of the demonstration project. These IA demonstration projects will generate either no revenue or insufficient revenue to pay back capital costs and cover operating costs. Their purpose, if built on a sound business plan, is to provide the backbone for subsequent flagship projects (TRL 8). Their scale and maturity at TRLs 6 and 7 should be sufficient to prove excellent technical, environmental and economic performance. They should also provide enough data to enable the technology to work on an industrial scale.

A total of 11 demonstration projects won grants in the 2014 and 2015 BBI calls and started running in 2015 (on 2014 grants) and 2016 (on 2015 grants). Table 1 lists the projects per call and topic under which they were submitted and are receiving the grant.

Table 1: Demonstration projects with grants in the 2014 and 2015 BBI calls

Call	Topic	Grant-funded projects
2014	VC1.D2 - Chemical building blocks and value-added materials through integrated processing of wood	ValChem
2014	VC1.D4 - Functional additives from residues from the agro-food industry	PULP2VALUE
2015	VC1.D1 - Lignocellulosic feedstocks into chemical building blocks and high added-value products	BIOFOREVER; GreenSolRes
2015	VC2.D2 - Innovative cellulose-based composite packaging solutions	PULPACKTION; FRESH
2015	VC3.D4 - High purity bio-based intermediates and end products from vegetable oils and fats	LIPES
2015	VC3.D5 - Valorisation of agricultural residues and side streams from the agro-food industry	FUNGUSCHAIN; GreenProtein; AgriMax
2015	D7 - Overcoming low product yields from fermentation processes	DEMETER

4.2.1.2 Innovation actions – 'flagship' projects

The developments in the demonstrated value chains will lead to investments in full-scale flagship innovation projects covering the entire value chain. These will include programmes for a sustainable feedstock supply, for a guaranteed market uptake, and for the integration of the value chain into existing rural and industrial infrastructures.

IA flagship projects mainly include operational activities along the whole value chain, corresponding to **TRL 8 on completion** (system complete and qualified). Flagship projects are the first links in value chains operating on an economically viable scale. They support the launch of an innovation that has been demonstrated but not yet deployed on the market. They cover a complete value chain, starting with the procurement, growth and supply of feedstock for conversion, via biorefining, into bio-based chemicals and materials for use in the end product(s). They include the establishment of a large-scale production facility; this may be a new installation, a substantially remodelled existing facility or a reconverted old or abandoned industrial facility. Building and running such plants incurs significantly higher costs and risks than demonstration plants because of the increased scale. Moreover, such plants carry significantly higher costs and higher risks than subsequent commercial plants, which benefit from a learning curve and have a lower risk premium for the capital and loans funding the project.

Four flagship projects won grants in the 2014 and 2015 BBI calls and started running in 2015 (on 2014 grants) and 2016 (on 2015 grants). Table 2 lists the projects per call and topic under which they were submitted and are receiving the grant.

Table 2: Flagship projects with grants from the 2014 and 2015 BBI calls

Call	Topic	Grant-funded projects
2014	VC3.F1 - Added-value products from underutilised agricultural resources	FIRST2RUN
2015	VC1.F1 - From lignocellulosic feedstock to advanced bio-based chemicals, materials or ethanol	BIOSKOH; LIGNOFLAG
2015	VC2.F2 - Valorisation of cellulose into new added-value products	EXILVA

4.2.2 Research and innovation actions – addressing the innovation challenge

RIAs address the specific R&I challenges that may arise from value chain demonstration activities, or the need to bridge technology gaps impeding the creation of new value chains. They generate the necessary enabling knowledge and technologies to build and boost the value chains – both existing and new – from biomass to biorefineries and products/markets. RIAs addressing the innovation challenge will each cover one of the parts of the value chain: biomass supply, biorefineries, products or market applications.

RIAs may also address completely new technologies still in early development but with sizeable potential for improving and expanding the bio-based industries in Europe. These new technologies may be the basis for the breakthrough needed for a post-petroleum era.

RIA projects set out mainly to bridge technology gaps and technological development demands from new or existing value chains. They correspond to **TRL 4 or 5 on completion**. TRL 4 includes validation at lab stage, TRL 5 at pilot stage. The minimum TRL on completion for RIA projects addressing a specific step in a value chain is 4. This is to speed up the much-needed uptake of industry-led actions for demonstration and industrial-scale projects. The preference is for RIA projects ultimately to achieve TRL 5, making them ready to proceed to the demonstration stage.

The applied research included in the RIA projects refers to scientific study and research directed primarily towards a specific practical aim or objective (for example, research that seeks new technologies for the conversion of biomass into bio-based products).

In some cases, RIA projects may conclude at TRL 3. TRL 3 includes experimental proof of concept. These lower TRL projects could be considered for specific technology themes that need further development to establish new value chains. Examples could be synthetic biology, new extremophiles, etc.

A total of 18 RIA projects won grants in the 2014 and 2015 BBI calls and started running in 2015 (on 2014 grants) and 2016 (on 2015 grants). Table 3 lists the projects per call and topic under which they were submitted and are receiving the grant.

Table 3: RIA projects with grants from the 2014 and 2015 BBI calls

Call	Topic	Grant-funded projects
2014	VC1.R1 - Efficient pre-treatment of lignocellulosic feedstock to advanced bio-based chemicals and biomaterials	US4GREENCHEM
2014	VC2.R2 - New sustainable pulping technologies	PROVIDES
2014	VC2.R4 - Fibres and polymers from lignin	SmartLi; GreenLight
2014	VC3.R6 - Fermentation processes to obtain bio-surfactants and specialty carbohydrates from agricultural and agro-industrial streams	CARBOSURF
2014	VC3.R7 - Protein products from plant residues	PROMINENT
2014	VC4.R10 - Nutrient recovery from bio-based waste streams and residues	NEWFERT
2015	VC1.R1 - Conversion of lignin-rich streams from biorefineries	LIBRE; Zelcor
2015	VC1.R3 - Bio-based functional molecules for coating and surface treatment	HYPERBIOCOAT
2015	VC2.R5 - Practices increasing effectiveness of forest management	EFFORTE; TECH4EFFECT
2015	VC2.R6 - Sustainable cellulose-based materials	NEOCEL
2015	VC3.R8 - Increasing productivity of industrial multi-purpose agricultural crops	LIBBIO
2015	VC3.R9 - Valorisation of aquatic biomass	MACRO CASCADE
2015	R10 - Innovative efficient biorefinery technologies	EnzOx2; BIOrescue; InDIRECT

4.2.3 Coordination and support actions – addressing the societal challenge

Non-technological, cross-cutting challenges often need to be overcome before successful value chains can be developed and demonstrated. IA demonstration projects and RIA projects will deal with some as side activities. Others will be overcome through BBI Initiative programmes (on communication, dissemination and outreach). And others still will require specific CSA projects. These projects are in principle studies and/or analyses that will enable the value chains to identify and resolve the many critical elements related to cross-disciplinary approaches. CSA projects should deliver practices and tools that can address market, legal, technology, quality and other aspects.

Cross-cutting issues include cross-sectoral and critical elements that connect the various steps in the value chains, the different levels of innovation and the various private and public stakeholders involved.

The CSA projects will address these and other cross-cutting issues:

Clustering and networking: Clusters are networks of stakeholders spanning regions and value chains. In connecting different partners – researchers, technology developers, operators/producers and consumers – they are essential to developing new value chains and supporting the emergence of new processes and materials. Some value chains seek to create integrated areas of rural and industrial bio-based activity (bio-based 'hubs'). Others aim for clusters interconnecting value chains and linking regional agriculture, industry and research networks. Ultimately, clusters and networks should form the basis for building an ecosystem to facilitate and support Europe's bio-based industries, along with a broad, solid bio-based community.

CSA projects may also involve developing new business models for new, integrated, cascaded biorefinery approaches, or industrial ecology and symbiosis systems: combined residue processing, bio-energy production, heat integration and valorisation, reuse of water and (organic) nutrients, energy stream analysis to discover which processes and/or companies could fit together, etc. Studies may include feasibility studies regarding the optimal locations for biorefineries and suitable unused facilities for conversion to biorefineries.

Standards: in the process of developing new bio-based products, the BBI projects will help give rise to new standards through a close working relationship with CEN[8]. The RIA and IA projects can support the pre- and co-normative research necessary for the development of new standardisation documents and validated approaches, including inter-laboratory testing of methodologies and testing approaches, if applicable[9].

CSA projects could look at how the biobased industries and CEN could best work together on the various types of new bio-based products and specific standards for those products.

Regulations: In this context, CSA projects could contribute to better regulations for bio-based products in various market segments at EU, national and regional level.

Market relevance of bio-based products: standards and regulations governing new bio-based products should closely match the products' applications. Labels and procurement also play a role in boosting market uptake of bio-based products. CSA projects could help identify specific market applications for bio-based products and their contribution to societal needs. These studies should include the development of a common language all along the value chain(s).

Sustainability: every RIA and IA project should include an assessment of the relevant economic, social and environmental impacts of the process and/or the products. The assessment should show that it will contribute to a higher sustainability level than the leading standard.

CSA projects could then address other sustainability aspects, such as carbon-storage potential, biodiversity and circularity of resources (bio-waste). In this context, there is a need to share databases of impacts resulting from feedstock cultivation and collection, industrial processing, end-of-life handling, etc. Collective information of this kind about the production process for bio-based products, will make for better comparison with traditional fossil-based products. This comparison, in turn, will greatly help the market uptake of bio-based products as well, in areas such as public procurement.

Policy: CSA projects can analyse the impact of bioeconomy policies on market development, investment and job creation at EU, national and regional levels. These analyses should include good practices for bioeconomy policies and the transfer of information and best practices to countries and regions that are seeking to fully exploit opportunities and further develop their bio-based industries.

Financing: CSA projects can analyse business models for the bio-based economy and recommend financing instruments to suit the scale and nature of bio-based economy investments. They should follow the 'guiding principles' for combining BBI Initiative and ESIF funding[10], taking ongoing flagship projects as examples.

Mapping regional bio-based economy capacities: CSA projects can develop tools and modelling to understand the bio-based economy's regional capacities in terms of resources, industries and potential for new developments.

Education: while expanding across Europe, the bio-based industries should work closely with educational institutions to ensure that there are enough people with the right skills in the future.

Apart from applied research to enable value chains to develop, educational institutions should also maintain basic research to achieve breakthroughs in processing and applications, and higher levels of innovativeness in the bio-based industries.

CSA projects could explore those educational elements that could feed into future models of cooperation between industry and the education sector.

Communication and awareness: public acceptance of bio-based applications in day-to-day life is crucial for the sustainable development of a bio-based economy.

CSA projects could provide tools to boost awareness and support for activities under the BBI Initiative, the qualities of bio-based products and the benefits of their applications for people, the economy and the environment. The projects could also make use of bio-based success stories. And ultimately, CSA projects could propose tools and methodologies to give end-consumers and society as a whole feedback on the impact of the European bio-based economy.

Three CSA projects won grants in the 2015 BBI call (the 2014 BBI call did not include CSA topics) and started running in 2016. Table 4 lists the projects per call and topic under which they were submitted and are receiving the grant.

Table 4: CSA projects with grants from the 2015 BBI call

Call	Topic	Grant-funded projects
2015	S1 - Standards and regulations	STAR4BBI
2015	S2 - Communication and awareness	BioCannDo; BIOCOM

Endnotes chapter 4

1 This graphic shows the framework in which the bio-based industries in Europe operate, the aim being the integrated production of chemicals, materials, fuels, etc. The BBI joint undertaking work programmes will dovetail with other parts of Horizon 2020 and overlaps will be excluded. For example, standalone biofuel projects (including aviation) and energy-driven biorefinery projects are a focus of Horizon 2020 - Societal Challenge 3 (secure, clean and efficient energy) calls. The industries cover advanced biofuels in BBI through cascading biomass-driven biorefinery projects focused on high added-value products (materials, chemicals) and a limited number of advanced bioethanol activities conceived as a stepping stone to integrated biorefineries.

2 Projects for the IAs and RIAs needed to deliver a specified TRL on completion.

3 See Commission Delegated Regulation (EU) No 623/2014 of 14 February 2014.

4 See Commission Delegated Regulation (EU) No 623/2014, which limits funding from the BBI joint undertaking for RIAs and CSAs in SMEs, secondary and higher education establishments and other entities, not including large enterprises; http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0623&rid=10

5 Council Regulation (EU) No 560/2014, Annex 'Statutes of the Bio-based Industries Joint Undertaking', Article 12.4: The financial contribution by the members other than the Union (i.e. BIC) to the operational costs referred to in paragraph 3 (b) (i.e. BIC's financial contribution to the operational costs of the BBI JU) shall be at least 182,5 M€ over the period provided for in Article 1 of this Regulation (i.e. until 31 December 2024). (See also total financial overview in Chapter 8 on Finances). In 2014 and 2015 this financial contribution has only been delivered at project level: € 2.0 million in 2014 and € 0.9 million in 2015 for a total of € 2.9 million (1.6 % of € 182.5 million).

6 The proposal for amendment was adopted by the EC on 22 February 2017 and the institutional process is currently following its course.

7 e.g. Leuna, Biobase Europe Ghent, BRI platform Reims, Bioprocess Pilot Facilities Delft, facilities at RTOs, and company-owned pilot and demonstration facilities.

8 European Committee for Standardisation (*Comité européen de normalisation – CEN*)

9 See the recent mandated standardisation programme for algae biofuels (DG Energy, European Commission) and the soontobecompleted programmes for bio-based products (DG GROW, European Commission). Also, see relevant workshop results at https://ec.europa.eu/energy/en/events/3rd-european-workshop-lca-algal-biofuels-and-biomaterials

10 Combining BBI (H2020) and European Structural and Investment Funds (ESIF) to deploy the European bioeconomy – Guiding Principles; http://biconsortium.eu/sites/biconsortium.eu/files/downloads/Guidelines_BBI-ESIF-Final.pdf

5

MONITORING THE PROGRESS AND IMPACT

Fast implementation and performance feedback are key issues for the BBI Initiative. The BBI activities and results are designed to feed into the overarching strategic objectives towards a bio-based economy. These activities cover the entire value chain and cross-cutting areas.

Quantity, quality and impact will be the most suitable benchmarks for monitoring the success of the BBI Initiative.

Basically, the BBI Initiative connects a set of steps to ultimately create desired impacts in societies:

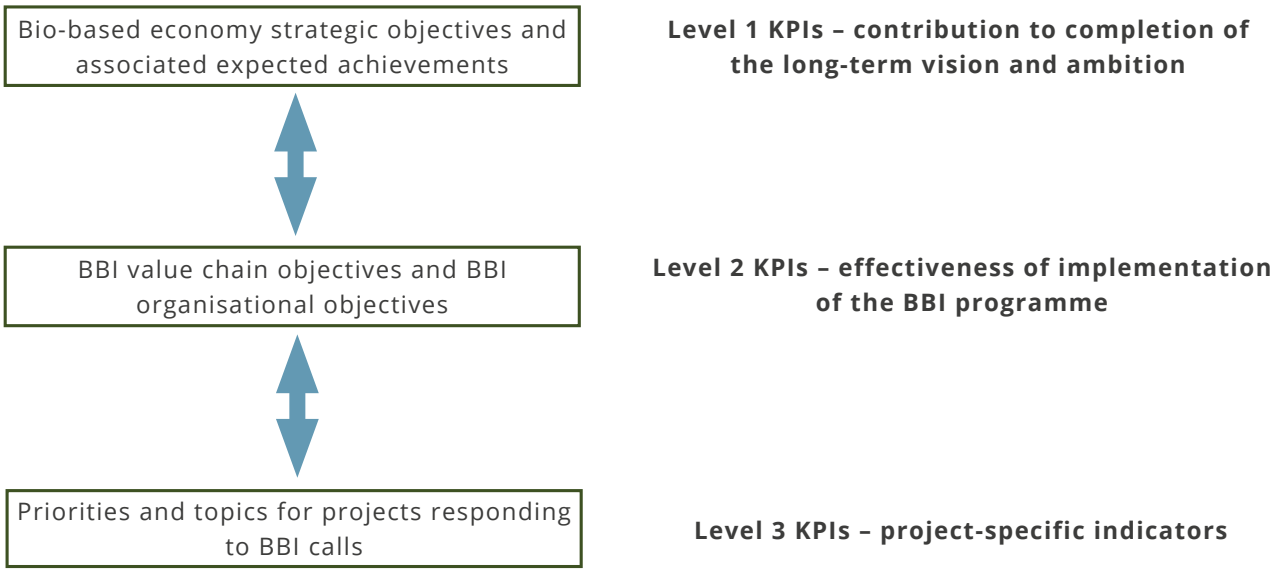
- input: the intake of resources – such as biomass feedstock, utilities, knowledge, finances – to use in some way to achieve a desired goal;
- output: the (physical) result of activities/action under BBI projects – such as chemicals, materials, products, knowledge and expertise;
- throughput: the rate/speed at which the Initiative (i.e. its projects, value chains) produces its output;
- outcome: something that happens because of BBI activities/action – such as purchases of bio-based products; and
- impact: a (lasting) effect or influence on society because of the outcome – such as lower GHG emissions, a lower overall environmental footprint, greater welfare and wellness.

The above steps will be monitored to evaluate how the BBI Initiative has performed as regards:

- **efficiency**, in terms of the output/input relationship ('doing things right'); and
- **effectiveness**, in terms of achieving the desired outcome and impact with our output ('doing the right things').

The Initiative will contribute to the overall strategic objectives at European level, at BBI programme level and at BBI project level. Results and impacts at each level will interact and collectively contribute to the emergence of a bio-based economy in Europe. Each level has its own specific set of quantitative and qualitative KPIs to monitor progress towards the objectives:

Figure 3: The different levels of KPIs and their interactions



The level 1 KPIs assess the contribution to the overall strategic objectives of the bio-based economy in Europe stemming from the bio-based industries' Vision 2030[1]. In this vision a competitive, innovative and sustainable Europe is leading the transition to a post-petroleum society, while decoupling economic growth from resource depletion and environmental impact. As the BBI Initiative is only one of the means of delivering the vision, monitoring the progress towards a bioeconomy in Europe is not a task for it alone. Instead, it should be a combined effort on the part of various bioeconomy advocates in Europe (including the Bioeconomy Panel, the Bioeconomy Alliance and Horizon 2020). Monitoring level 1 KPIs does not fall within the scope of this Agenda.

The BBI Initiative is one of the instruments supporting a bioeconomy in Europe. It makes only indirect contributions to the level 1 KPIs, especially through its flagship projects. Successfully operating flagship biorefineries may lead to many similar installations springing up across Europe. However, further rollout of BBI technological successes also depends on having the right policies, legislation and incentives in place and on 'external factors' such as the oil price, CO_2 targets and so on.

Level 2 KPIs measure the Initiative's progress towards the specific R&I targets for 2020 (output and outcome). The topics in the BBI annual work plans will include expected impacts under the relevant level 2 KPIs. Table 5 at the end of this chapter shows the level 2 KPIs and their objectives, impact and relationship to the relevant actions in the BBI programme.

Level 3 KPIs are included in all projects funded by the BBI joint undertaking and monitor their success.

5.1 Efficiency of the BBI Initiative

The level 2 KPIs should answer the question: 'Are we doing things right?'

Monitoring at this level will be for the programme management. Frequent monitoring gives insight into the efficiency of the programme in terms of the input/output ratio. As the programme goes forward the KPIs themselves will be evaluated for effectiveness, so that the programme monitoring can be changed where necessary.

5.2 Effectiveness of the BBI Initiative

Measuring and monitoring the impacts of the BBI programme at the project, programme and European levels will answer the question: 'Are we doing the right things?'

Part of this question should be answered by a European monitoring system for the level 1 KPIs.

Some of the level 2 KPIs could also help answer the question. This is especially true of the KPIs on the impacts of IAs and of flagship projects in particular.

Table 5: Monitoring the Progress off BBI towards specific research and innovation targets (KPI level 2)

1	**Objective**	New cross-sector interconnections in bio-based economy (new bridges creating cooperation between the different sectors and actors).			
	KPI	# of new cross-sector interconnections in BBI projects	31-12-'16	31-12-'18	31-12-'20
			10	20	36
	Description	Number of new forms of cooperation in BBI value chains. This refers to cooperation between companies and other actors from different sectors to build new value chains. These interconnections are new in the sense that the actors have not engaged with each other in cooperation or business in a value chain before (even if they have worked together in a totally different field). The new cooperation/interconnection may relate to feedstock, technology, product markets, and regions and business models.			
	Types of Action[2]	All: RIA, IA, CSA			
	How to measure[3]?	KPI measured at project level via annual reporting. Number of any forms of new cooperation between partners within a BBI project and number of additional interconnections based on any written commitment between parties linked to a BBI project. The quantitative information will be supplemented by qualitative information (sectors, kind of cooperation).			
2	**Objective**	New bio-based value chains.			
	KPI	# of new bio-based value chains created	31-12-'16	31-12-'18	31-12-'20
			1	4	10
	Description	Number of new value chains (from raw material to product application) created with BBI projects. A new value chain is one in which at least one part is new: the biomass feedstock, processing, end product or application. A new value chain is created when its resultant (new) product or service has been tested and validated to be ready for a specified and accepted market application (IA). The new value chains are economically viable and fulfil all relevant sustainability criteria. Each of the value chains has drawn up business cases or plans for commercialisation (if not already scaled up to flagship projects - see objective 7). (RIA results are delivered with the aim of facilitating or creating a value chain, but by themselves do not create full value chains.)			
	Types of Action	All: RIA, IA, CSA			
	How to measure?	KPI measured at project level via annual reporting. Number of any kind of new value chains created with the BBI project and number of additional value chains created by parties linked to a BBI project. The quantitative information will be supplemented by qualitative information (what is new in the value chain).			
3	**Objective**	BBI cooperation projects.			
	KPI	# of grant agreements signed between the BBI joint undertaking and project consortia	31-12-'16	31-12-'18	31-12-'20
			40 projects	140 projects	200 projects
	Description	Number of BBI projects started since the launch of the BBI joint undertaking, which applies Horizon 2020 rules. This means that the grant-funded projects are collaborative projects that include partners from industry (large enterprises, SMEs), academia, and other BBI stakeholders based in at least three different Member States or associated countries. The number refers to successful projects, i.e. all those for which grant agreements have been signed and the expected outcomes have materialised. It excludes those projects for which an agreement was signed, but which have failed to deliver the expected outcomes or have been terminated.			
	Types of Action	RIA, IA, CSA			
		Measured at programme level for each call and after signature of the grant agreements (each year by the end of May).			
4	**Objective**	New building blocks based on biomass of European origin.			
	KPI	# of new bio-based building blocks	31-12-'16	31-12-'18	31-12-'20
			1	2	5
	Description	New building blocks developed (TRL 3), validated (TRL 4 or 5) or demonstrated (TRL 6 or 7) with BBI projects. New bio-based building blocks are chemical building blocks that are identical to non-renewable building blocks and have not (successfully) been made on a (pre-)commercial scale yet, or new building blocks that perform better than fossil-based counterparts in comparable applications, or novel, breakthrough building blocks with no fossil-based counterparts. The new building blocks meet a clear (market) demand and fulfil all technical requirements, are economically viable and match all relevant sustainability criteria.			
	Types of Action	RIA, IA			
	How to measure?	KPI measured at project level via annual reporting. Number of new building blocks resulting from the BBI projects relates to B2B relationships[4]. Information on B2C relationships linked to this KPI will be explained further by the BBI projects (details on final markets, bio-based applications, etc.). The new elements of the bio-based materials will be also explained (feedstock, technology, functionalities, etc.).			

5	**Objective**	New bio-based materials.			
	KPI	# of new bio-based materials	31-12-'16	31-12-'18	31-12-'20
			10	20	50
	Description	New bio-based materials developed (TRL3), validated (TRL 4 or 5) or demonstrated (TRL 6, 7 or 8) with BBI projects. Examples of new bio-based materials are speciality fibres, plastics, composites and packaging solutions. The bio-based materials that replace fossil-based materials have proven to have an equal or overall better sustainability (because of the LCA, improved material efficiency, reduced GHG emissions, biodegradability, recyclability or other improved functionalities during use or reuse). The new bio-based materials meet a clear market demand and fulfil all technical requirements, are economically viable and match all relevant sustainability criteria.			
	Types of Action	RIA, IA			
	How to measure?	KPI measured at project level via annual reporting. Number of new bio-based materials resulting from the BBI projects relates to B2B relationships. Information on B2C relationships linked to this KPI will be explained further by the BBI projects (details on final markets, bio-based applications, etc.). The new elements of the bio-based building blocks will be also explained (feedstock, technology, functionalities, etc.).			
6	**Objective**	New demonstrated 'consumer' products based on bio-based chemicals and materials.			
	KPI	# of new categories of bio-based 'consumer' products or bio-based applications	31-12-'16	31-12-'18	31-12-'20
			5	15	30
	Description	New bio-based products and applications demonstrated (TRL 6, 7 or 8) with BBI projects. The bio-based intermediate products (materials, building blocks, chemicals) successfully converted into 'consumer' products (such as cosmetics, food applications, vehicles, fertilisers, adhesives, etc.). The 'consumer product' will have a better overall sustainability score than its current alternative (because of the LCA, improved material efficiency, reduced GHG emissions, biodegradability, recyclability or other improved effects during use or reuse). The bio-based 'consumer products' meet a clear market demand and fulfil all technical requirements, are economically viable and match all relevant sustainability criteria.			
	Types of Action	IA			
		KPI measured at project level via annual reporting. Number of new bio-based 'consumer' products or bio-based applications resulting from the BBI projects relates to B2B relationships. Information on B2C relationships linked to this KPI or examples of concrete and or more complex bio-based applications will be explained further.			
7	**Objective**	BBI flagship projects producing new bio-based intermediate products (materials, chemicals) or bio-based 'consumer' products which have proven to be cost-competitive with the alternatives based on fossil resources or other non-renewable resources.			
	KPI	# of flagship grant agreements signed between the BBI joint undertaking and project consortia	31-12-'16	31-12-'18	31-12-'20
			1	2	5
	Description	Number of flagship projects started since the launch of BBI joint undertaking, based on BBI and other demonstration projects. The number refers to successful projects, i.e. all those for which grant agreements have been signed and the expected outcomes have materialised. The number excludes those projects for which an agreement was signed, but which have failed to deliver the expected outcomes or have been terminated.			
	Types of Action	IA (flagship only)			
	How to measure?	KPI measured at programme level for each call and after signing of the GAs (yearly, by the end of May). The quantitative information relates only to the signed flagship grant agreements between the BBI joint undertaking and consortia. Additionally, qualitative information will be collected on deployment of the innovation resulting from joint undertaking activities among the flagship projects.			
8	**Objective**	RIA 'TRL gain': validated, improved technologies that fill gaps in value chains and make for new chemical building blocks, new materials, new 'consumer' products or new applications.			
	KPI	# of validated technologies that have realised a 'TRL gain' as compared with the level at the start of the project of one level, i.e. from TRL 3 to TRL 4 or TRL 4 to TRL 5.	31-12-'16	31-12-'18	31-12-'20
			-	-	20
	Description	Number of new and improved processing technologies validated with BBI projects. This KPI is complementary to KPIs 4, 5 and 6.			
	Types of Action	RIA			
	How to measure?	KPI measured at project level via annual reporting.			

Endnotes chapter 5

[1] The bio-based industries' *Vision 2030: Accelerating innovation and market uptake of bio-based products.*

[2] Types of action this KPI refers to.

[3] This refers to the type of information to be collected.

[4] The numeric input in all product related KPIs (KPI 4, 5, 6) relates to B2B relationships.

6

THE BIO-BASED INDUSTRIES CONSORTIUM

The BIC's members come from the worlds of industry and academia. The full members are both large enterprises and SMEs. The latter may either join the BIC directly or through an SME cluster. As of 15 September 2016, there were 72 full members in all, with SMEs making up just over half that figure[1]. Members are active in all main sectors of the emerging bio-based industries in Europe, namely:

- biomass feedstock;
- biomass processing;
- bio-based products;
- technology provision;
- cross-sectorial activities;

or a combination thereof.

As of 15 September 2016, industry members had operations in 16 Member States, chiefly in western and southern Europe. Together they account for more than half of the European bio-based community. The BIC has launched a wide-ranging programme to extend industry membership into more sectors (biomass feedstock, processing, brand owners) and more Member States (especially in central and eastern Europe).

The large enterprises and SMEs make up the BIC's General Assembly and Board. Every industry member, regardless of size, has equal voting rights on both bodies.

The BIC also has associate members. These are non-industry members such as universities, research organisations, European trade organisations and technology platforms[2].

The BIC and the European Commission jointly put together annual work plans, with the BIC's industry members taking the lead in pinpointing the topics. Associate members assist in ensuring that the topics have a more inventive edge and contribute to the strategic orientations. The basis for the topics is an annual priority paper, drafted using input requested from industry and associate members, BBI joint undertaking advisory bodies and other relevant stakeholders. The topics therefore have the support and commitment of the BIC's industry members and are relevant to all bio-based industries.

The annual work plan includes other sections on areas such as support for operations, governance and the internal control framework. The BBI joint undertaking's Governing Board (composed of five representatives each from the BIC and the European Commission) adopts the plan in December of the preceding year.

The BIC's members, as leaders in the bio-based economy in Europe, help identify gaps in the value chains, proposing those areas for action to eliminate the market failures that discourage private investment. Being actively involved in the BBI Initiative allows BIC members to become involved at an early stage in defining the annual priorities and pinpointing the relevant topics for inclusion in the annual work plan. This early involvement also gives BIC members an advantage in selecting partners for consortia to set up high-quality project proposals.

The BIC provides other assistance to its members, especially to SMEs. This may take the form of guidelines on improving access to financial instruments, market information and forecasts, on resolving legal obstacles and on pursuing international partnering.

Endnotes chapter 6

1 For the current list of full BCI industry members, go to http://biconsortium.eu/membership/members-full

2 For the current list of associate members, go to http://biconsortium.eu/membership/associate-members

7

THE EU'S ADDED VALUE

7.1 Added value of action at EU level and of public intervention using EU research funds

The BBI Initiative's multi-sectoral approach forges cross-border collaboration at European level to help overcome market failures in the bio-based industries. No single company, industrial sector or Member State has the capacity to deal with the challenges and (financial) risks facing the industry and other stakeholders. The BBI Initiative brings rather fragmented bio-based activities under one pan-European structure, pooling national and regional assets, strengths and skills. Out of such collective efforts a European bio-based economy and industries can grow. The four flagship projects from the 2014 and 2015 BBI calls are good illustrations of this[1].

Many bioeconomy initiatives build on close cooperation between the public and private sectors and support the development of bio-based industries at a national or regional level. Connecting these national and regional clusters is hampered by differences in funding levels and financing rules between Member States and regions. There is a degree of competition between them. A public-private partnership such as the BBI Initiative is a sound means of engaging in successful cross-border collaboration to create sustainable, competitive bio-based value chains.

A pan-European public-private partnership will also help deal with the many regulations with direct impacts on the bio-based industries. These are monitored and managed at European level and include the Bioeconomy Strategy, the circular economy package, the CAP, the Lead Market Initiative for bio-based products; and various targets and standards for bio-based products (see also chapter 2).

There are many arguments to justify why the BBI Initiative is the right context in which to tackle the challenges for a bioeconomy in Europe. These include:

- the need for complex research that no company or public research institution can conduct alone;
- the need for an agreed long-term budget plan and strategic technical and market objectives to encourage industry and the research community to commit more of their own resources;
- the gaps and overlaps in fragmented research coverage resulting from a sub-optimal allocation of funds;
- the need for sufficient funds for an integrated, continuous programme covering fundamental research, applied research and demonstration and flagship activities at EU level; and
- the dispersed bio-based value chains across different countries and sectors restricting the exchange and pooling of knowledge and experience.



With its pan-European long-term research, demonstration and flagship programme, the BBI Initiative clearly adds value at European level. It will allow large enterprises and SMEs to collaborate with each other and with European RTOs, universities, national governmental organisations and NGOs, working towards shared short-, medium- and long-term objectives across bio-based value chains.

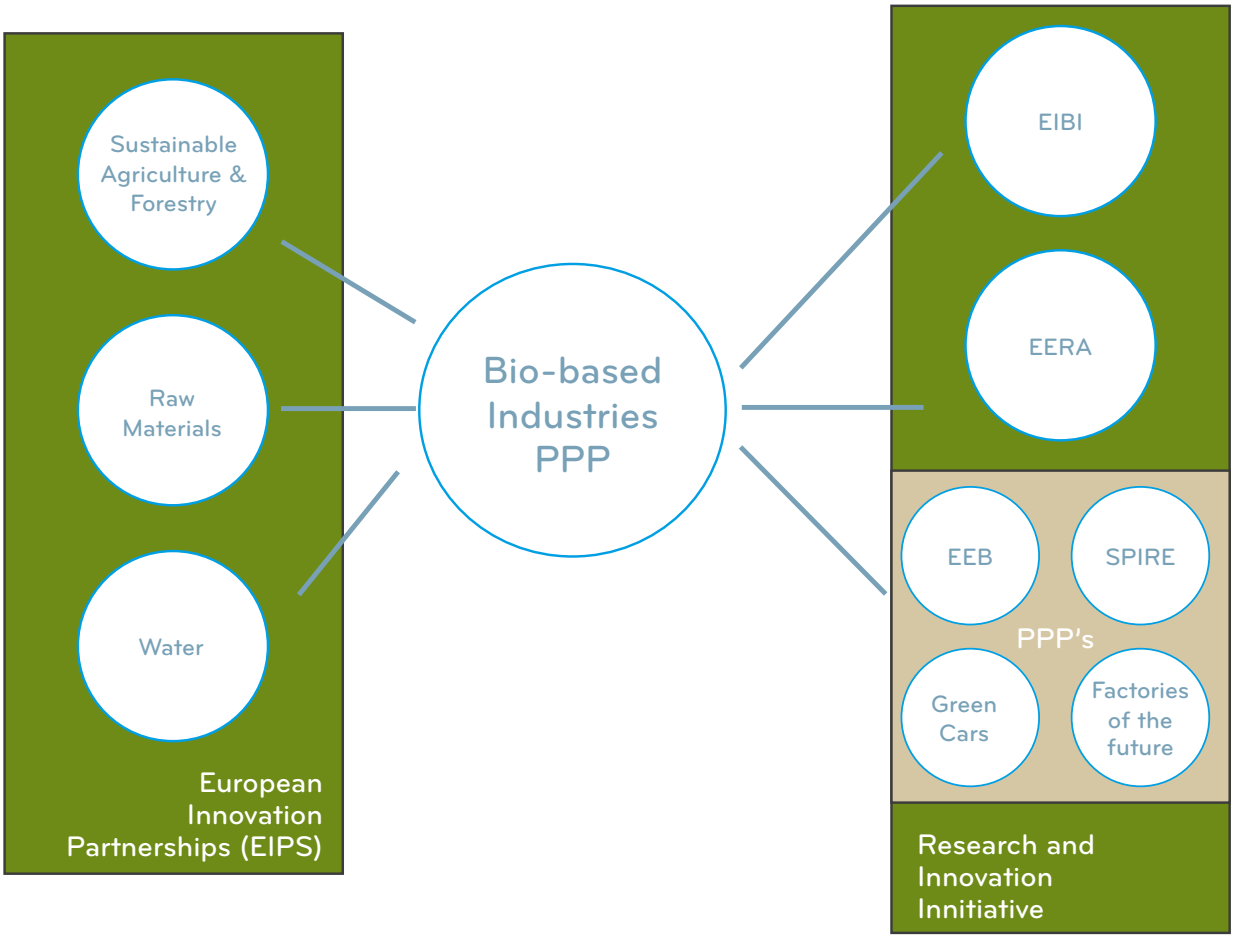
7.2 Additional contributions to existing activities

This Agenda sets out R&I priorities for 2014 to 2020 with the goal of stepping up the pace of the innovation taking us towards a sustainable bio-based economy. Making this a reality will mean building together, aligning fully, cooperating and exchanging with the main ongoing EU initiatives. The bio-based industries will work with the following EU initiatives and others to deliver the Agenda's objectives:

- the European Innovation Partnerships (EIPs), which address weaknesses in the European R&I system that may prevent innovations from entering the market. They provide a working interface between practitioners, scientists, policy-makers, advisors and other stakeholders at EU, national and regional levels. The EIPs of relevance to the BBI joint undertaking are those focusing on agricultural productivity and sustainability, raw materials and water efficiency;
- SPIRE, also developed under Horizon 2020, which aims to build a sustainable process industry through resource and energy efficiency. The BBI Initiative supports SPIRE and its stakeholders by developing sustainable value chains in the bio-based industrial sector, bringing together the critical stakeholders to provide infrastructure from feedstock supply to biorefinery output. SPIRE, in turn, strengthens the BBI Initiative and its stakeholders by developing energy- and resource-efficient processes (both fossil and bio-based) and prepares the current process and manufacturing industry for feeding in bio-based building processes and blocks. The BBI Initiative and SPIRE have jointly identified 'docking points' to draw and build on each other's strengths. The docking points set the basis for

significant mutual support: the BBI Initiative will lead to new sourcing options for bio-based platform chemicals in Europe and, in doing so, increase the sourcing portfolio for SPIRE projects. In turn, SPIRE will pave the way for bio-based feedstock in manufacturing and thereby support BBI goals in trms of creating new markets for bio-based products.

Figure 4: Complementarity and synergy of bio-based JU with main EU initiatives



Endnotes chapter 7

1 FIRST2RUN, BIOSKOH, LIGNOFLAG, EXILVA; see http://bbi-europe.eu/projects


CO2

8

FINANCES

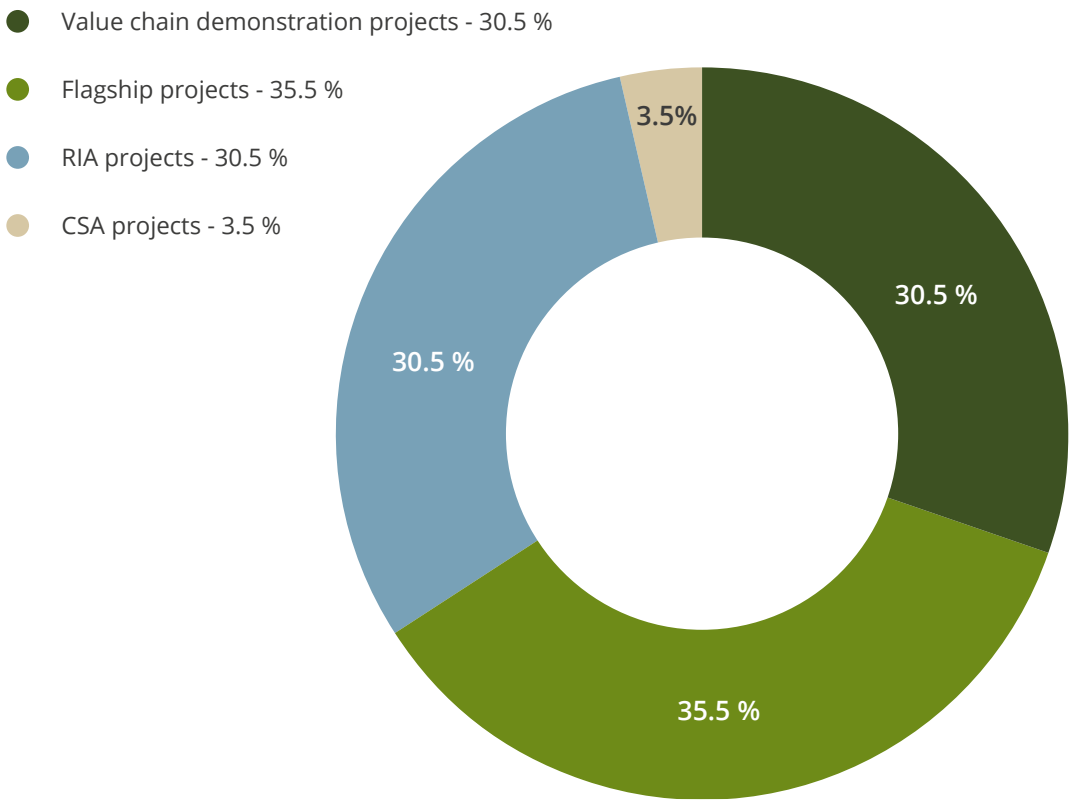
The founding partners together have committed to invest in the BBI Initiative at least € 3.7 billion between 2014 and 2020, given the right framework conditions. This includes up to € 975 million from the Horizon 2020 budget for the co-fundable parts of the BBI JU projects, under Horizon2020 rules, and financing the administrative costs of BBI JU.

The total investment in the BBI Initiative amounts to at least € 3 646.5 million, excluding up to € 58.5 million to cover the administrative costs of the BBI joint undertaking's Programme Office. The BIC and the European Commission share the office's costs equally.

The total investment from the industry consists of at least € 2 730 million, composed of up to € 29.25 million financial contribution to administrative costs, at least € 182.5 million financial contribution to operational costs, at least € 1 755 million as additional activities and the remainder of the investment as in-kind contribution to projects.

Figure 5 shows the indicative allocation of the funding for (demonstration and flagship) IAs, RIAs and CSAs.

Figure 5: Indicative allocation of the funding for the lifetime of the BBI Initiative[1]

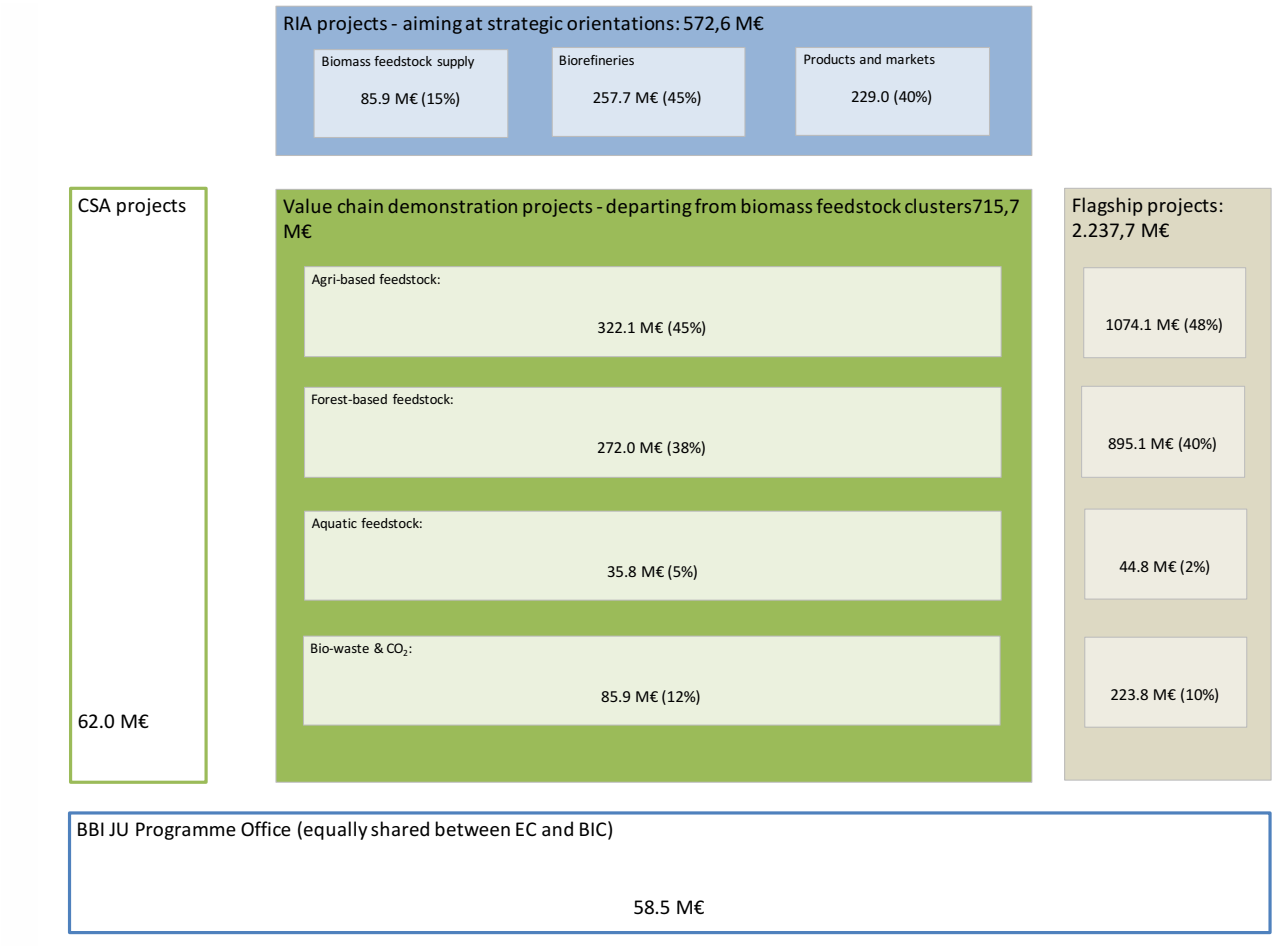


The funding for IA, RIA and CSA projects is based on the ambitions of the BIC members and allocated on the following basis:

- the RIA projects are mainly aimed at resolving technological issues as prioritised, based on the strategy paths for feedstock supply, processing and products;
- for the IA demonstration and flagship projects the allocation is based on the feedstock clusters (see section 3.1), to align investments responding to the 2016 BBI calls and later to those responding to the 2014 and 2015 calls. The topics in the latter calls were linked to the value chains in the original Agenda, while those in the calls as of 2016 follow the strategy paths and depart from the above-mentioned biomass feedstock clusters.

Figure 6 shows the indicative allocation of funding for the various actions[2].

Figure 6: Indicative allocation of funding for RIA, IA (demonstration and flagship) and CSA projects for the lifetime of the BBI Initiative. The BIC and the European Commission fund the BBI joint undertaking's programme office equally



The 2014 and 2015 BBI calls resulted in 33 grant-funded projects (18 RIA, 11 demonstration, 4 flagship and 3 CSA projects). Table 6 presents an overview of the total public funding received by the grant-funded projects in the 2014 and 2015 BBI calls. It also shows the progress of the various actions in terms of take-up of the total allocated budgets.

Table 6: Overview of total public funding received for the 2014 and 2015 BBI calls

Call	Type of action	Grant-funded projects	Public funding (€)	Total funding (€) per type of action (2014 & 2015 calls)	Allocated public funding (€)	(Public funding in 2014 & 2015 call) / (Allocated public funding)
2014	RIA	7	12 942 708	53 471 115	288 500 000	19 %
2015	RIA	11	40 528 407			
2014	DEMO	2	19 715 121	82 567 210	288 500 000	29 %
2015	DEMO	9	62 852 089			
2014	FLAGSHIP	1	16 995 882	90 737 119	335 700 000	27 %
2015	FLAGSHIP	3	73 741 237			
2015	CSA	3	2 960 575	2 960 575	33 100 000	9 %

Endnotes chapter 8

1 These figures are initial estimates and may be revised if the industry's financial contribution cannot be met.

2 These figures are initial estimates and may be revised to take account of project maturity and the industries' investment readiness.

9

APPENDICES

9.1 Main R&D&I areas to support bio-based value chains in Europe

Main technological and innovation challenges to support strategic orientation 1: Supply of sustainable biomass feedstock

1. Foster sufficient supply of sustainable biomass feedstock to feed both existing and new value chains.	
1.1 Increase biomass production by improving agricultural practices	
1.1.1	Development of higher efficiency in cultivation systems to increase yield, availability and use of forestry and agricultural biomass (in particular residues, co- and by-products) while meeting the range of other demands on arable and woodland. Reducing feedstock production costs under sustainable production methods with added-value for the complete production chain and demonstrating of value creation (economic, environmental and social) at the production/ mobilisation stage.
1.1.2	Development of concepts for reuse of fertilizer recovered from by-streams in biorefinery operations. Preferably leading to a separation of organic matter and minerals, helping to improve plant yields and soil quality and reducing waste and environmental impact of biorefineries.
1.1.3	Identifying the most appropriate crop cultivation systems to increase biomass production for specific value chains taking into account climate change, crop rotational effects, resistance to biotic and abiotic stresses, nutrient and carbon balance, water use efficiency, soil tillage practices and management needs.
1.1.4	Development of pre-transformation techniques at harvest and/or storage, in particular focusing on cost- effective concentration systems to facilitate transport and/or storage.
1.1.5	Development of agronomic solutions to maintain soil structure and fertility, reducing erosion, putting into value arable land and maximizing water use efficiency for specific areas in order to supply the biomass production for dedicated new fuels, chemicals and materials value chains.
1.1.6	Precision farming: improving soil quality, water, land use, new input management technologies (water, crop protection, animal husbandry techniques, sensor technology) for specific areas in order to increase the biomass supply for dedicated new value chains.
1.1.7	Develop regional closed loop systems in biorefinery clusters and hubs: study the use and impact of spreading safe and nutrient-rich process water from biorefineries onto fields on soil quality and productivity.

1.2 Mobilising and increasing sustainable supply	
1.2.1	New plant species or varieties: Improving composition of lignocellulose or other components for the use of plants as source of renewable materials to be used in specific value chains (e.g. more easily hydrolysable, lower lignin content, lignin with less stable bonds).
1.2.2	New plant species or varieties: Deliver specific ingredients (e.g. fatty acids, more homogeneous lipid composition, single and complex carbohydrates or protein components).
1.2.3	New plant species or varieties: Create a list of biomass genotypes (e.g., poplar, willow, miscanthus, reed canary grass) to be grown for specific new value chains.
1.2.4	Mobilisation of currently unused biomass and residues from agriculture and forest through precision equipment for harvesting and collection, while maintaining other important functions of woodland and crop land.
1.2.5	Storage: Develop technologies to improve biomass storage properties and to improve feedstock quality.
1.2.6	Logistics: Improved logistics and storage to provide a continuous supply of feedstock to specific value chains, minimise transport costs, exploitation of transport as process stage and guarantee intermediate product quality and availability.
1.2.7	Planning and managing integrated logistics chains at local and regional scale to achieve the maximum supply potential required for the value chains (also combining different transport types: road, railways and waterways).
1.2.8	Develop adequate advanced pre-treatment methods for bio-materials and residues (improved collection, sorting and pre-processing) to secure the stability of feedstock and overcome the seasonal variability of availability and quality; monitoring of supply, especially with respect to contaminants content.
1.2.9	Consider including the help of the “omics” tools and other disruptive technologies (e.g. nanotechnology) in basic experimental work to further develop marine-based bio-based industry.
1.2.10	Implement scaling-up to boost the development of new marine- value chains bringing laboratory (bench) R&I achievements to industrial size.
1.2.11	Set up an integrated, multi-product biorefineries, producing also high-value products, for an economically attractive marine-based value chain and for unlocking the full potential of the feedstock. This requires higher efficiency in the cultivation and harvesting systems, tested methods of energy efficient storage stability, recycling of process water and minimising effluent/waste water, and optimised energy- and CO_2-costs. Also, associated business models should aim to increase the total value of the biomass through sales of high, mid and low value bio-based products.

1.2.12	Seek financing for research to increase environmental protection of new marine bio-based value chains. Such research should place special emphasis on more efficient CO_2 capturing/storing devices, remote sensing technologies, etc., that use for example algae efficiency in capturing CO_2 or remove the excess of nitrogen and phosphorus emissions from agriculture and aquaculture, as well as mollusc. Also, implement demonstration of this circular and blue bioeconomy approach, with scientific documentation of the sustainable positive impacts on environmental, economic and social dimensions.
1.2.13	Identify the market opportunities for new marine bio-based products, involving the full value chain, from the extraction methods of raw compounds, through the design of suitable processing technologies to transform these compounds into high value products.
1.2.14	Develop a full map of (potentially) available lands (including abandoned land) and sites in the EU and associated new governances for spatial planning to improve the access to new sites and shorten the time to obtain a license. Also, research efforts could be focussed on standardisation protocols.
1.2.15	Improve information to the consumers/potential industry of new aquatic and marine-based value chains. Also, implement data analysis and demonstration projects to stimulate people´s confidence in new products.
1.2.16	Demonstrate the feasibility and profitability of new marine bio-based value chains and foster student vocation towards Research and Innovation in this area.
1.2.17	Provide open and transparent access to R&I publications on new marine bio-based value chains, samples and gene banks.
1.2.18	Improve and foster integration and collaboration among the actors and stakeholders potentially involved in value chains based on bio-wastes, especially of urban origin, such as institutions at different levels, waste operators, industrial subjects, consumers.

Main technological and innovation challenges to support strategic orientation 2: Innovative processing

2. Optimise efficient processing for integrated biorefineries through R&D&I.	
2.1 Primary conversion processes	
2.1.1	Efficient and cost-effective fractionation and separation technologies to simplify biomass into its basic components, such as lignin, cellulose, hemi-cellulose, minerals, oils and fatty acids, protein, starch, sugars and other carbohydrates and bioactive molecules.
2.1.2	Innovations in existing primary processes to minimise residues and obtain higher value.

2.1.3	Advanced technologies to mildly extract or separate components while preserving their functionalities and minimising the degradation of other components to enable their further valorisation.
2.1.4	Cost-efficient preparation of harvested material.
2.1.5	Ensuring flexibility on size of biorefineries while at the same time remaining price-competitive. Combining low investment costs with large regional stakeholder commitment improving market deployment with the specific advantages of local/ regional processing.
2.1.6	Technologies to improve yields of intermediates and bio-chemicals from bio-waste substrate, while optimizing the process, including energy consumption and environmental impacts control.
2.1.7	Biotechnologies to convert CO_2 - effluent from bio-waste treatments to bio-chemicals, with adequate reactivity of CO_2 at affordable conditions for sustainable utilisation of this feedstock.
2.1.8	Establish industrial symbiosis and synergies with established industrial sectors, allowing integrated biorefineries and/or interlinking industrial sites.
2.1.9	Implement a cascading biorefinery approach by extracting valuable molecules from substrates coming from sequences of bio-waste treatments (such as the secondary treatment sludge of waste water or the digestate).
2.1.10	Efficient pre-treatment technologies for the organic fraction of MSW to enhance the carbon conversion/production yields and to minimise the impacts associated with the seasonal variability of the feedstock in terms of availability and quality.
2.2 Secondary conversion processes	
2.2.1	Bio-technological
A	Investigate novel reactors designs to treat aquatic biomass, mainly micro- and macro-algae, aiming at optimising operational conditions and improving conversion or extraction yields in the target products.
B	Predict fermentation patterns in open microbial cultures converting wet bio-waste to new bio-chemicals in a cascading biorefinery approach. Design patterns to enhance the yields of intermediates and bio-chemicals from bio-waste substrates.
2.2.2	Chemo-catalytic
2.2.3	Thermo-chemical processes
2.2.4	Hybrid & consolidated processes

A	(Co-)digestion/(co-)fermentation of different feedstock sources (organic fraction of MSW, waste water sludge, agro-food waste, livestock wastes, etc.) within the processes already developed at a TRL of 5-7 (e.g. producing volatile fatty acids, light alcohols, medium-chain fatty acids, PHA/PHB, etc.), exploiting existing reactors. This would allow to penetrate the market with a larger biomass portfolio that includes bio-wastes currently un- or under-exploited, by initially integrating them with other sources.
2.2.5	Downstream processes
A	Improve separation and purification technologies to efficiently and sustainably recover or further convert identified bio-based chemicals, or to potentially recycle unconverted biomass to the previous steps, thus applying a circular and cascading biorefinery approach: this would result in a more sustainable process, in terms of economic and environmental aspects.
B	Improve the environmental protection of processes and products: investigate contamination issues as propagation of micro-pollutants from bio-waste supply to effluent; design the performance control systems to obtain robust, stable and sustainable production technologies and stable product quality; monitoring and control of contaminants in the products.

Main technological and innovation challenges to support strategic orientation 3: Innovative bio-based products for identified applications

3. Develop innovative bio-based products for identified market applications.	
3.1 New materials & products (incl. conversion and functionalisation technologies)	
3.1.1	Materials based on lignin (and bio-aromatic) chemistry.
3.1.2	Bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers.
3.1.3	High added-value biomolecules (e.g. pigments, lipids, fatty acids, proteins, antioxidant and bioactive compounds) in particular for pharmaceutical, nutraceutical and cosmetic sectors from different kind of marine biomass.
3.1.4	New (chemical) building blocks from renewable resources.
3.1.5	New functional bio-based materials and products: e.g. bio-based plastics, bio-based composites, materials based on lignin, starch, (nano-)cellulose or carbon fibres.
3.1.6	Materials based on cellulosic and hemicellulosic fibres and fibre/polymer composites.

3.1.7	Lignin-based carbon fibres and nano-cellulose fibres; this challenge should include addressing health, safety and environmental testing to allow for a shorter time-to-market. Actions addressing this challenge should refer to the OECD work on test methods and LCA methodologies for nanomaterials[7].
3.1.8	New packaging solutions derived from bio-based materials.
3.1.9	Other and different materials based on biopolymers (such as starch, polyesters from vegetable oils and sugar, chitin).
3.1.10	Biomass based oleochemistry: fatty acids conversion technologies, including chemistry and biotechnology.
3.1.11	New advanced fertilisers.
3.1.12	New high-value products (pharmaceuticals, cosmetics, chemical), in some cases directly extracted or derived from plants and other terrestrial biomass, including among others fungi associated with plants; and relevant compounds in plant-free expression systems.
3.1.13	New hygiene products derived from bio-based solutions.
3.1.14	Materials based on oils and fats from plants and animals e.g. bio-based lubricants, bio-based surfactants, bio-based solvents.
3.1.15	Recyclability concepts for bio-based materials and fibres.
3.1.16	New products design from bio-waste.
3.2 Conversion and functionalisation technologies	
3.2.1	Functionalisation and conversion technologies, including chemical catalysis, mechanical, thermal and biotechnology processes towards functionalised chemicals and products.
3.2.2	Fractionation and extraction technologies to preserve structure and activities of macromolecules of natural polymers. Advanced functionalisation technologies.
3.2.3	Biopolymer processing into products (films, fibres, packaging, structural composites for e.g. automotive, agriculture).
3.2.4	Polymerisation processes based on new bio-based monomers.

Main technological and innovation challenges to support strategic orientation 4: Market uptake

4. Create and accelerate the market-uptake of bio-based products and applications.	
4.1 New applications and market development	
4.1.1	Connect market demand with bio-based opportunities: combine required techno-economical specifications with opportunities of new bio-based chemicals and materials.
4.1.2	Increase consumer awareness on bio-based products, bio-based economy and related value chains.
4.1.3	Identify and create market applications for new bio-based products; diversification of markets of current biomass based products; networks and closer cooperation with downstream industries to better understand and serve industrial customers' and consumers' requirements.
4.1.4	Demonstrate industrial feasibility for new products, also to increase industrial confidence in the developed value chains, which is currently lacking mainly due to the wide 'Valley of Death' between research activities and market deployment of the obtained products.
4.1.5	Create combinations and synergies between fossil and bio-based materials.
4.1.6	Support policy developments and regulation amendments to foster the exploitation of current un- or under-exploited feedstock, such as bio-wastes and marine biomass, thus enlarging biomass portfolio and accelerating the efficient deployment of bioeconomy concepts and the establishment of 'new' bio-based value chains.
4.1.7	Improve procedures on standardisation as well as on licenses within the EU, to foster the creation of new and local value chains, aiming also at providing better support to integrating bioeconomy concepts within local communities.
4.1.8	Improve procedures to address the legal implications resulting from the absence of a clear pattern of liability from feedstock that could contain harmful and toxic contaminants.

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