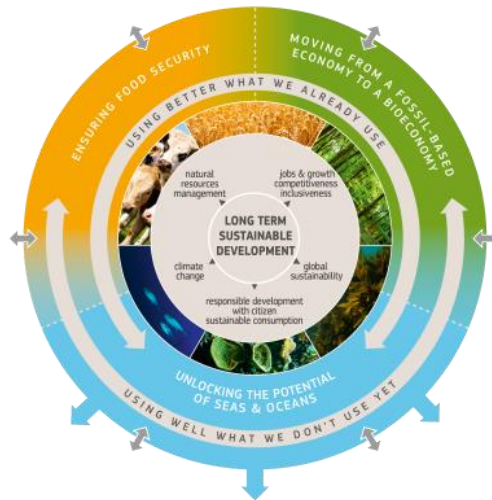




European
Commission



REVIEW OF THE 2012 EUROPEAN BIOECONOMY STRATEGY

Review of the 2012 European Bioeconomy Strategy

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List of acronyms

Acronym	Full name
BBI JU	Bio-Based Industries Joint Undertaking
CAP	Common Agricultural Policy
CE	Circular Economy
CFP	Common Fisheries Policy
CSA	Coordination and Support Actions
CoR	Committee of the Regions
DG	Directorate-General
EIP AGRI	European Innovation Partnership for Agricultural productivity and Sustainability
EC	European Commission
EIT	European Institute of Innovation and Technology
ERDF	European Regional Development Fund
ESIF	European Structural and Investment Fund
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
GHG	Greenhouse gas
H2020	Horizon 2020
FP	Framework Programme
IBF	International Bioeconomy Forum
IA	Innovation Actions
IKAA	In-kind additional activities
ISG	Inter-service Group
JPI	Joint Programming Initiative
JRC	DG Joint Research Centre
KBBE	Knowledge-Based Bio-Economy
KICs	Knowledge and Innovation Communities
KPIs	Key Performance Indicators
LULUCF	Land Use, Land Use Change and Forestry
MSCA	Marie Skłodowska-Curie Actions
P2P	Public-to-Public Partnership
PPP	Public-Private Partnership
R&D	Research and Development
R&I	Research and Innovation
RIA	Research and Innovation Actions
RIS3	Research and Innovation Strategies for Smart Specialisation
SCAR	Standing Committee on Agricultural Research
SIRA	Strategic Innovation and Research Agenda
SME	Small or Medium-sized Enterprise
S&T	Science and Technology
SC2	Societal challenge 2 "Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy" under Horizon 2020
SDGs	Sustainable Development Goals
TRL	Technology Readiness Level
WP	Work Programme

EXECUTIVE SUMMARY

This Staff Working Document provides a review of the European Commission (EC) 2012 Bioeconomy Strategy and Action Plan "Innovating for Sustainable Growth: A Bioeconomy for Europe". This review does not constitute a formal evaluation as defined by the Commission Better Regulation guidelines and consequently the approach followed differed from established evaluation practices and requirements.

The strategy defined the bioeconomy as "the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, bio-based products as well as bio-energy". The major aim of the strategy, therefore, was "to pave the way to a more innovative, resource efficient and competitive society that reconciles food security with the sustainable use of biotic renewable resources for industrial purposes, while ensuring environmental protection".

As a concretisation of this aim, the strategy identifies five objectives to which the strategy and its action plan are to contribute: (1) ensuring food security, (2) managing natural resources sustainably, (3) reducing dependence on non-renewable resources, (4) mitigating and adapting to climate change, and (5) creating jobs and maintaining EU competitiveness. These five objectives were addressed via the strategy's Action Plan that focused on 3 areas of action with a total of 12 actions, subdivided into 54 sub-actions.

This review gives an overview of the progress of implementation of the Action Plan and its first results (section 2.1 and Annex 1), its contribution to the five cross-cutting objectives (section 2.2), as well policy coherence (section 2.3). Section 3 provides an analysis of the relevance and the potential contribution of the Bioeconomy to the EU flagship initiatives such as the Circular Economy and the Energy Union. Section 4 "Conclusions" provides an analysis of the overall progress of the strategy and action plan.

Main findings of the review are the following:

The 2012 EU Bioeconomy Strategy and Action Plan is delivering on key actions in the Action Plan. *It has successfully mobilised R&I funding, in particular through a doubling of the EU R&I funding dedicated to the bioeconomy under Horizon 2020, and it has fostered R&I investments in Member States. It has also delivered on standards for bio-based products and supported private investment with major deliverables such as the launch of the BioBased Industries Joint Undertaking.*

The opportunities that the bioeconomy offers and the importance of Bioeconomy Strategy coordination are increasingly recognised by EU Member States and regions. The overall objectives of the 2012 EC Bioeconomy Strategy have been taken up in numerous national and regional bioeconomy strategies developed since 2012 in the EU and globally. However, there is still room for further development in Member States, and also the potential contribution of cities to the bioeconomy remains largely unexploited.

Further mobilisation of investments is still needed, which requires a stable regulatory environment. Existing and new technologies and demonstrators need to be up-scaled and rolled out. Especially private investment in integrated bio-refineries, which are capital intensive and are associated with high technological and market risks, require specific support and a stable regulatory environment.

Policy coherence needs to be better addressed, as well as the design and implementation of the Strategy and its Action Plan. The review demonstrates that there is insufficient correspondence between the strategic objectives in the Strategy and the actions of the Action Plan that were designed to achieve these objectives. Furthermore, objectives and actions lack 'SMART' targets. Combined with an insufficient assessment and monitoring framework, this hampered the achievement of results, in particular regarding policy coherence and synergies.

The current policy context highlights the need for a sustainable, circular bioeconomy. The policy context in which the bioeconomy operates has changed significantly since 2012, with EU and global policy developments such as Circular Economy, Energy Union, the Paris Agreement and the Sustainable Development Goals. In consequence, the concept of a sustainable, circular bioeconomy is being proposed by various stakeholders. The scope of the 2012 Strategy and Action Plan and the relevance and focus of its objectives and actions have to be looked at in light of these developments.

Better monitoring and assessment frameworks are needed to assess progress. As sustainability in terms of production and consumption is core to the bioeconomy strategy, better understanding is necessary of the prospective development of biomass supply and demand, to ensure that the bioeconomy operates within the limits of the biosphere, while providing optimum social and economic gains. Indicators to assess progress can be based on an internationally shared monitoring and assessment framework that is in development for the Sustainable Development Goals, complemented with other appropriate indicators.

1 Introduction and background

The content of this document is based on SWD(2017)374 – Commission Staff Working Document on the review of the 2012 European Bioeconomy Strategy.

This document provides a review of the European Commission (EC) 2012 Bioeconomy Strategy "Innovating for Sustainable Growth: A Bioeconomy for Europe" and its Action Plan,¹ which was jointly developed by the Commissioners for Research and Innovation, Agriculture and Rural Development, Enterprise & Industry (now Internal Market, Industry, Entrepreneurship and SMEs), Environment, and Maritime Affairs & Fisheries. The Action Plan specifies that the Strategy and Action Plan shall be reviewed and updated at mid-term. The review furthermore responds to the Circular Economy package² and the June 2016 Environment Council Conclusions³, which requested that the EC "examine the contribution of the Bioeconomy Strategy to the Circular Economy and update the Bioeconomy Strategy accordingly". Recognising the interlinkages between the Bioeconomy and the Energy Union⁴, the EC Communication on Accelerating Clean Energy Innovation⁵ (ACEI, 2016) retained that "The action plan for the Circular Economy will contribute to increasing energy efficiency and reducing emissions by better using raw materials and recycling secondary raw materials and waste. The corresponding role of the bioeconomy will be considered in the upcoming review of the Bioeconomy Strategy and its possible update".⁶ Moreover, the Industrial Policy Strategy Communication, adopted on 13 September 2017, recognises that a stronger development of the bioeconomy can help to accelerate progress towards a circular and low-carbon economy, by improving production of renewable biological resources and their conversion into bio-based products and bio-energy.⁷ This Communication announces that the Commission will propose action in 2018 regarding the Bioeconomy Strategy.

The EU Bioeconomy Strategy and its Action Plan emerged from the "Innovation Union"⁸ and "Resource-efficient Europe"⁹ flagship initiatives of the EU 2020 strategy, recognising that the bioeconomy, worth EUR 2.2 trillion in turnover and accounting for 9% of the EU's workforce¹⁰, plays a central role in addressing a number of key interlinked challenges. It was preceded by various Council conclusions on the Knowledge-based Bioeconomy (KBBE) in 2005, 2007

¹ COM/2012/060final <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2012:0060:FIN>. Accompanying Staff Working Document: SWD/2012/0011 final, <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD:2012:0011:FIN>

² COM/2015/0614 final, <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614>

³ <http://www.consilium.europa.eu/en/press/press-releases/2016/06/20-envi-conclusions-circular-economy/>

⁴ A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy COM/2015/080 final

⁵ COM/2016/0763 final, <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2016:0763:FIN>

⁶ Furthermore, the European Parliament has requested the Commission to present a bi-annual report with regard to the implementation of the bioeconomy strategy: European Parliament resolution of 2 July 2013 on innovating for sustainable growth: a bioeconomy for Europe (2012/2295(INI)), P7_TA(2013)0302, OJ C 75, 26.2.2016, p. 41–46 .

⁷ COM(2017) 479 final, <http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52017DC0479>

⁸ COM(2010)0546, <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52010DC0546>

⁹ COM/2011/0571 final, <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52011DC0571>

¹⁰ Ronzon, T. et al (2017), Bioeconomy Report 2016, JRC Scientific and Policy Report, EUR 28468 EN

and 2010 under UK, DE and BE Presidencies¹¹, and by the launch of the specific programme under the 7th Framework Programme for Research and Technological Development¹² (FP7) (2007-2013) with the subtitle KBBE.

The Strategy, as well as the FP7 KBBE specific programme, defined the bioeconomy as "the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, bio-based products as well as bio-energy"¹³. The Strategy recognised that "in order to cope with an increasing global population, rapid depletion of many resources, increasing environmental pressures and climate change, Europe needs to radically change its approach to the production, consumption, processing, storage, recycling and disposal of biological resources". The major aim of the Strategy, therefore, was "to pave the way to a more innovative, resource efficient and competitive society that reconciles food security with the sustainable use of biotic renewable resources for industrial purposes, while ensuring environmental protection".

As a concretisation of this aim, the Strategy highlights that the bioeconomy's cross-cutting nature offers a unique opportunity to comprehensively address inter-connected societal challenges, and identifies five objectives to which the strategy and its action plan are to contribute: (1) ensuring food security, (2) managing natural resources sustainably, (3) reducing dependence on non-renewable resources, (4) mitigating and adapting to climate change, and (5) creating jobs and maintaining EU competitiveness.

These five key interlinked objectives were addressed via the Strategy's Action Plan that focused on 3 areas of action (see Figure 1 below). A Commission Staff Working Document¹⁴ further detailed the three areas of action into 12 actions and 54 sub-actions.

The Strategy and Action Plan reflected the recognition that major research and innovation investments were necessary to sustainably address the supply side and to increase productivity, reducing losses and tapping into new biomass resources, such as waste and aquatic resources. The 2012 Strategy went, however, beyond R&I, pointing out that a coherent policy framework was needed to ensure best use was made of available biomass resources and to avoid conflicts arising from competing uses, including ecosystems services and climate mitigation potentials. Also, actions to enhance markets and competitiveness were deemed essential to realise the jobs and growth potential of the bioeconomy.

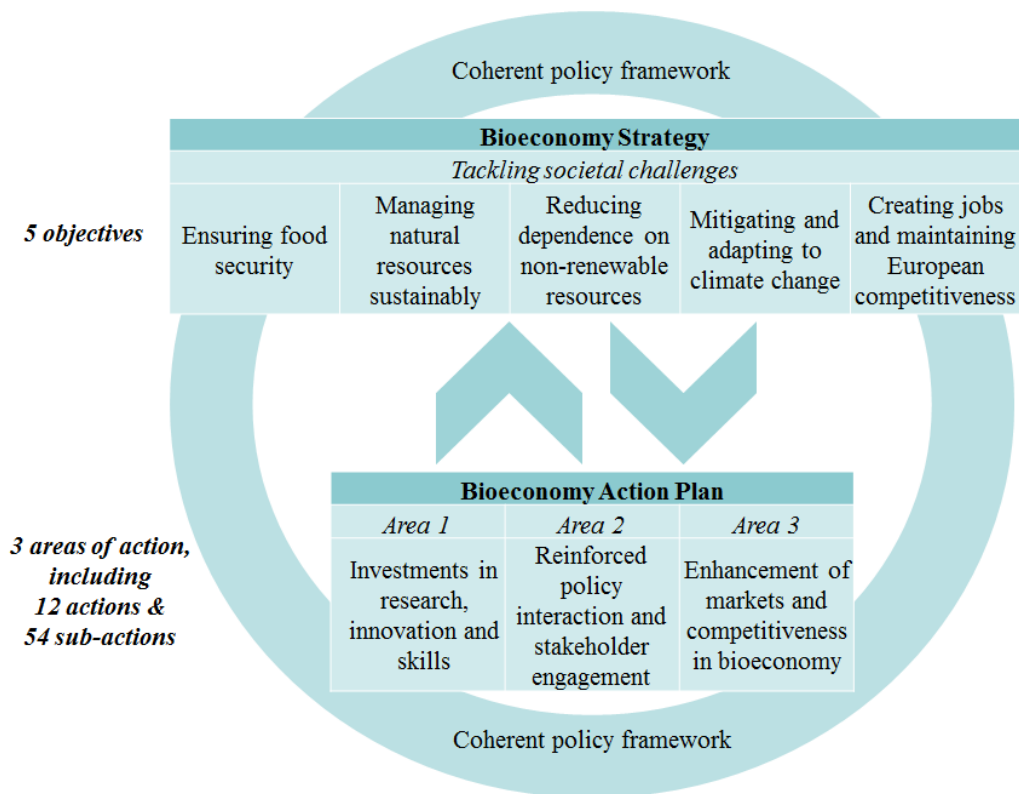
¹¹ United Kingdom Presidency (2005) - "The Knowledge-Based Bio-Economy in Europe", German Presidency (2007) - "En Route to the Knowledge-Based Bio-Economy" (Cologne Paper), Belgian Presidency (2010) - "The Knowledge Based Bio-Economy in Europe: Achievements and Challenges"

¹² http://ec.europa.eu/research/participants/data/ref/fp7/91155/spcooperation_en.pdf

¹³ The terms "bioeconomy" or "bio-based economy" differ widely. Whereas the OECD has a more narrow definition and equates bioeconomy to biotechnology, the EU strategy is understood as an economy covering all "bioresources". The term 'bio-based economy' is used mostly equivalently, but sometimes is understood as the opposite to the "fossil-based economy", i.e. covering bio-based chemicals, biofuels and -energy that substitute the fossil based equivalent.

¹⁴ SWD/2012/0011 final, <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD:2012:0011:FIN>

Figure 1: Visual representation of the structure of the 2012 Bioeconomy Strategy and Action Plan



It should be highlighted that this review of the Bioeconomy Strategy does not constitute a formal evaluation as defined by the Commission Better Regulation guidelines and consequently the approach followed differed from established evaluation practices and requirements. In light of limited availability of quantitative data and metrics in particular regarding long-term impacts, the review focuses on the results obtained through the implementation of the Action Plan.

This review provides an overview of the progress of implementation of the Action Plan and its first results (section 2.1 and Annex 1), its contribution to the five cross-cutting objectives (section 2.2), as well policy coherence (section 2.3). This review builds on the input of an external expert group that carried out an independent review of the implementation of the strategy, as well as internal inputs and analysis. Section 3 provides an analysis of the relevance and the potential contribution of the Bioeconomy to the EU flagship initiatives such as the Circular Economy and the Energy Union. Section 4 "Conclusions" provides an analysis of the overall progress of the Strategy and Action Plan, both on whether the initial objectives of the Bioeconomy Strategy are still up to date, in particular in light of EU and global policy developments (Circular

Economy (CE), Paris Agreement¹⁵, Sustainable Development Goals¹⁶ (SDGs), and whether the Action Plan is still fit for purpose in terms of achieving these objectives.

¹⁵ United Nations / Framework Convention on Climate Change (2015) Adoption of the Paris Agreement, 21st Conference of the Parties, Paris: United Nations.

¹⁶ United Nations, "transforming our world: the 2030 agenda for sustainable development," 2015. <https://sustainabledevelopment.un.org/post2015/transformingourworld>

2 Implementation and assessment of the 2012 Bioeconomy Strategy and Action Plan

This section provides a summary of the main findings of the review of the Action Plan by area of action, of the contribution of the Strategy to achieve its objectives, and an analysis of the policy coherence. The full and detailed assessment of the Action Plan and the detailed methodology are provided in Annex 1.

2.1 Assessment of the implementation of the 2012 Action Plan

Area of action 1: Investments in research, innovation and skills

The first area of action of the 2012 Action Plan included a set of actions, as follows:

- Ensuring substantial EU and national funding and private investment for bioeconomy R&I, strengthen coherence and synergies between public programmes;
- Increase the share of multi-disciplinarity and cross-sectoral research by improving the existing knowledge-base and developing new technologies for the bioeconomy;
- Promote the uptake and diffusion of innovation for the bioeconomy;
- Build the human capacity for the bioeconomy.

Given the long-term nature of the research and innovation activities, only preliminary results and assessments can be presented at this stage. Nevertheless, a direct result of the 2012 Action Plan is the over two-fold increase in dedicated **EU funding** for the bioeconomy under the Horizon 2020 programme (total financial envelope for bioeconomy of EUR 4.52 billion for the period 2014-2020) compared to FP7, its predecessor programme (EUR 1.9 billion for 2007-2013). This financial envelope could exceed EUR 7 billion when also considering other actions under Horizon 2020 which are not labelled "bioeconomy" per se and which support - in an indirect manner - the development of the bioeconomy. Further support is also available from EU cohesion policy funds¹⁷. Moreover, EU funding had a leverage effect on both **national public and private funding**. For each euro invested by the EC in bioeconomy-relevant public to public actions, the participating states have invested an additional amount of EUR 3.8 (see Table 3 in Annex I). Substantial

¹⁷ Cohesion policy funds are part of the European Structural and Investment Funds (ESIF) and include the European Regional Development Fund (ERDF), the Cohesion Fund (CF) and the European Social Fund (ESF). Examples of projects are: http://ec.europa.eu/regional_policy/en/projects/belgium/bio-based-booster-shot-for-north-west-europe ; http://ec.europa.eu/regional_policy/en/projects/portugal/centro-bio-bio-based-growth-for-rural-economies ; http://ec.europa.eu/regional_policy/en/projects/finland/redefining-the-concept-of-waste-above-biomass-pilot-plant ; http://ec.europa.eu/regional_policy/en/projects/unitedkingdom/beacon-meeting-the-demands-of-an-ever-increasing-population

private funding has also been mobilised through the Bio-Based Industries Joint Undertaking (BBI JU), with a leverage effect of 2.6 for the period 2014-2016, whereas a leverage of 2.8 is expected to occur by 2024¹⁸. Altogether, these investments in bioeconomy-related activities exceed EUR 3.7 billion, of which EUR 975 million EC contribution and at least EUR 2.73 billion total private contribution¹⁹.

There is already early indication that projects funded under the EU FP are generating relevant **excellent and multi-disciplinary research** (i.e. quality of publications in terms of citations). Evidence from projects also shows that these are developing useful **innovations** aiming at for example reducing the environmental impact of food processing, generating food crops which are resource-efficient and high in protein, generating land-based and aquatic biomass for non-food use, improving underwater observation to monitor the marine environment, fish stocks and pollution. Preliminary evidence from the BBI JU-funded projects indicates that this public-private partnership is providing a substantial boost to the **innovation performance** of the European bio-based industry, with new bio-based value chains, materials and demonstrated "consumer" products being created.

Also in 2012, the **European Innovation Partnership for Agricultural Productivity and Sustainability**²⁰ (**EIP –AGRI**) kicked off to promote and diffuse innovation with dedicated attention to include all the relevant actors in the chain. The EIP-AGRI uses funding from both Horizon 2020 and the CAP, and interlinks between the European level (about EUR 500 million Horizon 2020 multi-actor projects from 2014 till 2016) and the national/regional level (CAP and MS' funding for Operational Group innovative projects). Although it was a voluntary CAP measure, the EIP Operational Group measure was taken up in 27 Member States and 98 rural development programmes, with over 3200 national or regional Operational Groups planned between 2014 and 2020.

The integration of **bioeconomy skills** in High Education Institutions (HEI) and R&I organisations has been supported through the Marie Skłodowska-Curie Actions (MSCA) under Horizon 2020, with more than EUR 600 million awarded between 2014 and 2017 to bioeconomy relevant projects. This amount has supported so far about 2680 recruited MSCA-Individual Fellowships and MSCA-Innovative Training Networks researchers and over 15.000 planned secondments via the staff exchange action MSCA-RISE.

At least four Master programmes were a direct result from the Bioeconomy Strategy: (1) Master in Management of Bioeconomy Innovation and Governance²¹ at the University of Edinburgh, (2) Bioeconomy Master²² at the

¹⁸ https://www.bbi-europe.eu/sites/default/files/bbi_ju_aar_2016.pdf

¹⁹ See BBI JU mid-term review at <https://ec.europa.eu/research/evaluations/pdf/bbi.pdf>

²⁰ EIP Commission Communication COM(2012) 79 final: areas of innovative action of the EIP-AGRI:

- (1) Increased agricultural productivity, output, and resource efficiency,
- (2) Innovation in support of the bio-based economy,
- (3) Biodiversity, Ecosystem services, and soil functionality,
- (4) Innovative products and services for the integrated supply chain,
- (5) Food quality, food safety and healthy lifestyles

²¹ <http://www.ed.ac.uk/studying/postgraduate/degrees/index.php?r=site/view&id=769>

²² <https://www.uni-hohenheim.de/en/bioeconomy-masters>

University of Hohenheim, (3) Master of Bioeconomy in Circular Economy²³ offered by the University of Bologna, University of Milano Bicocca, University of Naples Federico II + University of Turin, (4) Master of Science in Bio-economy and Natural Resources Management at the University of Eastern Finland²⁴. In addition, Table 11 in Annex presents bioeconomy relevant Master's and Doctoral Programmes. Coordination with National Research programmes is needed to secure that key bioeconomy skills are taught in University programmes (Chemistry, Natural and Environmental Science, Agriculture and Forestry Science, Engineering, Biological Science, Food and Technology, Architecture). Further support to skills development for the marine bioeconomy was also provided through the European Maritime and Fisheries Fund²⁵. These efforts, together with the EU and national strategies on bioeconomy, are likely to have contributed to the emergence of master courses on bioeconomy (see Annex II).

Whilst efforts have been deployed to reinforce the human capacity for the bioeconomy, the scope and level of ambition of the strategy and of the actions implemented have remained limited (e.g. vocational training is largely absent and needs to be addressed, so as to have a workforce equipped for the bioeconomy such as in the maritime sector where steps have been taken to address this issue). Similarly, whilst technologies are being researched and developed, it remains difficult to predict whether (and when) some of these will reach the market.

Area of action 2: Reinforced Policy Interaction and Stakeholder Engagement

The second area of action of the 2012 Action Plan included a set of actions, as follows:

- Creating a Bioeconomy Panel to enhance policy synergies and coherence and organise Bioeconomy Stakeholder Conferences;
- Establishing a Bioeconomy Observatory to assess and review progress and impact;
- Supporting the development of national and regional bioeconomy strategies;
- Developing international cooperation on bioeconomy R&I to jointly address global challenges.

The **Bioeconomy Panel** was created in 2013 to support interactions between different policy areas, sectors and stakeholders in the bioeconomy (e.g. business and primary producers, policy-makers, researchers and civil society organisations²⁶). The Panel was reorganised in 2016 to improve its representativeness of all the bioeconomy-relevant sectors and stakeholders and

²³ <http://masterbiocirce.com/>

²⁴ <http://www.uef.fi/web/biotalous/opetus>

²⁵ Blue careers call (EUR 3.6 million).

²⁶ <http://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=panel>

to focus, in a more explicit manner, on stakeholders' dialogue²⁷. The main output so far of the reorganised Panel has been the 2017 Stakeholders Manifesto²⁸, which lays down guiding principles and identifies actions that stakeholders and policy makers can take to develop the bioeconomy along a shared societal agenda. Furthermore, four Bioeconomy Stakeholder Conferences took place during the period 2012-2016 (Copenhagen 2012, Dublin 2013, Turin 2014 and Utrecht 2016).

As laid down in the Bioeconomy Action Plan, the **Bioeconomy Observatory** was set up in 2013 by the EC Joint Research Centre (JRC) under the name Bioeconomy Information System and Observatory²⁹ (BISO). Its objective has been to assess the progress and impact of the bioeconomy and develop forward-looking and modelling tools. The need to provide a more systemic and dynamic approach to support the Bioeconomy Strategy (i.e. cross-sectoral and cross-policy) and related policies has led to a new entity that integrated BISO as of July 2017, namely the **Bioeconomy Knowledge Centre (BKC)**. The BKC will act as a knowledge hub on the bioeconomy, providing relevant scientific and policy knowledge available in the JRC, EC policy DGs and beyond, as well as identifying critical knowledge gaps.

One of the key results of the 2012 Bioeconomy Strategy is that it has brought the bioeconomy principles and cross-cutting objectives to the attention of national and regional policy-makers, as demonstrated by the number of countries and regions that have adopted bioeconomy policies since 2012 (see Figure 2 below)³⁰. However, dedicated national bioeconomy related policies have mainly been established in EU15, while EU13 lag behind. It is worthwhile noting that **national strategies** go beyond R&I and follow the more holistic approach of the 2012 EC strategy and have often been developed jointly by various ministries covering bioeconomy-relevant policy areas such as: research, agriculture, forestry, industry, environment, regional, etc.

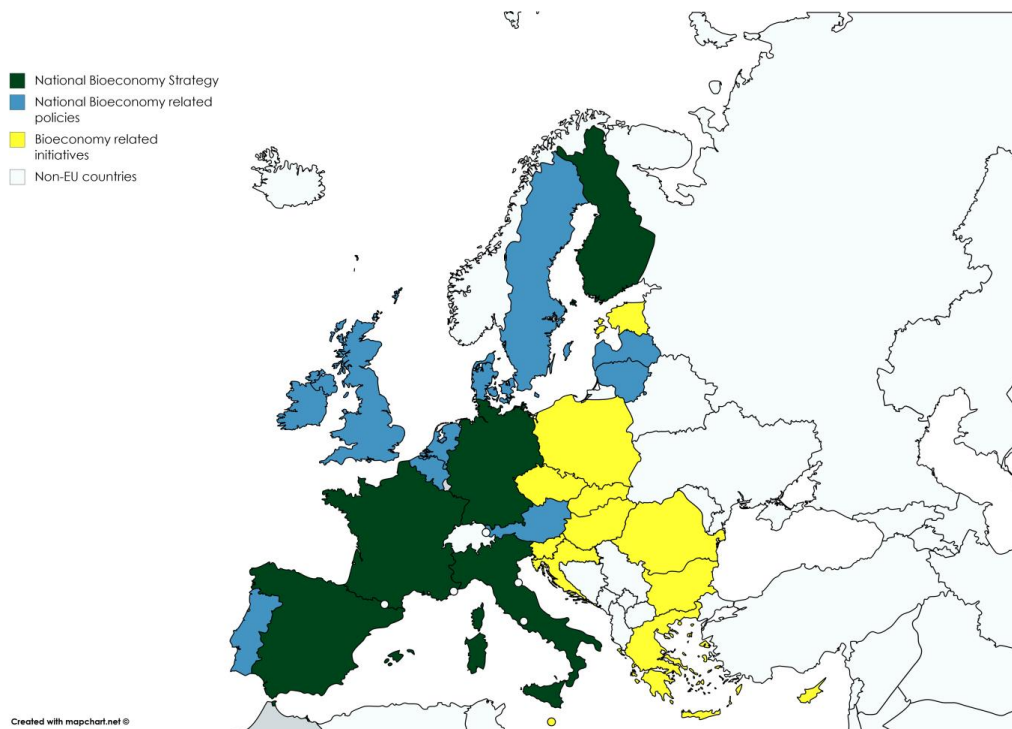
²⁷ The Panel was renamed "Bioeconomy Stakeholders Panel" to reflect the change in member composition.

²⁸ <http://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=panel>

²⁹ BISO operated as an FP7-funded project (2013-2016) that provided a website with bioeconomy-relevant S&T, policy and market data as well as research on bio-based industries and environmental aspects. It was followed (2016-2017) by the JRC institutional project-funded EU Bioeconomy Observatory (BeO)

³⁰ Table 12 in the annex gives an overview of the Members states and third countries that have dedicated bioeconomy policies or related initiatives as well as the year of adoption.

Figure 2: Bioeconomy strategies and bioeconomy related policies in the EU



Source: European Commission, DG Research and Innovation

Existing evidence³¹ shows that bioeconomy-related R&I has become a priority for many **European regions**, with a substantial number of regions having included bioeconomy-related priorities in their Research and Innovation Strategies for Smart Specialisation (RIS3). These Strategies are a funding precondition for EU cohesion policy, in particular for the research and innovation priority under the ERDF for which EUR 41 billion have been allocated for all areas. Out of 210 analysed territorial units (EU regions and countries) by a recent study²⁶, 207 have included bioeconomy-related aspects in their 2014-2020 RIS3 and related documents suggesting that also significant financial support will be made available from the ERDF. However, the study also shows that a large number of regions have a low level of maturity (35.7%) and cannot fully exploit the potential of the bioeconomy on their own. In addition, only a few cities have been identified that have bioeconomy-related priorities in their policies, despite the potential off municipal bio-waste for nutrient recovery, bio-based products and energetic use.

The EC's role in driving an **international bioeconomy R&I agenda** is evidenced by the setting up of the International Bioeconomy Forum (IBF)³². The

³¹ European Commission (2017), *Study on Bioeconomy development in EU regions, Mapping of EU Member States' / regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy*", Final Report, February 2017 and Annex 8 of the study; https://ec.europa.eu/research/bioeconomy/pdf/publications/bioeconomy_development_in_eu_regions.pdf

³² <https://ec.europa.eu/research/bioeconomy/index.cfm>

IBF, which is a platform gathering major countries³³ and international and regional organisations³⁴, is expected to develop a policy dialogue on the bioeconomy (e.g. indicators, availability of biomass, microbiome), align research funding programmes and increase R&I investment and international awareness of the central role of bioeconomy.

Area of action 3: Enhancement of markets and competitiveness in bioeconomy

The third area of action of the 2012 Action Plan included a set of actions, as follows:

- Providing the knowledge-base for sustainable intensification of primary production, improving understanding of biomass supply and demand, developing an agreed methodology for the calculation of environmental footprints;
- Supporting the development of (integrated and diversified) bio-refineries and the cascading use of biomass and waste streams, establish a PPP for biobased industries;
- Support the expansion of new markets through standards and other relevant schemes;
- Develop science-based approaches to inform consumers and promote a healthy and sustainable lifestyle.

The development of **data, models and analyses** on EU and global biomass flows, supplies and demands and their sustainability, by the European Commission Joint Research Centre (JRC) has contributed to developing a common knowledge base on biomass supply and demand. The JRC furthermore carried out studies on the land-use impacts, direct and indirect, of increasing demand for different biomass feedstocks. The major findings and insights up to date show the complexity of a comprehensive biomass assessment facing significant data gaps, a diversity of supply, demand, policies and a large variety of sectors potentially affected. At the same time, data are lacking in some areas (waste, bio-based products) and, due to the inherent complexity, limited progress has been made with regard to different supply and demand scenarios and their economic, social and environmental impacts.

The role of the public-private partnership BBI JU is proving crucial in supporting the **development of European industrial bio-based infrastructures and value chains**. The BBI JU has already launched six flagship projects on **bio-refineries** for a total contribution close to EUR 160 million³⁵ and this figure is

³³ These include the EU, Argentina, Australia, Brazil, Canada, China, India, New Zealand, South Africa and USA. Source: DG Research and Innovation

³⁴ These include the OECD, the FAO as well as the European Forest Institute and the Joint Programming initiatives under Horizon 2020 such as JPI OCEAN, FACCE and HDHL. Source: DG Research and Innovation

³⁵ For instance, the first flagship "First2Run" project, with a total investment of EUR 58 million, aims at setting up a commercial scale bio-refinery in Sardinia (Italy) for converting low input oil crops grown in

expected to more than double by 2020. Research and innovation efforts have also been undertaken at EU level to address the issue of **cascading use of biomass and waste streams**. EU funding has been allocated to R&D projects covering both the bioeconomy and the circular economy (ca. EUR 157 million); examples include the project ECOALF (Upcycling the Oceans) producing clothes from marine litter and projects looking at the issue of food waste and its key components (ca. EUR 74 million).

Moreover, the issue of **standards, labelling, public procurement, sustainability certification schemes** and cross-sector cooperation in the bio-based and chemical markets has been investigated through a number of R&D projects³⁶ (ca. EUR 16 million invested up to July 2017). Recommendations for the development of commonly accepted sustainability criteria, labels, and certification schemes for bio-based products to facilitate public procurement selection processes have been produced, whilst voluntary guidance on the cascading use of some biomass is expected to be finalised by the end of 2018.

R&D on **diets, consumer behaviour and food quality** has also been undertaken (ca. EUR 311 million) with relevant outputs such as dietary guidelines/recommendations, new food-processing technologies and technologies for the production of nutritious and personalised food³⁷. It is worth noting that this area of action will further be informed by the EC's recent FOOD 2030 initiative³⁸, which analyses the need for a more systemic approach to future-proofing nutrition and food systems towards becoming sustainable, resilient, diverse, responsible, inclusive and competitive in the longer term.

Progress on the issue of the **regulatory framework for the development of new markets** for the bioeconomy has remained limited.³⁹ In its assessment on the implementation of the measures recommended by the Lead Market Initiative, the Commission Expert Group on Bio-based Products indicated that progress in this area has been rather slow, thus potentially hampering the development of a broad bio-based economy within the EU. Whilst actions have been taken at EU level to address the issue of food waste and encourage the cascading use of biomass where appropriate⁴⁰, investment opportunities related to integrated and diversified bio-refineries remain largely untapped. In order to strengthen the regulatory framework for bio-based products and its contribution to an industrial transformation, the strategic approach may need to be adjusted, with more focused and ambitious actions.

arid or marginal lands, to produce added value chemicals, feed products and energy. Source: <https://www.bbi-europe.eu/projects/first2run> , <http://www.first2run.eu/>

³⁶ See table 10 of Annex I for a list of projects

³⁷ See section 5.2.3.4 of Annex I which gives examples of funded projects.

³⁸ A staff working document on FOOD2030 outlining the current R&D activities and challenges facing the food sector was presented in SWD(2016)319

³⁹ It is noteworthy that relevant measures are currently proposed in the Circular Economy Action plan, for example amendments to EU waste legislation that aims to increase the availability of quality bio-waste, measures that facilitate industrial symbiosis, in particular to valorise plant based feed materials, and the proposal for the revised Fertilising Product Regulation that provide specific measures for nutrient recovery from waste.

⁴⁰ COM/2015/0614 final states that "The Commission will promote efficient use of bio-based resources through a series of measures including guidance and dissemination of best practices on the cascading use of biomass and support for innovation in the bioeconomy".

2.2 Contribution of the 2012 Bioeconomy Strategy to achieve the five objectives

As stated in the introduction, the strategy aims to contribute to five objectives: (1) ensuring food security, (2) managing natural resources sustainably, (3) reducing dependence on non-renewable resources, (4) mitigating and adapting to climate change, and (5) creating jobs and maintaining EU competitiveness. Clearly, there are many EU policies in place that address one or more of these objectives such as: the CAP, the CFP, the 7th Environment Action Programme⁴¹ the Energy Union Strategy, the recent Clean Energy for all Europeans Package⁴², the EU Forest Strategy⁴³ and the Circular Economy Package⁴⁴. In addition, important global policy objectives have been adopted since the 2012 Strategy, such as the Sustainable Development Goals and the Paris Agreement on climate change. These policies and other factors such as the macro-economic context have had an important influence on addressing these objectives. It is, therefore, not possible in this review to quantify the direct contributions that the Bioeconomy Strategy and its Action Plan have made to help achieve these objectives. Nevertheless, important qualitative contributions can be demonstrated. First, at a general level, the strategy provided a holistic policy framing of the important connections, impacts and opportunities that the bioeconomy sectors have with regard to the societal challenges. The strategy and its implementation also increased awareness and understanding with regard to the need for coherent, holistic policy agendas at regional, national and EU levels. It furthermore identified the important role that R&I has in improving the prospects for traditional bioeconomy sectors that are key parts of the EU economy. The review demonstrates that the investments made in bioeconomy R&I are already starting to enhance modernisation of bioeconomy sectors (e.g. via the activities of the BBI JU)^{45,46}. In the following, a number of qualitative observations towards the achievement of the five objectives are made. Annex I provides concrete examples of projects and actions for each objective.

(1) Ensuring food security

The FOOD 2030 initiative, initiated in 2016, is an EU R&I framework calling for a systemic approach to future-proofing our nutrition and food systems towards becoming sustainable, resilient, diverse, responsible, inclusive and competitive in the longer-term. FOOD 2030 further deepens the contribution of the Bioeconomy Strategy to ensuring food and nutrition security as a means to deliver⁴⁷ on a number of the Sustainable Development Goals, and in particular

⁴¹ Decision No 1386/2013/EU of the European Parliament and of the Council

⁴² <https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition>

⁴³ COM(2013) 659 final; <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2013:0659:FIN>

⁴⁴ COM(2015)0614; <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52015DC0614>

⁴⁵ See BBI JU mid-term review at <https://ec.europa.eu/research/evaluations/pdf/bbi.pdf>

⁴⁶ A sizeable investment in the bioeconomy via EFSI relates to a loan of EUR 75 million to Finnish company METSÄ for the construction of their bioproduct mill <http://www.eib.org/infocentre/press/releases/all/2015/2015-131-finland-first-loan-under-investment-plan-for-europe-eib-supports-construction-of-large-scale-bio-product-mill.htm>

⁴⁷ COM(2016) 739 final

SDG2⁴⁸. FOOD 2030⁴⁹ builds on four priorities: Nutrition for sustainable and healthy diets, Climate-smart and environmentally sustainable food systems, Circular and resource efficient food systems, Innovation and empowerment of communities.⁵⁰ It is at the heart of the bioeconomy with a focus upon the sustainable provision of sufficient food for health and wellbeing.

The CAP provides a key EU policy framework for ensuring food security. Decoupling of CAP helps to ensure flexibility for farmers to adapt to market demand, thus ensuring agriculture and forest biomass provision. In addition, in the context of the Rural Development Policy there are significant opportunities for supporting the development of the bioeconomy. Particular opportunities for innovation in this domain arise through in-built linkages between the CAP, the EIP-AGRI and Horizon 2020 (SC2) – these altogether providing a comprehensive innovation framework. Such a framework could be improved and strengthened in the possible context of a revised Bioeconomy Strategy. In acknowledging that the CAP must be part of the solution to deliver food and nutrition security and address major public health and natural resources challenges, the Bioeconomy Strategy offers a unique opportunity to develop a more ambitious R&I strategy. This applies also in the context of the Common Fisheries Policy (CFP), as seafood makes up an increasing part of our food supply.

Horizon 2020 Societal Challenge 2 is co-programmed by DG RTD and DG AGRI, which enhanced the links to CAP agenda (e.g. Sustainable Food Security and Rural Renaissance action lines). The box below give examples on how this strategic objective has been addressed through Horizon 2020 in concrete activities and projects.

Contribution to food security: examples of analyses and EU R&D project

The Commission asked the High Level Group for Scientific Advice how to obtain more food from the ocean. As a first step, the "Science Advice for Policy by European Academies" group prepared a scoping paper based on the best scientific evidence. They concluded that the increased aquaculture production had the highest potential with particular emphasis to species low in the food chain such as shellfish. The impact of climate change would be less for aquaculture than for capture fisheries because species could be selected according to the environmental conditions. The scientific results will be presented to stakeholders and a final report from the High Level Group expected for the end of 2017; the whole process being completed within a year. The results of this analysis will feed into the EU's ocean governance⁵¹ and blue economy strategies as well as FOOD 2030⁵².

⁴⁸ SDG 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

⁴⁹ SWD(2016)319

⁵⁰ More practically, FOOD 2030 aims to: a) structure EU R&I systems by convening EU services, Member States & stakeholders for R&I programme alignment and leveraging of funds (public and private), b) connect the "whole food value chain" via R&I by linking land and sea, "farm-to-fork-to-gut-and back", producer-to-consumer, engaging all players, and c) scale-up R&I via "digital" take-up, open innovation and open science, investment, education, skills and capacities.

⁵¹ Joint Communication International ocean governance: an agenda for the future of our oceans, JOIN/2016/049 final

⁵² Report on the Blue Growth Strategy Towards more sustainable growth and jobs in the blue economy, SWD(2017) 128 final

The **PROTEIN2FOOD** project⁵³ will contribute to the development of innovative, cost-effective and resource-efficient plant protein-rich food sources with positive impact on food security and human health. It will do so by developing four innovative prototypes of high value protein-enriched food and six food and beverage products. The quality and quantity of protein from selected highly nutritious seed crops (quinoa, amaranth and buckwheat), and legumes with high protein quantity (lupin, faba beans, pea, chickpea, lentil) will be significantly enhanced. Ultimately, the project aims at contributing to a 25% increase in protein production and shift in consumption of animal-based protein to plant-based protein in Europe.

(2) Managing natural resources sustainably

Bioeconomy research and innovation activities, both under FP7 and Horizon 2020, have catalysed the development of smart sustainable farming, forestry, fisheries and aquaculture practices by improving the knowledge base for a resilient primary production, achieving productivity increases while ensuring sustainable resource use.

The strategy has played an important role in providing scientific evidence on biomass supply (from land and sea, incl. waste) and biomass demand (food, feed, bio-based products and materials, energy, etc.) The 4th SCAR Foresight study has also delivered scenarios for biomass supply and demand development up to 2050, pointing towards the challenges of a high-demand/high supply scenario⁵⁴.

More work is needed for the Strategy to support the implementation of an ecosystem-based management, valuing the provision of ecosystem services and stimulate synergies and complementarities with environmental policies on protection of water, soil, and biodiversity and habitats⁵⁵. Ongoing Commission and Member States work on the Mapping and Assessment of Ecosystems and their Services (MAES)⁵⁶ and on ecosystem accounting is focusing on measuring ecosystem condition, and how this is linked to the ability of ecosystems to provide a range of ecosystem services. Such tools can support the analysis of trade-offs and synergies amongst ecosystem services and help consider sustainability aspects of biomass production and of the bioeconomy.

The BLUEMED Initiative aims at advancing a shared vision of a Mediterranean Sea that is healthy, productive, resilient, understood and valued so as to promote the well-being and prosperity of our citizens and future generations and boost socio-economic growth and jobs⁵⁷.

⁵³ PROTEIN2FOOD, project ID 635727, <http://www.protein2food.eu/>

⁵⁴ <https://ec.europa.eu/research/scar/index.cfm?pg=foresight4th>

⁵⁵ For instance DG ENV is examining, through a tender study, the implementation of sustainable forest management according to the EU biodiversity strategy and the EU Bioeconomy Strategy.

⁵⁶ <http://biodiversity.europa.eu/maes>

⁵⁷ http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-food_en.pdf

Contribution to managing resources sustainably: example of EU R&D projects

The **AGROCYCLE** project⁵⁸ will convert low value agricultural waste into highly valuable products, achieving a 10% increase in waste recycling and valorisation by 2020. This will be achieved by developing a detailed and holistic understanding of the waste streams and piloting a key number of waste utilisation/valorisation pathway from the wine, olive oil, horticulture, fruit, grassland, swine, dairy and poultry sectors.

The **PLANTOID** project⁵⁹: Plants as a source of inspiration for artificial intelligence. Plants are essential to our survival and play a fundamental part in maintaining a balanced ecosystem. Now scientists are trying to explore the idea of engineering robots inspired by them. A new line of research exploring the capabilities of plants suggests that they might not be the passive organisms that many believe them to be. A group of researchers developed a robot that replicates the behaviour and mechanisms of plants. The STREP PLANTOID Project will aim at designing, prototyping, and validating a new generation of ICT hardware and software technologies inspired from plant roots, called PLANTOIDS, endowed with distributed sensing, actuation, and intelligence for tasks of environmental exploration and monitoring.

The **INFRES** project⁶⁰ (Innovative and effective technology and logistics for forest residual biomass supply in the EU) was implemented from Sep 2012 to Aug 2015 to accelerate the technological development and open new paths to EU's renewable and climate change mitigation targets by producing knowledge, technological solutions and service innovations for forest residue feedstock supply to heat, power and bio-refining industries. In this respect, INFRES developed a computational tool that compares cost, fuel consumption and carbon dioxide emissions from machinery used in common fuel wood supply chains, and assessed the most suitable means to dry and store woody feedstock. In addition to improved technology, INFRES developed flexible fleet management systems to run the harvesting, chipping and transport operations, and devised innovative business models that mutually benefit several sectors.

(3) Reducing dependence on non-renewable resources

The Strategy has triggered development of nature / bio inspired solutions, innovation and technologies that can replace fossil raw materials: e.g. BBI JU flagships, Horizon 2020 SC2 Biobased calls. The BBI-JU in particular is financing projects like First2Run (see box below) that make use of low input crops, agri-food and forestry waste streams and other biowaste streams to turn them into products that replace fossil-based products. One of the targets of the BBI initiative is to increase the use of bio-based chemicals to 25% in 2030, which would translate into replacing about 1% of current EU fossil resources use, assuming this extra demand would be met by EU production⁶¹.

⁵⁸ AGROCYCLE, project ID 690142, <http://www.agrocycle.eu/>

⁵⁹ PLANTOID, project ID 293431, http://cordis.europa.eu/project/rcn/103889_en.html

⁶⁰ INFRES, project ID 311881, http://cordis.europa.eu/project/rcn/104506_en.html

⁶¹ The chemical sector currently accounts for 6% of annual fossil resource consumption in Europe, and 10% of all chemicals are currently bio-based.

Contribution to reducing dependence on non-renewable resources: example of a BBI-JU funded flagship project

First2Run is a EUR 25 million BBI-JU flagship project⁶² to demonstrate a first-of-kind value chain where low input and underutilised oil crops (i.e. cardoon) grown in arid and/or marginal lands are exploited for the extraction of vegetable oils (and not in competition with food or feed). These oils are further converted into bio-monomers as building blocks for high-added value products such as bio-lubricants and bio-plastics. The First2Run bio-refinery is located in Sardinia (Italy) and the products produced have the potential to replace products currently made from non-renewable resources.

(4) Mitigating and adapting to climate change

Knowledge and technologies currently developed will support the adaptation of agricultural, forestry and maritime sectors to climate change. Furthermore, it is expected that these actions will play a role in climate change mitigation, notably through a reduction in greenhouse gas emissions⁶³ in line with the specific Priority 5 of the Rural Development Regulation, and at the same time help other sectors to decarbonise by producing biomass for substitution of fossil-based materials. This issue is further explored in section 3.2 below.

⁶² First2Run BBI-JU project, <http://www.first2run.eu/>

⁶³ Research and innovation efforts of the Bioeconomy Strategy have contributed to climate change mitigation by developing increased bio-resource efficiency whereby all parts of the crop plants, the trees, the husbandry animals, and aquaculture products (fish and bivalves) are used in order to decrease the emission per ton produced. In addition, the strategy further advanced the understanding of how climate change influences important fish and shellfish resources in Europe and the economic activities depending on them.

Contribution to mitigating and adapting to climate change: examples of EU R&D funded projects

The objective of the **RUMINOMICS** project⁶⁴ is to contribute to the reduction of GHG emissions from the dairy industry, whilst improving productivity of this sector. The project's main study was a large-scale genetic association study involving 1,000 cows in four different countries (UK, SE, FI, IT) and looked at how feed intake, digestion efficiency, milk production/composition and methane emissions are related to the ruminal microbiome and host genome. The project findings provide a wealth of data on the genetics underlying greenhouse gas emissions in the dairy industry and have the potential to improve the efficiency of dairy farming, while decreasing emissions.

FORMIT (Forest management strategies to enhance the mitigation potential of European forests)⁶⁵ worked from Oct 2012 to Sep 2016 on the identification of forest management strategies that optimise the contribution of the sector to climate change mitigation in different regions/forest types in Europe, while accounting for trade-offs with other forest functions. Mitigation options refer to carbon sequestration in forests and in wood-based products, and substitution of fossil fuels, while the trade-offs include biofuel use, biodiversity conservation, and economics of timber production. This implied inter alia resource assessment, life cycle assessment (LCA) "from cradle to grave", and development of scenarios for forest management strategies oriented toward different objectives, including climate change mitigation and adaptation combined. While acknowledging the complexity of synergies and trade-offs, an important conclusion resulted from the analysis of "Representative Adaptation and Mitigation Pathways" (RAPS) was that enhanced use of wood-based products is feasible under both forest management-driven and wood market-driven scenarios, and has net benefits to global climate change mitigation and beyond through both reduced wood imports to Europe and enhanced exports from Europe.

(5) Creating jobs and maintaining EU competitiveness

Horizon 2020 Societal Challenge 2 and the BBI JU have delivered on funding R&I that contributes to generating jobs and increased competitiveness in the bioeconomy sectors. For example, the Rural Renaissance action line in SC2 has stimulated the development of knowledge, technologies and products providing the basis for rural and coastal livelihoods through improved agriculture, forestry, aquaculture and fishery and bio-based business models suitable for utilization by rural actors. The BBI JU has developed bio-refinery technologies and products for improved food and feed use based on local resources (see box). Latest research and further analysis of multipliers show the potential of the bioeconomy to create also jobs (multiplier effect of about 0.5 additional new job per bioeconomy job) and growth (about 60% of additional value added) in non-bioeconomy sectors⁶⁶.

⁶⁴ RUMINOMICS, Project ID: 289319, http://cordis.europa.eu/result/rcn/191776_en.html

⁶⁵ FORMIT, project ID: 311970, http://cordis.europa.eu/project/rcn/104508_en.html

⁶⁶ Mainar-Causapé, A., Philippidis, G., Sanjuan, A.I. (2017). "Analysis of structural patterns in highly disaggregated bioeconomy sectors by EU Member States using SAM/IO multipliers". EUR 28591. JRC Technical Reports. European Commission-Joint Research Centre. doi:10.2760/822918

Contribution to job creation and EU competitiveness: examples of the BBI JU and SME instrument under Horizon 2020

The Bioeconomy Strategy has contributed to **direct and indirect employment and growth** notably via the BBI JU, which will help maintain and further develop a competitive and knowledge-intensive rural economy in Europe, based on bio-refineries. These will result in new, higher and more diversified revenues for farmers and cooperatives and create up to 400,000 new highly skilled jobs by 2020⁶⁷. Similarly, early estimates show that bioeconomy innovations developed with the support of the Horizon 2020 SME instrument are expected to produce on average EUR 2.19 million turnover per SME⁶⁸ in the first year of commercialisation. The average SME expects to employ 10 extra personnel in the first year following commercialisation of the innovation, the number rising to 14 in year two, 19 by the third year, 25 and 46 in years four and five respectively⁶⁹.

As described above, the review demonstrates that a number of (sub-)actions of the Action Plan have been successfully implemented, and have made qualitative contributions to addressing the five objectives of the Strategy. However, the review also points to intrinsic weaknesses in the design of the Strategy and its Action Plan, namely that the objectives and actions are only described in a general sense, and the **linkages between the (sub-)actions in the Action Plan and the five objectives of the Bioeconomy Strategy are not always clear**. There is no explicit articulation showing how the implemented (sub-)actions are meant to contribute to the achievement of the five objectives, and the sub-actions in general do not refer to concrete policies. More generally, the **lack of "SMART"⁷⁰ targets and monitoring indicators** for each of the five objectives, the three areas and the actions/sub-actions also means that it is difficult to monitor progress and fully assess, or evaluate, the extent to which the implementation of the actions contribute to the five strategic objectives. Furthermore, implementation of the sub-actions is only generally attributed to actors (mostly to "EU", and "Member states"), with generic time-frames for delivery (short-, medium-, long-term). Also, the sheer number and diversity of (sub-)actions may have resulted in a suboptimal focus and some overlap.

⁶⁷ http://ec.europa.eu/research/participants/data/ref/h2020/other/legal_basis/jtis/bbi/bbi-sira_en.pdf

⁶⁸ This is based on 55 SME Instrument Phase 2 projects for which information was available at the time of the interim evaluation of SC2 and which reported a combined turnover of EUR 46 million for the first year of commercialisation. Source: Expert Group on Horizon 2020 SC2 Interim Evaluation, (2016), *Interim Evaluation of Horizon 2020, Societal challenge 2: Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy*, Final Report, 6 December 2016

⁶⁹ Expert Group on Horizon 2020 SC2 Interim Evaluation, (2016), *Interim Evaluation of Horizon 2020, Societal challenge 2: Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy*, Final Report, 6 December 2016

⁷⁰ Specific, Measurable, Attainable, Relevant and Timely

2.3 Policy coherence and synergies

Achieving a good level of policy coherence is crucial for the implementation of the 2012 Bioeconomy Strategy and Action Plan, since the achievement of the interlinked bioeconomy objectives requires an integrated (i.e. cross-sectoral and cross-policy) approach within the EC and beyond. This is needed in order to adequately address the issue of multiple trade-offs but also of synergies and interconnected objectives related to bioeconomy policy (e.g. sustainability and protection of natural capital, mitigating climate change, food security).

Section 3 provides an analysis of the relevance of the bioeconomy strategy for two EU flagship initiatives such as the Circular Economy (3.1) and for energy efficiency and emission reduction (3.2) and the related synergies. Policy coherence and synergies with other policies is detailed in Annex I.

In terms of coherence between the Bioeconomy Strategy and Action Plan and key EU policies, such as CAP, other ESIF, CFP, Biodiversity Strategy and circular economy, an appropriate degree of interaction and coherence has been achieved (see Annex I). At the same time, there are several areas of action where policy coherence and synergies are insufficiently developed:

- With regard to the **regulatory framework for bio-based products markets**: there is currently no clear and coherent policy approach regarding the regulation of bio-based products markets. Some steps have been taken to address the issue of certification, labelling and public procurement, such as the EU Ecolabel⁷¹ and action on green public procurement. Furthermore, the current proposal for a revision to the EU Fertiliser Regulation proposes EU level end-of-waste criteria for biowaste and digestate, which would allow them to circulate freely in the EU internal market. Proposed amendments to the EU waste legislation also envisage specific measures targeting quality biowaste for recycling and targeting industrial symbiosis for feed materials. However, there are currently no dedicated policy tools at European level to support the development of bio-based products markets, contrary to other countries such as the United States⁷². This regulatory situation, which has been deemed "uncertain" by some stakeholders, has potential negative impacts with the bio-based private sector being reluctant to take risks investing into new areas;
- Funding of **high risk investments** is not well supported by current EU instruments: whilst the Strategy and Action Plan called for investments to support integrated activities (e.g. biorefineries), current EC funding instruments do not provide sufficient funding for this type of high risk activities. Some funding has been made available through Horizon 2020, ESIF and the BBI JU, but this remains insufficient given the scale of the investments needed. A recent study has shown that insufficient support to the scaling up from pilot to demonstration and subsequent flagship/first-of-

⁷¹ E.g. the EU Ecolabel for lubricants that promotes products with large fractions of bio-based material.

⁷² See e.g. the US biopreferred programme <https://www.biopreferred.gov/BioPreferred/>

a-kind and industrial-scale projects, as well as regulatory uncertainty, is holding back private investments in the bio-based sector⁷³.

- The generation of **knowledge on biomass supply and demand** is often produced following a sectoral approach (e.g. biomass for food or feed or bioproducts or bio-energy use) and socio-economic and environmental trade-offs are poorly reflected in policy. As a result, there is insufficient coherence between policies which are relevant for the bioeconomy.
- As the Strategy identified, the main aim is to achieve a more innovative, resource efficient and competitive society that reconciles food security with the sustainable use of renewable resources for industrial purposes, while ensuring environmental protection. Reconciling these, in part competing, policy objectives not only imply trade-offs but also imply the availability of sufficient **understanding and evidence about current and future impacts of various policy options**.

⁷³ See findings of study released by EIB in May 2017:
<http://www.eib.org/infocentre/publications/all/access-to-finance-conditions-for-financing-the-bioeconomy.htm>

3 Contributions of the Bioeconomy Strategy to other EU policies

This section provides an analysis of the relevance of the Bioeconomy Strategy to the Circular Economy and an energy-efficient, low-carbon economy, as provided by the mandates in the Circular Economy package and the Communication on Accelerating Clean Energy Innovation.

3.1 Bioeconomy contributions to a Circular Economy

3.1.1 The Bioeconomy and Circular Economy: Concepts and complementarities

The Communication laying out the Action Plan for the Circular Economy defines the Circular Economy as an economic system in which "the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised"⁷⁴. Bioeconomy is defined as "the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, bio-based products and bioenergy"⁷⁵.

The reference to the conversion of biological waste streams into value-added products in the definition of the bioeconomy indicates that an important principle of the circular economy has been built into the Commission's understanding of the bioeconomy from the start. The Communication laying out the Action Plan for the Circular Economy and the Bioeconomy Strategy also share several similar objectives, including increased resource efficiency, a reduction in green-house gas emissions and a reduction in the reliance on non-renewable primary resources.

The links between the Commission's approaches to the bioeconomy and the circular economy are further underlined by the fact that the Communication laying out the Action Plan for the Circular Economy addresses the sustainable production of biomass, the role of bio-based products and biorefineries, the management of bio-waste and food waste, and the facilitation of nutrient recovery. Together with that Communication the Commission also put forward proposals to revise certain pieces of legislation to address, amongst other things, the separate collection of bio-waste (Waste Framework Directive) and the role of bio-nutrients in the circular economy (Fertiliser Regulation). In order to support the development of bio-based products markets, the initiatives adopted in the context of the Circular Economy package include legal instruments that make the secondary material available (feed materials, biowaste), create industrial symbioses for feed materials and create the regulatory framework for fertilising products from waste.

A number of policy-makers at national and regional level have emphasised the complementarities between the bioeconomy and the circular economy. In the Netherlands, biomass and food are identified as one of five priority areas in the

⁷⁴ COM/2015/0614; <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52015DC0614>

⁷⁵ COM/2012/060final <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2012:0060:FIN>

National Agreement on the Circular Economy.⁷⁶ "Forest-based loops" and the "sustainable food system" are priorities of the Finnish roadmap to a circular economy.⁷⁷ The Nordic Council of Ministers has published a report on the challenge and opportunities of the better use of urban organic waste as a resource.⁷⁸ The city of Amsterdam has published a paper that sets out a vision of high value recycling of organic residue streams.⁷⁹

Some organisations have produced graphical representations of the circular economy that show biomass flows as an integral, and separately identifiable, part of the circular economy.⁸⁰ Some stakeholders are actively supportive of the links between the circular economy and the bioeconomy. For example, the Commission Expert Group for Bio-based Products has called for the "creation of a bioeconomy that uses bio-based resources in a circular way (circular bioeconomy)"⁸¹. Other stakeholders have a more cautious position on whether and how the bioeconomy can help to build the circular economy.⁸²

3.1.2 The contribution of the bioeconomy to a more circular economy based on renewable resources

Important principles of the circular economy are strongly reflected throughout the text of the 2012 Bioeconomy Strategy. The opening sentence of the strategy states that "Europe needs to radically change its approach to production, consumption, processing, storage, *recycling* and disposal of biological resources" [emphasis added]. There are frequent references to wastes and residues when discussing sources of biomass and biological resources. The Staff Working Document accompanying the strategy stresses the role of biorefineries, which "can [...] contribute to the principles of a zero-waste society."

Both the strategy itself and the accompanying Staff Working Document emphasise the importance of the principle of cascading use of biomass, and underline the need for the bioeconomy to foster resource efficiency. The Staff Working Document states that the cascading use of biomass "is based on single or multiple material uses followed by energy use through burning at the end of life of the material." As such it is highly consistent with the circular economy principle of keeping the value of resources in the economy for as long as possible. Integrated biorefineries, which use processing technologies to fractionate biomass and biological waste streams, to produce food, feed, bio-

⁷⁶ <https://www.circulaireeconomienederland.nl/grondstoffenakkoord/default.aspx>

⁷⁷ <https://media.sitra.fi/2017/02/28142644/Selvityksia121.pdf>

⁷⁸ <https://www.ellenmacarthurfoundation.org/publications/urban-biocycles> and <https://norden.diva-portal.org/smash/get/diva2:1087336/FULLTEXT01.pdf>

⁷⁹ <https://www.amsterdam.nl/bestuur-organisatie/organisatie/ruimte-economie/ruimte-duurzaamheid/making-amsterdam/circular-economy/report-circular/>

⁸⁰ See for example of the Ellen MacArthur Foundation <https://www.ellenmacarthurfoundation.org/circular-economy/interactive-diagram> and the nova Institut <http://bio-based.eu/graphics/>

⁸¹ See point 2.9. of the position paper on Bioeconomy Strategy Revision issued by the Commission Expert Group on Bio-based Products

⁸² See for example Friends of the Earth "Land Under Pressure: global impact of the EU bioeconomy", 2016 http://www.foeurope.org/sites/default/files/resource_use/2016/land-under-pressure-report-global-impacts-eu-bioeconomy.pdf

based materials and fuel/energy in an integrated manner, are critical infrastructures for enabling the cascading use of biomass.

The following actions from the action plan are considered to be most directly relevant to the circular economy: A9.1, A9.2, A10.2 and A11.10. An analysis of the implementation of each of these actions is provided below.

A9.1: Develop tools to aggregate data on biomass and biowaste availability and their use in bio-based industries, bioenergy and food sectors.

In 2015 a mandate was agreed for the European Commission's Joint Research Centre to "provide data, processed information, models and analysis on EU and global biomass supply and demand and its sustainability".⁸³ The scope of this work includes bio-waste as well as biological by-products, co-products and residues. It should therefore represent a major step forward in the presentation and analysis of data on biomass in the integrated bioeconomy, and on the circular and cascading flows of biological resources through our economy. The first major deliverables of this work are expected to be published soon.

The S2BIOM project⁸⁴, financed under FP7, is also highly relevant to Action 9.1. The aim of the S2BIOM was to support the sustainable delivery of non-food biomass feedstock at local, regional and pan European level through developing strategies, and roadmaps that are informed by a computerized and easy-to-use toolset. Forestry and agricultural residues, as well as municipal biowaste, are considered amongst the biomass sources covered by the project.

A9.2 - Enhance the markets in Europe for quality biomass and waste to provide producers of bio-based products, biofuels and bioenergy with equal accessibility.

A number of EU-funded research and innovation projects have contributed to the development of markets for bio-based products in a way that helps to build the circular economy, by addressing, amongst other things, the development of standards, awareness-raising, and public procurement. Some of the most relevant research and innovation projects are:

- Open-Bio⁸⁵ (2013-2016): This project fed directly into the standardization processes of CEN/TC411 on bio-based products, which covers terminology for bio-based products, sampling, bio-based content, life-cycle assessment and guidance on the use of existing standards for the end-of-life options. The end-of-life research carried out in Open-Bio included different biodegradation scenarios, composting and recyclability.
- InnProBio⁸⁶ (2015-2018): This project will build a community of public procurement practitioners interested in the procurement of bio-based products. Guidance and tools for public procurement practitioners cover

⁸³ <https://biobs.jrc.ec.europa.eu/biomass-assessment-study-jrc>

⁸⁴ S2BIOM, project ID: 608622, http://cordis.europa.eu/project/rcn/109514_en.html

⁸⁵ Open-Bio, project ID: 613677, http://cordis.europa.eu/project/rcn/110950_en.html

⁸⁶ InnProBio, project ID: 652599, http://cordis.europa.eu/project/rcn/194784_en.html

issues such as biodegradability and specifically address the role of bio-based products and services in the circular economy.

- STAR4BBI⁸⁷ (2016-2019): This project, financed by the Bio-Based Industries Joint Technology Initiative, aims to promote a level playing field for bio-based products by contributing to the establishment of a coherent and well-coordinated regulatory / standardisation framework. It specifically includes the encouragement of new value-chains from organic waste within its scope.

In 2016 the Commission published a study on the cascading use of wood that will serve as a basis to develop good practice guidance on the cascading use of wood for policy-makers and value-chain stakeholders.⁸⁸

A10.2 - Support the establishment of a network of diversified biorefineries across Europe, as well as the creation and networking of one or more clusters of integrated and diversified biorefineries in every Member State. Assist in the creation of supply chains and the necessary logistics for the cascading use of biomass and waste by the biorefinery networks and clusters.

The single most important contribution of the Bioeconomy Strategy under this action has come from the Bio-Based Industries Joint Technology Initiative. The Commission's first report on the implementation of its Circular Economy Action Plan refers to the role of the Bio-Based Industries Joint Technology Initiative in developing some of the key enabling technologies for the circular economy.⁸⁹

The Strategic Innovation and Research Agenda⁹⁰ (SIRA) of the Bio-Based Industries Joint Technology Initiative, updated in 2017, includes the objectives of "developing and deploying innovative technological and logistic solutions to efficiently set up new value chains based on bio-waste by making the best possible use of cascading and circular approaches"; and "the development of integrated and sustainable value chains using agri-based, forestry-based, [and] aquatic feedstock and their residues and side streams; and bio-waste and CO₂." It also says that "integrated biorefineries will apply the cascading principle where feasible to maximise conversion of the biomass feedstock and its by-products, side streams and residual streams into higher added-value products".

Amongst the approved BBI projects that help to build the circular economy by supporting bio-refining technologies and/or the development of new waste-based value chains are:

- PROMINENT⁹¹: this project aims to obtain proteins for food from side streams of the wheat and rice processing industry; and GREENPROTEIN,

⁸⁷ STAR4BBI, project ID: 720685, http://cordis.europa.eu/project/rcn/205455_en.html

⁸⁸ <http://publications.europa.eu/en/publication-detail/-/publication/04c3a181-4e3d-11e6-89bd-01aa75ed71a1>

⁸⁹ COM(2017) 33 final

⁹⁰ http://ec.europa.eu/research/participants/data/ref/h2020/other/legal_basis/jtis/bbi/bbi-sira_en.pdf

⁹¹ PROMINENT, project ID: 633929, http://cordis.europa.eu/project/rcn/193260_en.html

which aims to produce food-grade functional proteins and other ingredients from the residues of vegetable processing.

- NEWFERT⁹²: a research and innovation project that will explore the recovery of nutrients for fertiliser production from agricultural and municipal waste.
- PULP2VALUE⁹³: this project will demonstrate a cascading bio-refinery system to refine sugar beet pulp (a residue of the sugar beet processing industry) into high value products such as microcellulose fibers (MCF), arabinose and galacturonic acid.
- MACRO CASCADE⁹⁴: a research and innovation project to prove the concept of a marine macro-algal biorefinery by applying a cascading approach in which process residuals from seaweed are used for fertilisers and bioenergy.
- URBIOFIN⁹⁵: this project will demonstrate the techno-economic and environmental viability of the conversion at semi-industrial scale of the organic fraction of municipal solid waste into chemical building blocks, biopolymers and additives.
- OPTISOCHEM⁹⁶: a demonstration project for the transformation of excess wheat straw into bio-Isobutene (bio-IBN) derivatives, which can be used in a wide range of applications such as lubricants, adhesives, sealants, and flavours and fragrances.

The Expert Group Report argues that the Bio-Based Industries Joint Technology Initiative has played a significant role in orientating research and innovation funding to the practical implementation of the cascading use of biomass. Initially "a large proportion of the funds invested [was] dedicated to research on technologies where only the energy content is used, hereby not aiming at using the full potentials of the biomass", and "only with the start-up of the BBI activities [were] the valorisation optimising principles behind cascading use of biomass [...] brought in full use."

In addition to the Bio-Based Industries Joint Technology Initiative, a significant number of other research and innovation projects funded under Horizon 2020 also help to build a circular economy based on renewable biological resources. Examples include:

- DISCARDLESS⁹⁷: this project works towards the gradual elimination of fish discards, including by exploring the best uses of unavoidable unwanted fish catches.

⁹² NEWFERT, project ID: 668128, http://cordis.europa.eu/project/rcn/197313_en.html

⁹³ PULP2VALUE, project ID: 669105, http://cordis.europa.eu/project/rcn/197329_en.html

⁹⁴ MACRO CASCADE, project ID: 720755, http://cordis.europa.eu/project/rcn/205624_en.html

⁹⁵ URBIOFIN, project ID: 745785, http://cordis.europa.eu/project/rcn/210297_en.html

⁹⁶ OPTISOCHEM, project ID: 744330, http://cordis.europa.eu/project/rcn/210280_en.html

⁹⁷ DISCARDLESS, project ID: 633680, http://cordis.europa.eu/project/rcn/193250_en.html

- ECOPROLIVE⁹⁸: this project proposes a new process to obtain olive oil without generating wastewater or other wastes, by fully transforming the high valuable constituents of the olive into novel products.
- WHEYCOM⁹⁹: this project will help to reduce the amount of waste coming from the cheese industry by providing an alternative for whey waste as disinfectant in for the fruit and vegetable industry.
- RES URBIS¹⁰⁰: the objective of the project is to integrate into a single facility and to use one main technology chain for the conversion of several types of urban bio-wastes into valuable bio-based products, while also minimizing any residual waste.

Overall, more than 40 projects so far approved under Horizon 2020 and the Bio-Based Industries Joint Technology Initiative could be identified that work in the overlap of bioeconomy and circular economy. The total EU contribution to those projects is €157 million, representing about 38% of the EU contribution to all Horizon 2020 Societal Challenge 2 and BBI projects in the period 2014-2016.

The 2018-2020 Work Programme for Horizon 2020 Societal Challenge 2 includes a Circular Bioeconomy Thematic Investment Platform, which would provide access to finance, in particular in the form of debt or quasi-equity, to innovative bioeconomy projects, with a priority focus on circular bioeconomy projects.

As well as research and innovation funding, a number of other EU instruments have been used to support the biorefineries, biorefinery clusters, and the development of circular, bio-based value chains. The COSME programme has financed a "European Sustainable Chemicals Support Service" to provide advisory support services to six "Model Demonstrator Regions" in the production of sustainable chemicals. These regions will lead the way towards sustainable chemical production in Europe, by taking advantage of domestically available feedstock such as biomass or waste, and strengthen cross-sectorial cooperation between chemicals industries with other industries and sectors, notably agriculture, forestry, energy, waste management and recycling.

The European Regional Development Fund has supported a new investment in the Bio Base Europe Pilot Plant in Flanders, which can help industry to test the concept of circular, bio-based value chains prior to full commercial application. The ERDF has also supported the Vanguard Initiative¹⁰¹, a network of innovative regions focussed on inter-regional cooperation for transformative industries, which has selected the bioeconomy as one of its priority areas of work.

The European Agricultural Fund for Rural Development (EAFRD) includes a provision to support farmers and other supply-chain actors that work together

⁹⁸ ECOPROLIVE, Project ID 635597, http://cordis.europa.eu/project/rcn/193341_en.html

⁹⁹ WHEYCOM, Project ID 674797, http://cordis.europa.eu/project/rcn/198027_en.html

¹⁰⁰ RES URBIS, Project ID 730349, http://cordis.europa.eu/project/rcn/206585_en.html

¹⁰¹ <http://www.s3vanguardinitiative.eu/>

on the sustainable provision of biomass for use in food and energy production and industrial processes.

A11.10 - Provide the knowledge base for existing policy incentives (and if necessary for new policy initiatives, at both European and national level) with a view to reducing food wastage in food production, storage, transport, distribution and households. Support scientific research for the development of novel processing systems for converting food waste by-products for soil fertility, climate change mitigation or into higher value end-products.

Funding for food waste related projects already increased substantially from EUR 40.8 million in FP7 to EUR 74 million in the first three years of Horizon 2020 and further calls on food waste are planned for the 2018-2020 work programme of Horizon 2020. The REFRESH project¹⁰² of Horizon 2020 (see info below) is closely collaborating with the EU Platform on Food Losses and Food Waste (FLW Platform) established as part of the Circular Economy Action Plan. REFRESH is collaborating with the newly established subgroup for action and implementation plans. The digital tool established as part of the FLW platform to facilitate cooperation among FLW members will operate alongside a similar online tool from the REFRESH project that is addressing a large community of experts and stakeholders.

- **REFRESH: Resource efficient food and drink for the entire supply chain:** REFRESH focuses on the reduction of food waste, including packaging materials, and improved valorisation of food re-sources. Adopting an innovative and systemic approach to properly understand the drivers of food waste, the project will support better decision-making by industry and individual consumers. In addition, the project will provide guidance to legislators and policy makers to help support effective governance to combat food waste. REFRESH builds on and goes beyond existing initiatives to develop, evaluate, and ensure the spread of social, technological, and organisational insights and practices related to food waste. By developing a "Framework for Action" model, REFRESH will significantly contribute to a systems change towards a more sustainable and resource efficient food system based on circular economy principles.

In conclusion, there are strong complementarities between the Commission's approaches to the bioeconomy and the circular economy. They share a number of overarching objectives, such as resource efficiency, and reduced GHG emissions, and they both encourage the principle of cascading use of biomass, and the valorisation of biological wastes and residues.

The scope of the circular economy, however, goes well beyond biological resources. Similarly, the bioeconomy also includes areas such as the primary production of biological resources, which are beyond the scope of the Commission's Action plan on the circular economy, but highly relevant for ensuring a sustainable and renewable resource base for the circular economy.

¹⁰² REFRESH project, Project ID: 641933, http://cordis.europa.eu/project/rcn/197850_en.html

The bioeconomy incorporates to the overall economy natural cycles and processes, such as the photosynthesis or the nitrogen cycle, natural decomposition, and thus perturbation of these realms must be fully considered if circularity is to be ensured. To enhance the contribution, research efforts could focus further on the environmental and health impacts of bio-based materials (i.e. bio-plastics) while innovation efforts could take a more market-oriented approach and provide support to the establishment of industrial symbiosis sites. .

The EC commitments in the Bioeconomy Strategy are highly consistent with the subsequent 2015 Circular Economy Package. The most significant contribution of the Bioeconomy Strategy to building the circular economy in Europe has come from research and innovation funding under Horizon 2020.

3.2 Bioeconomy contributions to the Energy Union

The European Commission's "Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy" aims to bring about the transition to a low-carbon, secure and competitive economy. The key objective of the Energy Union Strategy is to promote a transition to a low-carbon economy, based on increased energy efficiency, lower GHG emissions and renewable energies, including biomass. The bioeconomy can make a decisive contribution to the various dimensions of the Energy Union. For instance the replacement of fossil resources by sustainable biomass can contribute to reducing the overall carbon footprint of the energy sector, as well as other sectors depending on fossil or other non-renewable resources. This is recognised in the 2016 Communication on Accelerating Clean Energy Innovation¹⁰³, which provides a mandate for this review to examine the role and potential of the bioeconomy to "contribute to increasing energy efficiency and reducing emissions by better using raw materials and recycling secondary raw materials and waste". The following section will therefore highlight some of the contributions the existing strategy and the bioeconomy has made to the Energy Union and in addition outline the untapped potential that can be addressed, in particular through research and innovation.

3.2.1 Bioeconomy and the Energy Union: complementarities and synergies

As a result of the EU Renewable Energy Directive and its national and European binding targets, the share of renewables in the EU rapidly increased from 10.4% in 2007 to 17% in 2015. Bioenergy is by far the largest renewable energy source in the EU, supplying 12% of the EU final demand, and having a significant role for the achievement of the 2020 and 2030 climate and energy targets. In November 2016, as part of the Clean Energy for All Europeans Package, the Commission adopted a proposal for a revised Renewable Energy Directive. This proposal lays out EU measures that should, together with Member States' contributions described in their national energy and climate plans, make sure that that EU RES target of at least 27% will be achieved. It proposes a reduced reliance on 1st generation biofuel and an increase of 2nd

¹⁰³ COM(2016) 763 final; http://ec.europa.eu/energy/sites/ener/files/documents/1_en_act_part1_v6_0.pdf

generation biofuels, and also includes a strengthened set of binding sustainability criteria for all energy uses of biomass, including in heat and power and transport.

More than any other type of renewable energy, bioenergy is closely related to land use and agricultural and forestry production that make up the global bioeconomy. The traditional bioeconomy has largely been composed of more or less separate sectors concerned with the production of food, feed for animals, forest products including construction materials, paper and pulp, or textiles, while also supporting local energy needs through the provision of firewood. The concept of integrated biorefineries provides an integration between these sectors, allowing the production of a wide range of high added-value products next to commodity materials, based on a variety of sustainably produced biomass feedstocks from land and sea, including waste and side streams.

The processing of biomass in integrated biorefineries into a range of bio-based products, including bioenergy and transport biofuels, has similarities with the approach of the petrochemical industry, which makes higher added-value products at relatively low volume and lower-value fuels at high volume. Bioenergy supply is an important feature of such plants, complementing the production of other bio-products, which may substitute those derived from fossil fuels, and enabling the biomass feedstocks and its side-streams to be fully valorised. Integrated approaches to bioenergy generation need to be developed and demonstrated in the context of optimising the overall economics and to maximise the efficiency of use from a resource and land use perspective. The deployment of biorefineries will depend heavily on the successful development and commercialisation of new technologies, and fostered by a supportive policy and regulatory enabling environment. It will also require the commercialisation and large-scale deployment of the less mature technologies¹⁰⁴.

Increased resource competition between the use of biomass for food and feed, materials, chemicals, and energy is in practise driven by the value and market demand for these products, with the value of bioenergy products being usually much lower than those used for food, chemicals or materials. Availability and costs of technology also play a role in choosing the most economical way of converting available biomass into a range of products. In most cases, the use of a fraction of the biomass feedstock for energy complements the use for other products and improves the overall economic case for projects. Examples include the use of sawmill residues and co-products as fuel for heating or electricity generation, production of biogas from waste waters, and integrated production of chemical products and bioenergy in biorefineries.

The bioeconomy can make a decisive contribution to key objectives of the Energy Union. The Energy Union policy framework (e.g. Renewable Energy Directive, Land Use, Land Use Change and Forestry (LULUCF), biomass sustainability) provides energy security, while ensuring biomass sustainability and minimising carbon footprint.

¹⁰⁴ A number of projects are supporting the development of integrated biorefineries, in particular through the BBI-JU (FIRST2RUN, BIOSKOH).

3.2.2 Maximising the contribution of the bioeconomy to the Energy Union

Besides the energy and transport sector, the Bioeconomy can also contribute to decarbonisation of other major industries, such as the chemical industry (e.g. plastics¹⁰⁵) and the construction sector (greater use of wood in the construction industry as a substitute for more energy-intensive non-renewable building materials^{106,107}). The integration of carbon capture storage or use technologies into industrial operations using biomass could offer the possibility for negative emissions, namely, acting as a carbon sink¹⁰⁸.

Combined with the use of renewable resources, there are other important opportunities in the path to lower GHG emissions such as increased resource and energy efficiency and the creation of closed loop systems. Solutions can be developed for promoting decarbonisation and product diversification by linking various sources of biomass (agri and forestry residues; food production and household "waste", underutilised aquatic resources) with the production of an array of products such as food, chemical/materials and bioenergy/biofuel production in integrated bio-refineries and valorising all side streams. Cascading use of biomass could result in a reduction of European GHG emissions by 7% to 9% according to one study¹⁰⁹.

Ecosystems such as forests, oceans and soils are crucial carbon sinks, without which achieving the balance, pointed out in the Paris Agreement, between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century is not possible¹¹⁰. In the EU, the LULUCF sector has been acting as an overall net sink since 1990, with relatively stable net CO₂ capture at around 300 Mt CO₂ per year (6-7% of total GHG emissions)¹¹¹, and the means of inclusion of the accounting quantity under the EU's climate change mitigation commitments are currently under the ordinary legislative procedure¹¹². Aquatic biomass is an important part of the blue bioeconomy and does not rely on significant soil and land resources. Microalgae could thrive in water that is fresh, salty or dirty. Because of their high growth rate (doubling biomass within few hours) and higher productivities per unit area, microalgae offer a less land-consuming production system than plants and therefore important applications in food, feed, industrial and pharma.

Biological aquatic and terrestrial systems and their functioning can provide innovative solutions to reducing emissions, improve waste management

¹⁰⁵ <http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/the-new-plastics-economy-rethinking-the-future-of-plastics>

¹⁰⁶ The cement industry is responsible for approximately 5% of global CO₂ emissions. WBCSD Cement Sustainability Initiative <http://www.wbcscement.org/index.php/key-issues/climate-protection>

¹⁰⁷ Forestry for a low-carbon future", Integrating forests and wood products in climate change strategies FAO, 2016. <http://www.fao.org/3/a-i5857e.pdf>

¹⁰⁸ Carbon capture from combustion of biomass, industrial processes and/or directly from the air depends on the availability of renewable energy at low costs (and low emissions).

¹⁰⁹ Odegard, Ingrid, Croezen, Harry and Bergsma, Geert. 13 Solutions for a Sustainable Bio- based Economy. Delft : CE Delft, 2012. http://www.cedelft.eu/art/uploads/file/CE_Delft_2665_Cascading_of_Biomass_def.pdf

¹¹⁰ Unless ground breaking technology advances in the direct capture of CO₂ from the air become reality in the near future.

¹¹¹ GHG Inventory submissions to UNFCCC

¹¹² https://ec.europa.eu/clima/policies/forests/lulucf_en

especially when it comes to signalling and response systems. Plants and their functioning play a relevant role in a new generation of bio inspired products and services in a wide range of sectors from energy to food, chemistry, forestry, buildings, IT and health hereby delivering future European growth and competitiveness.

However, the production of biological renewable resources is also associated with GHG emissions and risks, and the impacts for instance of increased harvesting of wood or direct or indirect impacts of increased crop production on deforestation need to be better understood and addressed. While agriculture reduced its GHG emissions, which is today nearly 25% less than the 1990 level, they still amount to about 10% of the EU's GHG emissions. However there is substantial potential for further reduction in the overall agro-food sector, in particular improvement of manure management, enteric fermentation (methane emissions of livestock), synthetic fertilisers (72% of total nitrous oxide emissions)¹¹³, food wastage and meat processing. The sector of livestock production counts for about 80%¹¹⁴ of the agricultural GHG emissions when considering associated emissions (e.g. land use change) and displaced emissions from outside (e.g. feed imports), so has a large potential for emission reductions, including through changed diets, consumption, avoidance of food waste^{115, 116} and new innovations.

Forests in the EU represent a net carbon sink. Carbon sequestration by forests is equivalent to about 7% of total annual GHG emissions in the EU. Under international guidance¹¹⁷ for the preparation of national greenhouse gas inventories, CO₂ emissions from biomass combustion are not reported in the energy sector ('zero rating'). This is to avoid double counting, because it is assumed that these emissions are accounted as part of the emissions from the land use, land use change and forestry (LULUCF) sector¹¹⁸ in the same national inventory.¹¹⁹ This zero rating has often been misinterpreted as meaning that biomass combustion emissions are always compensated by regrowth ('carbon neutrality'). The climate impact of solid and gaseous biomass used for heat and electricity are complex and can vary significantly (from very positive to very negative impacts, i.e. reducing or increasing emissions compared to fossil fuels). The greenhouse gas performance of bioenergy from a lifecycle perspective depends on the emissions from the supply chain of bioenergy (which include emissions from direct land use change, cultivation, transport, processing), as well as on biogenic CO₂ emissions, which include the emissions

¹¹³ Data computed based on 2014 GHG Inventories under UNFCCC, http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/81_08.php

¹¹⁴ JRC, 2015 - <http://iopscience.iop.org/article/10.1088/1748-9326/10/11/115004/pdf>

¹¹⁵ Fredrik Hedenus, Stefan Wirsenius, Daniel J. A. Johansson, Climatic Change (2014) 124:79–91

¹¹⁶ It is estimated that 3.3 billion tonnes of GHG are added to the atmosphere from food that is produced but not eaten ; Food Wastage Footprint, FAO (2013)

¹¹⁷ From the Intergovernmental Panel on Climate Change (IPCC)

¹¹⁸ For annual crops, the IPCC Guidelines assume that biomass carbon stock lost through harvest and mortality equal biomass carbon stock gained through regrowth in that same year and so there are no net CO₂ emissions or removals from biomass carbon stock changes. See also <http://www.ipcc-nggip.iges.or.jp/faq/faq.html>

¹¹⁹ They are accounted as occurring instantaneously at the moment of harvest of the wood.

from combustion of the biomass source and the CO₂ absorbed due to plant regrowth.

European forests have made considerable net CO₂ uptake for the last decades, representing the recovery of forests both in area and standing volume, from the overexploitation of centuries past. The evolving structure of forest (e.g. age class distribution) needs to be taken into account when considering the CO₂ impacts of forest management and the future use of forest-based biomass.

Mitigation actions in primary production of biomass also take place in the challenging context of adaptation to evolving climatic conditions, habitat lost, ocean acidification, marine litter and the overload of reactive nitrogen in the environment, making preservation and restoration of biodiversity, soil and oceans quality more challenging.

Besides the opportunity to mitigate climate change, the replacement of fossil by biogenic carbon could also become a challenge when being confronted with the projected growing demands of each of the various bioeconomy sectors (agri, food, energy, industry, forestry, marine) vis-à-vis the sustainably available amount of renewable biological resources, evidently under the premise to operate within the planetary boundaries. Research and innovation will play an important role in increasing sustainable supply, for instance by increasing plant yield and resource efficiency of primary production, investigating alternative sources of proteins, by better protecting carbon stocks in soil and vegetation, by reducing nitrogen leakage to the environment, and by providing technologies to use waste as a resource, by unlocking new biomass resources from oceans, etc.

A better understanding of biomass demand and supply and its drivers, their costs and their associated impacts (economic, environmental and social), would help to better understand the synergies and potential trade-offs between the various uses of biomass for climate change mitigation, but also food security, raw materials and energy security and natural capital conservation. Examining separately the specific needs of each sector without considering the whole bioeconomy system could lead to either overexploitation (possibly resulting in exacerbating climate change but also in greater food insecurity and environmental degradation) or a sub-optimal use of natural resources (potentially resulting in lost economic opportunities, and lower impacts on climate mitigation, substitution of non-renewable resources, etc.). Market effects are another important element to consider, as the cost and ease of access of available biomass will often be the primary factor of choice for economic operators.

The Directorate-General Joint Research Centre, the European Commission's science and knowledge service, has been tasked with providing the EC services with data, models and analyses of EU and global biomass potential, supply, demand and its sustainability on a long-term basis.

The Commission's proposal for a recast of the Renewable Energy Directive as part of the "clean energy for all Europeans" package¹²⁰ already strengthens and streamlines the sustainability criteria for bioenergy. The accompanying Impact Assessment on Bioenergy Sustainability¹²¹ identifies the main concerns about bioenergy.

It is important also to keep in mind that mitigation and adaptation to climate change is a global endeavour, reinforced through the Paris Agreement. International cooperation and technology transfer to developing countries contributes to both enlarge the competitiveness of the European industry, the development of poor and vulnerable regions bearing the impacts of climate change while helping mitigate its effect in a global perspective.

In conclusion, there is growing understanding that deep decarbonisation and obtaining the 2°C target will not be possible without the bioeconomy, given its potential for carbon sequestration, the substitution of fossil resources with sustainable biomass-based resources, and its huge GHG emission reduction potential related to more sustainable production and consumption patterns. Through the Energy Union policy, the Commission has already been working in order to: a) create incentives for fossil resource substitution; b) increase mobilization of sustainable biomass; c) develop a biomass sustainability framework, focusing on bioenergy for all uses. However, a better understanding of the contribution of the bioeconomy to decarbonisation pathways is necessary in order to steer and focus R&I investments on the appropriate solutions, as well as to steer a coherent policy approach that coordinates the different, and sometimes conflicting, demands for biomass and related policy objectives.

¹²⁰ <https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition>

¹²¹ https://ec.europa.eu/energy/sites/ener/files/documents/1_en_impact_assessment_part4_v4_418.pdf

4 Conclusions

Successful mobilisation of R&I funding

This review demonstrates that the 2012 EU Bioeconomy Strategy and Action Plan already delivered results on key actions in the Action Plan. It has **successfully mobilised R&I funding**, in particular through a doubling of the EU FP funding dedicated to the bioeconomy under Horizon 2020, as compared to FP7 and from ESIF. It is very likely that, through triggering national and regional bioeconomy strategies, it has also triggered R&I investments in Member States. The review of the Blue Growth Strategy highlighted that Horizon 2020 changed the way that marine and maritime research was done. Compared to previous EU Framework Programmes for R&I, more effort has been devoted to creating joint opportunities for previously separate strands of marine and maritime research, for shifting research from the laboratory to the marketplace and for co-operating with non-EU countries that share a common sea-basin¹²². It has also **supported private investment**, with major deliverables such as the launch of the BBI JU, the development of bio-based content and product standards, and preparations for a new dedicated risk-sharing financial instrument under the 2018-2020 Work Programme of Horizon 2020. Significant policy results can be demonstrated through actions on bio-waste, food waste, resource efficient use and biomass sustainability, which are part of the circular economy strategy and the Energy Union strategy, thus **demonstrating the cross-cutting nature of the bioeconomy for other policy areas**.

Importance of Bioeconomy Strategy is recognised

The opportunities that the bioeconomy offers and the importance of Bioeconomy Strategy coordination are increasingly recognised by many EU Member States and regions. The overall objectives of the 2012 EC Bioeconomy Strategy, which aimed to address key societal challenges, have been taken up in **numerous national and regional bioeconomy strategies developed** since 2012 in the EU and globally, demonstrating the relevance of these objectives. For example, the Committee of the Regions as well as the Standing Forestry Committee¹²³ recently adopted an Opinion on Bioeconomy¹²⁴, and the Central and Eastern European Member States have also recognised the potential that the bioeconomy offers for their countries¹²⁵. In recognising the cross-cutting and interlinked nature of these objectives, these national strategies have been designed jointly by different ministries and in most cases action plans go well beyond R&I investments to include broader policy actions

¹²² Report on the Blue Growth Strategy Towards more sustainable growth and jobs in the blue economy SWD(2017) 128 final

¹²³ https://ec.europa.eu/agriculture/sites/agriculture/files/forest/standing-committee/opinions/opinion-2017-forest-bioeconomy_en.pdf

¹²⁴ <http://cor.europa.eu/en/activities/opinions/pages/opinion-factsheet.aspx?OpinionNumber=CDR%2044/2017&cldee=a2F0ZXJpbmEuaGVqZG92YUBiYy5ldXJvcGEuZXU%3d&recipientid=contact-283fde6585f2e4118a29005056a05119-a47470bee3074a5fbca0540c7ad927ef&esid=ba57de13-6b36-e711-80dc-005056a00920&urlid=0>

¹²⁵ <http://data.consilium.europa.eu/doc/document/ST-14174-2016-INIT/en/pdf>, https://eip.fm.gov.hu/index.php?page=pages&page_name=bioeast-kezdemenyazes&language=en

and to ensure coherence between them. However, there is still room for further development in Member States, and also the potential contribution of cities to the bioeconomy remains largely unexploited.

Further mobilisation of investments is needed, requiring a stable regulatory environment

In order for the R&I investments of recent years not to become sunken investments, the existing or new technologies and demonstrators need to be up-scaled and rolled out. As a large number of these investments, in particular in integrated biorefineries, are both capital intensive and associated with high technological and market risks, **a stable regulatory environment is needed to encourage private investments** and support from EU instruments.

Policy coherence and synergies need to be addressed

The findings of the review also demonstrate several weaknesses in the design and implementation of the Action Plan, notably an **insufficient correspondence between the strategic objectives and the actions** designed to achieve these objectives. Furthermore, insufficient attribution of responsibilities to implementing the Action Plan, combined with an insufficient assessment and monitoring framework, also hampered the achievement of some of the expected results. The sheer number and diversity of actions and sub-actions have resulted in a **suboptimal focus** of the Strategy. Impacts of increased biomass use on water, soil, ecosystem services and biodiversity, including the indirect land-use changes, will require more specific attention in the future. As a consequence, the level of **overall policy coherence and synergies** across and between the policies affecting and being affected by the Bioeconomy Strategy could have been much higher.

New policy context highlights the need for a sustainable, circular bioeconomy

At the same time, the **policy context** in which the bioeconomy operates **has changed** significantly since 2012, with EU and global policy developments such as Circular Economy, Energy Union, the Paris Agreement and the Sustainable Development Goals. In consequence, the concept of a "circular bioeconomy" is being proposed by various stakeholders.¹²⁶ This new policy context is not fully reflected in the 2012 Strategy and its Action Plan and reflection on the relevance of the 2012 objectives and actions is needed in light of these new policy developments.

¹²⁶ E.g. Forthcoming EFI study, to be released early November 2017, see <http://www.efi.int/portal/>, Bioeconomy Strategic Working Group (BSW) of the Standing Committee of Agricultural Research (SCAR) Policy Brief on the Future of the European Bioeconomy Strategy: https://www.scar-swg-sbgb.eu/lw_resource/datapool/items/item_28/policy-brief-23082017_final_template.pdf , European Bioeconomy Alliance Policy asks for the bioeconomy strategy revision: <http://www.bioeconomyalliance.eu/sites/default/files/EUBA%20policy%20asks%20EN%20final.pdf>. See also the final reports of the Commission Expert Group for Bio-based Products and the Commission Expert Group on the review of the Bioeconomy Strategy.

Better monitoring and assessment frameworks needed

As sustainability in terms of production and consumption is core to the bioeconomy strategy, a better understanding is needed of the prospective development of biomass supply and demand, to ensure that the bioeconomy operates within the limits of the biosphere, while providing optimum social and economic gains¹²⁷. New actions are needed to develop relevant indicators and scientific evidence for policy making, and to implement a more holistic monitoring and assessment framework. Indicators should take into account recent policy developments, such as Circular Economy, CAP, Indirect Land Use Change and the Paris Agreement, and can be oriented along the lines of the SDGs. Combined, the SDGs and the circularity approach provide elements for a more explicit and "SMART" intervention logic, and one that can build on an internationally shared monitoring and assessment framework that is in development for the SDGs.¹²⁸

¹²⁷ The 4th SCAR foresight report presented five guiding principles to assure a sustainable bioeconomy that can achieve such multiple goals. These guiding principles are food first, sustainable yields, cascading use, circularity and diversity.

¹²⁸ The European Commission recently agreed upon an EU SDG indicator set to monitor progress towards the Sustainable Development Goals (SDGs) in an EU context, see <http://ec.europa.eu/eurostat/documents/276524/7736915/EU-SDG-indicator-set-with-cover-note-170531.pdf>

5 Annex I: Detailed assessment of the implementation of the 2012 Action Plan

5.1 Review Frame

5.1.1 Aims and objectives of the review

This review is in line with Action 6 of the Bioeconomy Action Plan, which calls for the Strategy to be reviewed and updated at mid-term. This was later recalled in various EU policy documents (see above). The review of the Bioeconomy Strategy however does not constitute a formal evaluation as defined by the Commission Better Regulation guidelines¹²⁹ and consequently the approach followed differs from established evaluation practices and requirements.

5.1.2 Methodology

Scope and timeframe: The scope of the review covers the Bioeconomy Strategy and the Action Plan. The review provides a systematic review of the 12 actions under the three areas of the Action Plan (R&I investments, policy coherence, markets and competitiveness) as well as the contributions of the Strategy to the five main cross-cutting objectives (food security, sustainable resources management; substituting non-renewable resources; climate change, and jobs & growth).

The review has considered funding and non-funding actions at EU, national and regional level which were adopted and implemented as a result of the Bioeconomy Strategy and its Action Plan. Particular attention was paid to the EU R&I funding instrument, Horizon 2020, which constituted an important vehicle for implementing the Bioeconomy Action Plan. In the last years of FP7, EU funding was also allocated to actions implementing the Bioeconomy Strategy and its Action Plan and this has been taken into consideration by the present review (see Box 1 below). No detailed analysis has been carried for other funding instruments, such as ESIF, due to the fact that project data is available at national and regional level rather than in a centralised way.

¹²⁹ http://ec.europa.eu/smart-regulation/guidelines/toc_guide_en.htm

Box 1: Contribution of the FP7 KBBE Programme to the implementation of the 2012 Bioeconomy Strategy and Action Plan

There is clear evidence that the last programming exercises under FP7 KBBE Programme aimed at contributing to the implementation of the 2012 Bioeconomy Strategy and Action Plan. As such, the following elements can be noted:

- The overall rationale of the 2013 FP7 KBBE Work Programme¹³⁰ makes an explicit reference to the 2012 Bioeconomy Strategy and the overall priority of the 2013 Work Programme is bio-resource efficiency;
- There is an alignment of objectives between the 2012 Bioeconomy Strategy and the FP7 KBBE 2012 Work Programme: sustainable primary production, mitigating and adapting to climate change, low carbon and resource efficient industry, Food security and safety, socially inclusive and healthy Europe.

Source: European Commission, DG Research and Innovation

Review questions: the present review has been structured around two main assessment questions, i.e.:

- (1) To what extent have the actions laid down in the Bioeconomy Action Plan been implemented?
- (2) What are the observed or expected results of the implemented actions (i.e. economic, social, environmental results as well as results on science and technology and policy)?

The present review looked at results for which there is sufficient evidence to establish a direct link with the Strategy or Action Plan. Also, when assessing the extent to which an action has been implemented, particular attention was paid to enabling and disabling factors which may have affected the achievement of results.

Methodological approach: the overall design of the review was based on a mixed method approach comprising a dedicated expert group, desk research and various ad-hoc consultations with stakeholders, as follows:

- **Desk research:** Covered the legal base and key policy documents for major EU policies. Particular attention was paid to Horizon 2020 documents produced as part of the Strategic Programming process, BBI JU Annual Work Plans and Strategic Innovation and Research Agenda (SIRA), Annual Activity Reports, projects documentation (e.g. project reports) as well as evaluations and impact studies. A quantitative analysis of the Framework Programme data (CORDA database) was also undertaken;

¹³⁰ https://ec.europa.eu/research/participants/portal/doc/call/fp7/common/1567646-2_fafb_upd_2013_wp_27_june_2013_en.pdf

- **Expert panel:** A panel made of 14 experts (Expert Group) was appointed in December 2016 with the task of reviewing the progress and delivery of the EU Bioeconomy Strategy. The panel included experts from the public and private sector with in-depth experience of the bioeconomy sectors. The analysis and main findings of the panel were presented in the expert group report (July 2017);
- **Stakeholders' consultations:** Ad-hoc consultations have been conducted with bioeconomy-relevant stakeholders in order to reflect on the implementation of the Bioeconomy Strategy and Action plan, to gather evidence of their results and potential limits. In particular, the Bioeconomy Panel (later renamed Bioeconomy Stakeholders' Panel) and the related stakeholders' conferences served as a valuable platform dialogue for this purpose. Moreover, a coordinators' survey and an open public consultation were conducted for the BBI JU projects.

5.1.3 Limitations - robustness of findings

- As indicated above, a variety of data sources were used to build a comprehensive evidence base for the review. However, there are limitations to the method applied such as the availability of data, the timeframe and the design of the Strategy and Action Plan itself which has an impact on the present review.
- **Timeframe:** a number of the actions either call for long-term efforts from Member States and the EU (e.g. action "Building the human capacity for the bioeconomy") or require a complex mix of policies outside the R&I sector in order to achieve the expected results (e.g. "Promote the uptake and diffusion of innovation"). As such, evidence may not exist yet to assess the results of these actions;
- **Design of the Strategy and Action Plan:** as noted in the expert group report¹³¹, the Strategy and Action Plan did not include "SMART¹³²" objectives or indicators. The expert group also noted¹³³ that there is insufficient correspondence between the overall objectives of the strategy and the specific actions laid down in the Action Plan to implement the Strategy, whilst several actions overlap with each other. In the absence of benchmarks and targets, it is difficult to precisely assess progress in achieving the expected results;
- **Direct and indirect results:** in a number of cases results can only be indirectly linked to the Strategy/Action Plan. Also, the achievement of some results depends on other factors outside the scope of the Strategy and Action Plan (e.g. other sectoral policies at EU or national level, macro-

¹³¹ Expert Group for the Review of the Bioeconomy Strategy and its Action Plan (2017), Final Report, Bioeconomy Strategy

¹³² SMART stands for specific, measurable, achievable, relevant and time-bound.

¹³³ Expert Group for the Review of the Bioeconomy Strategy and its Action Plan (2017), Final Report, Bioeconomy Strategy

economic context) and these factors may have an equal (if not greater) influence on the achievement of the expected results;

- **Availability of data:** although a monitoring system of implementation and result of the Strategy and Action Plan was foreseen (action 6), the issue of data availability proved problematic. This was partly due to the cross-cutting and relatively broad scope of the Strategy and Action Plan, for which no indicators to measure progress and result were available from the outset.¹³⁴

5.2 Implementation and assessment of the 2012 Bioeconomy Action Plan

This section of Annex I provides a review of the Bioeconomy Strategy and its Action Plan. In particular, it looks at each area of the Bioeconomy Action Plan and its related actions and sub-actions (Sections 5.2.1, 5.2.2, 5.2.3), including their strengths and weaknesses. It also provides an analysis of the internal and external policy coherence (Section 5.3).

5.2.1 Area of action 1: Investments in research, innovation and skills

Main findings

- + Increased funding and substantial leverage effect on public (EU, national) and private funding on bioeconomy-related R&I;
- + This major financial boost is already generating relevant multi-disciplinary and cross-sectoral scientific knowledge;
- + High share of close-to-market and user-centric R&I actions to promote uptake and diffusion of innovation for the bioeconomy;
- A Life Science, Marine and Agricultural Universities Forum has not been established.

5.2.1.1 Ensuring substantial EU and national funding and private investment for bioeconomy R&I, strengthen coherence and synergies between public programmes

By giving a political impetus and increased visibility to the bioeconomy, the 2012 Bioeconomy Strategy has contributed to ensuring that substantial **funding at EU level** is devoted to bioeconomy-relevant R&I. A direct result of the Strategy is demonstrated by the over two-fold increase in dedicated EU funding for the bioeconomy under the Horizon 2020 programme (total financial envelope for bioeconomy of EUR 4.52 billion for the period 2014-2020) compared to FP7, its predecessor programme (EUR 1.9 billion for 2007-2013) (see Table 1 below).

¹³⁴ Fundamental data and knowledge gaps exist for example in relation to the vast marine biological resources and their biodiversity dynamics: <http://www.un.org/sustainabledevelopment/oceans>

Table 1: Bioeconomy relevant funding under Horizon 2020, 2014-2020

Horizon 2020 funding stream	Planned funding (in million EUR)
SC2	3,050
BBI JU public-private partnership (85% from SC2, 15% from Leadership in enabling & industrial technologies (LEITs))	Up to 975
LEITs - Industrial biotechnology	500
Total	4,525

Source: European Commission, DG Research and Innovation

This financial envelope could exceed EUR 7 billion when also considering other actions under Horizon 2020 which are not labelled "bioeconomy" *per se* and which support - in an indirect manner - the development of the bioeconomy¹³⁵ (see Table 2 and Figure 3 below).

Table 2: Bioeconomy-relevant project funding in Horizon 2020 (excluding health-related R&I)¹³⁶, 2014-2017

	No. of projects	EU funding (in million EUR)
Bioeconomy-relevant R&I	3,860	7,051 28%
Total Horizon 2020 ^[1]	15,352	27,372 100%

Source: DG Research and Innovation

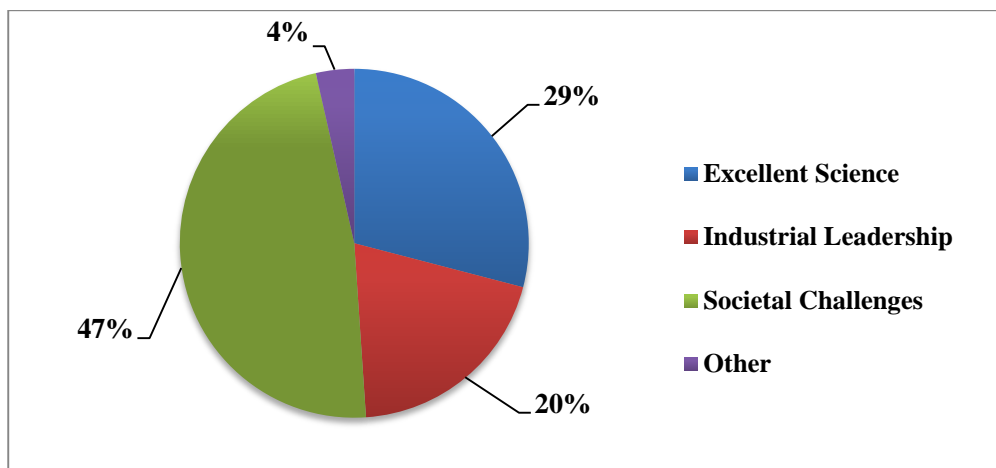
Data: CORDA data on projects funded; cut-off date: 12 July 2017

Note: [1] all the health-related projects have been excluded from the total Horizon 2020, as health was not included in the definition of the bioeconomy in the 2012 Strategy.

Figure 3: Distribution of bioeconomy-relevant project funding across Horizon 2020 pillars (excluding health-related R&I)¹³⁷, 2014-2017

¹³⁵ This is a conservative estimate based only on Horizon 2020 projects funded so far. As more projects will be funded between 2017-2020, this figure is expected to increase even more.

¹³⁶ Bioeconomy-relevant projects were identified through a keyword search using the project abstract. The keywords used were as follows: agri, food, nutri, diet, feed, biobased, biomass, livestock, forest, waste, water, aqua, fish, marine, maritime, biotech.



Source: DG Research and Innovation

Data: CORDA data on projects funded; cut-off date: 12 July 2017

This is complemented by support from EU cohesion policy funds, which has allocations of about EUR 41 billion for research and innovation in all areas. Bioeconomy is one of the priorities frequently chosen by regions in their research and innovation strategies for smart specialisation (see 5.2.1.3, 5.2.1.3 and 5.3.2). In other funding priorities, cohesion policy has additional support for innovative technologies to improve environmental protection and promote the low-carbon economy and industrial transition, which may include areas related to the bioeconomy.

The 2012 Bioeconomy Strategy has also contributed to leveraging **national public R&D funding** through public to public partnerships¹³⁸ (P2P) funded under Horizon 2020. Up to now, for each euro invested by the EC in bioeconomy-relevant P2P actions, the participating states have invested an additional amount of EUR 3.8 (see Table 3 below).

¹³⁷ Bioeconomy-relevant projects were identified through a keyword search using the project abstract. The keywords used were as follows: agri, food, nutri, diet, feed, biobased, biomass, livestock, forest, waste, water, aqua, fish, marine, maritime, biotech.

¹³⁸ P2P partnerships under Horizon 2020 include ERA-Nets Cofunds and Joint Programming Initiatives.

Table 3: Public to public bioeconomy-relevant instruments launched under Horizon 2020 (EU and national funding)

Instrument type	Number of instruments	EC total funding (in million EUR)	MS funding (in million EUR)
JPIs ¹	4	11.7	106 ²
ERA-NETs ³	19	125.7	427.3 ⁴
Total		137.4	533.3

Source: ERA-LEARN 2020, <https://www.era-learn.eu/>

Notes: DG RTD own calculations; [1]: these are FACCE, Climate, HDHL, Oceans; [2]: represents total actual investment in projects without EU contribution; [3] includes ERA-NETs+ and ERA-NETs Cofunds; [4] represents total pre-call budget committed without EU contribution

Moreover, the Bioeconomy Strategy and its Action Plan have contributed, (although in a more indirect manner) to **leveraging private funding** for the bioeconomy through the implementation of various public-private partnerships (PPPs)¹³⁹. The most relevant PPP for the bioeconomy is the Bio-Based Industries Initiative, which is implemented by the Bio-Based Industries Joint Undertaking (BBI JU) as a part of Horizon 2020. A **direct leverage effect** of 2.6 by private R&I investment (mainly from industry) was achieved for the period 2014-2016, whereas a leverage of 2.8 is expected to occur by 2024¹⁴⁰ (see Box 2 below).

¹³⁹ These include, *inter alia*, the Joint Undertakings funded under Horizon 2020, the European Innovation Partnerships and the Knowledge and Innovation Communities (KICs) under the European Institute of Innovation and Technology (i.e. Climate-KIC and Food-KIC)

¹⁴⁰ Annual Activity Report 2016, https://www.bbi-europe.eu/sites/default/files/bbi_ju_aar_2016.pdf

Box 2: Bio-based Industries Joint Undertaking: description, mission and objectives

The Joint Undertaking for Bio-Based Industries Joint Undertaking (BBI JU) is a EUR 3.7 billion Public-Private Partnership between the EU and the Bio-Based Industries Consortium (BIC). It was established in June 2014 as part of the Innovation Investment Package and as a key action of the European Bioeconomy Strategy. The Commission contributes up to EUR 975 million of EU funds from Horizon 2020 which are expected to leverage a further EUR 2.7 billion of private investments by industry, as well as additional private and public funds.

Driven by a vision, an industry-derived Strategic Innovation and Research Agenda (SIRA) and Annual Work Plans, the BBI-JU aims to establish a European bio-based industry sector that creates new markets and value chains, and that sustainably develops advanced bio-based products, technologies, materials and biofuels from renewable natural resources, waste and industrial side-streams.

Up to date, 65 projects have been funded consisting of 20 demonstration projects and 6 flagship projects, which correspond to a total of 729 beneficiaries from 30 countries for a total grant amount of EUR 414 million. The first flagship "First2Run" aims at setting up a commercial scale bio-refinery in Sardinia (Italy) for converting low input oil crops grown in arid or marginal lands, to produce added value chemicals, feed products and energy¹⁴¹. It represents a total investment of EUR 58M (ca. EUR 17 million in EU funding and EUR 41 million from industry).

The amount of certified in-kind additional activities (IKAA) reported for 2014-2015 is EUR 291 million, which accounts for 17% of the targeted EUR 1,755 million minimum IKAA by 2024. The mobilisation of private investments appears on track considering that BBI-JU only started by the end of May 2014, and the first grant agreements for the first projects financed by BBI JU were signed in June 2015.

Project outcomes monitored through Key Performance Indicators described in the SIRA already show better results compared to agreed objectives, which confirms the expected impact of the BBI initiative in bridging the gap between the research and the market (see Table 6 below).

Source: DG Research and Innovation

The observed leverage effect on public and private funding should be interpreted against the backdrop of a depressed GDP in the last years, whilst R&D expenditure at member-state level was kept largely stable in absolute terms and slightly rising in relative terms compared to GDP¹⁴².

¹⁴¹ Flagship demonstration of an integrated bio-refinery for dry crops sustainable exploitation towards biobased materials production, <https://www.bbi-europe.eu/projects/first2run>, <http://www.first2run.eu/>

¹⁴² EU public R&I intensity reached 0.72% in 2014 vs 0.63% in 2007, whilst EU business R&I intensity reached 1.30% of GDP in 2014 vs. 1.11% in 2005. Source: European Commission (2016), *Science, Research and Innovation performance of the EU, contribution to the Open Innovation, Open Science, Open to the World agenda*

5.2.1.2 Increase the share of multi-disciplinarity and cross-sectoral research by improving the existing knowledge-base and developing new technologies for the bioeconomy

The 2012 Bioeconomy Strategy and its Action Plan have highlighted the need to improve the Science & Technology (S&T) base by supporting multi-disciplinary and cross-sectoral research and new technologies, in particular to address the sustainable supply of biomass. This action has been primarily implemented through the funding of research and innovation projects under Horizon 2020. Whilst it is too early to identify major scientific breakthroughs stemming from the projects, there is already an indication that projects are generating excellent and multi-disciplinary research (i.e. quality of publications and public-private publications)¹⁴³.

Another significant outcome of the 2012 Action Plan has been the support to the development of new technologies and innovative solutions which address key societal challenges. Evidence from on-going projects shows that these are developing for example innovations aiming at reducing the environmental impact of food processing, generating food crops which are resource-efficient and high in protein, improving underwater observation to monitor the marine environment, fish stocks and pollution¹⁴⁴. Significant progress has also been achieved under the FP7 energy demonstration programme in the sugar platform where sugars are extracted from lignocellulosic biomass that can be subsequently converted into biofuels or biochemicals with significantly lower GHG emissions compared to their fossil alternatives¹⁴⁵. Through the funding of EU R&D projects, the Action Plan has also ensured the continuation and scaling-up of innovation actions that started before 2012 under FP7 (see Table 4 below).

¹⁴³ See Field-Weighted Citation Impact (FWCI) indicator for Horizon 2020 publications, which are cited more than twice the world average (i.e. FWCI of 2.46). Across the programme more than one publication out of 5 (21.5%) is based on the cooperation between academic and private organisations. Source: COM (2017), *Commission Staff Working Document, In-Depth Interim Evaluation Of Horizon 2020*, Brussels, 29.5.2017 SWD(2017) 220 final, p.87

¹⁴⁴ UTOFIA project, see http://cordis.europa.eu/project/rcn/193162_en.html

¹⁴⁵ COMETHA project, see <http://www.cometha.eu/> ; SUNLIQUID project, <http://sunliquid-project-fp7.eu>

Table 4: Examples of technologies developed with EU R&I funding

Projects	Bio-based technologies
<p>EU-PEARLS¹⁴⁶ (FP7)</p>	<p>Feasibility and proof of principle for producing alternative sources of natural rubber from Russian dandelion and guayule</p> <p>Medicinal gloves and car tyres were produced and tested by CIRDA (FR) and Apollo Vredestein, (NL) respectively</p> <p>Potential impact on reducing the EU's commercial dependence on rubber raw material from Asian Hevea-plantations</p>
<p>DRIVE4EU¹⁴⁷ (FP7)</p>	<p>Demonstration-level continuation of the FP7 EU-Pearls project which increased our knowledge on the alternative sources of natural rubber i.e. Russian dandelion (<i>Taraxacum koksaghyz</i> or TKS) and guayule (<i>Parthenium argentatum</i>),</p> <p>Scaling-up of each individual step in the production chain: breeding, seed production, cultivation, extraction of raw material (Natural Rubber and inulin), and conversion of raw materials in end products. Together with the knowledge gained from the previous project EU-PEARLS, Drive4EU will have impact on reducing the EU's commercial dependence on the Asian market for rubber</p> <p>Drive4EU focuses on Russian dandelion (<i>Taraxacum koksaghyz</i>, TKS) - plant varieties with higher productivities are created and the new genotypes are multiplied via seeds.</p> <p>Improved agronomical methods for an optimized cultivation for TKS are developed as well as bio-refinery approaches for inulin containing root crops.</p> <p>In addition, scientific information about the gene flow and interaction esp. competition between the cultivated TKS and the wild dandelions is gained</p>
	<p>Marine technologies</p>
<p>NoMorFilm¹⁴⁸ (Horizon 2020)</p>	<p>Development of novel marine derived biomolecules to be used in prosthetic devices to treat biofilm infections</p> <p>Exploration of a new field in the development of bio-refineries and polycultures in which no competitors exist (junction between clinical and blue biotechnology)</p> <p>Will improve clinical effectiveness of prosthesis, quality of life for patients and reduce health system costs and surgical interventions</p> <p>Potential market for a new antibiotic effective against biofilm pathogens can be estimated to be around EUR 200-600 million per annum.</p>

¹⁴⁶ http://cordis.europa.eu/result/rcn/144740_en.html

¹⁴⁷ <http://www.drive4eu.eu/>

¹⁴⁸ <http://www.nomorfilm.eu/>

	Food/agricultural technologies
HIPSTER ¹⁴⁹ (Horizon 2020)	<p>Deployment of the high pressure and temperature (HPT) food processing technology at industrial level with the demonstration of an industrial-scale prototype 30 l</p> <p>Techno-economic viability of the equipment validated with an envisaged retail price at least 25% lower than current HPP equipment</p> <p>Availability of a new range of food products for a new market niche (high-quality; both chilled and shelf stable; longer-shelf life up to 12 months from current 60 days average)</p> <p>Increased sustainability and reduced environmental impact of food processing (20% less use of process water or lower energy consumption compared to conventional thermal processing, minimisation of waste)</p> <p>Promotion of a healthier choice and more sustainable consumption patterns across Europe</p>

Source: European Commission, DG Research and Innovation

5.2.1.3 Promote the uptake and diffusion of innovation for the bioeconomy

The need to increase the uptake and diffusion of innovation for the bioeconomy has been successfully implemented, through a growing share of EU bioeconomy-relevant R&I funding dedicated to **close-to-market** research and innovation. Under Horizon 2020 SC2, about 37.5% of funding up to date has been dedicated to actions addressing the higher spectrum of the Technology Readiness Level (TRL) (see Table 5 below).

¹⁴⁹ <http://hipster-project.eu/>

Table 5: Share of EU Horizon SC2 funding allocated by type of research, 2014-2016

	Higher TRL research?	Total funding allocated (in million EUR)	Share of funding allocated
RIA		401.7	51.8%
IA	✓	18.2	2.4%
SME	✓	44.9	5.8%
RIA under BBI JU	✓	53.5	6.9%
Innovation Action Flagship under BBI JU	✓	90.7	11.7%
IA Demo under BBI JU	✓	82.6	10.7%
CSA under BBI JU		3	0.4%
CSA, ERA-Net Cofund		80.6	10.2%
TOTAL		775.1	100%

Source: SC2 Interim Evaluation

Notes: Based on 273 projects funded between 2014 and 2016

Available evidence also indicates that 88% of Horizon 2020 SC2 projects funded to date are developing technologies which have been assessed at TRL 5 and above¹⁵⁰. Moreover, a significant amount of SC2 funding (ca. EUR 500 million between 2014-2017)¹⁵¹ has been invested in demand-driven innovation projects implementing a user-focused and innovation ecosystem approach, i.e. the **"multi-actor approach"** (this figure will likely reach EUR 1 billion by 2020). Although not all multi-actor projects are focusing on agricultural issues, multi-actor projects are implementing the EIP-AGRI concept of interactive innovation, as applied under the CAP for EIP Operational Groups. Under this approach, innovation and impact amongst relevant bioeconomy stakeholders will be facilitated thanks to the "active" participation of R&I stakeholders in all stages

¹⁵⁰ Expert Group on Horizon 2020 SC2 Interim Evaluation, (2016), *Interim Evaluation of Horizon 2020, Societal challenge 2: Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy*, Final Report, 6 December 2016

¹⁵¹ In total, 100 multi-actor projects will have been funded between 2014-2017 with a budget of EUR 522 million. Out of these 100, 22 are thematic networks with a budget of approximately EUR 34 million. It is expected that in total more than 180 multi-actor projects will be contracted in the 2014-2020 period for a total budget of EUR 1 billion. Source: European Commission, DG Agriculture

of the R&I action. The multi-actor approach aims to cross the boundaries of knowledge systems, integrating also the empirical knowledge of practitioner's and thereby avoiding that research results remain too theoretical for real life applications. End-users like farmers, foresters or businesses will be more motivated to use the project results, because they were involved in generating them and feel "co-ownership".

A dedicated multi-actor project format, entitled "**Thematic Networks**", aims at spreading of existing knowledge and best practice which is close to being put into practice but not sufficiently known or used yet. Until 2017, 22 thematic networks have been funded, on a variety of subjects which are chosen bottom-up but must tackle the most urgent needs from practice. They produce a high number of easy understandable and concise recommendations from their project which feed into the main dissemination channels for practice, and also into the EIP-AGRI website. In doing so, they also connect a number of key actors on a specific subject, including EIP Operational Groups in regions and Member States. In this manner they bring experts (scientists and non-scientists) together and make way for further multi-actor work.

Cohesion policy also supports the uptake of innovative technologies with significant allocations in the 2014-2020 period, including for low-carbon economy, environmental protection and other areas related to the bioeconomy.

Preliminary evidence from the BBI JU-funded projects shows that this PPP is already providing a substantial boost to the **innovation performance** of the European bio-based industry, with new bio-based value chains, materials and demonstrated "consumer" products being created¹⁵² (see Table 6 below).

¹⁵² Source: Bio-Based Industries Joint Undertaking Annual Activity Report, 2016

Table 6: Economic contribution of the BBI JU: achieved and expected performance of the BBI JU by 2020

KPI number and definition	Total reported in 2016	KPI target by 2020
KPI 1: New cross-sector interconnections in BBI JU projects by 2020	146	36
KPI 2: New (or optimised) bio-based value chains created by 2020	82	10
KPI 3: Cooperation projects through cross-industry clusters	36	200
KPI 4: New bio-based building blocks based on biomass of European origin by 2020	46	5
KPI 5: New bio-based materials by 2020	106	50
KPI 6: New demonstrated "consumer" products based on bio-based chemicals by 2020	51	30
KPI 7: Flagships resulting from the BBI	4	5

Source: Bio-Based Industries Joint Undertaking Annual Activity Report, 2016

Data: data provided by 34 project coordinators as of end of 2016

5.2.1.4 Build the human capacity for the bioeconomy

The successful integration of bioeconomy skills in higher education is a key prerequisite for enhancing Europe's S&T base and supporting the uptake of innovation for the bioeconomy. This has been successfully implemented through the Marie Skłodowska-Curie Actions (MSCA) under Horizon 2020, with more than EUR 600 million awarded between 2014 and 2017 to bioeconomy relevant projects (this equals to approximately one quarter of all MSCA, see Table 7 below). This amount has supported so far about 2680 recruited MSCA-Individual Fellowships and MSCA-Innovative Training Networks researchers and over 15.000 planned secondments via the staff exchange action MSCA-RISE.

Table 7: Horizon 2020 funding in bioeconomy relevant MSCA projects, 2014-2017

	No. of MSCA projects	Project funding (in million EUR)
Bioeconomy relevant MSCA projects	1,123	695 (24%)
All MSCA projects	4,653	2,899 (100%)

Source: European Commission, DG Research and Innovation

Data: Corda database d.d. 12.10.2017

Note: Bioeconomy-relevant MSCAs were identified through a keyword search¹⁵³ using the project abstract.

Evidence shows that the impacts of MSCA on human capital are wider as they result in the development of partnerships as well as knowledge creation and circulation. Researchers participating in the EU Framework Programmes strengthen almost all skills and capacities¹⁵⁴. The continued development of post-graduate curricula with a bioeconomy focus across the EU can also be seen as a result - although much more indirect - of the Bioeconomy Strategy and Action Plan. Under the Erasmus Mundus programme, a total of 17 Master's and doctoral bioeconomy relevant programmes were created in Europe since 2012, benefitting over 800 students (see Table 11 in Annex II). Similarly, the European Innovation Partnership on Raw Materials is expected to create a European Institute of Innovation and Technology (EIT)-label for 1,000 Master's and doctoral graduates by 2018¹⁵⁵.

¹⁵³ The following bioeconomy relevant keywords were used: agri, food, nutri, diet, feed, biobased, biomass, livestock, forest, waste, water, aqua, fish, marine, maritime, biotech.

¹⁵⁴ COM (2017), *Commission Staff Working Document, In-Depth Interim Evaluation Of Horizon 2020* Brussels, 29.5.2017 SWD(2017) 220 final, p.82

¹⁵⁵ Source: <https://ec.europa.eu/growth/tools-databases/eip-raw-materials/en/call-commitments>, <https://eit.europa.eu/eit-community/eit-raw-materials> *European Innovation Partnership on Raw Materials, Strategic Evaluation Report 2016*, Presented to the High-Level Steering Group on 14/07/2016

5.2.2 Area of action 2: Reinforced Policy Interaction and Stakeholder Engagement

Main findings

+ Stakeholders' engagement in the development of bioeconomy policies has been enhanced and explicitly integrated through the Bioeconomy Stakeholders Panel; and the development of Research and Innovation Strategies for Smart Specialisation (RIS3);

+ The strategy has contributed to increased recognition from Member States and regions about the opportunities of bioeconomy for rural, coastal and marine/maritime development, and has catalysed the development of bioeconomy strategies at national and regional levels;

- Involvement of Member States and regions in bioeconomy remains however uneven, with many EU13 not having a bioeconomy approach/strategy yet, despite their large untapped biomass supply potentials.

5.2.2.1 Creating a Bioeconomy Panel to enhance policy synergies and coherence and organise Bioeconomy Stakeholder Conferences

By and large, this action has been successfully implemented with the creation of the Bioeconomy Panel in 2013, which gathered 30 members to support interactions between different policy areas, sectors and stakeholders in the bioeconomy (e.g. business and primary producers, policy-makers, researchers and civil society organisations¹⁵⁶). The Bioeconomy Panel produced two policy papers¹⁵⁷ and gathered evidence in relation to the development of bioeconomy markets. The Panel was reorganised in 2016 to improve its representativeness of all the bioeconomy-relevant sectors and stakeholders and to focus, in a more explicit manner, on stakeholders' dialogue¹⁵⁸. The first output of the reorganised Panel has been the 2017 Stakeholders Manifesto which lays down guiding principles and identifies actions that stakeholders and policy makers can take to develop the bioeconomy along a shared societal agenda. The Stakeholders Manifesto built on a series of stakeholders' interactions, and notably on the fourth Bioeconomy Stakeholders Conference¹⁵⁹. The Stakeholders Manifesto and its preparatory document "Building blocks for a European Bioeconomy Stakeholders Manifesto"¹⁶⁰ paved the way for a fruitful dialogue among a broad range of bioeconomy stakeholders and provide shared societal perspectives worth considering in the re-design of the EU Bioeconomy Strategy.

¹⁵⁶ <http://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=panel>

¹⁵⁷ These papers addressed the issue of biomass supply and market-making in the bioeconomy, see: <https://publications.europa.eu/en/publication-detail/-/publication/6e408028-0256-448f-9b1a-5556ade096be>

¹⁵⁸ The Panel was renamed "Bioeconomy Stakeholders Panel" to reflect the change in member composition.

¹⁵⁹ Other stakeholders' conferences took place in Copenhagen 2012, Dublin 2013, Turin 2014 and Utrecht 2016 as foreseen in the action plan.

¹⁶⁰ This document was adopted during the 4th Bioeconomy Stakeholders Conference in March 2016 in Utrecht, weblink: https://lumencms.blob.core.windows.net/site/30/Manifest_revisie_13_juni.pdf

As called for by this Action, similar panels have been created in a few Nordic countries¹⁶¹ (DK, FI¹⁶², DE¹⁶³). However, there is no clear indication that other Member States have set up similar structures.

Section 5.3 ("Internal and external policy coherence") below provides further insight into the policy synergies and coherence achieved by the Bioeconomy Strategy and Action Plan.

5.2.2.2 Establishing a Bioeconomy Observatory to assess and review progress and impact

As laid down in the Bioeconomy Action Plan, the Bioeconomy Observatory was set up in 2013 by the EC Joint Research Centre (JRC) under the name Bioeconomy Information System and Observatory¹⁶⁴ (BISO). Its objective has been to assess the progress and impact of the bioeconomy and develop forward-looking and modelling tools. The Observatory acted as a repository of S&T, market and policy data and analyses relevant for the bioeconomy. However, the monitoring data provided by the Observatory to assess progress of the Bioeconomy Strategy did not prove sufficient. Also, the need to provide a more systemic and dynamic approach to the bioeconomy policy (i.e. cross-sectoral and cross-policy) has led to a new entity that replaced BISO as of July 2017, namely the Bioeconomy Knowledge Centre. The Bioeconomy Knowledge Centre will act as a knowledge hub on the bioeconomy providing relevant scientific and policy knowledge available in the JRC, EC policy DGs and beyond.

The knowledge generated by the Bioeconomy Observatory has been used by policy-makers at EU¹⁶⁵ and national level (DE¹⁶⁶, FI¹⁶⁷), researchers¹⁶⁸, civil society¹⁶⁹ as well as the general public.

5.2.2.3 Supporting the development of national and regional bioeconomy strategies

One of the key results of the 2012 Bioeconomy Strategy is that it has brought the bioeconomy principles and cross-cutting objectives to the attention of national and regional policy-makers, as demonstrated by the number of

¹⁶¹ Nordic Council Bioeconomy Panel - members from Nordic countries Iceland, Norway, Sweden, Finland, Denmark, Faroe Islands, Greenland and Åland - weblink: <http://www.norden.org/en/theme/nordic-bioeconomy/nordic-bioeconomy-panel/members-of-the-nordic-bioeconomy-panel>

¹⁶² A Finnish national bioeconomy panel was set in 2015 gathering members from seven ministries, research institutions, representatives from regional councils and regional public services, industry, entrepreneurs' and farmers' organisations, trade unions and environmental NGOs. Weblink: <http://www.biotalous.fi/biotalouspaneeli-edistaa-strategian-toteutusta-ja-biotalousalan-vuorovaikutusta/>

¹⁶³ <http://bioekonomierat.de/>

¹⁶⁴ BISO operated as an FP7-funded project (2013-2016) that provided a website with bioeconomy-relevant S&T, policy and market data as well as research on bio-based industries and environmental aspects. It was followed (2016-2017) by the JRC institutional project-funded EU Bioeconomy Observatory (BeO)

¹⁶⁵ Notably for the Inter Service Consultations on bioeconomy and biomass

¹⁶⁶ German Bioeconomy Council and FNR - Fachagentur Nachwachsende Rohstoffe e.V., see <http://bioeconomie.de/en/worldwide-strategies>

¹⁶⁷ <http://www.bioeconomy.fi/new-website-of-the-european-bioeconomy-observatory/>

¹⁶⁸ See <http://www.nature.com/news/policy-five-cornerstones-of-a-global-bioeconomy-1.20228>

¹⁶⁹ See Oxfam, Presentation "Building the EU Bioeconomy on solid ground", 27/05/2016

countries which have adopted bioeconomy policies since 2012. Across the EU, four Member States (FI, ES, IT, FR) have adopted fully-fledged bioeconomy strategies since 2012¹⁷⁰, while Germany complemented its 2010 bioeconomy R&I strategy with a "National Policy Strategy on Bioeconomy", which was spearheaded by the German Agricultural Ministry¹⁷¹. It is worthwhile noting that all these strategies go beyond R&I and follow the more holistic approach of the 2012 EC strategy and have been developed jointly by various ministries covering bioeconomy-relevant policy areas such as: research, agriculture, forestry, industry, environment, regional, etc. Four Member States (EE, HU, LV, UK) are currently preparing bioeconomy strategies, whilst eight Member States (AT, BE, DK, IE, LT, NL, PT, SE) have streamlined bioeconomy policies into their national plans or strategies (see Table 12 in Annex II). These eight Member States have, according to their specific situation and comparative advantages, a diverse set of foci when approaching bioeconomy in their national plans or strategies (e.g. priority on chemicals in SE and NL, vs. primary production in IE).

Through the Standing Committee on Agricultural Research (SCAR), several Member States have formed a bioeconomy strategic working group to informally exchange among these Member States on national activities, strategies and the implementation of strategies in different action areas. It has also delivered a policy brief that analyses the current EC Bioeconomy Strategy and makes recommendations towards its future development¹⁷².

Existing evidence¹⁷³ shows that bioeconomy-related R&I has become a priority for most European regions, with a substantial number of regions having included bioeconomy-related priorities in their Research and Innovation Strategies for Smart Specialisation (RIS3). The development of regional and national RIS has been ensured by introduction of the ex-ante condition for ERDF support for research and innovation in the 2014-2020 period. The strategies aim at setting priorities in territories and building competitive advantage by developing and matching R&I own strengths to business needs in order to address emerging opportunities and market developments in a coherent manner. Out of 210 analysed territorial units (EU regions and countries) by a recent study¹⁷⁴, 207 have included bioeconomy-related aspects in their 2014-2020 RIS3s and related documents. In addition, the integrated and participatory approach of Smart Specialisation within regions has contributed to the strengthening of interactions within regional triple and quadruple helix, namely between the academic sector, research centres, businesses and local/national governments. Furthermore, dedicated regional bioeconomy strategies (or similar comprehensive documents) were developed in the 49 EU regions

¹⁷⁰ Germany developed its Bioeconomy Strategy prior to 2012.

¹⁷¹ <http://www.bmel.de/SharedDocs/Downloads/EN/Publications/NatPolicyStrategyBioeconomy.pdf>

¹⁷² https://www.scar-swg-sbgb.eu/lw_resource/datapool/items/item_28/policy-brief-23082017_final_template.pdf

¹⁷³ European Commission (2017), *Study on Bioeconomy development in EU regions, Mapping of EU Member States' / regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy*", Final Report, February 2017 and Annex 8 of the study

¹⁷⁴ European Commission (2017), study on Bioeconomy development in EU regions "Mapping of EU Member States' / regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy", Final Report, February 2017

analysed in the study¹⁷⁵. Among the regions with high bioeconomy maturity¹⁷⁶ are the Flemish Region (BE), Central Jutland (DK), South Netherlands (NL), England (UK), Baden-Württemberg and Hessen (both D) and several Swedish and Finnish regions. However, the study also shows that a large number of regions have a low level of maturity (35.7%) and cannot fully exploit the potential of the bioeconomy on their own. In addition only a few cities have been identified that have bioeconomy-related priorities in their policies.

The 2012 Bioeconomy Strategy and its Action Plan have also given a political impetus at European, national and regional levels – notably amongst the EU13 – as shown by the following high level initiatives and call for actions:

- In response to the 2012 Strategy, the European Parliament adopted a Resolution in 2013 on innovating for sustainable growth: a bioeconomy for Europe¹⁷⁷, following the report of the Committee on the Environment, Public Health and Food Safety and the Opinions respectively of the Committee on Development, the Committee on Employment and Social Affairs, the Committee on Industry, Research and Energy and the Committee on Regional Development¹⁷⁸;
- In response to the 2012 Strategy, the Committee of the Regions issued an Opinion¹⁷⁹ in 2012 stressing the importance of bioeconomy for job creation, and smart and green growth. In its second Opinion on the Bioeconomy in 2017¹⁸⁰, the Committee of the Regions recalled the need to further support the development of the bioeconomy and stressed the central role that the bioeconomy can play in rural and coastal development;
- High-level events on EU regions and political commitment: the conclusions of the Slovak Presidency Conference on the role of regions and the bioeconomy in 2016 called for regional development towards sustainable and circular Bioeconomy and an update of the EU Bioeconomy Strategy and Action Plan¹⁸¹; The Lodz Bioregions declaration (cooperation among Polish regions and synergies with EU initiatives)¹⁸² and the BIOEAST initiative (Central-

¹⁷⁵ European Commission (2017), study on Bioeconomy development in EU regions "Mapping of EU Member States' / regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy", Final Report, February 2017

¹⁷⁶ A bioeconomy R&I maturity index has been calculated for European regions and countries and refers to a composite index taking into account the overall innovation capacity of a territory, the existence of specific bioeconomy features such as strategies or cluster and the perceived intensity of bioeconomy R&I activity. Source: European Commission (2017), study on Bioeconomy development in EU regions "Mapping of EU Member States' / regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy", Final Report, February 2017.

¹⁷⁷ P7_TA(2013)0302, <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013IP0302&from=EN>

¹⁷⁸ A7-0201/2013, <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+REPORT+A7-2013-0201+0+DOC+PDF+V0//EN>

¹⁷⁹ <http://cor.europa.eu/en/activities/opinions/pages/opinion-factsheet.aspx?OpinionNumber=CDR%201112/2012>

¹⁸⁰ <http://www.consilium.europa.eu/en/press/press-releases/2016/06/20-envi-conclusions-circular-economy/>

¹⁸¹ <http://www.bioeconomybratislava2016.eu/>

¹⁸² https://eip.fm.gov.hu/index.php?page=pages&page_name=bioeast-kezdemenyезes&language=en. Annual conference on Bioeconomy "European Bioeconomy Congress in Lodzkie region (EBCL 2016)" organised on 6-7/10/2016, by the Lodzkie region Marshal's Office / Poland with the support of the EC.

Eastern European (CEE) Initiative for Knowledge-based Agriculture, Aquaculture and Forestry in the Bioeconomy)¹⁸³ are also prime examples of the political commitment made by Member States and regions.

In addition to national and regional specific factors that have contributed to the development of bioeconomy strategies in the EU Member States and regions since 2012, there is evidence that the Bioeconomy Strategy and Action Plan have played the role of initiator and enabler for the take up of bioeconomy as a strategic objective by policy-makers and other relevant stakeholders.

The diversity of focus chosen by Member States shows that the inclusion of the bioeconomy often follows a "smart specialisation" approach which is coherent with the other EU/national policies. It also indicates that there is no unique "bioeconomy blueprint" to be followed but rather a variety of "bioeconomies" to be developed at national and regional level. Such development depends on national and regional circumstances, including not only the type and form of biomass available (e.g. wood, agricultural, marine, waste etc.) but also infrastructures, markets, know-how and investment capacity, etc. More importantly, this diversity amongst Member States poses the question of what is (or should be) the added value of a European Bioeconomy Strategy. One should also note that a significant number of EU13 have not yet adopted bioeconomy strategies, and this despite the fact that these countries currently have a huge unexploited biomass potential¹⁸⁴. This is a reflection of the above other factors not being adequately provided.

5.2.2.4 Developing international cooperation on bioeconomy R&I to jointly address global challenges

This action has been implemented through the setting up of ambitious R&I cooperation programmes between the EU and strategic third countries on the bioeconomy. For example, cooperation actions with China¹⁸⁵ and African¹⁸⁶ countries around the issue of sustainable agriculture, food security and safety and nutrition are expected, *inter alia*, to enhance coherence between national R&I agendas for the bioeconomy, facilitate technology development and adaptation for addressing global challenges (e.g. climate change or food security), create new capacities and opportunities and improve decision making capacities regarding food supply and management. Research on the preservation and sustainable management of oceans and seas and their socio-economic potential for the bioeconomy are addressed through several

The Lodz Bioregions Declaration, endorsed by 8 Polish regions, establishes closer cooperation among various Polish regions aiming to specialise in Bioeconomy.

¹⁸³ https://eip.fm.gov.hu/index.php?page=pages&page_name=bioeast-kezdemenyvezes&language=en
BIOEAST is active since 2015 and gathers 30 national authorities and research institutes from HU, PL, CZ, SK, RO, and is aligned with the European Innovation Partnership in Agriculture (EIP-AGRI). With the support of the EC, BIOEAST now takes concrete action to exploit the full national/ regional/macro-regional bioeconomy potential as well as to steer R&I in CEE countries

¹⁸⁴ The potential comes from indigenous biomass streams from agriculture, forestry and bio-wastes which can create value for the local communities. Conclusions of the project: www.s2biom.eu; see also Marc de Wit, André Faaij, *European biomass resource potential and costs*, Biomass and Bioenergy, 34 (2010), pp. 188-202

¹⁸⁵ Approx. EUR 67 million of EU funding has been dedicated to this cooperation action.

¹⁸⁶ This cooperation action addresses Food and Nutrition Security and Sustainable Agriculture and has attracted EUR 70 million of funding (EU funding, 10 European and 9 African countries).

international initiatives developed since 2013 such as the BLUMED initiative¹⁸⁷, the BONUS programme¹⁸⁸, the Galway Statement on Atlantic Ocean Cooperation¹⁸⁹ and the Belém Statement on Atlantic Research and Innovation Co-operation¹⁹⁰. With a total envelope of ca. EUR 370 million¹⁹¹ in EU funding up to date, it is expected that the R&I actions developed within the framework of these agreements will play an important role in achieving the Sustainable Development Goals¹⁹² (SDGs) adopted in 2015.

The EC is strongly engaged in the Global Bioeconomy Forum, set up by the German Bioeconomy Council, which frequently organises international conferences, the Global Bioeconomy Summits, to bring together international stakeholders for discussing issues relevant to the global development of the bioeconomy¹⁹³. Last but not least, the EC's role in driving an international bioeconomy R&I agenda is evidenced by the setting up of the International Bioeconomy Forum (IBF). The IBF, which is a platform gathering major countries¹⁹⁴ and international and regional organisations¹⁹⁵, is expected to develop a policy dialogue on the bioeconomy (e.g. indicators, availability of biomass, microbiome), align research funding programmes and increase R&I investment and international awareness of the central role of bioeconomy.

5.2.3 Area of action 3: Enhancement of markets and competitiveness in bioeconomy

Main findings

+/- The development of analyses on biomass availability and sustainability across several EC services has contributed to developing a common knowledge base on biomass supply and demand, although data are lacking in some areas (waste, bio-based products) and further progress is needed with regard to different supply and demand scenarios and their economic, social and environmental impacts;

+ The role of the public-private partnership Bio-Based Industries Joint Undertaking is proving crucial in catalysing public and private investment and supporting the development of European industrial bio-based infrastructures and value chains;

+/- Actions have been taken to address the issue of food waste and the cascading use of biomass (e.g. in-depth studies and the development of good-practice guidelines),

¹⁸⁷ <http://www.blumed-project.eu/>

¹⁸⁸ <https://www.bonusportal.org/>

¹⁸⁹ <https://www.atlanticresource.org/aora/>

¹⁹⁰ http://ec.europa.eu/research/iscp/pdf/belem_statement_2017_en.pdf

¹⁹¹ This figure includes EU investment only (without taking into account the leverage effect of the ERANET, PRIMA and the Atlantic Ocean Research Alliance) as follows: EU-China initiative EUR 102 million, EU-Africa initiative EUR 28 million, BLUMED initiative EUR 50 million, BONUS initiative EUR 50 million, Atlantic Ocean Research Alliance EUR over 140 million, thus totalling about EUR 370 million. Source: DG Research and Innovation

¹⁹² Actions will contribute in particular to the achievement of SDGs 2 "Zero Hunger", 3 "Climate Action" and 14 "Life below water", 15 "Life on Land".

¹⁹³ <http://gbs2015.com>, <http://gbs2018.com>

¹⁹⁴ These include the EU, Argentina, Australia, Brazil, Canada, China, India, New Zealand, South Africa and USA. Source: DG Research and Innovation

¹⁹⁵ These include the OECD, the FAO as well as the European Forest Institute and the Joint Programming initiatives under Horizon 2020 such as JPI OCEAN, FACCE and HDHL. Source: DG Research and Innovation

although investment opportunities related to integrated and diversified bio-refineries remain untapped;

+/- In certain areas there is progress on the issue of the regulatory framework for the development of new markets for the Bioeconomy. The initiatives adopted in the context of the Circular Economy package include legal instruments that make the material available (feed materials, biowaste), create industrial symbioses for feed materials and create the regulatory framework for fertilising products from waste. However the impacts on the ground are in some cases still to materialise, given the above-mentioned diversity of member-state and regional circumstances.

5.2.3.1 Providing the knowledge-base for sustainable intensification of primary production, improving understanding of biomass supply and demand, developing an agreed methodology for the calculation of environmental footprints

This action has been implemented through the development of data, models and analyses on EU and global biomass flows, supplies and demands and their sustainability, by the European Commission Joint Research Centre (JRC) from 2015 onwards. The overall purpose is to identify supplies and demands (including projections) for various biomass types (forest-based, agricultural, marine, etc.) and develop scenarios for trade-offs and synergies between various end-use allocations, as a common basis for developing coherent policy measures for the short-term (2020), medium-term (2030) and long-term (2050)¹⁹⁶.

The focus of the five main tasks of work in the first two years has been on a review of existing literature and data sets to identify knowledge gaps, an assessment of current biomass supplies and potential, an analysis of current EU and global biomass supply chains and sustainability, as well as on demands for biomass products. Preliminary computer-based modelling work on developing first projections of future biomass flows, supplies and demands and associated impacts has also been undertaken.

The results are being disseminated by the JRC within the relevant scientific community and have supported other biomass-related activities¹⁹⁷. The major findings and insights up to date show the complexity of a comprehensive biomass assessment facing significant data gaps, a diversity of supply, demand, policies and a large variety of sectors potentially affected¹⁹⁸. Concepts such as the cascading use of biomass principle and its role within the Circular Economy led to additional research questions. In this context, EC actions have included

¹⁹⁶ The EC services agreed on an official mandate on the provision of data and analysis on biomass flow, supply and demand by the JRC on a long-term basis which was further specified in detailed technical specifications. These have been developed jointly between the JRC and the Biomass Inter-Service Group (ISG), which is formed by staff from the 13 DGs that have agreed to the Biomass mandate. Source: European Commission, DG Research and Innovation

¹⁹⁷ See funded project S2BIOM: <http://www.s2biom.eu/en/>

¹⁹⁸ The great diversity of bioeconomies across the EU needs special attention; for instance, agriculture contributes as little as 13% of the biomass supplies in Finland to as much as 90% in Hungary. See JRC Technical Report: Biomass flows in the European Union: The Sankey Biomass diagram- towards a cross-set integration of biomass, EUR 28565 EN, doi:10.2760/352412

an in-depth study¹⁹⁹ on cascading, particularly various types and forms of wood. There is a consensus among relevant stakeholders²⁰⁰ and within the EC Biomass Inter-Service Group (ISG) that the JRC shall carry on the work on a long-term basis, addressing aspects foreseen in the mandate that have not yet been covered and reconciling future work with the requirements of the policy agenda.

Significant work in this field has also been undertaken by the Standing Committee on Agricultural Research (SCAR)²⁰¹, which provides strategic policy advice to the EC, Member States and Associated Countries on the European agricultural and wider bioeconomy R&I²⁰². The 4th (and latest) SCAR foresight exercise²⁰³ developed scenarios regarding different possible bioeconomy developments by 2050 under the constraint of sustainability, identifying contradictions and conflicts within and across the different sectors. Depending on the scenario, by 2050 biomass may remain readily available (high growth in supply, low/high growth in demand scenarios) or may become a scarce commodity (low growth in supply, high growth in demand scenario). The foresight also revealed that R&I is needed to exploit unused biomass (waste), reducing waste, and using biomass more efficiently, as well as for increased sustainability and productivity. Also, alternatives to land-based biomass production can be explored through power-to-gas technologies. The foresight concluded that the governance of the bioeconomy is critical, and EU R&I policy should help develop a framework aimed at: fostering the bioeconomy, develop sustainability criteria and coherent policies, create a level playing field for different biobased pathways, avoid the over-exploitation of natural resources and foster a diversity of practices.

5.2.3.2 Supporting the development of (integrated and diversified) bio-refineries and the cascading use of biomass and waste streams, establish a PPP for biobased industries

The 2012 Bioeconomy Strategy and Action Plan provided for specific measures aiming at the development of integrated and diversified bio-refineries, notably through the setting up of the BBI JU which would catalyse public and private investment for these large-scale and technologically complex facilities. According to estimates, approximately 350 bio-refineries (equating to ca. EUR 46 billion of investment) could be built in Europe by 2030 in order to meet growing demand, with the markets for global bio-refinery output expected to grow at 13% per annum²⁰⁴. To date, the BBI JU has already launched six flagship projects on bio-refineries for a total contribution close to EUR 160

¹⁹⁹ Study undertaken by DG GROW and published in 2016

²⁰⁰ See point 3.3. of the position paper on Bioeconomy Strategy Revision issued by the Commission Expert Group on Bio-based Products

²⁰¹ https://ec.europa.eu/research/scar/pdf/24-09_ce_scar_role.pdf#view=fit&pagemode=none

²⁰² SCAR has developed joint foresight, common research agendas, mapping and analysis of SCAR Member States' research capacities, all of which feed into the development of the European Research Area, the Framework Programmes and joint initiatives such as ERANET Co-funds, JPIs, EIPs etc.

²⁰³ <https://ec.europa.eu/research/scar/pdf/ki-01-15-295-enn.pdf#view=fit&pagemode=none>

²⁰⁴ Source: <https://www.bccresearch.com/market-research/energy-and-resources/biorefinery-products-market-egy117a.html>

million²⁰⁵ and this figure is expected to more than double by 2020²⁰⁶ (see Table 8 below).

Table 8: Biorefineries flagship projects under the BBI JU, actual and expected funding for 2014-2020

Project name	Description	BBI JU contribution (in million EUR)
FIRST2RUN	Flagship demonstration of an integrated bio-refinery for dry crops sustainable exploitation towards biobased materials production	17.0
BIOSKOH	BIOSKOH's Innovation Stepping Stones for a novel European Second Generation BioEconomy	21.6
LIGNOFLAG	Commercial flagship plant for bioethanol production involving a bio-based value chain built on lignocellulosic feedstock	24.7
EXILVA	Flagship demonstration of an integrated plant towards large scale supply and market assessment of MFC	27.4
PEference	From bio-based feedstocks via di-acids to multiple advanced bio-based materials with a preference for polyethylene furanoate	25.0
[1]	[1]	22.0
Flagship topics in the 2017 Annual Work Programme	BBI 2017.F1 – Integrated "zero waste" bio-refinery utilising all fractions of the feedstock for production of chemicals and materials BBI 2017.F2 – Large-scale production of proteins for food and feed applications from alternative, sustainable sources	21
Total actual funding for projects until 2016		137.7
Total funding for projects until 2016 and for topics in 2017		158.7
Total funding expected for 2014-2020		ca. 340

²⁰⁵ For instance, the first flagship "First2Run" project, with a total investment of EUR 58 million, aims at setting up a commercial scale bio-refinery in Sardinia (Italy) for converting low input oil crops grown in arid or marginal lands, to produce added value chemicals, feed products and energy. Source: <https://www.bbi-europe.eu/projects/first2run> , <http://www.first2run.eu/>

²⁰⁶ Source: BBI JU 2017, *Strategic Innovation and Research Agenda* (SIRA)

Source: BBU JU 2017 Strategic Innovation and Research Agenda (SIRA)

Note: [1]: information related to this project will be made public in October 2017

Significant efforts have also been undertaken at EU level to address the issue of cascading use of biomass and waste streams. Approximately EUR 157 million have been invested between 2014-2016 on R&D projects which cover both the bioeconomy and the circular economy. A total of ca. EUR 74 million have been invested up to date into R&I projects under Horizon 2020 (see Table 9 below) looking at the issue of food waste and its key components (e.g. food packaging and processing, food waste conversion, consumer behaviour and food waste prevention throughout the food chain). These projects are expected to significantly contribute towards the objective of reducing food waste across the EU and thus contributing to the SDG 12.3²⁰⁷ by 2030²⁰⁸. Other important outcomes include a standard methodological approach for tracing food waste (incl. a Manual to support Member States in establishing more reliable monitoring of national food waste data) as well as feasibility of social innovative measures for optimised food use in the food chain²⁰⁹.

Table 9: Horizon 2020 projects addressing the issue of "food waste", 2014-2017

Horizon 2020 funding stream	No. of projects	EU funding (in million EUR)
MSCA	7	1.9
Industrial leadership (ICTs, Nanotechnologies)	6	11
Societal challenges (SC2, SC3, SC4, SC5)	28	61.5
Total Horizon 2020	41	74

Source: DG Research and Innovation

Data: CORDA data on projects funded; cut-off date: 12 July 2017

Note: [1] all the health-related projects have been excluded from the total Horizon 2020, as health was not included in the definition of the bioeconomy in the 2012 Strategy.

²⁰⁷ United Nations SDG 12.3 states that "By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses".

²⁰⁸ See REFRESH project, Project ID: 641933, http://cordis.europa.eu/project/rcn/197850_en.html

²⁰⁹ See FUSIONS, Project number 311972, Weblink: http://cordis.europa.eu/result/rcn/199531_en.html

5.2.3.3 Support the expansion of new markets through standards and other relevant schemes

This action has been directly implemented under Horizon 2020 with a total funding of EUR 19 million²¹⁰ from 2014 up to date. This funding supports R&I projects which address the issue of standards, labelling, public procurement, sustainability certification schemes, cross-sector cooperation opportunities and increased information and awareness in the bio-based and chemical markets (see Table 10 below). The Commission identified that standards for bio-based products are needed to allow for better understanding, uptake of these products by different end-users, and facilitate the functioning of the Single Market. Several mandates were issued and CEN generated different voluntary standards and other standardisation documents addressing aspects of the measurement of the bio-based content, Life-Cycle Assessment and others²¹¹. These led amongst other activities to three new official CN and PRODCOM Codes²¹² allowing for the better monitoring of trade other economic data for bio-based products.

Table 10: List of relevant R&D projects supporting the development of new markets, 2014-2017

Project name and number	Research Funding Scheme	Area	EU contribution (in million EUR)	(expected) outcomes
<p>OPEN-BIO: "Opening bio-based markets via standards, labelling and procurement" Project ID: 613677</p>	FP7	standards, labels	6	<p>Several standardised methods to help manufactures substantiate claims about bio-based content and related product properties. The developed OPEN-BIO methods were submitted to the European Committee for Standardisation (CEN) and the International Standardisation Organisation (ISO), with two methods being accepted as</p>

²¹⁰ The breakdown is as follows: EUR 6 million from FP7 KBBE, EUR 10 million from Horizon 2020 SC2 including the BBI JU. Source: European Commission, DG RTD

²¹¹ <https://www.cen.eu/work/areas/chemical/biobased/Pages/default.aspx>

²¹² <https://www.tariffnumber.com/2017/34031920>; <https://www.tariffnumber.com/2017/29053926>; <https://www.tariffnumber.com/2017/29171980> .

				standards already. A database system that provided relevant information about bio-based products to public procurement officers. The database has been fed in the INNPROBIO project, which specifically deals with public procurement of innovative bio-based products.
INNPROBIO: "Forum for Bio-Based Innovation in Public Procurement" Project ID: 652599	Horizon 2020	Public procurement	2	To build a community of public procurement practitioners interested in Public Procurement of Innovation (PPI) with Bio-Based Products and Services (BBPS). The project will develop online network facilities that will support the public procurement practitioners.
STAR-PROBIO: "Sustainability Transition Assessment and Research of Bio-based Products" Project ID: 727740	Horizon 2020	sustainability scheme, standards, labels and certifications schemes	5	Develop a fit-for-purpose sustainability scheme for bio-based products, including standards, labels and certifications schemes
STAR4BBI: "Standards and Regulations for the Bio-based Industry" Project ID: 720685	Horizon 2020	Standards	1	Recommendations on the steps to be taken by local, regional, national governments and EU to adapt regulatory and standards framework to support the development of a cutting-edge bio-

				based economy for Europe.
BIOOPEN "Open-innovation Platform strengthening cooperation and joint development of bio-based industries and downstream sectors" Project ID: 745719	Horizon 2020	Information / awareness	1	"Creation of an Open innovation platform aiming at developing new value chains as well as favouring the emergence of co-innovation partnerships across the value chains through clustering, networking and stakeholders engagement".
RoadToBio: "Roadmap for the Chemical Industry in Europe towards a Bioeconomy" Project ID: 745623	Horizon 2020	information and cross sector cooperation opportunities	1	A roadmap and an engagement guide describing the benefits and a way forward for the European Chemical Industry towards an increasing production of bio-based chemicals

Source: European Commission, DG Research and Innovation

Going beyond the R&I field, one can note that the implementation of this action has also benefitted from on-going efforts as follows:

- Recommendations for the development of commonly accepted sustainability criteria, labels, and certification schemes for bio-based products, their uptake and the widespread application of such labels by manufacturers²¹³ by the Commission Expert Group on Bio-based Products as well as efforts to incorporate bio-based criteria, based on available standards²¹⁴, into the EU Ecolabel scheme to facilitate public procurement selection processes²¹⁵;
- Voluntary guidance on the cascading use of biomass is foreseen to be developed, including the setting up of a working group to help derive good-practice guidelines, as suggested by the Council conclusions on the Circular Economy package. The guidelines are expected to be finalised by the end of 2018. They would build, amongst other inputs, on the above-mentioned EC study on the cascading use of wood.

²¹³ Source: Expert Group on Bio-based Products (2016), *15 recommendations for an increased uptake of bio-based products in public procurement*

²¹⁴ <https://www.cen.eu/work/areas/chemical/biobased/Pages/default.aspx>

²¹⁵ Source: Expert Group on Bio-based Products (2016), *15 recommendations for an increased uptake of bio-based products in public procurement*

Overall, it can be argued that the implementation of this action could be further strengthened. In its assessment on the implementation of the measures recommended by the Lead Market Initiative, the Commission Expert Group on Bio-based Products indicated that progress in this area has been rather slow, thus potentially hampering the development of a broad bio-based economy within the EU.

5.2.3.4 Develop science-based approaches to inform consumers and promote a healthy and sustainable lifestyle

Actions to develop the processes, technologies and the knowledge base to increase sustainable primary production from land and sea, to produce and supply safe and nutritious food, to understand the factors that underlie food choice, dietary and lifestyle behaviour and study their impact on health and the environment, have been directly implemented through the funding of R&I activities under the FP7 and Horizon 2020 SC2 programme. EU funding into R&I projects related to consumer research, nutrition, food processing, quality and safety, the food chain and environmental impacts totalled EUR 174 million under FP7²¹⁶ and EUR 137 million under Horizon 2020 SC2. In addition, the Joint Programming Initiative (JPI) "A Healthy Diet for a Healthy Life"²¹⁷ (JPI HDHL) which is made up of 26 countries, has funded eight Joint Actions for a total of EUR 50 million on research and innovation in the area of food, nutrition and health.

Relevant outputs up to date include, *inter alia*, dietary guidelines/recommendations (e.g. pregnancy diets to reduce obesity risks in infants²¹⁸), new food-processing technologies for reducing content of salt, fats and sugars in various foods²¹⁹ and technologies for the production of nutritious and personalised food²²⁰. In the long run, these outputs are expected to contribute to healthier and more sustainable lifestyles.

Furthermore, the Joint Programming Initiative on Healthy and Productive Oceans²²¹ planned joint actions on the ecological aspects of micro-plastics, and projects like Sea Change²²² introduced campaigns for ocean literacy and citizen engagement, building upon the latest social research on stakeholder attitudes, perceptions and values.

The implementation of this action was further supported by similar initiatives launched at EU level and aiming at educating European citizens in areas of particular importance for the bioeconomy. For instance, the "Farmed in the EU"²²³ school initiative aims at raising awareness of the aquaculture sector

²¹⁶ These are the 2012-2013 KBBE calls.

²¹⁷ <http://www.healthydietforhealthylife.eu/index.php>

²¹⁸ EARLYNUTRITION, Project ID: 289346, weblink: http://cordis.europa.eu/project/rcn/101862_en.html

²¹⁹ TERIFIQ, Project number 289397, funded under FP7-KBBE.

²²⁰ HIPSTER. Project ID: 635643, weblink: http://cordis.europa.eu/project/rcn/193343_en.html and PERFORMANCE, Project no. 312092

²²¹ www.jpi-oceans.eu

²²² <http://www.seachangeproject.eu/>

²²³ https://ec.europa.eu/fisheries/inseparable/en/farmed-eu#quicktabs-farming_in_the_eu_en=5

among European teenagers (12-18 years old) and it is currently being piloted in 20 schools across 10 Member States²²⁴.

The work done under this sub-action has had the catalytic effect of laying part of the foundations for the development of the EC's more recent FOOD 2030 Staff Working Document²²⁵. FOOD 2030 is an EU R&I initiative calling for a systemic approach to future-proofing our nutrition and food systems towards becoming sustainable, resilient, diverse, responsible, inclusive and competitive in the longer-term²²⁶. FOOD 2030 is tightly coupled with the Bioeconomy Strategy via shared basic principles: sustainability of production and consumption, circularity and resource efficiency, and climate mitigation and adaptation.

5.3 Internal and external policy coherence

Main findings

- + Improved external policy coherence between EU R&I policy and other EU policies relevant for the bioeconomy.
- However, the internal coherence of the Bioeconomy Strategy and its Action Plan remains to be improved. To this end, the definition of "SMART" objectives and indicators, a clear intervention logic and a reduced number of actions would allow for a better focus;
- The implementation of the Bioeconomy Strategy and Action Plan in an integrated and cross-sectoral manner remains a challenge.

5.3.1 Internal policy coherence

The assessment of the implementation of the Action Plan shows that whilst a number of actions have been successfully implemented, the overall linkages between these actions and the five objectives are not always clear. As noted by the expert group report, the articulation between the Bioeconomy Strategy and Action Plan shows the following issues:

- **Weak correspondence between the Bioeconomy Strategy and its Action Plan:** the Bioeconomy Strategy and Action Plan are not sufficiently well articulated. The Action Plan is structured around three areas, whilst the Strategy is structured around five objectives and the intervention logic linking the Action Plan (and the specific action/sub-actions) to the overall objectives remains unclear. In particular, there is no explicit articulation

²²⁴ These are Czech Republic, France, Germany, Greece, Hungary, Ireland, Italy, Poland, Spain, and the United Kingdom. Source: https://ec.europa.eu/fisheries/inseparable/en/farmed-eu#quicktabs-farming_in_the_eu_en=5

²²⁵ COMM (2016), Commission Staff Working Document, *European Research and Innovation for Food and Nutrition Security*, SWD(2016)319

²²⁶ FOOD 2030 builds on four priorities: Nutrition for sustainable and healthy diets, Climate-smart and environmentally sustainable food systems, Circular and resource efficient food systems, Innovation and empowerment of communities.

showing how the implemented actions are meant to contribute to the achievement of the five objectives;

- **Lack of SMART objectives:** the lack of "SMART" objectives and monitoring indicators for each of the five objectives, areas and actions/sub-actions also means that it is difficult to monitor progress and fully assess the extent to which the implementation of the actions contribute to the five strategic objectives. Whilst the Strategy put forward ambitious and cross-cutting objectives, these objectives should have been broken down into specific and operational objectives allowing for a better follow up; relevance of objectives may also need to be looked at in the light of new policy developments, such as Circular Economy, Energy Union, Industrial Policy, the Paris agreement and the Sustainable Development Goals.
- Also, the **sheer number and diversity of (sub-)actions** may have resulted in a suboptimal focus. By limiting the number of actions (and hence priorities) to be implemented, resources could have been better (re)-allocated to key areas in order to maximise impact.

5.3.2 External policy coherence

Achieving a good level of policy coherence has been crucial for the implementation of the 2012 Bioeconomy Strategy and Action Plan, since the achievement of the bioeconomy objectives requires an integrated (i.e. cross-sectoral and cross-policy) approach within the EC and beyond. This is needed in order to adequately address the issue of multiple trade-offs but also synergies and interconnected objectives related to bioeconomy policy (e.g. sustainability, mitigating climate change, food security). As pointed out by the Expert Group for the Review of the Bioeconomy Strategy and its Action Plan²²⁷, the bioeconomy policy is (often) approached from a sectoral perspective, whilst the overall definition of the bioeconomy in the 2012 Strategy would need further clarification, as it is currently understood differently by the various policy-makers and stakeholders.

This indicates that whilst some synergies and complementarities exist between EU policies and funding instruments, more explicit linkages could have been achieved when implementing the Bioeconomy Strategy and Action Plan. In this respect, the following points can be drawn:

- **Internal coherence of the Bioeconomy Strategy and Action Plan:** as noted already in the Methodology section, there is no explicit connection between the overall objectives in the Bioeconomy Strategy and the specific areas/actions in the Action Plan²²⁸. The overall design would have benefitted from a clearer (or at least more explicit) intervention logic supported by "SMART" indicators and objectives and a robust monitoring system. However, evidence shows that there is a good **level of coherence between**

²²⁷ Expert Group for the Review of the Bioeconomy Strategy and its Action Plan, (2017), *Final Report, Bioeconomy Strategy*

²²⁸ Expert Group for the Review of the Bioeconomy Strategy and its Action Plan, (2017), *Final Report, Bioeconomy Strategy*

the Strategy and Horizon 2020: complementarity and alignment of objectives between the bioeconomy and other Societal Challenges under Horizon 2020 is evidenced by 14% of the SC2 budget for 2014-2017 contributing to Societal Challenge 1 (Health, demographic change and well-being) and Societal Challenge 5 (Climate action, environment, resource efficiency and raw materials)²²⁹. Considering the importance of diet and food quality in human health, well-being and ageing, funding under Societal Challenge 2 will contribute to Societal Challenge 1 by supporting the development of food value chains that help combat the challenging disorders and food-related diseases of the aging European population. Regarding marine and maritime R&I, close coordination and joint activities with other parts of Horizon 2020 has been implemented. Particular projects funded under Horizon 2020 SC2 relevant to the exploitation of marine biodiversity and blue biotechnology touch upon the goals served by the European Marine Biological Resource Centre, which is a European Strategy Forum on Research Infrastructures (ESFRI) project²³⁰. Furthermore, the recent acceptance of the Svalbard Integrated Arctic Earth Observing System in the ESFRI roadmap brings ESFRI infrastructures closer to the objectives of the blue growth theme under Societal Challenge 2²³¹. Limited (or little) explicit linkages between Horizon 2020 SC2 and the other parts of Horizon 2020 funding fundamental research (i.e. European Research Council) have been found²³². Similarly, coherence with SC5 could be significantly improved, notably on the issue of the sustainable use of natural resources through nature-based solutions for increased and improved delivery of multiple ecosystem services. These limits point to the need to link, in a more systematic fashion, the different parts of the EU R&I funding instrument.

- **Coherence with other EU policies:** complementarities between R&I policy for the bioeconomy and other EU policies is evidenced by a series of linkages which provide for an alignment of scope and objectives as shown below:
- **Complementarities with the European Fund for Strategic Investments (EFSI):** the funding of the next generation of a bio-product mill²³³ in Äänekoski (Finland) by EFSI provides an illustration of the alignment of objectives between Horizon 2020 and the Investment Plan for Europe. Once completed and fully operational, the mill will provide a wide range of bio-based products. Meanwhile, it will increase the share of renewable energy in Finland by more than two percentage points, and in so doing it will have a positive impact on the Finnish economy and employment

²²⁹ Expert Group on Horizon 2020 SC2 Interim Evaluation, (2016), *Interim Evaluation of Horizon 2020, Societal challenge 2: Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy*, Final Report, 6 December 2016

²³⁰ EMBRC is a distributed research infrastructure that supports both fundamental and applied research based on marine bioresources and marine ecosystems, aiming to drive forward the development of blue biotechnologies.

²³¹ Expert Group on Horizon 2020 SC2 Interim Evaluation, (2016), *Interim Evaluation of Horizon 2020, Societal challenge 2: Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy*, Final Report, 6 December 2016

²³² Expert Group on Horizon 2020 SC2 Interim Evaluation, (2016), *Interim Evaluation of Horizon 2020, Societal challenge 2: Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy*, Final Report, 6 December 2016

²³³ This bio-product mill is part of MetsäBoard, leading European producer of folding boxboards and white linerboards made from fresh forest fibres. Source: European Commission, DG Research and Innovation

(e.g. annual increase in the value of exports of EUR 0.5 billion and creation of 1,500 new jobs²³⁴);

- **Links with the "European Structural and Investment Funds" (ESIF):** evidence of complementarities is apparent in terms of the funding opportunities available for innovation, including for bioeconomy, and its market uptake. The Cohesion policy funding pre-condition to develop RIS3 has helped many EU regions to define their R&I priorities and 98.6% of the strategies focus on bioeconomy related aspects in their R&I priorities²³⁵. The "Seal of excellence"²³⁶ initiative, which offers ESIF funding as an alternative to Horizon 2020 funding for high-quality R&D projects, offers further support. Several countries and regions²³⁷ have joined this initiative, whilst 370 SMEs²³⁸ have received the Seal of Excellence for bioeconomy-related excellent proposals under the SME Instrument in Horizon 2020 between 2014 and 2016. Similarly, the 2016 Work Programme of the European Maritime and Fisheries Fund (EMFF) allocates funding to promote, *inter alia*, sustainable fisheries and aquaculture. A number of projects funded under the blue technology (innovative solutions for transfer to sea basin economies) and blue labs (innovative solutions for maritime challenges) initiatives aim to bring new services for the blue bioeconomy closer to market²³⁹. The Thematic Smart Specialisation Platform²⁴⁰ on Agri-Food and Industrial Modernisation is another relevant example of complementarities achieved. This partnership supports interregional cooperation based on RIS3 priorities and aims at creating an investment pipeline of mature projects relevant for the bioeconomy (e.g. development of new bio-based value chains and new connections among sectors as chemistry, agro, wood & paper, cosmetics and energy)²⁴¹. At the same time, evidence²⁴² shows that structured linkages between the EC services responsible for R&I policy and the European Structural and Investment Funds could be further developed in order to increase synergies between these two important policies for the bioeconomy.

²³⁴ This project will receive circa EUR 275 million in loans from the European Investment Bank of which EUR 75 million are guaranteed under EFSI, out of a total investment of EUR 1,200 million. The most significant employment effects are expected to be in the forest industry and transport and new opportunities will be created for small and medium-sized enterprises. Source: <http://bioproductmill.com>

²³⁵ European Commission (2017), study on Bioeconomy development in EU regions "Mapping of EU Member States' / regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy", Final Report, February 2017.

²³⁶ The Seal of Excellence is the high-quality label awarded to projects submitted to Horizon 2020 which were deemed to deserve funding but did not receive it due to budget limits. It recognises the value of the proposal and supports the search for alternative funding. Source: <https://ec.europa.eu/research/soe/index.cfm?pg=what>

²³⁷ IT, FI, CZ, ES, FR, Scotland, Lombardy. Source: European Commission (2017), *Bioeconomy development in EU regions, Mapping of EU Member States' / regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy*, Final Report, February 2017

²³⁸ Source: DG RTD, B5; cut-off date: 11/2016.

²³⁹ Expert Group on Horizon 2020 SC2 Interim Evaluation, (2016), *Interim Evaluation of Horizon 2020, Societal challenge 2: Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy*, Final Report, 6 December 2016

²⁴⁰ <http://s3platform.jrc.ec.europa.eu/s3-thematic-platforms>

²⁴¹ <http://s3platform.jrc.ec.europa.eu/bio-economy>

²⁴² Expert Group on Horizon 2020 SC2 Interim Evaluation, (2016), *Interim Evaluation of Horizon 2020, Societal challenge 2: Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy*, Final Report, 6 December 2016

- **Complementarities with the Common Agricultural Policy (CAP):** the "agriculture" activity under SC2 is well aligned with the objectives of the current CAP, and the bioeconomy remains important for the future of the CAP as well²⁴³. Moreover, the European Innovation Partnership "Agricultural Productivity and Sustainability" (EIP AGRI) - funded through both Horizon 2020, EAFRD and the Rural Development Programmes - provides support to rural innovation and could extend its relevance to value chains as outlined in the EIP-AGRI communication of 2012²⁴⁴. The facilitation/mediation with Operational Groups funded under Rural Development Programmes also reinforces the coherence between Research and Rural Development Policy;
- **Complementarities with the Common Fisheries Policy (CFP) and the Blue Growth Strategy:** The CFP aims to ensure that fishing and aquaculture are environmentally, economically and socially sustainable and that they provide a source of healthy food for EU citizens. Its goal is to foster a dynamic fishing industry and ensure a fair standard of living for fishing communities. The Blue Growth strategy is the long term strategy underpinned by the CFP which supports sustainable and competitive growth in the marine and maritime sectors as a whole. There is an alignment of objectives between the Bioeconomy Strategy and the Blue Growth Strategy²⁴⁵, which focuses on selected high-potential value chains, with priorities such as sustainable aquaculture and marine biotechnology. Regarding aquaculture, efforts have been deployed to stimulate economic growth by cutting administrative red tape at national level and by promoting the value, quality and sustainability of EU products. Similarly, EU R&D funding supported research and high-technology spinoffs in the area of marine biotechnology and addressing, *inter alia*, the issue of habitat and ecosystem preservation, and industrial products and processes such as enzymes, biomaterials or algae bio-refineries²⁴⁶. The Blue Growth strategy emphasises growth in regions, macro-regions and peripheral areas.
- **Complementarities with the Energy Union:** the supply of sustainably produced biomass for energy purposes (heat, power and fuels) is very relevant to the goals of the Energy Union (bioenergy currently accounts for about 60% of the EU's renewable energy). The Commission recognises the potential for synergies as well as for competition between different uses of biomass (food/feed, materials and energy), and supports analyses to better understand and model biomass supply and demand for these different uses in a holistic and integrated manner. The Commission proposal for a regulation on the Governance of the Energy Union would require the biennial EU bioenergy sustainability report to include data and analysis on biomass availability and demand, including on the impact of increased demand for biomass on biomass using sectors. A number of EU-funded research and

²⁴³ See the inception impact assessment for the Communication on Modernising and Simplifying the Common Agricultural Policy: "Emerging opportunities for action in the areas of health, trade, the bioeconomy, the circular economy and the digital economy also need to be further considered.", http://ec.europa.eu/smart-regulation/roadmaps/docs/2017_agri_001_cap_modernisation_en.pdf

²⁴⁴ COM(2012) 79 final, <http://eur-lex.europa.eu/procedure/EN/201382>

²⁴⁵ https://ec.europa.eu/maritimeaffairs/policy/blue_growth_en

²⁴⁶ SWD(2017)128 final, https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/swd-2017-128_en.pdf

innovation projects have addressed the production of biomass for bioenergy and other uses. The BBI JU is financing two first of its kind commercial-scale second generation bio-refineries to produce cellulosic ethanol, which should contribute to meet the EU biofuel mandates of second generation biofuels, as well as other projects on integrated bio-refineries capable of processing biomass for multiple uses.

- **Complementarities with other EU policies:** the complementarities with the EC Circular Economy Action Plan are described in section 3;
- Some (more limited) linkages have also been observed with the **European Institute of Innovation and Technology (EIT)** and the network of thematically focussed Knowledge and Innovation Communities (KICs). The KIC EIT Food, launched in 2016 will implement an R&I agenda fully aligned with FOOD 2030 and the Horizon 2020 SC2 objectives (i.e. improving nutrition and making the food system more resource-efficient, secure, transparent and trusted);
- **Complementarities with other relevant bodies:** the Knowledge Exchange Platform was launched in 2015 by the EC and the European Committee of the Regions and aims at maximising synergies between Horizon 2020 and ESIF, for example by harnessing new knowledge created through Horizon 2020 projects and increasing their take-up at local/regional level;
- **Increased coherence between EU and national/regional policies:** as discussed above, P2P partnerships under Horizon 2020 have explicitly contributed to the alignment of R&I priorities for the bioeconomy between EU and national programmes. By implementing joint calls, strategic research agendas and other joint activities of national R&I programmes²⁴⁷, a high degree of coherence is achieved between national and EU programming. Moreover, the SCAR Bioeconomy Strategic Working Group is a coordinating mechanism between participating Member States to further develop the bioeconomy. The recent policy paper²⁴⁸ issued by this group called upon the EC to revise the definition of the bioeconomy, whilst better taking into account the issue of ecosystem services and aligning the bioeconomy policy with the recent political developments such as COP21, the Circular Economy and the SDGs. Macro-regional strategies and territorial cooperation programmes are also examples of synergies between EU and (macro) regional policies. In this regard, the Baltic Sea Region Strategy²⁴⁹ and the EU Strategy for the Danube Region²⁵⁰ have allowed political leaders to include bioeconomy in their regional political agendas and promote the development of transnational, cross-border and interregional projects.

²⁴⁷ For example, the selection of topics for the ERA-NET Cofund actions is part of the Horizon 2020 Work Programmes.

²⁴⁸ https://www.scar-swg-sbgb.eu/lw_resource/datapool/_items/item_28/policy-brief-23082017_final_template.pdf

²⁴⁹ www.balticsea-region-strategy.eu

²⁵⁰ www.danube-region.eu

6 Annex II: Detailed information

Table 11: List of bioeconomy relevant Master's and Doctoral Programmes

Degree type	Year	Name	Acronym	# of scholarships awarded to date	# of non-scholarship holders
Master	2012-0193	SUFONAMA Erasmus Mundus Masters Course in Sustainable Forest and Nature Management	SUFONAMA	48	8
Master	2012-0198	European Wind Energy Master	EWEM	69	98
Doctorate	2013-0037	Sustainable INDUSTRIAL CHEMistry	SINCHEM	28	2
Master	2013-0222	European joint masters in Management and Engineering of Environment and Energy	ME3	45	31
Master	2013-0224	International Master in Applied Ecology	IMAE	49	29
Master	2013-0229	TROPIMUNDO - Erasmus Mundus Masters Course in Tropical Biodiversity and Ecosystems	TROPIMUNDO	64	35
Master	2013-0233	Public Health in Disasters	EMPHID	64	4
Master	2013-0241	Erasmus Mundus Master in Chemical Innovation and Regulation	ChIR	58	2

Master	2014-2611	EMJMD in Aquaculture, Environment and Society	ACES	41	4
Master	2014-3553	Groundwater and Global Change - Impacts and Adaptation	G-watCH	39	10
Master	2015-2317	PlantHealth - European Master degree in PLANT HEALTH IN SUSTAINABLE CROPPING SYSTEMS	PlantHe	28	3
Master	2015-2516	European Master of Science in Food Science, Technology and Business	BIFTEC	40	13
Master	2016-2051	MSc European Forestry	MSc EF	18	n/a
Master	2016-2058	Erasmus Mundus Master in Membrane Engineering for a Sustainable World	EM3E4SW	19	n/a
Master	2016-2061	EuroPubHealth Plus	EPH+	24	n/a
Master	2016-2280	International Master in Marine Biological Resources	IMBRSea	n/a	n/a
Master	2016-3221	EuroAquae+	EA+	n/a	n/a
Total				634	239

Source: Education, Audiovisual and Culture Executive Agency

Table 12: Overview of Member States and third countries with bioeconomy policies

Country	Name of Strategy	Year of adoption	Weblink	Focus and scope
MS with dedicated bioeconomy strategies				
France	A Bioeconomy Strategy for France	2017	agriculture.gouv.fr/telecharger/84625?token=e13f5ba7a8d26a552c8509c3c551418f	Focus on Bioenergy, green chemicals, clusters, circular economy
Spain	The Spanish Bioeconomy Strategy	2015	http://bioeconomia.agripa.org/download-doc/102159	The Strategy is based on the sustainable and efficient production and use of biological resources. Targeted sectors are food and agriculture, as well as forestry, conditioned by water availability. Industrial bioproducts and bioenergy obtained from other sources of biomass are also included.
Italy	Bioeconomy in Italy	2016	http://www.agenziacoesione.gov.it/open-cms/export/sites/dps/it/documentazione/NEWS_2016/BIT/BIT_EN.pdf	The Strategy includes primary production - such as agriculture, forestry, fisheries and aquaculture - and industrial sectors using and/or processing biological resources, such as the food and pulp and paper industries and parts of the chemical, biotechnological and energy industries.
Finland	The Finnish Bioeconomy Strategy	2014	http://biotalous.fi/wp-content/uploads/2014/08/The_Finnish_Bi	The Bioeconomy Strategy in Finland is mostly focussed on important renewable resources as the biomass

			oeconomy Strategy 110620141.pdf	in the forests, soil, fields, water bodies and the sea, and fresh water.
Germany	National Research Strategy BioEconomy 2030	2011	https://www.bmbf.de/pub/National_Research_Strategy_BioEconomy_2030.pdf	R&I on Food security, sustainable agriculture, healthy nutrition, industrial processes, bioenergy.
Third countries with dedicated bioeconomy strategies				
USA	National Bioeconomy Blueprint	2012	https://obamawhitehouse.archives.gov/blog/2012/04/26/national-bioeconomy-blueprint-released	Focused on Life Sciences (Biomedicine) and Agriculture (multiple areas).
Japan	National Plan for the Promotion of Biomass Utilization	2010		The term bioeconomy is hardly used in Japan, however, there are strategies and plans directed exclusively at the production and industrial use of the biomass
Malaysia	Bioeconomy Transformation Programme (BTP)	2013	http://www.bioeconomycorporation.my/wp-content/uploads/2011/11/publications/BioEconomy-BTP_AR2013.pdf	Malaysia has been the first country in South East Asia to develop a holistic policy strategy fostering the development of bioeconomy. In Malaysia the term bioeconomy is strongly associated to industrial upgrading and the application of biotechnology
South Africa	The Bio-economy Strategy - Partnership for Action on Green Economy	2014	www.un-page.org/file/1529/download?token=eZBApDmw	The strategy seeks to improve the bioeconomy innovation capacity in south Africa. Training and education for scientists, engineers and technicians along bioeconomy value-chains

				is considered of highest priority.
Norway	Norwegian Bioeconomy Strategy	2016	https://www.regjeringen.no/contentassets/32160cf211df4d3c8f3ab794f885d5be/bioekonomi-eng-kortversjon_uu.pdf	Integrated approach to Bioeconomy and Climate, Green shift, Circular economy, Resource effectivity, Low carbon society.
Nordic Council of Ministers	Future opportunities for bioeconomy in the West Nordic Countries	2014	http://www.matis.is/medias/matis/utgafa/Future-Opportunities-for-Bioeconomy-38-14.pdf	Includes Denmark, Finland, Iceland, Norway, Sweden, Greenland, Faroe Islands and Aland. The strategy focuses on the fishing industry since it represents a large part of the region's GDP.

In addition to these countries that have developed a holistic approach to the bioeconomy, many other countries have introduced a bundle of bioeconomy relevant policies:

Country	Bioeconomy related policies	Target Sectors
Austria	Research, Technology and Innovation Strategy for Biobased Industries in Austria (2014), Policy Paper on Bioeconomy (2013)	Agro-industry, chemicals, timber industry, health care.
Great Britain	Agri-Tech strategy (2014), UK Bioenergy Strategy (2012), UK Cross-Government Food Research and Innovation Strategy (2010), Natural Environment White Paper (2011), S&I strategy for Forestry in Great Britain (2010), Marine Science Strategy (2012)	Agro-industry, bioenergy, forestry, marine.
Ireland	Harnessing our Ocean Wealth (2012), Delivering our Green Potential (2012), Towards 2030 (2008)	Forestry, fisheries, marine sector, agro-industry, health care.

Lithuania	National Industrial Biotechnology Development Programme (2007-2010)	Energy, chemistry incl. bioplastics, health care.
Netherlands	Groene Groei: voor een sterke, duurzame economie (2013), Groene Groei – van Biomassa naar business (2012), Framework memorandum on the Biobased Economy (2012), Green deal Program (2011)	Energy, chemicals, biobased industries.
Belgium	Bioeconomy in Flanders + Action Plan (2014)	Agriculture, forestry, fisheries, energy, agro-industry, chemicals.
Denmark	Growth Plan for Water, Bio and Environmental solutions (2013), Growth Plan for Food (2013)	Energy, agro-industry, cosmetics, chemicals, health care.
Portugal	Estrategia Nacional para o Mar (2013-2020)	Aquaculture, energy, cosmetics, health care.

Source: Dieckhoff, P., El-Chichakli B., Patermann, C. 2015²⁵¹

NUTS-Codes	National Bioeconomy Document or similar
MS	Name
AT	Various documents, such as "FTI Strategy for the biobased industry, Action plan for material use of renewable resources."
BG	"National Strategy for Sustainable Development of Agriculture 2014 - 2020" and "National Strategic Plan for Aquaculture in Bulgaria 2014-2020"
DE	Various documents, such as "National R&I Strategy for the Bioeconomy 2030" and "National Policy Strategy Bioeconomy - renewable resources and biotechnology applications for Food, Energy and Industry" Nationale Politikstrategie Bioökonomie"

²⁵¹ Patrick Dieckhoff, Beate El-Chichakli and Christian Patermann, "Bioeconomy Policy (Part I). Synopsis and Analysis of Strategies in the G7", published by the Office of the Bioeconomy Council, January 2015 and Patrick Dieckhoff, Beate El-Chichakli, Christian Patermann and Christin Fund " Bioeconomy Policy (Part II). Synopsis of National Strategies around the World", published by the Office of the Bioeconomy Council, January 2015

DK	Various documents such as "Growth Plan for Water, Bio and Environmental Solutions"; "Growth Plan for Food"
EE	Is preparing a national Bioeconomy Strategy
ES	"Spanish Bioeconomy Strategy", also National Research Strategies for Innovation in Agriculture and in Fisheries/Aquaculture.
FI	"Finnish Bioeconomy Strategy"
FR	"French Bioeconomy Strategy"
HU	Not yet. A national Bioeconomy Strategy has been commissioned by the Hungarian Innovation Association.
IE	"Delivering our Green Potential Government Policy Statement on Growth and Employment in the Green Economy"
IT	"Italian Bioeconomy Strategy"
LV	Not yet. The Government of Latvia has assigned the Ministry of Agriculture to develop the Bioeconomy Strategy document for Latvia until 30th June 2017.
NL	"Dutch Bioeconomy Strategy" and various documents such as Research Agendas, "Agro Agenda", etc.
PT	"Green Growth Commitment"
PL	In 2015, a draft for the "National Programme for Low-Emission Economy" has been developed.
RO	Various sectoral documents developed or under preparation such as "Low carbon green growth strategy", "Agro-food innovation" etc.
SE	Various documents such as "Swedish Research and Innovation Strategy for a Bio-based Economy"
SI	"Framework Programme for Transition to Green Economy"
UK	Various documents, such as "Building a High Value Bioeconomy, Opportunities from Waste" and "Biodesign for the Bioeconomy, UK Synthetic Biology Strategy Plan 2016", "UK Strategy for Agricultural Technologies"

Source: European Commission (2017), Bioeconomy development in EU regions, Mapping of EU Member States' / regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy, Final Report, February 2017

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This Staff Working Document provides a review of the European Commission (EC) 2012 Bioeconomy Strategy and Action Plan "Innovating for Sustainable Growth: A Bioeconomy for Europe". This review does not constitute a formal evaluation as defined by the Commission Better Regulation guidelines and consequently the approach followed differed from established evaluation practices and requirements.

Studies and reports

