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Boosting European Citizens' Knowledge and Awareness
of Bio-Economy Research and Innovation

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Bioeconomy mapping report

An overview of the bioeconomy

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Introduction

This deliverable is meant to give a starting point for BLOOM project to develop and disseminate implementation of the bioeconomy to European stakeholders, and develop regional hubs, by creating an overview of relevant issues in the bioeconomy. This deliverable contains 5 chapters:

1. Framework of the bioeconomy: Problem statement and perspective
2. A generalised technical overview of the bioeconomy
3. Framework of Concepts for transition
4. (Inter)national policies relevant to the bioeconomy
5. Ethical issues

The first chapter gives the reader the context in which the bioeconomy exists, and the problems that may arise in further implementing the biobased economy. This includes an overview of possible scenarios, when the bioeconomy is or is not adopted. In the second chapter, a schematic overview of the bioeconomy is shown, describing feedstocks, processes and products. This overview will be used further to describe activities in BLOOM hubs, and produce hub-specific dissemination material, to support implementation of the bioeconomy. The third chapter describes 6 concepts that have to be made operational to overcome organizational, economical and societal challenges. The fourth chapter gives an overview of policies that have been adopted by the UN, EU and national/regional stakeholders. In the fifth chapter overarching ethical issues are described that are not related a specific hub, but to implementation of the bioeconomy in general. Chapter three, four and five will support the BLOOM dialogue, among which the co-creation workshops.

1. General framework: Bioeconomy and biobased economy in a nutshell, the problem and perspectives

1.1. Bioeconomy

The bioeconomy includes all biomass related applications and valorization routes, including human food and animal feed. There are multiple definitions in circulation: "A bioeconomy can be defined as an economy where the basic building blocks for materials, chemicals and energy are derived from renewable biological resources (McKinsey, 2013)". The biobased economy is the part of the broader bioeconomy focussing on the transition from the use of fossil fuel to renewable biomass use in non-food applications. On their website[1] the EU defines bioeconomy as: "The bioeconomy comprises those parts of the economy that use renewable biological resources from land and sea – such as crops, forests, fish, animals and micro-organisms – to produce food, materials and energy."

On the same website the EU also addresses the goals for a Bioeconomy Strategy:

"Europe is setting course for a resource-efficient and sustainable economy. The goal is a more innovative and low-emissions economy, reconciling demands for sustainable agriculture and fisheries, food security, and the sustainable use of renewable biological resources for industrial purposes, while ensuring biodiversity and environmental protection.
To achieve this, the European Commission has set a Bioeconomy Strategy and action plan which focuses on three key aspects:

- developing new technologies and processes for the bioeconomy;
- developing markets and competitiveness in bioeconomy sectors;
- pushing policymakers and stakeholders to work more closely together.

In his Agenda for Jobs, Growth, Fairness and Democratic Change, President Juncker identified 10 key priorities for the European Commission. The bioeconomy is central to three of them:

- **A New Boost for Jobs, Growth and Investment**
  The innovative bioeconomy is an important source of new jobs – especially at local and regional level, and in rural and coastal areas – and there are big opportunities for the growth of new markets, for example in bio-fuels, food and bio-based products.

- **A Resilient Energy Union with a Forward-Looking Climate Change Policy**
  Europe needs to diversify its sources of energy and can support breakthroughs in

[1] https://ec.europa.eu/research/bioeconomy/index.cfm

low-carbon technologies with coordinated research. Replacing fossil raw materials with biological resources is an indispensable component of a forward-looking climate change policy.

- **A Deeper and Fairer Internal Market with a Strengthened Industrial Base** Innovative bio-based and food industries will contribute in raising the share of industry in GDP from 16% to 20% and to creating a circular, resource-efficient economy. The food and drink industry is already the largest manufacturing sector in the EU.

In addition, marine issues and food security are two aspects of the bioeconomy where Europe can and should lead the global agenda as part of President Juncker's strategy to make the EU a stronger global actor."

The climate challenge is the foremost reason why bioeconomy gains attention. The biobased economy contributes to resolving climate change with various techniques, ranging from very simple such as re-using a waste stream from one process as feedstock in another, to very complex like building new materials such as bioplastics from fractions (or components) of the original biomass. The aim is always to maximize the efficiency of material flows, especially of carbon. In the production process and during transport of various products carbon is burned to meet the energy requirements, and those requirements vary with the products and the applied techniques. Carbon can be captured in constructions based on biomass fibres such as wood for a long time and even at its end of life the wood can serve as fuel to offset fossil fuel. A specific biomass feedstock can be used to produce many different products if it is decomposed and refined. The total amount of carbon used in specific processes and products, i.e. the carbon footprint, can be estimated with so-called lifecycle assessments (LCA) for which comprehensive lifecycle inventories (LCI) databases already exists (Durlinger et al, 2017).

An economy founded on biomass instead of fossil fuels represents a significant shift in socio-economic, agricultural, energy and technical systems. Regions and countries need better information and participation of the general public, including all potential stakeholders in existing and new/modified value chains (farmers, SMEs, consumers, consumer associations, environmental NGOs, media, waste collectors and convertors, citizens, schools and public services etc.). Raising the awareness on the positive effects of the bioeconomy and a circular economy is an important goal in several projects and/or strategies. In order to promote new and more bio-based products, it is necessary to generate understanding, social acceptance and support among the general public and to assure quality and availability of the new products. A lack of popularisation of RDI activities in the region and science communication with the general public is thus leading to insufficient awareness of the population (and businesses) of the region and elsewhere.

1.2. Problem and perspective

Figure 1 presents an overview of the domain in which the biobased economy operates. The main reason why the biobased economy is so high on the agenda nowadays is because existing practices contribute to serious climate problems. Continuation of fossil fuel extraction brings more and more carbon in the atmosphere which works as the well-known greenhouse gas blanket. Up until now it has been proven unfeasible to bring back the carbon (at least in large quantities) to the deep earth layers where it came from. The IPCC is concerned that without adequate action earth temperatures will rise with more than 2 degrees Celsius by the year 2050 posing numerous threats to the living environments. The climate problem has to be seen as a so-called grand challenge, recognized by the EU (Esir, 2017) and most other nations in the Paris agreement.

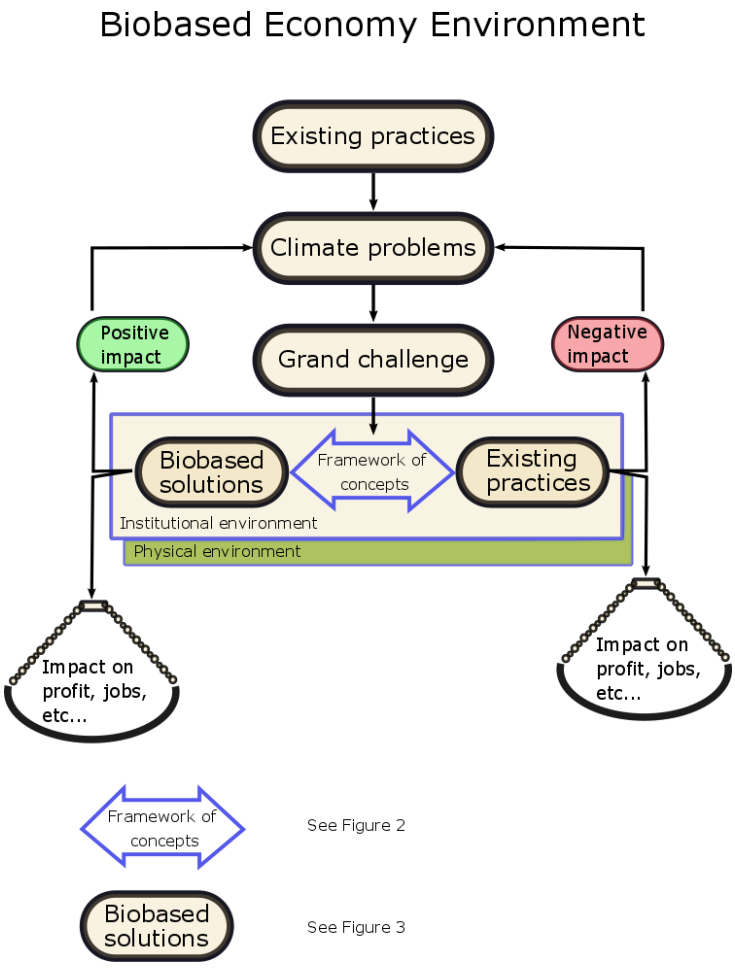

Figure 1 Overview of the Biobased economy environment (Raymond Schrijver, Remco Kranendonk, WEnR)

While the climate issue constitutes a major problem, there are many other good reasons to reconsider the use of biomass and the way in which it is produced and transported to consumers, including environmental protection and social inclusion as mentioned by Juncker in the key priorities.

In order to prevent worst case scenarios from happening (in all scenarios there is considerable damage anyway, and therefore calling for adaptation strategies) there are basically three alternative routes for climate mitigation.

1. Prevent further use of fossil fuel
2. Carbon Capture Storage to deep earth layers (CCS)
3. Enhance the carbon cycle and capture more carbon in the living biosphere (including living organisms in the top-soil layer) and in the Soil Organic Matter pool) e.g. greenhouses to combat greenhouse gases (In greenhouses up to 16 t/ha/yr C can be captured)

The biobased economy mainly focuses on the first strategy, i.e. to replace the use of fossil fuels in combustion and for materials production with renewable biomass. The potential role of the biobased economy in this strategy is substantial. According to a recent Dutch study on creating 'negative emissions' (Strengers et al, 2018), 17 to 19% of the technical potential and more than 30% of the realistic practical potential to create negative emissions in the Netherlands by the year 2050 can be allocated towards the biobased economy (chemical and the green concrete routes).

However, when applying this strategy, the innovative biobased solutions compete with existing practices. Obviously the biobased solutions perform better on climate related issues than the existing practices; otherwise they would not be accepted as solutions. But climate change is not the only impact at stake, there can be numerous other impacts on other relevant issues for the bioeconomy stakeholders, for instance on jobs or on profit for shareholders. The climate gain of the biobased solution is weighed against the impacts of other changes by the stakeholders. This involves complex social processes which are addressed by a framework of concepts.

2. General overview of the bioeconomy

This chapter gives an overview of the resources, processes and products that are produced in the bioeconomy. It aims to be generic and fully inclusive. For each European region, and the regional hubs as defined in the BLOOM project, different aspects of this overview will be relevant. During BLOOM, the bioeconomy overview for each hub will be defined in further detail, to facilitate tailor-made dissemination per hub. This gives BLOOM a tool to show where the hubs strength lies, what and how to communicate to stakeholders, and where they may develop their bioeconomy further.

Figure 2 describes the carbon flows through the bioeconomy, starting in the centre with photosynthesis. It contains Biorefineries (yellow blocks), where incoming streams are separated into multiple other streams, and factories where incoming streams are converted to (intermediate) products (purple blocks). In grey, intermediate and end products are defined. These processes and products are explained in more detail in subchapter 3.1. The arrows describe streams of feedstocks, intermediate products, products and residues. A detailed description is shown in subchapter 3.2. This figure shows the entire bioeconomy – on the left side a food factory, where food and feed production and their recycling are included. The biobased economy is shown at the top part of the figure, at the non-food factory. The value chains start with growing biomass from sunlight and CO_2 through photosynthesis. The next step is fractionation and conversion within refineries, and further processing and valorization in biobased products in non-food industries. Certain products, especially chemicals and materials, can be reused; eventually, all products are combusted into energy and CO_2, where the cycle restarts.

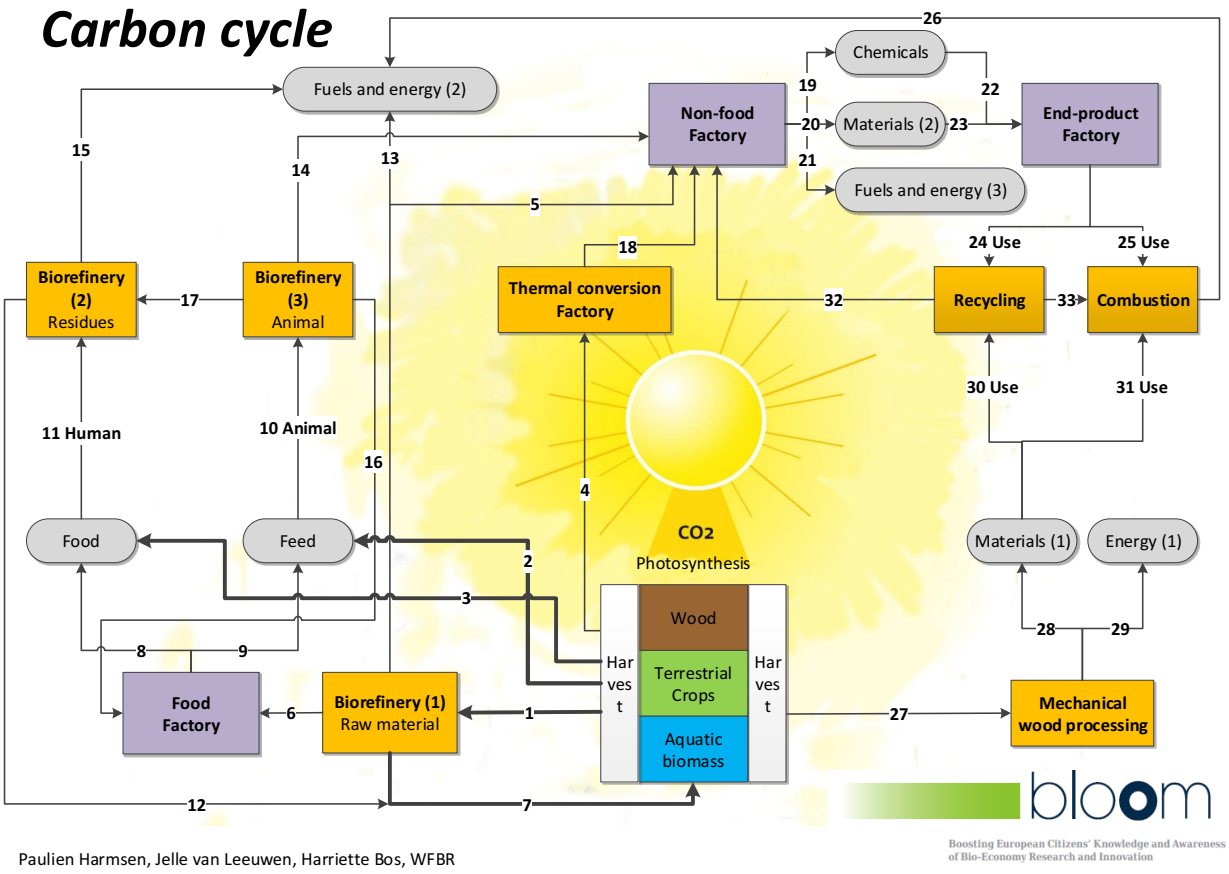

Figure 2 General overview of the bioeconomy

2.1. Description of processes

This subchapter explains the processing steps that occur in the biobased value chains (shown as yellow, purple and grey blocks in Figure 2). Descriptions are short and general, to include the entire bioeconomy.

Photosynthesis

Photosynthesis is a process used by plants and other organisms to convert light energy into chemical energy that can later be released to fuel the organisms' activities (energy transformation). This chemical energy is stored in carbohydrate molecules, such as sugars, which are synthesized from carbon dioxide and water.
For related topic see: http://edepot.wur.nl/353079

Wood

Woody biomass like logs, branches etc.

Terrestrial crops

Mainly agricultural crops like corn, wheat, potatoes, sugar beets, olives, grapes etc. For further reading, see http://edepot.wur.nl/291817

Aquatic biomass
Microalgae, macroalgae, and fresh water plants

Harvest
Harvesting of biomass, often combined with mechanical separation.

Biorefinery (1) raw material
In the first biorefinery harvested biomass is separated into several (intermediate) products for applications in food (**arrow 6**, e.g. starches, oils, flour) and non-food (**arrow 5**, e.g. starches, paper pulp, sugars, oils). Part of the biomass returns back to agricultural land as fertilizer (**arrow 7**). This Biorefinery includes also a papermill producing pulp and lignin for energy purposes.

Biorefinery (2) residues
Processing of used cooking oils into biodiesel and human-based sources ((e.g. GFT, faeces) in composting installations and wastewater treatments) and animal-based sources (manure) to Energy (2) (**arrow 15**) and back to land (**arrow 12**) as soil improvement and fertilizer.

Biorefinery (3) animal
Processing of animal-based sources for food (**arrow 16**, e.g. milk, meat, gelatine) and non-food applications (**arrow 14**, e.g. tallow, skins, bone meal). Residues and manure to **Biorefinery (2) residues**.

Thermal conversion factory
Processing of whole biomass to produce inputs for the **Non-food Factory.** Processes include combustion (heat and electricity), gasification (heat, electricity, syngas, SNG), pyrolysis (biochar and pyrolysis oil), torrefaction (biomass pellets for combustion).

Recycling
Recycling facilities for conversion of used end-products to new raw materials for non-food factory (e.g. paper, plastic bottles, textiles) (arrow 32).

Combustion
All product streams not suitable for recycling (arrows 25 and 33) go to combustion to generate heat and electricity (arrow 26)

Mechanical wood processing
Processing of wood by sawing to mainly beams, planks and sawdust.

Food factory
Processing of intermediate biomass components into food (main output) and feed (residual stream) end-products.

Non-food factory
Conversion of all kinds of biomass components to multiple non-food products. Chemical, biochemical and mechanical processes.

End-product factory
Production of end products (textiles, building materials, plastics, furniture etc)

2.2. Explanation of flows

Table 1 gives a concise overview of the (intermediate) product and residue streams that are shown as arrows in Figure 2. Streams are defined broadly, as to contain the entire bioeconomy.

Table 1: Explanation of streams in Figure 3, describing the bioeconomy

Arrow nr.	Description
1	Whole biomass transported to **Biorefinery (1) Raw material** for further processing
2	Harvested crops for feed (e.g. maize)
3	Harvested crops for food, ready to eat like vegetables, fruit.
4	Harvested biomass for thermal conversion as feedstock for non-food factory
5	Biomass components (e.g. starch, oil, cellulose (pulp), lignin, sugars) from **Refinery (1) raw material** to be converted to non-food products (chemicals, materials, fuels and energy).
6	Intermediates for **Food Factory** (e.g. starches, oils, flour)
7	Residual streams from **Biorefinery (1) Raw material** going back to the land as soil improver or fertilizer.
8	Processed food products for human consumption
9	Residual streams coming from the food industry for feed applications (e.g. brewers spent grain, beet pulp)
10	Animal products (e.g. milk, meat, bones, skins, manure) as input for **Biorefinery (3) animal**
11	Used cooking oil, Human waste and GFT to **Biorefinery (2) residues**
12	Digestate and compost back to land
13	Electricity and heat produced from residues that are not suitable for other applications **Biorefinery (1) Raw material**.
14	Animal-based feedstocks (tallow, skins, bone meal) to **Non-food Factory**
15	Electricity and heat produced from residues that are not suitable for other applications, biodiesel produced from used cooking oil **Biorefinery (2) Residues**
16	Animal-based products to **Food Factory** like milk, meat, bones for gelatin.
17	Manure to **Biorefinery (2) Residues**
18	Pyrolysis oil to **Non-food Factory**

19	Green chemicals (chemical building blocks) produced in **Non-food Factory** (e.g. lactic acid, succinic acid etc). For further reading, see https://onlinelibrary.wiley.com/doi/abs/10.1002/bbb.1468
20	Green chemicals and polymeric materials produced in **Non-food Factory** for material production
21	Residues from **Non-food Factory** for energy applications (heat and electricity) and biofuels produced by chemical and biochemical (fermentation) technologies from mainly sugars and vegetable oils.
22	Chemicals to **End-product Factory**
23	Materials to **End-product Factory**
24	End-products suitable for recycling
25	End-products not suitable for recycling and to be converted by combustion to electricity and heat
26	Energy (electricity and heat) from combustion of end-products
27	Wood from forestry to **Mechanical wood processing**
28	Products from **Mechanical wood processing** like beams and planks for furniture, building materials, construction materials.
29	Residues from **Mechanical wood processing** to be converted to electricity and heat
30	Wood-based materials suitable for recycling to e.g. materials, or board applications.
31	Wood-based materials after use for **Combustion** to electricity and heat
32	Recycled resources (chemical building blocks and/or materials) as input for **Non-Food Factory**
33	Residues from recycling for **Combustion** to electricity and heat

3. Framework of Concepts

This chapter identifies 6 overarching concepts that are needed to manage the complex problems that come with the transition toward a bioeconomy. This framework defines critical issues to address during implementation of the bioeconomy, will be used during co-creation workshops as background for discussion.

The complexity of the bioeconomy is many times mentioned in the 3rd bioeconomy Stakeholder meeting in Torino. Bioeconomy is seen as a game changer, with a need for integrated approach towards the generation of new innovative products. The creation of new biobased value chain developments is to be seen as a complex problem, especially regarding the EU biobased landscape (small scale), characteristics, specific objectives and frameworks. The following dimensions can be distinguished:

- cross-sectoral: connecting different sectors: new value chains to be developed from biomass production to biobased products between agricultural sector with the chemical or energy, construction or materials industries etc.
- triple helix interplay: business, research and government. Extension with the Civil Society. Different domains, values, cultures and languages.
- cross-regional value chain development, connect regions with biomass availability to regions with processing facilities, industries, knowledge centres; bringing together knowledge, capacities and investments.
- cross-disciplinary (natural and human science; plant science, biobased, environmental and economic research) and valorization of knowledge (fundamental research, applied research; education and innovation)
- integrated approach: economy, climate, energy, biodiversity, food security; technological, organizational, financial and cultural challenge

To deal with complexity of different partners, cultures, perspectives, disciplines, domains and phases in the development processes, suitable management concepts and techniques are needed, to set conditions for innovations, collaboration and investments, and to steer, manage and coordinate the deployment of bioeconomy in European regions.

Next to the complexity of the bioeconomy, in the execution of new strategies and policies, gaps between current practices and biobased solutions are being identified which hamper the uptake of the bioeconomy in Europe.

Within universities and research centres there has been conducted technological research for years on the potential of crops and crop components for other applications than food or feed. There is also developed and tested technologies as extraction techniques and refineries to convert the plant components to building blocks for chemistry, energy and other valorization routes. There is a gap between the technology development and the awareness of potential value chain partners and the general public, which hampers a larger uptake. The current uptake is characterised by small scale pilots and demos. There is still limited demand for

biobased resources, building blocks or products, as well within the value chain and at the end of the value chain, from consumers. Products are still very limited available. Products seem to be not better or cheaper than regular equivalents of oil based products.

According to Heckert (2015) transitions do face lock-in problems, such as resistance, current business practices, conflicting interest (Heckert, 2015). Klikou (2015) adds learning effects, economies of scale, economies of scope, network externalities, informational increasing returns, technological interrelatedness, collective action, institutional learning effects and the differentiation of power.

To overcome the gaps and to deal with lock-in situations, theory, concepts and frameworks are used to deal with complexity and to manage the transition to a bioeconomy. Six interacting concepts were identified that offer information about patterns of and phases in the development process, and offer organisational basics about conditions for innovation and instruments to stimulate and support the transition and to arrive to well performing regional innovations systems. The following concepts are distinguished and illustrated in Figure 3:

- Clusters: spatial (appearance of new industrial sites, new crops, collection points of biomass and conversion sites; fragmentation vs clustering, economies of scale) and organizational (from network to innovation ecosystem)
- Regional innovation strategies of smart specialization (RIS3)
    - Triple and quadruple helix
    - Entrepreneurial discovery
- Value chain management – connection of biomass producers, refineries and industries
- Readiness
    - Technological innovations in search of new value chains
    - Social: awareness and understanding of the value of biobased innovations and products, ethical issues
- Circular Economy: the principles behind circular economy and the routes to (re) use and valorise waste streams
- Innovation pipeline: from fundamental knowledge to applied knowledge, piloting and demonstration and to investment, business case development and upscaling

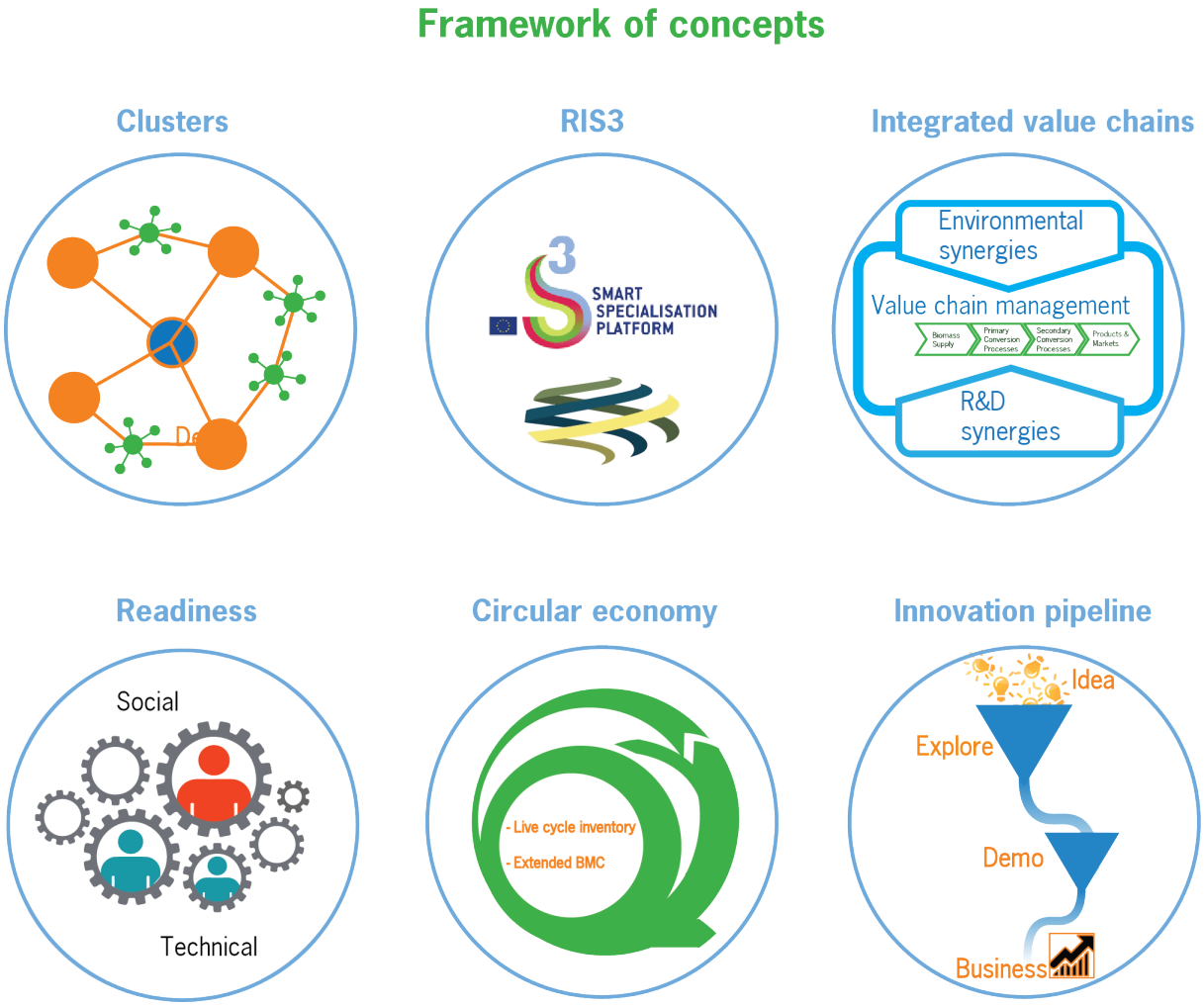

Figure 3 Framework of concepts to address bioeconomy social issues

In Figure 3 the six interacting concepts are displayed that are relevant for proceeding biobased innovations and transitions towards more sustainable societies.

Within the concepts the following processes, labelled as 'functions of innovation systems' are relevant (Heckert, 2015):

- Supply incentives for companies to engage in innovative work
- Supply resources (capital and competence)
- Guide the direction of search (influence the direction in which actors deploy—resources)
- Recognize the potential for growth (identifying technological possibilities and economic viability)
- Facilitate the exchange of information and knowledge
- Stimulate/create markets
- Reduce social uncertainty (i.e., uncertainty about how others will act and react)
- Counteract the resistance to change that may arise in society when an innovation is introduced (provide legitimacy for the innovation) (Heckert, 2015).

3.1. Clusters

Clusters and competitiveness are conceptual frameworks used to analyse the differences in economic performance across locations. Clusters, understood as co-located activities in related industries connected through different types of linkages and externalities, are a naturally emerging feature of market economies (Ketels, 2015). Clusters might also be associated with a specific type of competitive behaviour by companies that can be summarized as a 'high road'-strategy. In facing customers, high-road strategies are characterized by a focus on value through high quality and unique features. In production, high-road strategies are characterized by investments in internal assets such as the capital stock, skills and technology. They often also have an external dimension as companies work with their suppliers and service providers in upgrading their respective capabilities, and in jointly developing innovations. These investments are likely to generate positive spill-overs that reinforce the cluster through deepening the local supply of specialized skills and adding to the available knowledge stock. In parallel, the presence of the cluster is likely to provide an environment in which companies will find the external inputs that make opting for high-road strategies more likely; they will be able to access the advanced skills and supplies needed. Regions with a strong presence of clusters are those more likely to settle in an equilibrium where a sufficient majority of companies chooses 'high-road' strategies (Ketels, 2015).

Clusters seem to be an interesting concept, as this offers spatial, organizational and energetic efficiencies, which will offer conditions for biobased industries in general and bio chemical production in particular. Industrial clustering and industrial symbiosis, based on the principles of the circular economy, should be explored and potentially promoted as an aid to the more effective utilisation of knowledge, resources and infrastructure in developing the bio-economy (IEEP, 2015).

Clusters represent regional hotspots in *networks* which are:

- a necessary infrastructure in modern society for various actors (from government, civil society and business) to interact which each other
- probably important steering mechanisms in economic decision making (perhaps even more important than markets and all kind of hierarchies within society are)
- channels for transport of knowledge

Cluster development can be strengthened by policies, regional innovation management and entrepreneurial strategic decisions, instruments and investments. The EU Regional Innovation Strategies of Smart Specialization form a good framework to explore the opportunities and the comparative advantages and to make steps in the regional development pathway. France has developed clusters (pole de competite) since the early 2000's. The IAR cluster is to be seen as a good practice bioeconomy cluster:

> *IAR Cluster (North of France) has successfully developed an integrated organisation structure which facilitates the active involvement of regional partners across sectors. In detail, the following issues have been observed during the three development stages:*

- *The initial stage comprised of the establishment of a network that served as the basis for interactions and collaborations with regional partners, fifteen farmer cooperatives and the local agro- industry. The network applied the triple helix concept and its activities focused on raising awareness and developing a common strategy.*
- *The drive to maturity stage focused on the establishment of collaborative initiatives and creating crossovers between the agricultural and other sectors as well as familiarising with the capabilities of the cluster partners and creating synergies among them through applying for funding under common initiatives, such as:*
    - *investments in R&D, pilots and demo's to "overcome the valley of death" and come to de-risking. During that stage more almost 200 R&D projects have been approved. All initiatives from IAR consortia and cluster partners, focused on strengthening the cluster and progressing in biobased value chain development are being evaluated and approved by the IAR cluster organisation. One of the eligibility criteria has been that an application always has to be submitted by three organisations.*
    - *creation of labs, pilot plants, large investments in equipment, with priority at commonly shared facilities to be of use also for other companies, even from outside the regions. So far there are three of these open facilities: sugar, lipids and protein.*
    - *augmentation of the network by attracting and integrating new companies from potential value chains, some of them outside the region.*
- *During the mature stage the cluster focuses on 'making it happen' by:*
    - *Finding new business opportunities: facilitation of technological business partnerships, help in accelerating the value chain development.*
    - *Expanding innovation dynamics: optimizing and animating the working groups – enlarging the EU horizon.*
    - *Integrating new partners: international outreach of the network, strategic partnerships, exploration of export potential of knowledge and technologies, developed in the cluster.*
    - *Attracting investment.*

3.2. Regional Innovation Strategy of Smart Specialization (RIS3)

The European Smart Specialisation Strategy: "Research and Innovation strategies for Smart Specialisation" or **RIS3** initiated by the European think tank (ERA) can also be seen in this context. Rather than following each lead, regional cluster organisations should focus on a few integrated value chains at most in order to avoid – or at least minimize – regional fragmentation of initiatives. The EU Regional Innovation Strategies of Smart Specialization (RIS3) has the objective to make optimally use of regional strengths and opportunities and the regional comparative advantages - location factors do matter a lot. Entrepreneurial Discovery process (EDP) is an inclusive and interactive bottom-up process in which participants from different environments (policy, business, academia, etc) are discovering and producing information about potential new activities, identifying potential opportunities that emerge through this interaction, while policymakers assess outcomes and ways to facilitate the realisation of this potential. The EDP pursues the integration of

entrepreneurial knowledge fragmented and distributed over many sites and organisations, companies, universities, clients and users, specialised suppliers (some of these entities being located outside of the region) through the building of connections and partnerships. The EDP consists of the exploration and opening up of a new domain of opportunities (technological and market), potentially rich in numerous innovations that emerge as feasible and attractive. This process leads also to strengthen regional profile. A regional profile is a **configuration** of:

- physical characteristics, economical structure, infrastructure
- type of bioregion, chain, function/position within the wider bio economy landscape and with specific crossovers between biomass production and converting industries
- organizational structure, governance, network, support structure and services
- strategy: vision, development path, short term/long term, instruments and measures

Regional profile has an **external** effect in which competitive advantages are showed with marketing instruments to attract attention of new businesses, investments and funding. Regional profile has an **internal** effect in strategic decision making of partner organizations, which helps to focus and clarifies future objectives. The profile creates communality and connectedness and mobilizes people and organizations along the lines of strategic decisions, te create a support infrastructure and new intermediates in triple helix. It also creates new dynamics in the entrepreneurial discovery process.

3.3. Integrated Value Chain

The integrated value chain is nothing more than a logical chain of partners working together to add value to primary biomass in several steps and to look for synergies in production pipelines.
In many EU regions, there are opportunities for biobased production. The availability of biomass is precondition number 1. As Europe does not have a large scale biomass production like in the USA, EU should search for optimal concepts and appearance of biobased industries and added value activities within their regions. Transport costs still determine to a large extend the optimal location of bioeconomy facilities. Therefore pre-treatment at the farm level may lead to increase the income of farmers and to decrease the transportation costs, because less water, and therefore mass, will be transported.
The second local factor seems to be the presence of processing industries, such as agricultural cooperations and industries and chemical industries (forward integration) or the presence of a petrochemical refinery plot, which could be turned into a biochemical refinery (backward integration).

- Corn ethanol plants: CO_2 selling, novel proteins, integrated process, many side streams – cluster biorefineries with side facilities
- Cost competiveness of sugar beets – high yields in NW-Europe. The Netherlands is a good location.
- Strong chemical industry – searching nowadays for new synergies

- Use of existing biorefineries, pilot plants or large new production locations? use of production facilities of existing industries (for example pulp, pre-treatment, CO_2 availability)

Next to these preconditions, a wide network of business partners with al kind of services is needed to come to full production, as well as buyers of bio chemical building blocks, as packaging industry and end users as commercial brand owners. Also governments, knowledge institutes, financial institutes play important roles in the bio economy transition process.

3.4. Innovation Pipeline and Readiness

The **innovation pipeline** represents a logical order by which innovations usually evolve. Transitions from one phase to the next don't always run smooth. The so called valley of death often occurs when innovations have reached and passed the demo phase. Then all of a sudden the most difficult part, reaching maturity, has yet to come. It is important to recognize these hurdles in advance and be prepared. That's also where **readiness** levels come in. Technological readiness levels (TRL) were recognized by the European Commission in 2014 (EC, 2014). The primary purpose of using technology readiness levels is to help management in making decisions concerning the development and transitioning of technology. It should be viewed as one of several tools that are needed to manage the progress of research and development activity within an organization (can also be a cluster or a region). There are nine levels all in all.

Where a topic description refers to a TRL, the following definitions apply (EC, 2014):

1. TRL 1 – basic principles observed
2. TRL 2 – technology concept formulated
3. TRL 3 – experimental proof of concept
4. TRL 4 – technology validated in lab
5. TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
6. TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
7. TRL 7 – system prototype demonstration in operational environment
8. TRL 8 – system complete and qualified
9. TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Next to the technology development and implementation, innovations have also social implications, regarding societal acceptance and the societal uptake of the innovation. It involves topics/ issues such as awareness rising, knowledge transfer, coalition building, addressing and coping with resistance (lock-ins) (e.g. by compensating for real losses instead of just enforcing new realities), trust building, institutionalizing new practices. All TRL phases have equivalent Societal Readiness Levels (SRL), which "is a way of assessing the level of societal adaptation of, for instance, a particular social project, a technology, a product, a

process, an intervention, or an innovation (whether social or technical) to be integrated into society"[2]. Additionally Wenger (1998) emphasizes that with social instruments, the social aspects of innovations can be supported and managed.

Besides the innovation pipeline and the readiness levels the concept of circular economy is highly relevant for bioeconomy and therefore BLOOM.

3.5. Circular economy

In January 2012, a report entitled "Towards the Circular Economy: Economic and business rationale for an accelerated transition"(2012) was released, commissioned by the Ellen MacArthur Foundation and developed by McKinsey & Company. It was the first report to consider the economic and business opportunity for the transition to a restorative, circular model. Using product case studies and economy-wide analysis, the report details the potential for significant benefits across the EU. It argues that a subset of the EU manufacturing sector could realise net materials cost savings worth up to $630 billion annually towards 2025—stimulating economic activity in the areas of product development, remanufacturing and refurbishment. Towards the Circular Economy also identified the key building blocks in making the transition to a circular economy, namely in skills in circular design and production, new business models, skills in building cascades and reverse cycles, and cross-cycle/cross-sector collaboration.

A circular economy is a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing energy and material loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling. This is in contrast to a linear economy which is a 'take, make, dispose' model of production. (McArthur Foundation, 2012), as shown in Figure 4.

[2] https://innovationsfonden.dk/sites/default/files/societal_readiness_levels_-_srl.pdf

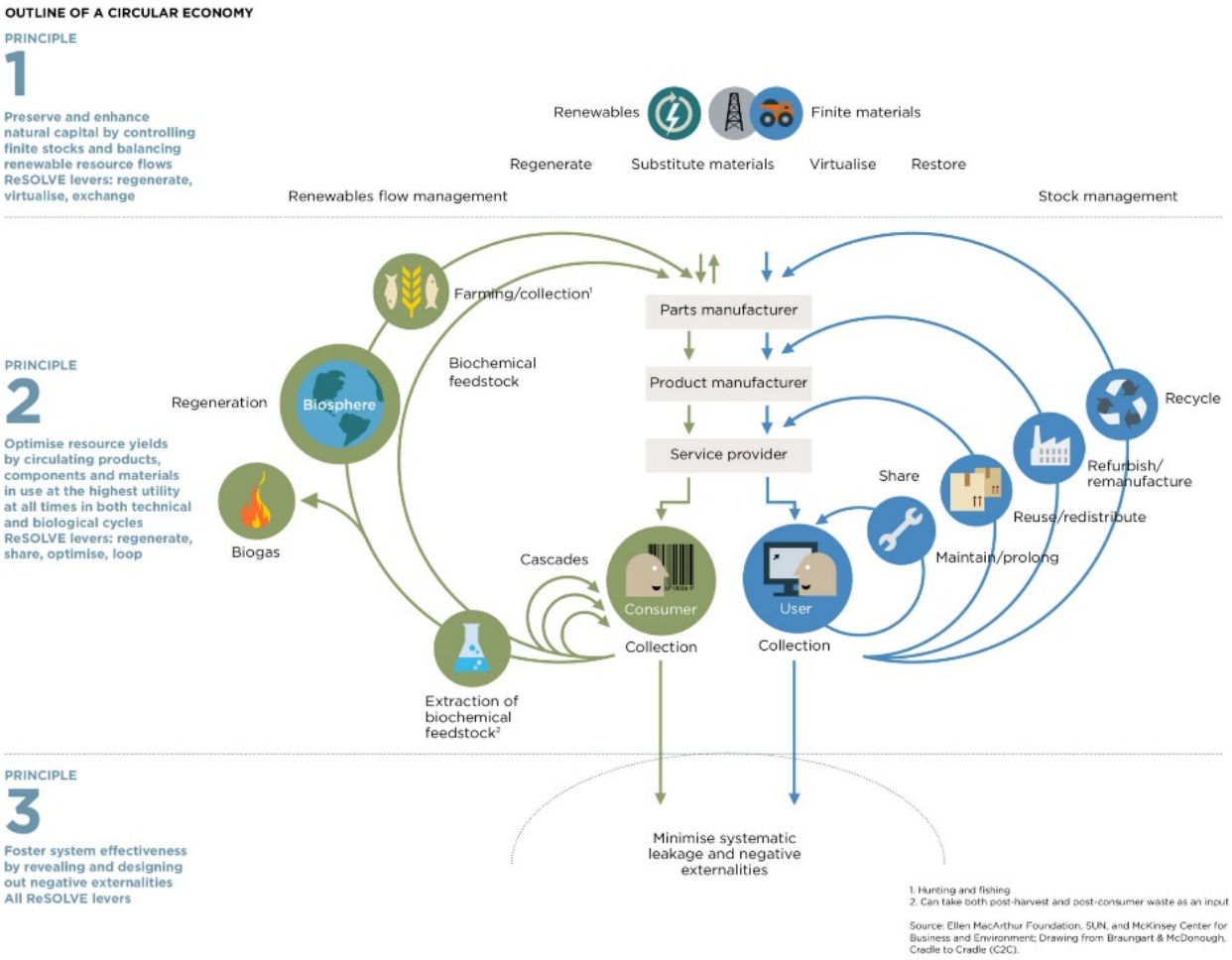

Figure 4 the outline of the Circular Economy (Ella MacArthur Foundation, 2012)

Knowing the concept of the possible routes for re-use and valorise waste and biomass, regional networks or the partners should use this conceptual information to manage, facilitate or support the uptake of the circular economy. The general idea is to use available biomass resources and nutrients efficient, i.e. at low non-renewable carbon costs and to move carbon from the atmosphere to other pools (such as the biosphere- and the top-soil layers). This can be achieved for instance by keeping nutrient cycles as local as possible, by lengthening the lifetime of physical products or subtracting from the use of fossil feedstock's. The latter method is the most important aim of many biobased solutions. In order to monitor the impact (evidence base) life cycle inventories are set-up as a part of the new economy, also to support actors such as businesses with their transition towards circular business models.

4. Policy Framework

On global, European, national and regional levels, policies regarding the bioeconomy have been made. BLOOM interacts with these frameworks through stakeholder management, and will therefore impact and be impacted by the boundaries they set, especially on regional level. To understand the possible effects of these impacts, and serve as a guide during co-creation workshops, this chapter aims to give an overview of the most relevant policies.

EU Grand Challenges Horizon 2020

At the start of the second decade of the 21st century, Europe faced a series of crucial challenges: low growth, insufficient innovation, and a diverse set of environmental and social challenges. The solutions to all of these problems are linked: it is precisely by addressing its environmental and social challenges that Europe will be able to boost productivity, generate long-term growth and secure its place in the new world order. The OECD (2011) has acknowledged that 'green and growth can go hand-in-hand'. The United Nations, too, has observed that there is no inescapable trade-off between environmental sustainability and economic progress: the greening of economies creates growth and employment (UNEP, 2011). In the same vein, the European Commission published the communication *GDP and beyond — Measuring progress in a changing world* (EC, 2009a) and is pursuing sustainable and inclusive growth through Europe 2020.

The following challenges have being distinct:

- Health, demographic change and wellbeing;
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bioeconomy;
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, environment, resource efficiency and raw materials;
- Europe in a changing world - inclusive, innovative and reflective societies;
- Secure societies - protecting freedom and security of Europe and its citizens.

UN Sustainable Development Goals

On 25 September 2015, the United Nations General Assembly formally adopted the universal, integrated and transformative 2030 Agenda for Sustainable Development, along with a set of 17 SDGs and 169 associated targets.

The adoption of the 2030 Agenda and its SDGs represent a change of paradigm of the international policies on development cooperation. The EU has committed to implement the SDGs both in its internal and external policies. The following SDGs are relevant as Framework for the Bloom approach:

Goal 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

The EU approach focuses on four strategic priorities:

- Supporting agricultural growth in developing countries, with a focus on small-scale farmers.
- Promoting sustainable agricultural practices.
- Fighting undernutrition/stunting.
- Strengthening resilience to climatic, economic and political crisis of the most vulnerable populations.

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

The EU development cooperation policy: the Agenda for Change focuses on inclusive and sustainable growth for human development as one of its priorities in particular in those sectors that have stronger multiplier impact on developing countries' economies, notably sustainable agriculture and energy.

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Blending, which combines EU grants with loans or other public and private funding, is increasingly supportive of actions on infrastructure which have a multiplier effect on sustainable development in partner countries. EU actions are geared towards inclusive and sustainable growth and economic integration, building on partner countries' comparative advantages in the manufacturing or services sectors.

Goal 12: Ensure sustainable consumption and production patterns

The EU promotes for example responsible supply chains and responsible business practices of European companies in developing countries. The EU also promotes the transition to an inclusive green economy that generates growth and creates decent jobs in partner countries, notably through the Switch to Green initiative.

Goal 13: Take urgent action to combat climate change and its impacts

The EU has been at the forefront of international efforts towards the Paris global climate agreement. The EU is stepping up its international climate diplomacy to maintain the political momentum and support other countries in the implementation of the Paris Agreement and their climate plans.

Missions - Horizon Europe

The future EU framework for knowledge and innovation will be built on the Mazzucato (2018) publications about mission oriented innovation policies. Missions provide a way to harness and direct the power of research and innovation, not only stimulate economic activity and growth, but also to find innovative solutions to the most pressing challenges of our time (EU publication, Mazzucato, 2018).

The issue of public engagement and missions is crucial because of the symbiotic nature of the relationship between the two. Missions provide a straightforward explanation to the public of how diverse, and sometimes difficult to understand, developments in research and

innovation can contribute to a better society. In addition, the potential impact of missions is much higher when they inspire and engage widespread support (Mazzucato, 2018).

EU policies and Frameworks

In February 2012, the European Commission submitted its strategy and action plan for a sustainable bioeconomy in Europe, "Innovating for Sustainable Growth: A Bioeconomy for Europe," to the European Parliament (EC, 2012). This strategy is Europe's response to key environmental challenges the world is facing today. It's meant to reduce the dependence on natural resources, transform manufacturing and promote sustainable production of renewable resources, while growing new jobs and industries (Figure 5).

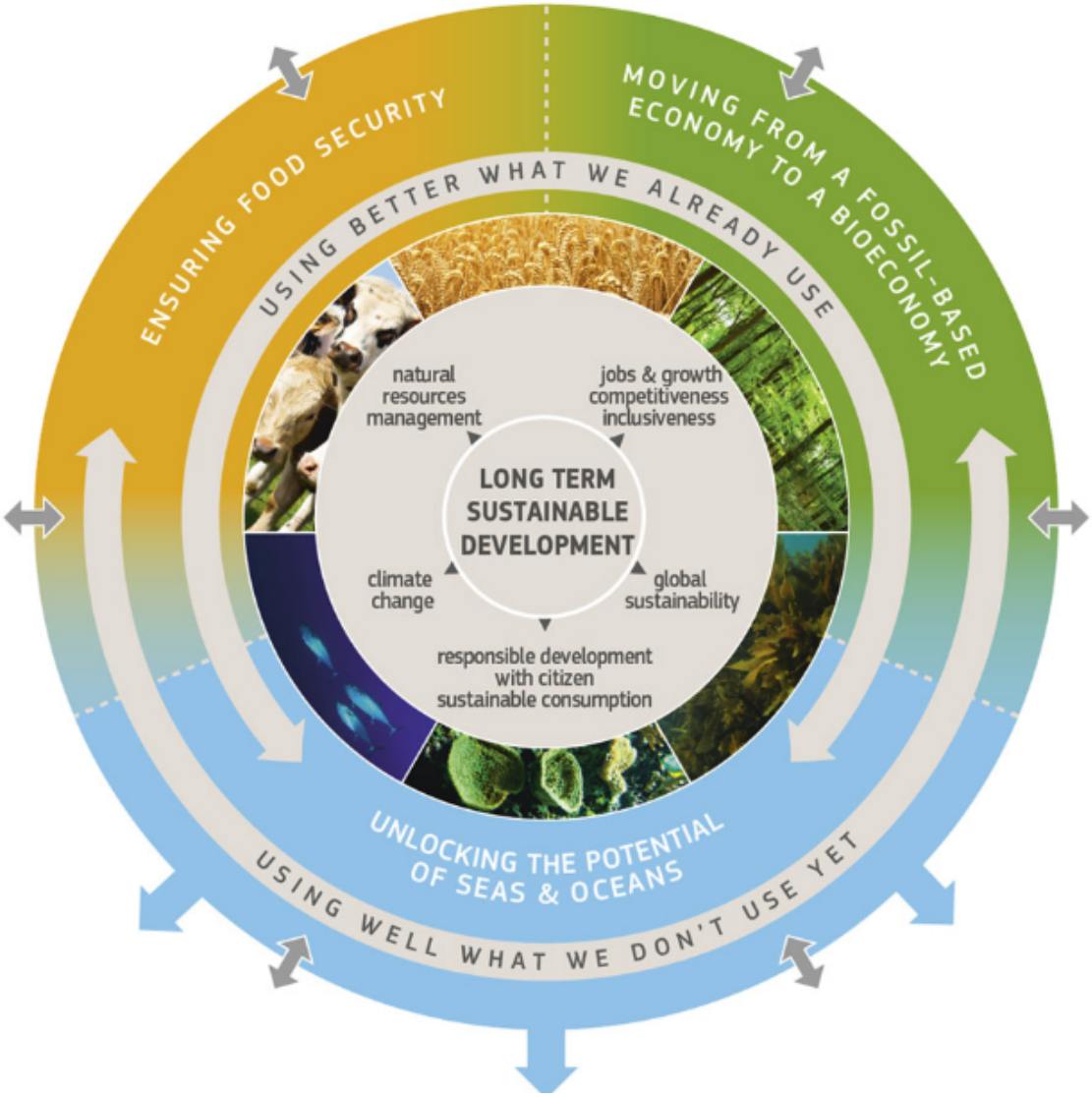

Figure 5 EU strategy (2012)

The strategy is structured around three pillars:

- Investments in research, innovation and skills;
- Reinforced policy interaction and stakeholder engagement;
- Enhancement of markets and competitiveness

The Action Plan focuses on cross-sectorial and multi-disciplinary approaches by developing Joint Programming Initiatives (JPIs), ERA-Net activities, by supporting bio-clusters and Knowledge and Innovation Communities (KICs) and by establishing a Bioeconomy Panel to support synergies and coherence between different policy areas and a Bioeconomy Observatory to gather data and indicators to assess the progress (Scarlat et al, 2015). The strategy is also affected by a number of other ongoing or recent EU policies. We mention here the action plan on circular economy where also a new dedicated plastics strategy is being prepared, the promotion of climate SMART agriculture, the Digital agenda for technological development and innovation and the bioeconomy stakeholders manifesto. The bioeconomy strategy is probably most affected by the Renewable Energy Directive and the Emission Trading System (ETS).

The European Commission is currently working on a new EU Bioeconomy Policy and Strategy, expected to be launched in October 2018. The strategies will be developed towards a sustainable circular bioeconomy, influenced by the concepts of Circular Economy, Paris Agreement and the UN Sustainable Development Goals. More investment and coherence will be needed, alongside better monitoring and assessment and improving the connection between supply and demand.

National Policy frameworks

16 Member States have National Bioeconomy Strategies. Some countries (Austria, Germany) are developing new strategies. We will describe shortly two strategies as good examples, which are also relevant to the BLOOM hubs:

Finland

According to national Bioeconomy Strategy Finland will reduce its dependence on fossil natural resources, prevent biodiversity loss and create new economic growth and jobs in line with the principles of sustainable development. The objective of the Bioeconomy Strategy is to push economic output up to EUR 100 billion by 2025 and to create 100,000 new jobs. By 2025 Finland is expecting bioeconomy to provide turnover €
60 bn, share of employment 13 % and share of exports 26 % (speech of Waldemar Kutt, Biostep meeting, march 2018).

The Netherlands

In the Netherlands, the first policy framework at national level was being published in 2007: 'The vision of the National Government on biobased economy and the energy transition – close the value chain", focussing on a bio-based economy towards a sustainable energy supply service:

- Energy savings of 2% per year (Regeerakkoord, 2007)
- Growing use of non-fossil energy resources, 20% sustainable energy in 2020: solar, wind, waterpower and biomass.
- 30% reduction of CO_2, in 2020.

The national government started a working program on "'Schoon en Zuinig" "clean and economical"', focussing low energy use and alternative energy supply in specific economic sectors. Also a knowledge and innovation program has been set up (2011), which resulted in an Innovation Contract on Green Growth: from biomass to business (2012), to support the R&D between knowledge institutes and companies, focussing on innovations, new business development and start-ups.
"'Biomassa 2030 (2016)"' is a strategic vision and route for the use and valorization of biomass, to contribute optimally to the policy goals on food, energy, climate, mobility, biobased and circular economy. Biomass will be seen in the context of climate problem, renewable resources and circular economy. This vision focusses on:

- Enlarging the sustainable supply of biomass: improve collection of rest streams towards new commodities, enlarge the production of current biomass and on waste land and aquatic biomass.
- Optimization of utilization of crops and components.
- New applications of biomass in a broad pallet of biochemicals and biopolymers.
- Investment in new production capacity, in research and development and in new technologies: first of a kind fabrics, biorefineries, alternative protein production.
- Sustainability in the production chain and waste management.

Regional Policy Frameworks

For the regional implementation the EU developed the RIS3 framework: regional innovation strategies for SMART specialization. Regions are challenged and forced to make strategic choices for specific sectors, which fit to the characteristics of their economies and environment, physically as well as culturally. SWOTs have been applied and regions have chosen their profiles, strategies and plans and organisational structures for implementation. Many regions have mentioned the bioeconomy as one of the main drivers for regional innovation and growth. Within the bioeconomy many routes are possible, depending on the combination of availability and components of the regional biomass and the existing industries in which the biomass components can be valorized.

Bioeconomy Stakeholder Panel

The Bioeconomy stakeholder panel has originally been set up in 2013. The membership of the Panel was renewed in 2016 to strengthen the diversity in stakeholders' representation. The panel represents different groups: business and primary producers, policy-makers and public administrations, scientists and researchers and civil society organisations. The Panel has an important say in the new European Bioeconomy Strategy. The input will be based on the reflection and discussions on the uptake of the bioeconomy in Europe. The Panel has developed a bioeconomy stakeholder Manifesto signed by many stakeholders in May 2016. The Manifesto recognises the opportunities and challenges of developing the bioeconomy and provides inspiration to stakeholders, regions and Member States, at various stages of development of their bioeconomy strategies, as well as to the EU as a whole. The Guiding Principles for Development of the bioeconomy of the Manifesto, addressing Societal and Environmental Challenges are:

1. Resource use within the limits of the planet
2. Mitigating Climate Change
3. Producing for people
4. Sustainable Management of Resources Facilitating Innovations and Business Opportunities

In order to facilitate innovations and business opportunities the bioeconomy needs:

1. A stable and predictable legal framework
2. Cooperation between sectors (production of biomass, processing and application in industrial sectors) and along
   value
   -
   chains creates synergies and critical mass
3. A
   Long
   -
   term Research and Innovation Agenda
4. Recognize the importance of regional strategies and rural renaissance

To reach these goals the following actions are defined:

1. Education, Training and Skills
2. Open Science and Research Programme Alignment
3. Bridging the Innovation Gap by Public-Private Partnership
4. Embracing the Circular Economy
5. Strengthening the Regional Bioeconomy and Inter-Regio
6. Raising Public Awareness and Improving Communication
7. Establishing a Socio-Economic Monitoring System
8. Promoting Biomass Availability
9. Research and assessment of biomass potentials

BLOOM aligns very well with the actions defined in the Bioeconomy Stakeholder Panel. Especially point 1, 4, 5 and 6 are core goals in the project.

5. Ethical issues

Under bioeconomy also controversial approaches are discussed (or presented on conferences) that might not be in line with sustainability and/or raise issues with ethical concerns. These issues concern all hubs, and are therefore not specifically hub-related. These issues need to be raised and discussed in the BLOOM co-creation workshops. The follow list includes issues that have been proposed, but is not exhaustive:

1. Genetic Modification
2. Indirect Land Use Change (ILUC) - Food versus fuel discussion
3. Use of fertilizers
4. Economies of scale
5. Waste processing (degradability of residual streams)

5.1. GMO

Genetic Modification is widely applied in biobased refinery processes. Even when the modifications are not used in any way within the food-chain, the application opens several discussions:

- ethical: are we as humans allowed to intervene in such a way with the Creation?
- perception of safety: Some people fear that modified organisms can escape from their containers and infect / contaminate other organisms. Traditional reactions from scientists pointing at proof of safety based on rational reasoning do not help the discussion, but what does?
- Need for control: Typically the circumstances in bio refinery factories are hard to handle. The quality of biomass feedstock often fluctuates to an extend that the refinery processes can become unstable, causing declines in operational efficiencies of the plants. Robust micro-organisms that can handle different conditions are needed and genetic modifications can help.

5.2. ILUC

The biobased economy activities can both induce indirect land use changes that are not wanted (because they threaten local food production) as help to mitigate ILUC effects, by extracting feed (e.g. sugars and proteins) as well as fibres from the same biomass source for instance, even from sources that would otherwise not be available for feed or food.

5.3. Fertilizers

The use of fertilizers for non-food biomass production is contested. Some fertilizers cost a huge amount of energy to produce, especially the nitrogen fertilizers. More problematic are fertilizers with non-renewable characteristics such as phosphate. Those should be used with care, even for producing food.

5.4. Economy of scale

Primary biomass production is more or less evenly distributed across the whole of Europe. This raises questions as to what is optimum scale of production facilities. In this case there's a trade-off between the economies of scale of production facilities and (energy costly) transportation of biomass. Different modes can be investigated: small scale production facilities spread all over Europe, pre-treatment and storage capacity at strategic places between sourcing area and HUB, and concentration of all processing activities at HUBs.

5.5. Waste processing (degradability of residual streams)

Besides sustainable production, a circular bioeconomy would want to optimally use waste streams. This would reduce the pressure on sustainable resource acquisition, and reduce pollution and environmental impact. In implementing a bioeconomy, choices for degradable products or collection systems can be made.
This may be considered out of scope for the BLOOM project, but is certainly a critical aspect for any type of economy that wants to be efficient with its resources and both economically and environmentally sustainable.

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