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Annex 3 (Part 1) of the Impact Assessment

Accompanying the document

Proposal for a
COUNCIL REGULATION

on the Bio-Based Industries Joint Undertaking

{COM(2013) 496 final}
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BRIDGE Public Private Partnership
Biobased and Renewable Industries for Development and Growth in Europe

Strategic Innovation and Research Agenda (SIRA)

Disclaimer:
This document reflects the ambitions and objectives of the members of the Biobased Industries Consortium (BIC) in March 2013, and is the basis for road mapping towards the BRIDGE calls for proposals. The BRIDGE SIRA will frequently be adjusted based on technology and market developments, results obtained and ambitions of new members entering the BIC.

1. EXECUTIVE SUMMARY

The Biobased Industry Vision

The industry vision is that of a competitive, innovative and sustainable Europe leading the transition towards a **post-petroleum society** while decoupling **economic growth** from **resource depletion** and **environmental impact.**

In this vision, the Biobased Industries will optimize land use and food security through a sustainable, resource-efficient and largely waste-free utilisation of Europe's renewable raw materials for industrial processing into a wide array of biobased products:

– Advanced transportation fuels[1]
– Chemicals
– Materials
– Food ingredients and feed
– Energy

In doing so, the Biobased Industry will play an important role in spurring **sustainable growth** and boosting Europe's competitiveness by re-industrialising and **revitalising rural areas,** thus providing tens of thousands of high-skilled research, development and production jobs over the next decade.

How to realise this Vision?

At the heart of this vision, the **development of biobased value chains** will be accelerated. **New biomass supply chains** will be developed to feed new **integrated biorefineries while existing biorefineries will be brought to a new level:** to secure feedstock availability and flexibility throughout the year, with multiple inputs and multiple outputs. These developments will gradually complement and replace product streams from fossil oil and provide innovative new products and solutions and markets. The Biobased Industries play a critical role in the realisation of this vision and are already making significant investments in biorefineries.

However, critical technological, political and market challenges remain before full-scale commercialisation of the innovations can succeed and innovative solutions are brought to the market. Another fundamental challenge is the innovation "Valley of Death", from research to market. These challenges cannot be overcome by individual companies or the industry alone.
The competitiveness will be increased by reversing the currently seen trend of significant biobased economy investments in regions outside Europe where framework conditions appear to be more attractive. A long term research and innovation agenda jointly funded by public and private players can help address this challenge. This will be done by developing new value chains, de-risking investment in **demonstration projects** of innovative processes and in building first-of-its-kind **flagship plants**[2].

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[1] Biofuel from waste, residue and non-food cellulosic material, RED Article 21(2). This means that any R&D, demonstration and flagships in the PPP dedicated to biofuel production will be based on waste, residue and non-food cellulosic feedstock.

[2] Flagship plants are the first units of value chains operating at an economically viable scale

BRIDGE Public Private Partnership (PPP)

The PPP on Biobased Industries (BRIDGE PPP) is an integrated and fundamental tool under Horizon 2020 to realise the biobased industry vision. BRIDGE focuses on developing EU-based value chains and accelerating the transition to advanced feedstock for biorefineries: It will focus on:

- Building **new value chains** based on the development of sustainable biomass collection and supply systems with increased productivity, and improved utilisation of biomass feedstock (incl. co- and by-products), while unlocking utilisation and valorisation of waste and lignocellulosic biomass;

- Bringing **existing value chains to new levels**, through optimised uses of feedstock and industrial side-streams, and offering innovative added value products to the market, thus creating a market pull and reinforcing the competitiveness of EU agriculture and forest based industries;

- Bringing technology to maturity through **research and innovation**, and through upgrading and building **demonstration and flagship biorefineries** that will process the biomass into a range of **innovative biobased products**;

BRIDGE fully recognises that biomass is not an unlimited resource. It must be utilised intelligently, to ensure that additional uses of biomass do not compromise **the ability to produce food in sufficient quality and quantity**. By doing so, the PPP will ensure availability of a sustainable and secure supply of biomass **both for food and feed applications as well as for chemicals, materials, fuels and energy.**

To enable supply of additional and sufficient biomass for a biobased economy, it is critical to increase the productivity and output of biomass from European forest and agricultural land in a sustainable way and to unlock the potential of the residues and side-streams and waste. BRIDGE focuses on optimising utilisation of existing feedstock (forest and agricultural biomass) and the development of new feedstock supply chains (e.g. forest residues, agricultural lignocellulosic residues or dedicated crops), as well as industrial side streams and organic municipal waste. Providing new markets for biomass producers strengthens rural economies, and allows further development and investment in the production system. Albeit essential for the future of the biobased economy, the advanced feedstock supplies are still underdeveloped and require significant infrastructure for mobilization and logistics. The goal of BRIDGE is to address those issues by 2020 through research, demonstration of technologies and flagship plants to build efficient and cost competitive supply chains and transformation units.

Cooperation towards new biobased value chains and markets

All developments will occur in parallel and will lead to technology and competence transfer between sectors. In the short term existing value chains will drive the product development, in particular for added value products. Without biobased product market development at an early stage, there will be no market pull in Europe for the biobased economy and thus significant delay in its deployment. As new supply chains develop to 2020 and become economically viable, the biobased economy feedstock will increasingly come from lignocellulosic supply.

The PPP builds upon the strong agricultural, agro-food, forestry and pulp & paper sectors and world-leading companies in the plant breeding, biotechnology, chemistry, energy and bioprocess engineering. It also capitalizes on the vast amount of R&D investments and results, both optimising and utilizing Europe's existing pilot and demonstration facilities, and realising the required leap forward towards advanced technologies utilizing waste and lignocellulosic feedstock. But not least, BRIDGE will leverage the combined and complementary knowledge and skills of academia, research organisations, SMEs[3] and larger corporations to achieve its innovation objectives.

The Strategic Innovation and Research Agenda (SIRA)
The BRIDGE multi-annual SIRA translates the PPP ambitions into a coherent set of actions that will deliver tangible and increasingly ambitious results by 2020 and by 2030.

The SIRA includes a balanced combination of:

- **Value chain demonstration projects** aiming towards integration and deployment of technologies and R&D results into actual value chains and bringing technology close to commercial scale through upscaling in demonstration activities and flagship plants;

- **R&D projects** focused on filling the gaps in technological innovations: dedicated projects on the development of specific technologies and concepts needed to realise the value chains, and proving the principles in pilot installations;

- **Supporting projects**, addressing the cross-sectoral challenges and supporting the value chains to become reality.

The projects of the SIRA will be developed around 5 value chains, where specific deliverables will be demonstrated, ultimately leading to flagship projects.

- From lignocellulosic feedstock to advanced biofuels, biobased chemicals and biomaterials: realising the feedstock and technology base for the next generation of fuels, chemicals and materials

- The next generation forest-based value chains: utilisation of the full potential of forestry biomass by improved mobilisation and realisation of new added value products and markets

- The next generation agro-based value chains: realising the highest sustainability and added value by improved agricultural production and new added value products and markets

- Emergence of new value chains from (organic) waste: From waste problems to economic opportunities by realising sustainable technologies to convert waste into valuable products.

- The integrated energy, pulp and chemicals biorefineries: Realising sustainable bio-energy production, by backwards integration with biorefinery operations isolating higher added value components.

[3] The primary mode of participation by SMEs in PPP activities is expected to be as regular industry actors

To have competitive biobased products in the market in 2020, each step of the value chains needs to be competitive: the feedstock supply, the processing, as well as the product(s) and market (both in term of price and environmental performance). BRIDGE focuses on developing, optimizing and demonstrating this competitiveness throughout the five value chains.

2. THE LONG-TERM STRATEGIC OBJECTIVES FOR THE BIOBASED ECONOMY

BRIDGE activities reflect clearly the ambitions of industrial partners to contribute to a sustainable society on the longer term. The PPP will **trigger** further developments leading to long-term benefits: new value chains and products initiated and demonstrated by BRIDGE will come into full deployment, biorefineries will be upgraded and new flagships will be built, new biobased developments will be triggered by the PPP activities, and dedicated policy measures will be put in place.

BRIDGE will achieve concrete and significant results by 2020, yet the greatest leverage effect and commercial deployment will be reached in the period from 2020 to 2030. Thus the strategic objectives of the Biobased Economy that will be stimulated and triggered by the PPP are evaluated over two periods[4].

Table 1. OVERALL STRATEGIC OBJECTIVES FOR 2020 and 2030

- The PPP activities will help to guarantee a secure and sustainable supply of lignocellulosic biomass (incl. waste) for European biorefineries through the development of integrated and sustainable agricultural and forestry value chains;
- There is a potential to better valorise agriculture land that currently is no longer under production or is currently not under optimal use. BRIDGE aims to contribute to put **15%** of this underutilized land back into production or at least be better utilized in 2020 **(35% by 2030)**;
- Current EU biomass utilisation for food, feed and materials is **1100 Mton**. The amount of biomass used in the EU for energy and material uses is estimated to amount to **500 Mton**[5]. The PPP results will contribute to achieve **10%** increase in biomass supply in Europe by 2020 (**20% by 2030**) by increasing productivity and mobilization in sustainable manner while making best use of innovations in agriculture and forestry practices;
- Current unused by-products and wastes from various biobased sources (agriculture, forestry, waste water treatment, sludge, organic household waste, yard waste, food processing waste, debarking waste) amount to a total of 2.8 bn tons/year in the EU[6]. BRIDGE activities will stimulate the mobilisation and utilisation of these potential resources to be increased to **15%** of the total amount in 2020 (**25 %** in 2030).
- BRIDGE results will contribute to maintain and further develop a competitive and knowledge intensive rural economy in Europe based on biorefineries resulting in new, higher and more

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4 The qualitative and quantitative objectives in this table have been identified through intense discussions among all partners, and reflect business plans and expected investments. Unless otherwise stated the reference for the figures is the current situation in 2012

5 Of this, approx. 400 Mton comes from forestry and other wood sources. In 2010, 229 Mton wood was used for materials, 173 Mton for energy (*Mantau, U. et al. (2010), EUwood. Final report, 30. June 2010*). In 2008, industry used some 18.6 million tonnes of biomass (excl. wood), and the total quantity of biomass (excl. wood) used for both materials and energy use amounted to over 98 million tonnes (*Jossart, J.-M. (2009): Development of the bioenergy sector – future European demand factors, technological development and competition. EEA-JRC-UASE Workshop Biomass resource assessment for biofuels/bioenergy and competition with other biomass. Eberswalde, December 2009*). No numbers exist for EU alone, but the worldwide harvested biomass in 2008 was 13 bn tons (forestal and agricultural). Of this, 73% was used for food and feed, 11% was wood for material use, 10% wood for energy use and only approx. 3 % each was renewable raw materials for material and energy use (*Nova-Institut 2011, FAO 2011, Kausmann et al 2008*).

6 IEA Bioenergy Task 37. See also: http://www.iea-biogas.net/_download/publi-task37/Potential%20of%20Codigestion%20short%20Brosch221203.pdf, http://www.iea-biogas.net/_download/publi-task37/IEA_ABP-Brochure_en_2.pdf, http://www.iea-biogas.net/_download/publi-task37/Biogas%20upgrading.pdf, http://www.biores.eu/docs/BIOGASFUNDAMENTALS/IEA-MSWAD.pdf, http://epp.eurostat.ec.europa.eu/portal/page/portal/waste/waste_generation_management/generation

diversified revenues to farmers and cooperatives and creating up to **400.000** new skilled jobs in 2020 (**700.000 by 2030**), of which more than **80%** will be in rural and today underdeveloped areas;

- The biomass available will be fully utilized and cycles will be closed. The PPP will contribute to protein isolation and valorisation from additional biomass processing, that will result in **15%** reduced import of protein (e.g. soy) for feed in Europe in 2020 (**50% by 2030**). Currently **2300 Mton** of phosphate and **2700 Mton** of potash are consumed in the EU, most of which **(estimated 90 %)** are imported in the form of rock materials or processed rock (non-renewable resources) into the EU. Optimisation of soil fertility programmes including recovery and use of phosphate and potash, as triggered by the PPP activities, will lead to a **10%** reduced import of those components for fertilizers applied to feedstock production (**25% by 2030**);
- BRIDGE will contribute to and trigger industrial deployment of biobased chemicals, biomaterials and advanced biofuels, so that
  - **20%** of the chemicals and materials production in Europe will be biobased by 2020 (**30% to 2030**); this is compared to the current situation **10%** of chemicals and materials being biobased.
  - By 2020 at least **2%**[7] of Europe's transport energy demand will be met by sustainable advanced biofuels (**25% in 2030**, together with an overall 50% improved road transport system efficiency[8]); This is compared to the current situation of **no** advanced biofuels in European fuel mix.
  - At least 5 first-of-its-kind flagship plants will be realised to optimise technology for biomass conversion and ensure price-competitiveness for a second wave of commercial production to kick-in from 2017.
- BRIDGE will realise a new generation of biobased materials and composites, allowing the production of better-performing components for application in several industries. With this the PPP contributes to the ambition that in 2020, the market supplied by biobased polymers and composites at comparable quality-price ratio compared to the fossil alternatives will be **5** times higher than today **(factor 10 in 2030)**; increased consumer acceptance, concerted policy and labelling, awareness of biobased products as well as recycling and reuse will have an important contribution to the improved market penetration.
- Through its combined efforts the PPP will have a significant contribution to the European objective of achieving **20%** reduction in greenhouse gas emissions in 2020 (compared to 1990 levels).
- As a consequence of following the openness and excellence principles, BRIDGE intends to actively involve academia, research organisations, and SMEs[9] such that at least **15%** of the Horizon 2020 funds allocated through the PPP goes to these actors. It is expected that significant additional industry funding will go to academia, RTOs and SMEs through their participation in industry-driven demonstration activities

7 A 2% substitution of the transport fuels in 2020 with advanced ethanol would require 45 Mton of biomass.

8 ERTRAC SRA 2010

9 Should SMEs decide to participate in contract research. But it is expected that the primary mode of participation by SMEs in PPP activities will be as regular industry actors, which significantly increases the industrial SME participation.

3. THE OBJECTIVES AND ACTIVITIES OF BRIDGE PPP

The long-term strategic objectives will be achieved by the triggering of and leverage effects on the **BRIDGE direct deliverables**. This Chapter describes the BRIDGE activities, as well as the direct deliverables (**the Key Performance Indicators - KPIs**), which will be achieved if the right framework conditions can be developed.

Table 2. BRIDGE direct deliverables 2020

- **36** new cross-sector interconnections in biobased economy clusters (new bridges creating cooperation between the 9 different sectors (see figure 3);
- **At least 10** new biobased value chains (new products and feedstock);
- Realising a total industrial investment of **2.8 bn Euro** by the PPP partners in research, development and innovation via R&D projects, realised demonstration projects and flagship plants: both by building of new operations and upgrading existing and abandoned industrial sites to be converted into biorefinery operations (reindustrialisation).
- **More than 200** cooperation projects through cross-industry clusters
- The new biobased products resulting from BRIDGE will on average have an at least **50%** reduction on green house gas emission compared to their fossil alternatives.
- **10** new regional biorefinery clusters raised: biorefinery demonstrations, with regional biomass supply
- **10** conversion of existing and unused facilities into biorefineries
- At least **5** flagships resulting from BRIDGE producing new biobased materials, chemicals and fuels which have proven to become cost-competitive to the alternatives based on fossil resources (at least 1 per value chain)

BRIDGE aims at accelerating the building of biobased value chains, starting from sustainable feedstock production and mobilization towards the implementation and use of biobased materials and products (see Figure 1).

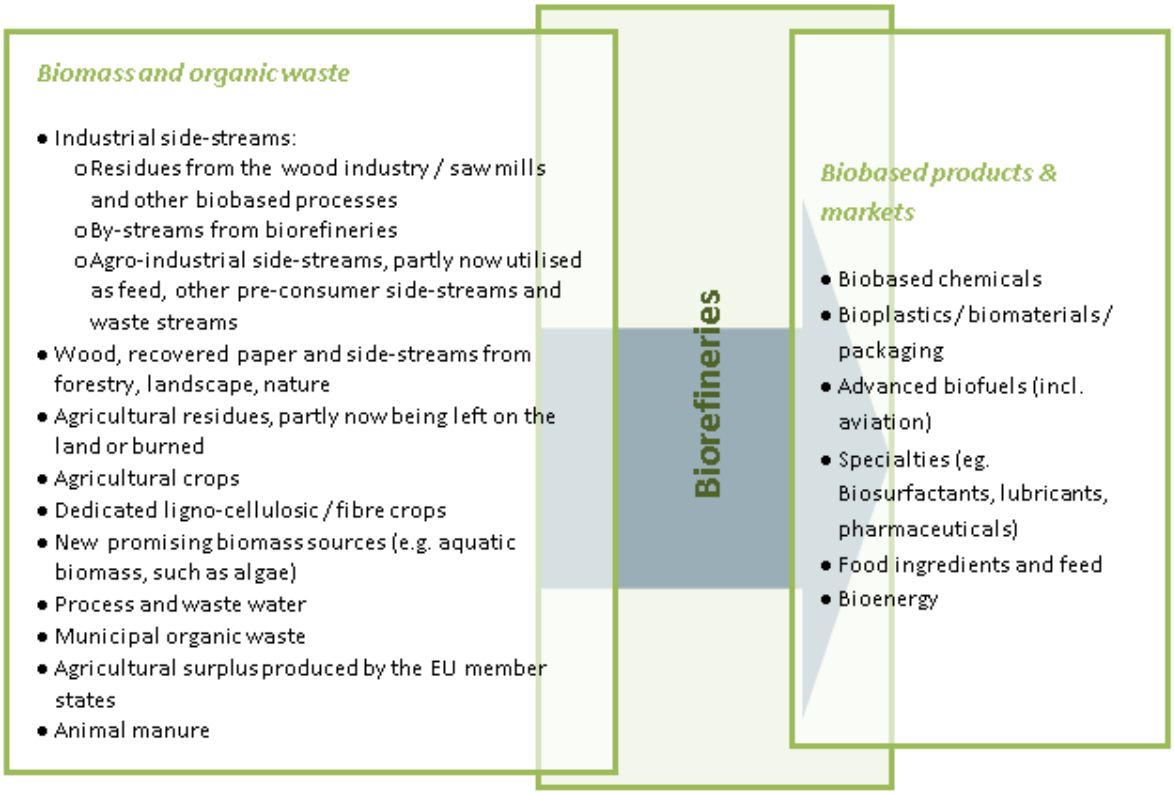

Figure 1: Biobased value chains envisioned in BRIDGE.

3.1. BRIDGE activities in the period 2014-2020

A sustainable growth of the biobased economy requires a dedicated and balanced approach addressing specific common research and innovation challenges, while integrating and demonstrating cooperation between stakeholders over different disciplines and value chains. These key challenges have been grouped into three types of projects, as follows:

- **Value chain demonstration projects** aiming towards integration and deployment of technologies and R&D results into actual value chains and bringing technology close to commercial scale through upscaling in demonstration activities and flagship projects;

- **R&D projects** focused on filling the gaps in technological innovations: dedicated projects on the development of specific technologies and concepts needed to realise the value chains, and proving the principles in pilot installations;

- **Supporting projects**, addressing the cross-cutting challenges and supporting the value chains to become reality.

Projects in BRIDGE, especially the value chain demonstration and their resulting flagship projects, will consider the **whole value chain**. To have competitive biobased products in the market in 2020, each step of the value chain needs to be competitive: the feedstock supply, the processing and the product (both in term of price and performances).

Further details about the different types of projects are presented in the following chapters.

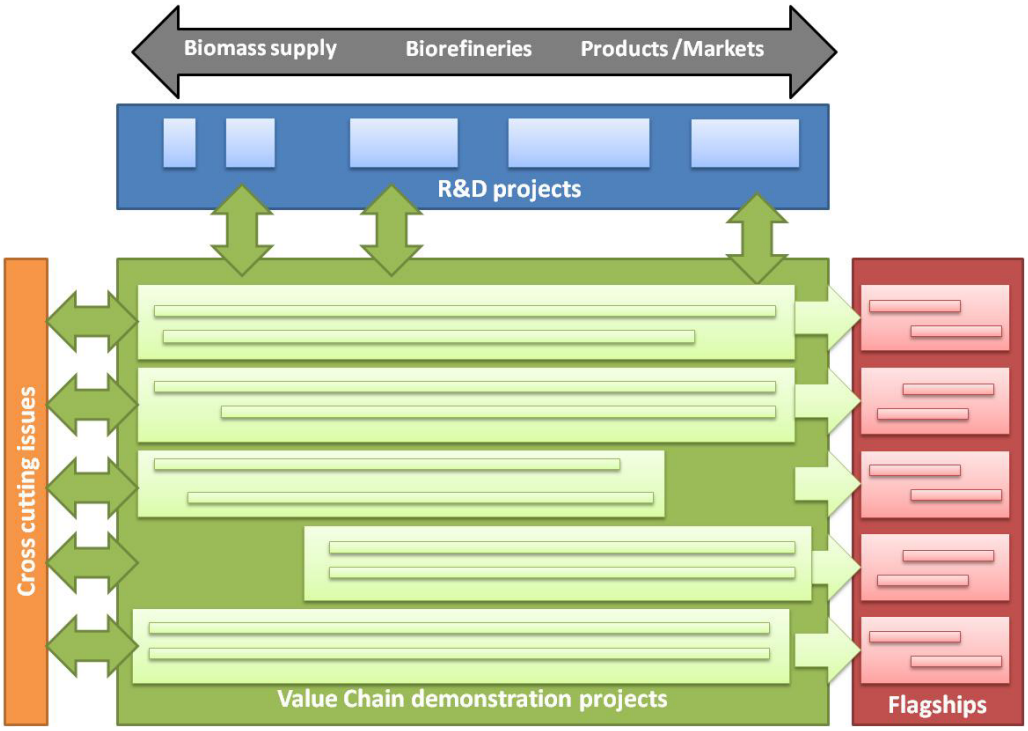

Figure 2: Overview of BRIDGE projects

Value chain demonstration projects contain mainly demonstrator activities corresponding to Technology Readiness Level (TRL) levels 4 to 6. This activities are considered as being the last non-commercial step to demonstrate 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 demo unit. Operation of such projects for the purpose of demonstration of the innovative technologies will either not generate any revenue or generate insufficient revenues to pay back capital costs and cover operating costs. The purpose of these value chain demonstration projects is to provide the backbone for subsequent flagships (demonstrator TRL 7-8 projects). The scale / maturity of demonstrators TRL 4-6 should be high enough to be able to prove technical, environmental and economical performance and provide enough data so that the technology can be realistically scaled-up to industrial size after successful operation of the demonstration.

Flagship projects mainly include Demonstrator activities corresponding to TRL levels 7-8. Flagships are the first units of value chains operating at an economically viable scale. Building and running such plants entails significantly higher costs and risks than demonstration plants because of the increased scale. They have significantly higher costs and higher risks than subsequent commercial plants which benefit from a learning curve and lower risks premium for the capital and loans funding the project.

R&D projects mainly include Research activities, which are focused on applied research to be performed based on R&D demands arising from the Value Chain demonstration projects. Applied research here refers to scientific study and research directed primarily towards a specific practical aim or objective (e.g. research that seeks for new technologies for the conversion of biomass into biobased products). These research questions arise directly from the running and foreseen demonstration activities towards actual implementation of new technologies in the innovative biobased value chains. R&D activities to be performed correspond to TRL levels 3 to 5, including validation on pilot scale.

Supporting projects mainly include Research activities, focused on solving cross-cutting issues arising from the Value Chain demonstration projects. The research activities in these projects correspond to TRL levels 3 to 5.

Table 3. Definitions of the innovation and research phases[10]

[10] Starting points are the definitions provided in the EIBI Implementation plan, as well as the TRL-definitions used by the Commission (Reference to Commission document on TRL levels). TRL 3: Analytical and experimental critical function and/or characteristic proof-of-concept; TRL 4: Technology validation in a laboratory environment; TRL 5: Technology validation in a relevant environment ; TRL 6: Technology demonstration in a relevant environment; TRL 7: Technology prototype demonstration in an operational environment ; TRL 8: Actual technology system completed and qualified through test and demonstration ; TRL 9: Actual technology system qualified through successful mission operations;

3.1.1. Value Chain demonstration projects - addressing the integration challenge

The core of BRIDGE is the realisation of new untraditional partnerships. This aims for accelerating the building of biobased value chains by the cooperation throughout and across value chains. Value chains will be well integrated to existing infrastructure, demonstrated at suitable level and fully aligned with market demand and sustainable policies. Addressing these challenges through demonstration activities will prove the viability of the new value chains thus contributing to overcome investments barriers.

The demonstration activities in the value chain projects of BRIDGE aim to provide the final proof of technological and economic feasibility of a process or product manufacturing and the necessary supply chain before moving into a commercial phase. A demonstration activity allows, for instance, to scale-up a process to industrial or near-industrial scale. Each step of the process has previously been tested and validated individually on a pilot scale. The demonstration activities focus on proving how different sub-processes can be combined using equipment available at industrial scale. Research activities within the demonstration activities focus therefore mainly on optimization of flows and cost reduction. Those research activities could be for instance testing operational conditions that have been identified before at research and pilot scale to optimize productivity, or to reduce costs. The monitoring, data collection and analysis is critical during this phase. A demonstration also aims at fine tuning the process to ensure a reproducible and constant quality of the product(s).

Wherever possible the value chain demonstration projects will make use of the existing infrastructure and available demonstration facilities for the Biobased Economy (available at the PPP partners - industry and SMEs, or open shared facilities[11]). For some of the new innovative value chains new and near-industrial scale facilities will be required. The developments in the demonstrated value chains will lead to investments in flagship plants.

The value chain demonstration projects will also reveal technological challenges that need more extensive R&D. These specific technological challenges are the basis of the calls for **R&D Projects** (See 3.1.2).
Moreover, demonstrating the value chains will require non-technological, cross-cutting challenges to be solved. This will lead to calls for specific **Supporting Projects** on cross-cutting issues (See 3.1.3). The value chains demonstration projects will lead to investments in full-scale **Flagship projects.** Each value chain area will lead to at least one flagship project. These flagships projects will cover the full value chain. They will include programmes realising feedstock supply, ensuring the market uptake, and integrating in the existing rural and industrial infrastructures.

Five main innovative biobased **value chains** have been identified, in which demonstration projects will be carried out. These value chains are built on the ambitions of the existing sectors / industries (the 'pillars') that all have biobased ambitions, though from different perspectives. The current agro- and forest biobased sectors want to strengthen their competitiveness by increasing their product portfolio and maximise the use of scraps and residues. The waste-sector aims to achieve a valuable and sustainable solution for converting waste-streams into resources. And the chemicals, materials, fuels and energy sector have ambitions to transform their current fossil-based products into new sustainable biobased

[11] E.g. Leuna, Biobase Europe Ghent, BRI platform Reims, Bioprocess Pilot Facilities Delft, facilities at RTOs, as well as company-owned pilot and demonstration facilities

products with low environmental footprint aiming for consolidation of existing markets and creation of new ones.

BRIDGE will thus strengthen the sustainability and competitiveness of all biobased industries, by strengthening the innovation pillars. This increased innovation capacity will facilitate and accelerate the emergence of new sustainable value chains building on an innovative and economically strong infrastructure: effectively building the bridges towards new value chains (Figure 3).

Figure 3: Bridging between the pillars – towards the Biobased Economy

Though starting from different feedstock and/or ambitions, all value chains aim to improve the biomass supply chains and to cooperate for the development and demonstration of new biobased chemicals, fuels, materials and products. Therefore common ambitions are set on achieving the supply chain and product deliverables:

Table 4. BRIDGE direct deliverables 2020 - Biomass Supply
• **5** to **10** new/innovative species varieties • **10%** higher mobilisation of forest biomass by innovative technologies • **10%** higher biomass yield by combining innovative cultivation methods with the regional most suitable crop rotation • Higher efficiency of fertilizer use (focus on N, P, K) by **15%** increase of harvested biomass per unit of fertilizer • **15%** increase in the water use efficiency by adapted crop rotations and management practices

Table 5. BRIDGE direct deliverables 2020 - Biobased Products
• **5** new building blocks based on biomass of European origin validated at demonstration scale, further increasing to **10** in 2030 • **10** functionalized chemicals and materials developed, with demonstration of their economic feasibility, lower environmental footprint and societal benefits • **5** successfully demonstrated concepts for valorisation of proteins from plant residues • **50** new biobased materials (eg. such as specialty fibres, plastics, composites and packaging solutions) • **30** new demonstrated 'consumer' products based on biobased chemicals and materials • **10** new biodegradable, compostable or recyclable bio based products and materials for short life application

Value chain 1

From lignocellulosic feedstock to advanced biofuels, biobased chemicals and biomaterials: realising the feedstock and technology base for the next generation of fuels, chemicals and materials.

The projects within this value chain aim at realising sustainable and efficient cascaded value chains at scale to mobilise and convert lignocellulosic feedstock into cost-competitive advanced biofuels[12] and biobased chemicals and materials. This includes new/improved profitable lignocellulosic biomass sources with a higher efficiency in the production (fertilizer, water use, logistics) and/or improved digestibility in biorefineries. This will reduce industrial waste streams and improve the environmental impact, contributing to reducing the pressure on natural resources, the European dependency on imports and increasing the development of rural livelihood. Moreover, it focuses on creating a financial incentive and better revenues for farmers and forest owners to produce and mobilise more biomass at a competitive price.

This value chain furthermore includes the demonstration of advanced technologies to hydrolyze and convert lignocellulosics in a sustainable and economic way into valuable chemical building blocks, materials, and advanced biofuels.

The value chain demonstration projects will achieve:

- Mobilizing an increasing supply by sustainably increasing productivity and mobilization of currently unused biomass and residues for agro and forest with special attention to SMEs and farmers/foresters
- Cost-efficient preparation of harvested material at farm level including suitable packaging and e.g. water extraction from the biomass to reduce transport volume and improved storage capability
- Improved logistics and storage to provide a continuous supply of feedstock
- Development and demonstration of new feedstock with higher sugar content (C6 and C5)
- Integration of lignocellulosic feedstock (e.g. agricultural residues) supply, transportation and storage into a complete biorefinery logistics concept to demonstrate economics of year-round operation
- Evaluate feedstock flexibility of lignocellulosic enzymatic conversion processes for European lignocellulosic biomasses (available agricultural residues, wood residues, energy crops) at demonstration scale
- Demonstration of cost-effective fractionation, separation and purification technologies for lignocellulosic biomass into its basic components, such as lignin, cellulose, hemi-cellulose, sugars and other carbohydrates
- Development and demonstration of low-cost integrated bioreactors in order to reduce the investment needed for the production of biofuels and biochemicals.
- Separation and purification technologies for high quality (low cost) sugar streams for chemicals and fuels
- Development and testing of robust enzyme cocktails for (ligno-cellulosic) biomass conversion for improved performance and cost price reduction
- Demonstrate innovative biotechnological, biocatalytic and catalytic routes to obtain building blocks and chemicals from cellulosic sugars (C5 and C6), to convert ethanol into butanol, and to produce ethanol and butanol derivatives
- Production of biobased advanced fuels and materials via innovative advanced technologies

[12] biofuels include road transport fuel and aviation jet fuel

- Improving the overall conversion yield from the lignocellulosic feedstock into biochemicals and biofuels
- Demonstrate processes for transforming lignin into high(er) value products, such as hydrocarbons, biomolecules, aromatic platform chemicals, resins, additives, new materials and composites
- Demonstrate production of derivative products from ethanol and other fermentation products (e.g. ethylene, ethylene oxide, butanol derivatives, jet fuels)
- Demonstrate processes that decrease Capex and / or Opex and increase the overall process sustainability of processes based on lignocellulosic feedstock
- Demonstrate the economics of combined production of biofuels and bio-based chemicals from lignocellulosic feedstock at large scale
- Demonstrate the added value of integration of existing chemical and catalytic conversion technologies into production processes based on lignocellulosic feedstock
- Polymerisation processes based on new biobased monomers, biopolymer processing into products (films, fibres, packaging, structural composites for e.g. automotive, agriculture) and demonstration of routes to replace specific fossil-based polymers
- Demonstration of new value chains leading to consumer products
- Increase consumer awareness on biobased products and biobased economy.
- Identify and create market applications for new biobased 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
- Demonstrate industrial feasibility for new products.

The value chain demonstration projects will also reveal technological challenges that need more extensive R&D. These specific technological challenges are the basis of the calls for **R&D Projects** (see section 3.1.2 for the description behind the topics):

R&D project topics
1.1.1; 1.1.4; 1.2.1; 1.2.3; 1.2.4; 1.2.5; 1.2.6; 1.2.7; 2.1.1; 2.1.2; 2.1.3; 2.1.4; 2.2.1; 2.2.2; 2.2.4; 2.2.5; 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; 3.3.5

Moreover, demonstrating the value chains will require non-technological, cross-cutting challenges to be solved. This will lead to calls for specific **Supporting Projects** on cross-cutting issues (See 3.1.3).

The value chains demonstration projects will lead to investments in full-scale **Flagship projects.** This value chain will lead to at least flagship project. These flagships projects will cover the full value chain. They will include programmes realising feedstock supply, ensuring the market uptake, and integrating in the existing rural and industrial infrastructures. See below an example of one of the possible flagship projects to be realised within value chain nr 1.

Value chain Flagship Example
A flagship for advanced biofuels using 400.000 dry tons of straw could produce biofuels and biochemicals (ethanol, butanol, polyols, diols) and energy

Value chain 2

The next generation forest-based value chains: utilisation of the full potential of forestry biomass by improved mobilisation and realisation of new added-value products and markets.

Projects within this value chain are built on the current sustainable practice of forestry and its processing value chain (e.g. the pulp and paper industry). The ambition of this sector is to increase the product portfolio and to create new markets in addition to the current products. Technologies and applications will be developed based on their current raw materials and the residues and side streams.
This will be achieved by creating more added-value products from the current feedstock base: by increasing feedstock mobilisation (forest residues), and improved utilization of side and waste streams. For this, innovative and efficient technologies will be implemented, new innovative products developed and co-products, side-streams and residues valorised. This improves the competitiveness of the European forest-based value chains while reducing the pressure on biomass resources by producing more and better from less, and thus developing rural livelihood.
The biobased products from this value chain help to mitigate climate change by realising the replacement of fossil-based materials by biobased materials with a positive social impact and lower environmental footprint. This will fulfil market and consumer demand and create new markets by demonstrating routes and concepts for new and innovative materials into new products.

<u>The value chain demonstration projects will achieve:</u>

- Mobilizing an increasing supply by increasing productivity and mobilization of forest biomass and residues in sustainable manner while making best use of innovations in forestry practices
- Biostimulants that enhance forestry output increasing the nutrient use efficiency
- Innovative tree species that can provide biomass to the biorefinery with sustainable management practices
- Development and demonstration of cost-effective fractionation, separation and purification technologies for wood
- Development and demonstration of new functional biobased chemicals and materials from side streams and residues from forestry and pulp and paper mills (e.g. based on lignin, cellulose, or e.g. hemicelluloses)
- Demonstration of new processes (biological, chemical, and combination thereof) at scale, for added value products, and in particular their economic viability and environmental benefits
- Integration of new biobased additives and formulation for high performance products / in cooperation with converters, formulators and users
- Demonstration of new and more efficient production concepts for specialty and performance chemicals (e.g. biosurfactants, emulsifiers, pigments, lubricants, specialty polymers, additives, etc.)
- Develop adequate advanced recycling methods for bio-materials and residues (improved collection, sorting and processing)
- Replacement of petrochemical specialties / performance chemicals such as stabilizers, emulsifiers, chelants, surfactants, solvents, thickeners, lubricants, antioxidants, pigments, etc. with bio-based counterparts

- Develop and demonstrate new functional biobased materials: e.g. bioplastics, biocomposites, materials based on lignin, starch, (nano-)cellulose or carbon fibre: towards fit-for-purpose solutions for diverse industrial customers
- Formulation of new materials into end-user products and demonstration of new value chains leading to consumer products with higher bio-content, improved ecoefficiency and/or improved performance at the production and customer side (films, fibres, packaging, structural composites for e.g. automotive, construction)
- Application testing and demonstration of the industrial feasibility of new products.
- Increase consumer awareness on biobased products and biobased economy.
- Identify and create market applications for new biobased 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

The value chain demonstration projects will also reveal technological challenges that need more extensive R&D. These specific technological challenges are the basis of the calls for **R&D Projects** (see section 3.1.2 for the description behind the topics):

R&D project topics
1.1.1; 1.2.7; 1.2.8; 2.1.1; 2.1.2; 2.1.4; 2.2.1; 2.2.3; 2.2.4; 2.2.5; 3.1.1; 3.1.2; 3.1.3; 3.1.4; 3.1.5; 3.1.6; 3.1.8; 3.1.9; 3.1.11; 3.1.13; 3.1.15; 3.2.2; 3.2.3; 3.3.1; 3.3.2; 3.3.3; 3.3.4; 3.3.5

Moreover, demonstrating the value chains will require non-technological, cross-cutting challenges to be solved. This will lead to calls for specific **Supporting Projects** on cross-cutting issues (See 3.1.3).

The value chains demonstration projects will lead to investments in full-scale **Flagship projects.** This value chain will lead to at least one flagship project. This flagship project will cover the full value chain. They will include programmes realising feedstock supply, ensuring the market uptake, and integrating in the existing rural and industrial infrastructures. See below an example of one of the possible flagship projects to be realised within value chain nr 2.

Value chain Flagship Example
A flagship converting a pulp mill into a multiproduct forest-based biorefinery producing new biobased products. Production of innovative pulp fibres for textiles at a volume of 200.000 ton/y from wood, coproducing new biobased products, e.g. biocomposites and biopolymers at 20.000 ton/y

Value chain 3

The next generation agro-based value chains: realising the highest sustainability and added value by improved agricultural production and new added value products and markets.

Projects within this value chain build on the current sustainable practice of agriculture (incl. horticulture, and fertilizer companies) and its processing value chain (e.g. agro-food industry). The ambition of this sector is to increase and broaden the product portfolio and create new bio-based markets on top of the current products. Technologies and applications will be developed based on the current raw materials and increase the use of their residues and side streams. This strengthens the competitiveness of the existing value chains thereby securing the production of their primary products and increasing the added value of industry in rural environment.

This will be achieved by creating more added value products from the current feedstock base through increasing feedstock production and flexibility, improved utilization of side streams and mobilising residues. Moreover new and improved profitable crops with a higher efficiency in the production (regarding fertilizer and water use, logistics) will reduce industrial waste streams and improve the environmental impact. For the existing and new crops, innovative and efficient technologies for growing, harvesting and logistics will be implemented, new innovative products developed and co-products, side-streams and residues valorised. Moreover, for specific value chains an innovative range of inputs will become available enhancing agricultural productivity whilst not threatening the environment. New plant protection products (biocides, biocontrol, …) and plant nutrition products (biostimulants, high -efficiency fertilizers) will be obtained under this value chain. This improves the competitiveness of the European agricultural value chains while reducing the pressure on biomass resources by improved utilisation of by-products and side streams. Moreover, it will create a more competitive European farming sector, thus especially developing rural areas.

The biobased products from this value chain help to mitigate climate change by realising the replacement of fossil-based materials by biobased materials with a positive social impact and lower environmental footprint. This will fulfil market and consumer demand and create new markets by demonstrating routes and concepts for new and innovative materials into new products.

<u>The value chain demonstration projects will achieve:</u>

- Mobilizing an increasing supply by increasing productivity and mobilization in sustainable manner while making best use of innovations in agriculture practices (eg. By improved soil structure and fertility, innovative crop and plant species)
- New plant species or varieties: Deliver specific ingredients for the new value chains (e.g. fatty acids, more homogeneous lipid composition, single and complex carbohydrates or protein components)
- Cost-efficient preparation of harvested material: introduction of innovative technologies and machinery that reduce pre & post-harvest losses and prepare the biomass in the best possible way.
- Demonstration of technologies that recover minerals (such as phosphate) from agricultural, agro-industrial and dairy farming residues, convert them into fertilizers and prove new fertilizer concepts by eg. field trials

- Demonstration of valorisation concepts of co-products and side-streams (proteins, pulp, fibres) from agro-food industry towards higher added-value products including feed and food ingredients, including efficient and cost-effective fractionation, separation purification technologies to simplify biomass into its basic components, mildly extract or separate components while preserving their functionalities (eg. Functional proteins)
- Demonstration of production concepts that specifically use a combination of various biomass feedstocks thereby increasing the diversity and functionality of products
- Integration of new biobased additives and formulation for high performance products / in cooperation with converters, formulators and users
- Demonstration of new and more efficient production concepts for specialty and performance chemicals (e.g. biosurfactants, bioplastics ,emulsifiers, pigments, lubricants, specialty polymers, additives, etc.)
- Replacement of fossil-based plasticizers and flame retardants with biobased (superior) alternatives
- Introduction of new biobased molecules: platform chemicals and polymers going towards 100% biobased solutions, providing alternatives and new solutions to fossil-based chemicals and materials, which should be competitive in the market place and demonstrate environmental benefits (through Life Cycle Assessment)
- Develop and demonstrate new functional biobased materials: e.g. bioplastics, biocomposites, materials based on lignin, starch, (nano-)cellulose or carbon fibre: towards fit-for-purpose solutions for diverse industrial customers
- Formulation of new functional biobased materials into end-user products and demonstration of new value chains leading to consumer products with higher bio-content, improved eco-efficiency and/or improved performance at the production and customer side (films, fibres, packaging, structural composites for e.g. automotive, construction, infrastructure)
- Application testing and demonstration of the industrial feasibility of new products.
- Demonstration of new biodegradable, compostable or recyclable materials and products and development of adequate advanced recycling methods for bio-materials and residues (improved collection, sorting and processing)
- Establishing stronger links and better understanding of the needs (quality, performance) of downstream industries
- Increase consumer awareness on biobased products and biobased economy.
- Identify and create market applications for new biobased 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

The value chain demonstration projects will also reveal technological challenges that need more extensive R&D. These specific technological challenges are the basis of the calls for **R&D Projects** (see section 3.1.2 for the description behind the topics):

R&D project topics
1.1.1; 1.1.2; 1.1.5; 1.1.6; 1.1.7; 1.2.7; 1.2.8; 1.2.2; 2.1.1; 2.1.2; 2.1.4; 2.1.5; 2.2.1; 2.2.2; 2.2.3; 2.2.4; 2.2.5; 3.1.1; 3.1.2; 3.1.3; 3.1.4; 3.1.5; 3.1.6; 3.1.8; 3.1.9; 3.1.11; 3.1.13; 3.1.15; 3.2.2; 3.2.3; 3.3.1; 3.3.2; 3.3.3; 3.3.4; 3.3.5

Moreover, demonstrating the value chains will require non-technological, cross-cutting challenges to be solved. This will lead to calls for specific **Supporting Projects** on cross-cutting issues (See 3.1.3).

The value chains demonstration projects will lead to investments in full-scale **Flagship projects.** This value chain will lead to at least one flagship project. This flagship project will cover the full value chain. They will include programmes realising feedstock supply, ensuring the market uptake, and integrating in the existing rural and industrial infrastructures. See below an example of one of the possible flagship projects to be realised within value chain nr 3.

Value chain Flagship Example
A flagship processing agricultural green or lignocellulosic residues (beet leaves, grass, …) and surplus into 100.000 ton/y of proteins, and valuable chemicals and materials, like dicarboxylic acids

Value chain 4

Emergence of new value chains from (organic) waste: From waste problems to economic opportunities by realising sustainable technologies to convert waste into valuable products.

Projects within this value chain aim to develop and demonstrate value chains based on currently unused by-streams and waste from various biobased sources (agriculture, forestry, waste water treatment, sludge, organic household waste, yard waste, food processing waste, debarking waste). Realising cost competitive value chains producing added-value products will create solutions for the environmental problem of increasing waste flows (partly due to urbanisation), reducing pressure on virgin resources, and increasing the competiveness of industry.
Energy, fuels and building blocks produced from this value chain help in mitigating climate change by realising the replacement of fossil-based solutions with alternatives with a positive social impact and lower environmental footprint.

The value chain demonstration projects will achieve:

- Cost-efficient preparation of heterogeneous waste material, e.g. through e.g. separation technologies for the biogenic part of municipal solid waste (MSW), or thermocatalytical processes (gasification, torrefaction or pyrolysis)
- Modification of the pretreatment conditions to make the cellulose from (MSW) accessible to the enzymes.
- Adaptation of existing technologies to alternative feedstock, like the organic fraction of urban waste.
- Development and demonstration of new enzymes that can hydrolyse the cellulose fraction of MSW to sugars with improved yield, from which biofuels, building blocks and bioproducts can be obtained using different biological and chemical routes.
- Organic waste (agro-food residues and MSW) bioconversion to added value molecules using microorganisms and also higher organisms (e.g. insects)
- Development and demonstration of processes based on bark and other “wastes / sidestreams" from existing industrial uses of biomass as feedstock for high value biobased chemicals and biomolecules.
- Implement adequate advanced recycling methods for bio-materials and residues (improved collection, sorting and processing);

The value chain demonstration projects will also reveal technological challenges that need more extensive R&D. These specific technological challenges are the basis of the calls for **R&D Projects** (see section 3.1.2 for the description behind the topics):

R&D project topics
2.2.1; 2.2.3; 2.2.4; 2.2.5; 3.1.3;

Moreover, demonstrating the value chains will require non-technological, cross-cutting challenges to be solved. This will lead to calls for specific **Supporting Projects** on cross-cutting issues (See 3.1.3).

The value chains demonstration projects will lead to investments in full-scale **Flagship projects.** This value chain will lead to at least one flagship project. This flagship project will cover the full value chain. They will include programmes realising feedstock supply, ensuring the market uptake, and integrating in the existing rural and industrial infrastructures. See

below an example of one of the possible flagship projects to be realised within value chain nr 4.

Value chain Flagship Example
A flagship that Converts 400 000 tons of straw, 650,000 tons of manure and 50.000 tons of municipal solid waste into 73 million litres of bioethanol and about 99 million cubic meters of biogas (of which 76 million cubic metres of biogas will be upgraded and fed into the natural gas grid). In addition, district heating for approx. 10-20 000 households and electricity equivalent to 15-25,000 households' consumption will be produced.