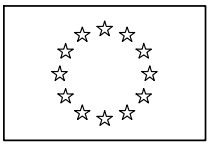

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COMMISSION STAFF WORKING DOCUMENT
Accompanying the document

Communication on

Innovating for Sustainable Growth: A Bioeconomy for Europe

{COM(2012) 60 final}

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Introduction

1. AIM OF THE STAFF WORKING DOCUMENT

The present Staff Working Document accompanies the Communication from the European Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions on "Innovating for sustainable growth: A bioeconomy for Europe" (hereafter "the Communication"). The Communication presents a Bioeconomy Strategy and Action Plan whose goal is to emphasise the importance of the bioeconomy for Europe in addressing major societal and economic challenges and to create a more favourable environment for its realisation.

The Staff Working Document presents in Section A some background information, supporting facts and concrete examples that demonstrate the critical importance of the Bioeconomy Strategy to address the significant societal and economic challenges that Europe needs to overcome. It is complemented by a more detailed version of the Bioeconomy Action Plan that aims at implementing this ambition. Section B of the Staff Working Document presents some scenarios based on Horizon 2020 and reinforced policy interaction arising from the Bioeconomy Strategy..

2. THE BIOECONOMY IN EUROPE

The bioeconomy encompasses the production of renewable biological resources and their conversion into food, feed, bio-based products[1] and bioenergy. It includes agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries. Its sectors have a strong innovation potential due to their use of a wide range of sciences (life sciences, agronomy, ecology, food science and social sciences), enabling and industrial technologies (biotechnology, nanotechnology, information and communication technologies (ICT), and engineering), and local and tacit knowledge.

Based on available data from a wide range of sources it is estimated that the European bioeconomy has an annual turnover of about € 2 trillion and employs more than 22 million

[1] Note: Bio-based products are products that are wholly or partly derived from materials of biological origin, excluding materials embedded in geological formations and/or fossilised, CEN - Report on Mandate M/429

people and approximately 9% of the total EU workforce[2] (see Table 1). With more than 80% of its land covered by farms or forests and maritime areas supporting fisheries of global significance, the EU is largely self-sufficient for many farm, forest and some sea products. The EU also has a strong innovation potential arising from an excellent science and technology base, which has given rise to many well-established and world-leading food, pulp and paper, chemical and petrochemical industries.

[2] BECOTEPS (2011) The European Bioeconomy in 2030: Delivering Sustainable Growth by addressing the Grand Societal Challenges

Table 1: The bioeconomy in the European Union[3]

Sector	Annual turnover (billion €)	Employment (thousands)	Data source
Food	965	4400	CIAA
Agriculture	381	12000	COPA-COGECA, Eurostat
Paper/Pulp	375	1800	CEPI
Forestry/Wood ind.	269	3000	CEI-BOIS
Fisheries and Aquaculture	32	500	EC***
Bio-based industries			
Bio-chemicals and plastics	50 (estimation*)	150 (estimation*)	USDA, Arthur D Little, Festel, McKinsey, CEFIC
Enzymes	0.8 (estimation*)	5 (estimation*)	Amfep, Novozymes, Danisco/Genencor, DSM
Biofuels	6**	150	EBB, eBio
Total	**2078**	**22005**	

*Estimation for Europe for 2009; **Estimation based on a production of 2.2 million tonnes bioethanol and 7.7 million tonnes of biodiesel at average market price in Europe; ***EC, Facts and figures on the CFP, Basic Statistics Data, ISSN 1830-9119, 2010 Edition

3. PROCESS, CONSULTATION AND PREPARATION

The idea to consider, in a common context, various sectors of the economy that produce, process and reuse renewable biological resources has been discussed in Europe since the middle of the last decade. In 2005, the UK Presidency of the EU organised with the Commission a conference on the knowledge-based bioeconomy under the slogan "Transforming life sciences knowledge into new, sustainable, eco-efficient and competitive products". The German Presidency supported this initiative and hosted in 2007 a conference entitled "En Route to the Knowledge-Based Bio-Economy", where the Cologne Paper[4] was presented, a document prepared by experts from both academia and industries and outlining a perspective for the bioeconomy in Europe within the next 20 years.

On 13-14th of September 2010, the Belgian Presidency, in cooperation with the Commission, hosted the conference on "The knowledge based bio-economy towards 2020", the conclusions of which have "highlighted the importance of the European bio-economy today", "concluded that the EU has core strength in research in the biological sciences", and "confirmed the strong commitment of all stakeholders to build the European bio-economy for bringing the bio-economy to its full potential, but through practical and concrete actions which will make a difference to businesses and the way we lead our lives"[5].

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3 Table adapted from Table 1 (page 14) of The Knowledge-Based Bio-Economy (KBBE) in Europe: Achievements and Challenges, Full Report, presented at the KBBE Conference on 14 September 2010 – www.kbbe2010.be/en/kbbe2010/about-kbbe/kbbe-report

4 German Presidency (2007) En Route to the Knowledge-Based Bio-Economy (Cologne Paper)

5 Belgian Presidency (2010) The Knowledge Based Bio-Economy in Europe: Achievements and Challenges

These conclusions have urged the Commission to prepare a Communication to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions entitled "Innovating for Sustainable Growth: a Bioeconomy for Europe", as one of the operational proposals of the Europe 2020 Strategy and its flagship initiative "An Innovation Union", also contributing to other flagships, such as "A Resource Efficient Europe"[6], "An industrial policy for the globalisation era" and "An agenda for new skills and jobs". The Multi-annual Financial Framework for 2014-2020[7], and some of its key proposals, such as Horizon 2020 and the Common Agricultural Policy (CAP) post-2013, duly take into account the bioeconomy.

Many sources inspired the preparation of the Communication "Innovating for Sustainable Growth: a Bioeconomy for Europe" and this accompanying Staff Working Document. They build on a number of important, recently published foresight reports, which call for ambitious approaches incorporating and integrating all scientific disciplines of the bioeconomy to address major societal challenges at European and global level. Reports include, among others: "The Bioeconomy to 2030" by the Organisation for Economic Co-operation and Development (OECD)[8], the World Wildlife Fund (WWF) report on industrial biotechnology[9], the report on the future of industrial biorefineries by the World Economic Forum (WEF)[10], the French "Agrimonde" study[11], the British study on the future of food and farming[12], the 3rd foresight report of the Standing Committee on Agricultural Research (SCAR)[13], the BECOTEPS final report[14] and KBBE-Net analyses. It has also taken stock of the increasing number of bioeconomy initiatives launched at Member States level, e.g. in Germany[15], the Netherlands[16], Finland[17], France, Belgium and Sweden (non-exhaustive list).

The results of ex-post evaluations of projects funded under past and the current Framework Programme for Research and Technological Development, i.e. FP5, FP6 and FP7, in the field of Food, Agriculture and Fisheries and Biotechnology have been another important source of information, as they describe the achievements and shortcomings of European funded research and innovation in the bioeconomy. Furthermore, two independent experts groups have produced crucial background information on the social, environmental and economic impacts of the bioeconomy, as well as on skills. The latter were identified as a key element to support the development of the bioeconomy in Europe. Finally, Commission services have

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6 COM(2011)21

7 COM(2011) 500/I final and COM(2011) 500/II final

8 OECD (2009) The Bioeconomy to 2030: Designing a policy agenda

9 WWF (2009) Industrial Biotechnology: More than green fuel in a dirty economy?

10 WEF (2010) The Future of Industrial Biorefineries

11 Agrimonde (2011) AGRIMONDE foresight study on global agriculture and food between now and 2050

12 The Government Office for Science (2011) Foresight. The Future of Food and Farming. Final Project Report

13 SCAR (2011) The 3rd SCAR Foresight Exercise; Sustainable food consumption and production in a resource-constrained world, Standing Committee on Agricultural Research (SCAR), February 2011

14 The Bio-Economy Technology Platforms project; Final report: "The European Bioeconomy in 2030: Delivering Sustainable Growth by addressing the Grand Societal Challenges"

15 BioÖkonomieRat (2010) Bio-economy Council Report 2010: Bio-economy Innovation

16 Wetenschappelijke en Technologische Commissie voor de Biobased Economy (2011) Kennis- en innovatieagenda voor de biobased economy: Naar groene chemie en groene materialen

17 Bio-based economy for Europe: state of play and future potential - Report on the European Commission's Public on-line consultation http://ec.europa.eu/research/bioeconomy/news-events/news/20110926_en.htm

benefited from the support of an expert review group to assess the expected impacts of different policy options to support the development of the bioeconomy in Europe.

In order to gather information and opinions from stakeholders and civil society, the public consultation "Bio-based economy for Europe: state of play and future potential"[18] was open from 22 February to 2 May 2011. It consisted of a series of multiple-choice and semi-open questions, designed to collect views of stakeholders active in the field and of public at large on the benefits, risks and concerns and potential of the bioeconomy today and in the future. It further sought to gather their opinions on future directions for policy interactions, research and innovation actions, actions in relation to the promotion of bio-based industries and the involvement of the public.

About 200 replies were received from the private sector (42%), the academic sector (33%), the public sector (14%) and NGOs (11%). Respondents also represented a wide range of economic sectors, mainly agriculture (34%), environment (20%), food and feed (20%), industrial biotechnology (16%), but also energy and biofuels, forestry, socio-economics, chemicals, health, fisheries and aquaculture, transport, and others. Respondents to the public consultation thus covered the main sectors of the bioeconomy. Two independent experts assisted in providing quantitative and qualitative analysis of the results of the public consultation and in outlining main opinion trends.

- Optimism over the potential of the bioeconomy to address key challenges…

The outcome of the public consultation showed that most respondents were optimistic over the potential benefits of the bioeconomy. The main benefits perceived achievable in the short term were reducing waste and pollution (73%), providing agricultural advisory services and/or knowledge transfer systems to farmers (66%) and increasing the uses of bio-waste and other waste streams (64%). It is important to observe that respondents from public (61%) and private sector (51%) were more optimistic over the short term benefits of the bioeconomy than academic sector (43%) or NGOs (45%), which have a high share of respondents cautious over the perspective for the bioeconomy (23%).

- … but concerns related to risks associated to the bioeconomy's expansion

Despite being mainly optimistic, an important share of respondents (48%) perceived high risks in the development of the bioeconomy. The main concerns were that food security and resources in developing countries were put under pressure because of increased production for non-food use (80%); natural resources were overexploited and biodiversity decreased (70%); and deforestation increased due to food and non-food production (63%). Opinions differed according to sectors of respondents; NGOs (73%) and academic (54%) sectors believed that high risks were related to the expansion of the bioeconomy, while public (46%) and private (38%) sectors tended to minimise them. In terms of professional fields, while respondents from industrial biotechnology were the only ones perceiving more frequently low risks than high risks, an overwhelming majority of respondents from the forestry sector (66%) perceived mainly high risks.

- Necessity of developing a coherent policy framework for bioeconomy

[18] Public consultation "Bio-based economy for Europe: state of play and future potential" from 22 February to 2 May 2011 - http://ec.europa.eu/research/consultations/bioeconomy/consultation_en.htm

- The involvement of a wide range of policies was considered necessary to support the bioeconomy: Research and innovation (92%), agriculture and rural development (86%), environment (83%), energy (80%), industry (71%), and climate change (67%) are perceived as very important to foster the development of the bioeconomy.

- Barriers at EU and national levels prevent the efficient development of a European bioeconomy today

Respondents observe that barriers hindering the development of the bioeconomy exist at both EU and national levels (77%), or mainly at EU level (9%). The main barriers perceived at both EU and national levels are the insufficient links between decision makers and stakeholders from the bioeconomy (76%), and the insufficient links between policies related to the bioeconomy (73%).

- The development of the bioeconomy requires action at both EU and national levels

The outcome of the public consultation shows that respondents request that action be taken at both EU and national levels. This concern is fully taken into consideration in the Bioeconomy Strategy and Action Plan, which set up objectives to aim at and actions to take at both EU and Member States' levels. According to the respondents, the main actions required at both EU and national levels are:

- A coherent framework for effective policy interactions and coordination:
  - Strengthen links between existing funding instruments for the promotion of the bioeconomy (80%)
  - Provide a coordination mechanism for all relevant policy portofolios related to the bioeconomy (78%)
- Research actions necessary to implement the European bioeconomy:
  - Support research into industrial applications (78%)
  - Foster industrial involvement in research and innovation projects (77%)
- Support to bio-based markets, economic growth and sustainable employment:
  - Improve access to finance for research and innovation (82%)
  - Propose incentives for industries trying to take innovative bio-based products to market (73%)
- Better engagement of society and foster social innovation in the bioeconomy:
  - Enhance actions related to communication and dissemination of information on the advantages and risks of the bioeconomy (77%)
  - Improve information on bio-based products for consumers (71%)

Overall, respondents were confident on the potential benefits of a European strategy for a sustainable bioeconomy (44% strongly, and 42% moderately). Strongest agreement is on the

advantages of securing a sufficient supply of food and biomass (57% strongly agree), developing integrated, sustainable agricultural, aquatic and ecosystem services (43%), and fostering the move towards a zero waste society (43%). However, analysis of the results of the public consultation and of the 35 position papers received show that NGOs tend to support a definition of the bioeconomy more public goods-oriented, using natural inputs, expanding minimum amounts of energy, and producing minimum amounts of waste.

An analysis of position papers received on the public consultation on the EU Framework Programme for Research and Innovation from the bioeconomy sector provided also useful indication on the public request to engage more with society and to support Small and Medium Enterprises efforts in research and innovation. Respondents underline that primary objective of the bioeconomy should be to ensure food security, to mitigate and adapt to climate change and to preserve natural resources.

4. THE BIOECONOMY STRATEGY AND ACTION PLAN

The Bioeconomy Strategy through its Action Plan strives to address the issues highlighted during the public consultation and in discussion with various stakeholders. It aims to pave the way to a lower emission, resource efficient and competitive society that reconciles food security with the sustainable use of renewable resources for industrial purposes and environmental protection.

Section A – Background to the Bioeconomy Strategy and Detailed Action Plan

Section A of this Staff Working Document provides further background information, supporting facts and concrete examples to the Bioeconomy Strategy and Action Plan. It does this by providing more comprehensive discussions of the main elements that will be covered by the three large areas of the Strategy, which is complemented by a more detailed version of the Action Plan that formulates sub-actions to the main list of actions of the Communication.

1. BACKGROUND TO THE BIOECONOMY STRATEGY FOR EUROPE

The Bioeconomy Strategy focuses on three large areas: the investment in research, innovation and skills, the reinforcement of policy interaction and stakeholder engagement and the enhancement of markets and competitiveness in bioeconomy sectors.

1.1. Investments in research, innovation and skills

1.1.1. Research and innovation funding

As highlighted in the Innovation Union, the European research and innovation landscape is still deeply compartmentalised. This also affects the bioeconomy: 85% of public research and development (R&D) is programmed, financed, monitored and evaluated at national level with only little trans-national collaboration or coordination. Less than 6% of total R&D investment and only 15% of European publicly funded R&D is financed in a cross-border collaborative manner[19], in particular through the EU Framework Programmes for Research and Technological Development (FPs). Lack of collaboration and coordination between national public R&D programmes is one of the obvious causes for sub-optimal returns from R&D spending[20].

The setting up of 16 ERA-NETS and 2 Joint Programming Initiatives (JPIs) related to the bioeconomy over the past years has demonstrated the willingness and benefits of cross border collaboration in public research. Supporting technology transfer or stimulating SMEs to participate in "open innovation" programmes are also an essential procedure[21], for example through the Competitiveness and Innovation Programme (CIP). Innovation is expected to play a major role in driving the European science base, strengthening links with policies and the exploitation of research results within the implementation of policies. Moving to a strong bioeconomy would require leveraging further public and private investment, increasing the positive effects of spill-over, improving research productivity, launching public-private partnerships (PPPs), and creating incentives for and reducing barriers to technology development and research-based innovation.

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19 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the committee of the Regions. Towards Joint Programming in research: Working together to tackle common challenges more effectively. Brussels, COM(2008) 468.

20 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the committee of the Regions. Towards Joint Programming in research: Working together to tackle common challenges more effectively. Brussels, COM(2008) 468

21 Belgian Presidency (2010) The Knowledge Based Bio-Economy in Europe: Achievements and Challenges

Providing a scientific evidence base for policy-making will remain an important objective of European research. The bioeconomy will further enrich this function by making the research more multidisciplinary through the integration of disciplines and sectors; in this context it will also address societal challenges taking into account social, economic, environmental and policy dimensions.

1.1.1.1. Horizon 2020

The EU budget for Europe 2020[22] proposes a EU Framework Programme for Research and Innovation "Horizon 2020" (2014-2020) with an associated budget of € 87.7 billion. It aims to boost Europe's smart, sustainable and inclusive growth by increasing excellence in the science base, promoting competitiveness and industrial leadership, and tackling societal challenges identified in Europe 2020.

Horizon 2020 is expected to address several aspects of the bioeconomy. Research and innovation under several Horizon 2020 societal challenges are clearly related to the bioeconomy, in particular under "*Food security, sustainable agriculture, marine and maritime research, and the bioeconomy"* – for which a dedicated budget of € 4.1 billion has been proposed – but also under parts of other challenges such as "*Climate action, resource efficiency and raw materials"*, "*Secure, clean and efficient energy"*, "*Health, demographic changes and wellbeing" and "Inclusive, innovative and secure societies".* This will be complemented by actions to promote *"Industrial Leadership and Competitive Frameworks*", through the development of various enabling technologies including several relevant to the bioeconomy (biotechnology, nanotechnology, ICT, advanced materials, manufacturing and processing, and space), as well as by supporting innovation in SMEs and providing access to risk finance. The European Institute of Innovation and Technology (EIT) with its Knowledge and Innovation Communities (KICs) in different areas will also address questions related to the bioeconomy. This applies in particular to the theme "Food4future", which has been suggested for one of the KICs to be selected after 2014. Finally, Horizon 2020 research and innovation under "*Excellent science base*" has also a high potential to contribute to progress across various bioeconomy sectors – through general support to frontier research, future and emerging technologies, research infrastructures and to research training and career development.

Recognising the need for increased coherence among research and innovation funds and in order to achieve the greatest possible impact of EU funding, Horizon 2020 will also aim at developing closer synergies with national and regional research and innovation programmes (e.g. through public-public partnering), as well as with other EU programmes (e.g. in education, competitiveness and SMEs) and funds, such as the structural and Cohesion Policy funds. This will help strengthening national and regional research and innovation capacities and skills, also in the context of the bioeconomy. PPPs will equally be sought, for research and innovation agendas which are of strategic importance to EU competitiveness and to address societal challenges, including in the bioeconomy. Commission services are exploring the possibilities for establishing a PPP on bio-based industries.

[22] COM(2011) 811/3

1.1.2. Leadership in biosciences

Today, Europe is a global leader in various fields of biosciences and -technologies, for example it has a competitive edge in industrial biotechnology for chemical, enzyme, food and feed ingredients industries. However, the US, Canada, Japan, India and China are also rapidly adopting industrial biotechnology solutions and there are justified concerns about the long-term competitiveness of the European industry[23]. Europe still has a very strong advantage but is increasingly loosing out in pace to other global players[24], thus it has already lost leadership in plant biotechnology. Investment in research and innovation and adapting education and training possibilities to today's needs are prerequisites to maintain leadership in these areas.

1.1.3. Implement multidisciplinary education programmes across the EU

The transition to a bioeconomy creates new scientific and technical occupations in key manufacturing and energy sectors, requiring workers with specific mixes of qualifications and competences[25]. The bioeconomy will also need professionals capable of moving at the interface of different areas, understanding the economical and societal impact of their activities, fostering cross-talk between sectors and meeting the public demand for transparency and accountability[26]. Furthermore, the demand for people with the necessary skills to exploit the results of this research and innovation (e.g. creativity, marketing, management and entrepreneurship) will increase. It is also important to point out that many SMEs in sectors such as agriculture, forestry, aquaculture and food often lack in-house technical skills to undertake research or take up results of innovation[27].

Technological advances and structural changes require life-long learning. For example in rural and coastal regions, new uses of biological materials require new skills in the primary production sector. It is forecasted that 2.2 million skilled agricultural and fishery workers will be needed by 2015[28]. This means that a mix of traditional and completely new competences will have to be applied across various fields of activities in agricultural, aquaculture and forestry sectors.

Establishing a *Life Sciences and Agricultural Universities Forum* will be instrumental to facilitate the uptake and development of the bioeconomy in academic contexts, by networking and fostering appropriate education, training and research careers related to the bioeconomy.

1.1.4. Increasing opportunities for high- and low-skilled labour forces

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

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23 Directorate-General for Enterprise and Industry (2007). Competitiveness of the European biotechnology industry.

24 Directorate-General Research and Innovation (2011) Review group for the Staff Working Document related to the Impact Assessment of the bioeconomy strategy, September 2011

25 COM(2009)512

26 Belgian Presidency (2010) The Knowledge Based Bio-Economy in Europe: Achievements and Challenges

27 Directorate-Genaral Research and Innovation (2011) Review group for the Staff Working Document related to the Impact Assessment of the bioeconomy strategy, September 2011

28 Cedefop (2008) Skillsnet sectorflash: agrifood

curricula targeted at developing interdisciplinary competences in a broad range of fields including life sciences, natural sciences, engineering, business, economy, learning, and social sciences should be intensified[29]. Mobility between country and cross-recognition of qualifications between Member States, but also between sectors and stakeholder groups needs to be improved and implemented. In addition a strong entrepreneurial and innovation culture needs to be stimulated as well as life-long learning programmes, with short modules leading to recognised European qualifications.

At the same time, studies related to innovation in some bioeconomy sectors indicate that these often employ a relatively important share of low skill employees. This has implications for increasing EU job opportunities[30].

1.2. Reinforced policy interaction and stakeholder engagement

1.2.1. Creating a favourable environment for the bioeconomy: policy coherence and cross-sectoral interaction

Due to its broad scope, the bioeconomy is subject to a wide range of policies at national, European and international level, ranging from supply-side research through to demand-side support to business and consumers. It also takes into account society's legitimate concerns about the safety, quality and origin of biological resources and products. Owing to the cross-sectoral nature of the bioeconomy, many of its activities are controlled by different public bodies or are part of wider organisational structures in the private sector.

Poor coherence between decision-makers and stakeholders are often at the origin of regulatory failures, as is the lack coherent approaches between Member States and across sectors. The incompatibility of market regulation with environmental and social regulation can sometimes cause conflicts, such as the European targets on renewable energy that distort the market for biomass. Subsidies or trade can also be an issue due to irreconcilable international obligations or policy objectives. Trade-offs are inevitable.

1.2.2. Policy coherence

Developing and promoting a bioeconomy that provides biological resources, products and public goods in a sustainable manner is a relatively new concept. Accordingly, this observation was confirmed by the results of the Public Consultation[31] and stakeholder meetings (also see Section B of this Staff Working Document). According to their findings regulatory and market failures as well as fragmented policies and activities are the main obstacles to the efficient development of the bioeconomy, as well as the lack of a coherent policy interaction model.

The potential of the bioeconomy will only be fully realised by working across several disciplines, policy areas and sectors with a strong willingness to jointly address diverse responsibilities. Areas where greater benefit could be obtained from better policy coherence

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29 Directorate-General Research and Innovation (2011) Experts group report for "Skills needs in the future bio-based economy" (p.46) June 2011

30 Directorate-General Enterprise and Industry (2009) Ecorys Study on the "Competitiveness of the EU eco-industry" (p.56) October 2009

31 European Commission Public Consultation "Bio-based economy for Europe: state of play and future potential", Feb-May 2011

may include the identification and deployment of the most promising pathways for next generation biofuels and bio-based products, facilitation of their commercialisation and use, coordinated national planning with respect to waste management and use, better consumer acceptance of new technologies, and understanding the linkages between non-food use of food commodities and agricultural land, on the one hand, and food price levels and volatility on the other hand in view of adapting measures to prevent adverse effects.

The EU is engaged in the harmonisation of legislation and monitors the implementation of European policy objectives. It also promotes new instruments that could improve the achievement of different kinds of objectives, such as the application of emission trading to the waste issue. It has been demonstrated that such instruments could generate more employment if financial benefits are invested in research and innovation.

One of the major objectives of the Bioeconomy Strategy is to contribute to achieving the full potential of the bioeconomy by providing the knowledge base for a coherent policy framework and promoting relevant innovation activities, thereby giving specific support to markets and policies related to the bioeconomy. The Strategy will achieve this by building on FP7, Horizon 2020 and by complementing other relevant existing policy initiatives, such as the EIPs.

1.2.3. Improved policy interactions

A bioeconomy interaction model will be established, building on existing structures, to promote the bioeconomy by developing synergies, complementarities and a more informed dialogue on policies and programmes, increasing the availability of resources, developing joint actions, involving stakeholders, and monitoring and reviewing progress. The creation of similar interaction models in Member States will be encouraged.

The policy interaction model for the bioeconomy will encompass the following elements:

A *Bioeconomy Panel* will provide a discussion platform and flexible framework to support interaction, strategic planning and implementation of the bioeconomy strategy. It will be mandated to: (1) give advice on the implementation of the strategy, reinforcing interaction between various policies and reinforcing synergies between national and European efforts; (2) suggest European joint actions and measures; and (3) monitor and evaluate progress in a systematic manner. The Bioeconomy Panel will be composed of:

- The relevant European Commission services covering the main bioeconomy related policies and sectors (including the Directorates-General for Research and Innovation, Agriculture and Rural Development, Enterprise and Industry, Environment, Maritime Affairs and Fisheries).

- Member States representatives from bioeconomy-relevant ministries, with an overall balanced representation of the main bioeconomy sectors and policies (i.e. agriculture and forestry, fisheries and aquaculture, environment, research and education, enterprises and industry, and health and consumer affairs), as well as of the different Member States.

- Representatives of relevant stakeholders groups, including respectively: i) industrial sectors associations ii) universities, researcher organisations and the scientific

community; iii) farmers, foresters, fishermen; and iv) non-governmental environmental organisations.

The Panel participants will be invited and the meetings will be chaired by the European Commission.

A regular *Bioeconomy Stakeholders Conference* will provide opportunities for public awareness raising and for an informed dialogue on the yearly progress of the Bioeconomy, involving researchers, stakeholders, policy makers and the civil society at large.

A *European Bioeconomy Information System* will be created (*Bioeconomy Observatory*) building on various existing sources and databases. The Observatory will perform EU capacity mapping, technology watch, bioeconomy policy outlook, and market monitoring in various areas related to the bioeconomy, as well as forward looking analyses at EU and world-wide levels. Collaboration with the Joint Research Centre (JRC), the European Environment Agency (EEA) and Eurostat will be sought.

Broad advice will be provided through a flexible system of *Hearings*, where various existing Commission working/advisory groups or committees (e.g. Standing Committee for Agricultural Research; Ad-hoc Advisory Group for Bio-based Products within the Lead Market Initiative, the EU Food Sustainable Consumption and Production Round Table, etc) as well as stakeholders groups can provide information and raise issues with the Bioeconomy Panel. Links will be ensured also with relevant European Innovation Partnerships, public-public partnering (e.g. Joint Programming Initiatives) and public-private partnerships established in bioeconomy related areas.

1.2.4. Engaging society, reaching end-users and linking with policy makers

The Public Consultation[32] pointed out the importance of developing suitable discussion and coordination platforms for the European bioeconomy with wide participation of stakeholders. Open and informed public debates should take place on bioeconomy related research and innovation issues that may raise societal concerns, such as the "food versus fuel" debate. These debates should involve the research and innovation community, stakeholders, policy makers and society at large and thus provide a basic mechanism for reliable insight into the benefits and risks of innovative technologies and existing practices, and more ample opportunities to discuss new findings and their implications. Furthermore, citizens have to be provided with more information about product properties (e.g. on sustainability) and the impacts of consumption patterns and lifestyle (for instance on the issue of waste), in order to enable responsible and informed consumer choices.

A stronger EU scale dissemination of research and innovation results, continuous knowledge exchange and information flow to end-users and policy-makers should be systematically ensured. Reinforcing informed dialogue between bioeconomy research and policy making and securing EU public funding for research in support to bioeconomy-related policies will also be fundamental to ensure that public research results provide a sound scientific basis for responsible political decisions.

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[32] European Commission Public Consultation "Bio-based economy for Europe: state of play and future potential", Feb-May 2011

Organising meetings of leading scientists on an ad-hoc basis would provide valuable opportunities to facilitate consensus reaching and to promote the use of scientific evidence towards tackling societal challenges as input for policy making, as well as for pinpointing missing elements in the knowledge base.

1.2.5. Regional approaches

The bioeconomy can significantly contribute to the future development of rural and coastal areas because it will promote both supply and demand actions with regional dimension, such as the creation of supply chains for residues and waste as feedstock for bio-based industries, setting up of a network of small-scale local biorefineries or developing aquaculture infrastructures.

Research and innovation will have an important upstream role in the development of these activities and will be supported by Horizon 2020, as well as by the reformed CAP and Cohesion Policy. In particular, the proposed reinforced focus of the future Cohesion Policy on innovation and sustainable growth will offer broad opportunities to local and regional authorities and stakeholders to co-finance programmes and projects boosting the bioeconomy in the framework of national and regional strategies for smart specialisation. Support to infrastructures within the management of coastal and rural areas is also compatible with the Common Fisheries Policy (CFP) and Cohesion Policy objectives. They contribute to the local and regional economy[33] which is the appropriate environment for the development of the above mentioned technologies. However, scale-up dynamics for these activities must account for a wide range of factors such as transport and storage costs, environmental regulations, and land use aspects.

Adaptation to climate change will be subject to regional choice of fund investment and social innovation initiative will also strengthen local and regional development

1.2.6. International cooperation for a global bioeconomy

Engaging with global partners for a faster advance of research and innovation related to the bioeconomy world-wide will be essential to maximise the sustainable use of natural resources and to foster positive socio-economic, environmental and climate change impacts. The Bioeconomy Strategy will engage in systematic international policy dialogues and strategic partnerships. Cooperation in research and innovation and other policy areas related to the bioeconomy can be reinforced through diverse partnerships.

These cooperations will include the G20 and major trade partners (e.g. on globally relevant criteria for sustainability of biomass production and use), major agricultural producers (e.g. on cutting edge technologies for food safety, reduced water and environmental impacts, and energy security), emerging economies, which are showing very fast developments in bioeconomy strategies and actions, and developing countries to address the Millennium Development Goals of tackling hunger and ensuring environmental sustainability. The world initiative Rio+20 on green economy will also support bioeconomy activities. Adaptation to and mitigation of climate change will have to be addressed in depth, taking into account trade-offs between policies which could occur in various global regions, in particular in developing countries.

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[33] COM(2010) 1183

1.2.7. Social innovation

The bioeconomy is a domain where many examples of social innovation could take place both at European and international level. The aim of social innovation is to solve social issues at large or at local scale through the promotion of innovative approaches and practices. These should combine organisational development and new forms of interaction and cooperation between organisations in the public, private and NGO sectors, cutting across established responsibilities, learning environments uses of technology, and socio-economic or scientific knowledge. Participation of stakeholders is essential to ensure acceptance, end-user orientation and benefits of the innovative solutions promoted, and to facilitate the exchange of best practices. Social enterprises are key drivers for social innovation in the bioeconomy domain

Bioeconomy social innovation could include increasing energy and resource efficiency through attitudinal and organisational changes, ways to re-use and recycle bio-based products, treatment of end-use level waste, the development of local networks for the production and distribution of food products requiring new forms of production. The bioeconomy also offers a huge potential for social innovation in the area of health, diet, education, and rural and coastal development.

1.3. Policy implementation and enhancement of markets in the main bioeconomy sectors

1.3.1. Agriculture and forestry

Over the coming decades Europe will be challenged by dwindling natural resources, the effects of climate change and the need to provide a sustainable, safe and secure food supply for a growing global population. The goal is to provide agriculture and forestry with the required knowledge and tools to support productive, resource-efficient and resilient systems that supply food, feed and other bio-based raw-materials without compromising ecosystems services, while supporting the development of incentives and policies for thriving rural livelihoods.

The expected 70% increase in world food demand by 2050[34] and a steep increase in the demand for biomass for industrial purposes will and must trigger a supply reaction of EU agriculture, being one of the biggest suppliers to global agricultural markets. EU agriculture has a share of 18% in world food exports, worth € 76 billion. In production values, EU agriculture provides more than 40% of total OECD food production. Stakeholders, including farmers, businesses, industry consumers, and advisory services, need to be provided with the solutions they need. To this end close collaboration and synergies need to be ensured across all sectors, regions, and policy areas[35].

Policy has a major influence on primary production. In particular environmental policy (e.g. through directives on soil, biodiversity, water, nitrate) and the Common Agricultural Policy (CAP) have an impact on agricultural production methods as well as on individual agriculture market sectors concerning the quality and production of products such as wine dairy, horticulture, cereals, etc. Agriculture also interacts with and influences consumer, competition

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[34] FAO (2009) How to Feed the World in 2050, High-Level Expert Forum, Rome 12-13 October 2009

[35] Directorate-General for Agriculture and Rural Development (2011) Roadmap for the European Innovation Partnership "Agricultural Productivity and Sustainability"

and health policy, along with industrial, and information policies. Equally important, the agricultural sector is concerned by and contributes to meeting international commitments, in particular as regards policies for trade, biodiversity, climate change, development and food security. The Bioeconomy Strategy will strive to ensure that the strategic importance of the primary production sector is clearly recognised in the light of these manifold – and often conflicting – demands. The following issues were identified as crucial to the introduction of sustainable production systems in the context of the bioeconomy.

1.3.1.1. Land use and the transition towards more sustainable production

In order to meet food and biomass demand Europe should examine trade-offs concerning land resources. In 2008 the total land cover of EU 27 was around 420 million hectares with approximately 43% dedicated to agricultural production and 40% to forestry. More than 1000Km^2 are subject to 'land take' every year for housing, industry, roads or recreational purposes, including some of the most productive agricultural land[36]. Progress on remediation and reuse of brownfield land remains slow, particularly in the continuing absence of specific Union legislation on soil protection. Land abandonment in some rural areas is a reality and linked with loss of biodiversity depending on farming systems. Concerning non-food production 5% of land was dedicated to industrial usage (mostly biofuel oilseed). Work on land as a resource to develop the full range of ecosystem services, from crops to fresh water to climate change mitigation and adaptation, and taking into account landscape level effects and connectivity, is needed to meet this challenge. Balancing food versus fuel demand will require greater study along with further research into agri-environmental land management concerning landscapes in the context of biodiversity, green infrastructure and interconnectivity of habitats, creating eco-corridors while providing functional services for pest suppression carbon sequestration or coexistence[37].

1.3.1.2. Agriculture and climate change

Agriculture is a significant contributor to climate change and is in return dramatically affected by climatic instability. Agriculture and food production represent 40% of the total global industrial energy demand (including emissions embedded in inputs)[38], while global direct agriculture emissions (without carbon losses from land use and land-use change) make up 10-12% of total greenhouse gas emissions[39]. Livestock ruminants alone provide a major portion of these emissions. Contrary to the situation in EU, global nitrous oxide and methane emissions from agriculture are projected to increase by 50% by 2030 due to the growing global demand for meat and biomass for industrial and energy purposes[40].

Research and innovation will aim at increasing the adaptive capacity of plants, animals and production systems to cope with rapidly changing climate conditions and environments, as well as increasingly scarce resources. This will include dealing with diversification and

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36 Gundula Prokop, Heide Jobstmann and Arnulf Schönbauer, Overview of best practices for limiting soil sealing or mitigating its effects in EU-27, Environment Agency Austria, Final report on behalf of the Environment Directorate-General of the European Commission, 2011 (http://ec.europa.eu/environment/soil/sealing.htm).

37 European Environment Agency: http://www.eea.europa.eu/themes/landuse

38 FAO (2009) How to Feed the World in 2050, High-Level Expert Forum, Rome 12-13 October 2009

39 IPCC Fourth Assessment Report http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter8.pdf

40 FAO (2002) World Agriculture towards 2015/2030: Summary Report

specific adaptation, mixed farming systems and land use practices, adaptation of plants, animals and cropping systems to biotic and abiotic stress, conservation and use of biodiversity, as well as specific climate change mitigation and stress adaptation measures at farm, forest and landscape level to water scarcity, heat, highly saline soils, new diseases and pests, etc, and in deploying different agricultural practices, including biotechnology as an enabling technology. In addition research will promote the sustainable management of soils, exploit advances in conservation agriculture and reduce green house gas emissions from agriculture and forestry activities, while enhancing sequestration of carbon in soils.

1.3.1.3. Livestock production

Food demand is expected to increase by 70% by 2050[41] and many of today's food production systems already compromise the capacity of the planet to produce sufficient future food supplies. Meat consumption, for example, in both the developed and developing world, is projected to double from the 229 million tonnes produced worldwide in 1999/2001 to 465 million tonnes in 2050[42]. In the future, livestock production will increasingly be affected by competition for natural resources particularly land and water, by the need to reduce fossil energy dependency and environmental impact, and by societal concerns concerning animal welfare.

Developments in breeding, nutrition, and animal health will contribute to increasing potential production and further efficiency and genetic gains. In this respect the tools of molecular genetics could have considerable impact, in particular marker assisted selection for traits that are difficult to measure, such as meat quality and disease resistance. The availability of increasingly annotated genome sequences of most livestock species and the decreasing price for sequencing offer unprecedented opportunities for advances in evolutionary biology, animal breeding and animal models for human diseases. For instance, genomic selection should be able to significantly improve different production traits in the cattle industry, such asfeed efficiency and disease resistance. Livestock breeding will need to check that selection for certain traits (e.g. productivity) are not made at the expenses of other traits (e.g. fertility, welfare). In parallel, the preservation of farm animal genetic resources will be critical for ensuring that livestock systems can adapt to climate change and other challenges. Indeed, the objective should be to rear the optimal animal for a defined production system with fine-tuned management support. Therefore, the whole spectrum of production systems, from the extensive, low input, organic ones to the intensive indoor systems will equally require attention.

1.3.1.4. Forestry

The EU has a total forest area of approximately 177 million ha (around 40% of the EU territory), of which 130 million ha are available for wood supply[43] and the production of non-wood goods and services (cork, resins, berries, mushroom, hunting for example). The forest-based industries are a very important EU economic sector (woodworking industries, pulp and

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41 The 3rd SCAR Foresight Exercise; Sustainable food consumption and production in a resource-constrained world, Standing Committee on Agricultural Research (SCAR), February 2011

42 FAO (2006) Livestock's Long Shadow

43 Directorate-General for Agriculture and Rural Development: http://ec.europa.eu/agriculture/fore/index_en.htm

paper, printing industries), with a production value of € 365 billion, and an added value of around € 120 billion created by more than 3 million jobs[44].

Forests play a crucial role in the global carbon cycle and the fight against climate change. The demand for wood, and for wood fuel in the context of increasing renewable energy demand, is a strong stimulus for increasing forest growth and productivity and for improving management practices more wood and residues could be harvested and mobilised while demand for forest products is growing for material and energy uses as a way to reduce carbon emissions by substituting products that cause higher emissions. However, increased harvest reduce carbon sinks. There is a need for speeding up production rates and developing forest raw materials with new properties. Forests of the future will be increasingly dedicated to producing fibres, timber, energy or customised needs, which will have considerable impacts on the provisioning of a broad range of public goods.

Forests serve multiple and interrelated social, economic and environmental functions. Besides providing jobs, income and raw material to industry, forests contribute to soil fertility and prevent soil erosion, mostly by limiting runoff and lowering wind speed. They also regulate and purify freshwater supplies, and act as a water buffer, reducing flooding. In addition, forests act as carbon sinks thus contributing to the mitigation of climate change and as significant carbon stocks, that are important to protect. They conserve biodiversity, protect against landslides and avalanches, and provide recreation, vibrant rural landscapes, and a wide range of commercial non-wood products. An important goal is to mobilise more wood in appropriate areas while safeguarding biodiversity and other public goods delivered by forests.

1.3.1.5. Policies and public goods

Agriculture and forestry are unique systems delivering commercial products but also wider non-marketed ecological and societal public goods. Research will address these manifold roles and explore their non-market value, thus supporting the provision of important non-material benefits to society (landscapes and recreation) as well as of ecological goods and services (functional and *in-situ* biodiversity, pollination, prevention of nutrient leaching, enhanced carbon sequestration, water and climate regulation, control of soil erosion). Research will provide the necessary tools to policy makers and other actors to support the implementation and monitoring of relevant strategies, policies and legislation to prevent perverse effects by correcting for externalities and to encourage synergistic outcomes. Research will include socio-economic and cost-benefit analysis, support to cross-sectoral agro-meteorological models for short-term harvest forecasts linking to climate change modelling as well as comparative assessment of farming systems, including aspects of multifunctionality and interactions with forestry, in addition to an analysis of long term developments and potentials to guide long-term decisions.

1.3.1.6. Agricultural advisory and support services, extension services

Many recent reports have all identified an information and knowledge transfer gap that exists between innovators, researchers, and biotechnologists and the farming community. Transferring the latest research results, best practice approaches and improved methodologies, including biotechnological advances, to the farming community, is key to advancing agricultural productivity while limiting environmental impacts. Organised exchanges through

[44] COM(2008) 113 final

re-constituted extension services must be put in place together with instruments and mechanisms to make knowledge transfer more efficient at the European scale, such as the European Innovation Partnership (EIP) for "Agricultural productivity and sustainability".

A specialised support infrastructure for SMEs across the EU would be beneficial. It could advise interested stakeholders, for instance on strategic use of instruments (e.g. standards, labels, certificates), and assist with specific sustainability tools, access to demonstration, testing and certification facilities, or mediate investments.

Finally, it will be necessary to support pilot and demonstration activities for up-scaling of practices and processes. Increased investments into demonstration plants and actions will therefore be needed.

1.3.2. Fisheries and aquaculture

The maritime sector accounts for nearly 5 million jobs in Europe, of which 20% are in fisheries, aquaculture and food processing[45]. The sustainable management of fisheries, combined with the competitive development of EU aquaculture and seafood processing industry, are key issues for supplying quality and safety seafood to European citizens and supporting livelihoods in European coastal areas. While these activities mainly fall under the Common Fisheries Policy (CFP), the Integrated Maritime Policy (IMP), the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD), they also form the "marine pillar" of the bioeconomy. Marine biotechnologies are estimated to grow at a rate of 12% per year with a current global market of € 2.4 billion[46]. The added value of the bioeconomy approach to these issues is the potential, through research and innovation, to address aquatic living resources on a broad sense: fisheries management; aquaculture development; food waste; by-products; seafood safety; and "blue biotechnologies" for food and non-food use.

Seas and oceans provide a vital contribution to the Europe 2020 goal of smart sustainable and inclusive growth. But they also represent a largely unknown territory, changing rapidly through a combination of human and natural pressures (including climate change), which will have major implications for our health, our well-being, food and energy supply. To conquer this new frontier, advanced knowledge on marine living resources is necessary to maximise its exploitable value in a sustainable way, optimise the response to climate change and mitigate human impacts on the marine environment as well as ensuring a Good Environment Status (GES) of EU waters by 2020[47] and optimising the planning of marine space.

Exploring seas and oceans and making the most of our aquatic resources are research challenges of considerable complexity with an important socio-economic dimension. Horizon 2020 should support multidisciplinary collaborative research as well as large cross-cutting and technological actions between marine and maritime research addressed in different major societal challenges e.g. resources efficiency, transport, energy, food security and bioeconomy in order to boost innovation and stimulate exchanges and complementarities between the marine and maritime sectors. The Bioeconomy Strategy will contribute to strengthening synergies at European level and within regional seas as well as improving scientific advice to

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45 ECOTEC Research & Consulting (2006) An exhaustive analysis of employment trends in all sectors related to sea or using sea resources

46 COM(2008) 534

47 Directive 2008/56/EC

support relevant policies (e.g. CFP, IMP, MSFD, WFD etc) in line with "Innovation Europe" and "Resource Efficient Europe" flagships.

1.3.2.1. Sustainable fisheries

The economic and social viability of fisheries can only result from restoring the productivity of fish stocks. It is then necessary to rebuild European fisheries resources by maximizing their sustainable yield as targeted in the latest reform of the CFP. This will require developing research in order to improve scientific knowledge and innovation for supporting a robust decision making, the move towards an ecosystem approach and the necessary fishery sector adaptation. A comprehensive research effort should also target innovative solutions for the "greening" of the fisheries sector by reducing its ecological footprint on the marine ecosystems, including reducing discards and wastes and making the best use of by-catches. Fisheries rely directly on the productivity and health of aquatic ecosystems, which are under increasing pressures, including impact from other sectors and conflicting claims for the use of maritime space. Fisheries related research shall therefore address how marine ecosystems function, what constitutes healthy and productive marine ecosystems, and how one can develop harvest strategies which ensure services to society while maintaining the integrity of the ecosystems.

1.3.2.2. Sustainable aquaculture

The huge potential for the development of a competitive European aquaculture sector should be supported by strengthening the knowledge base for the sustainable exploitation of aquatic biodiversity (fish, shellfish, micro and macro algae etc) through farming, taking into account the existing legal framework, the interactions with the environment (including environmental services), as well as, the social and economic dimensions of aquaculture, including the competition in the global markets and the consumer needs. As the coastline is getting more crowded with growing population and diverse economic activities competing for the use of the maritime space, there is a strong drive to move activities further off-shore which poses considerable challenges both from a technological and spatial planning perspective. It can be expected that applications from blue biotechnology will contribute to the production of sustainable and healthy aquaculture products by ensuring better control of reproduction processes, developing innovative methods for selective breeding, feed ingredient optimisation and industrial processing, health and welfare monitoring, disease control and mitigation, preservation and bioremediation of aquatic ecosystems, energy production.

1.3.2.3. Marine biotechnology

New innovative products and services could be brought to the markets by promoting further exploration of marine biodiversity and strengthening marine biotechnology. Components derived from marine organisms through biotechnology are already being used in food, pharmaceutical, cosmetic and chemical industries. The unexploited potential of the sea is even bigger since more than 90% of marine biodiversity remains unexplored, offering a huge potential for discovery of new species and applications derived from biotechnologies, which is foreseen to generate a 10% annual growth for this sector.

1.3.3. Bio-based industries

Bio-based industries are industries, which either use renewable resources and/or apply bio-based processes in their production processes. Europe has a number of well-established

traditional bio-based industries, ranging from the food, pulp and paper and other forest-based industries, starch and biotechnology to the chemical, eco- and energy industries. The European chemical industry employs almost 1.2 million people in the EU and directly accounts for 1.1% of the total EU GDP; it is the manufacturing sector with the highest value added per employee[48]. The EU's eco-industry has a turnover of about € 319 billion[49] and employs more than 3.4 million people[50]. The European energy sector has an annual turnover of almost € 900 billion and employs over 1.2 million people[51]. Today, only a small fraction of these industries are part of the bioeconomy, however, these are likely to gain significantly in importance in the future: the OECD estimates that biotechnology's share of all chemical production alone is likely to increase from less than 2% in 2005 to 25% in 2025[52].

Significant increase in economic activity is expected to arise from the innovation potential of industrial biotechnology and biorefineries, which provide the opportunity to develop new bio-based industries, transform existing ones, and open new markets for bio-based products. Estimates foresee that industrial and plant biotechnology will overtake health biotechnology by 2030 and account for 75% of the total gross value added from the biotechnology sector[53]. While Europe's position in plant biotechnology is modest, it is still a world leader in the area of industrial biotechnology with about 70% of the world enzyme production[54]. It is therefore important for Europe to maintain its competitiveness in this sector and to foster interactions with other bio-based industries.

To build a competitive and sustainable low emission society in the EU, it will be critical to provide stakeholders in these industries and along the entire bioeconomy value chain with a technological toolbox that includes a range of Key Enabling Technologies (KETs), such as biotechnology, nanotechnology, ICT and advanced materials. The Bioeconomy Strategy recognises the importance of the KETs for opening new markets to established and rising industries and for delivering on many European policy objectives, such as the development and promotion of bio-based products under the Lead Markets Initiative[55], the targets set by the Renewable Energy and Fuel Quality Directives[56] and the Strategic Energy Technology (SET) plan[57], as well as the objectives of the flagship initiative on "A Resource Efficient Europe". Furthermore, the Strategy will contribute to enhancing the availability of biomass and biowaste at a competitive price without interfering with food security.

1.3.3.1. Biorefineries

The concept of biorefineries is analogous to that of petrochemical refinery processes, which produce a wide range of products and fuels from fossil resources. Biorefineries aim to produce multiple bio-based products and fuels using renewable resources as a carbon source and bio-based processes. Ideally, they should adapt their inputs and outputs in response to

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48 Cefic (2011) Cefic European Facts and Figures

49 Ecorys (2009) Study on the Competitiveness of the EU Eco-industry, prepared for Directorate-General Enterprise & Industry

50 Ecorys (2011) Revision of Ecorys (2009) Study on the Competitiveness of the EU Eco-industry

51 Eurostat (2009) Statistics in Focus 72/2009: Energy Sector in Europe

52 OECD (2009) The Bioeconomy to 2030: Designing a Policy Agenda

53 OECD (2009) The Bioeconomy to 2030: Designing a Policy Agenda

54 SusChem (2005) Innovating for a Better Future: Sustainable Chemistry Strategic Research Agenda 2005

55 COM(2007)860

56 Directives 2009/28/EC and 2009/30/EC

57 COM(2009)519

market supply of different types of biomass and wastes and to the demand for bio-based products, biofuels and bioenergy.

Biorefineries should adopt a cascading approach to the use of their inputs, favouring highest value added and resource efficient products, such as bio-based products and industrial materials, over bioenergy. The principle of cascading use is based on single or multiple material uses followed by energy use through burning at the end of life of the material, including taking into account the greenhouse gas emissions (GHG) mitigation potential [58]. By-products and wastes from one production process are used to feed into other production processes or for energy. Biorefineries can thus contribute to the principles of a "zero-waste society".

The biorefinery concept can be integrated in a wide range of environments, ranging from small-scale plants using agricultural residues in remote rural areas to large plants using waste from surrounding industries and municipalities in a symbiotic manner. The FP7 project Star-COLIBRI formulated a European Biorefinery Vision for 2030 and strategic research recommendations for 2020.

Pilot and demonstration activities

In order to enhance the competitiveness and growth and maintain the leading role of European industries in the sector of biorefineries, it will be necessary to support pilot and demonstration activities for up-scaling of products and processes. A mapping on existing biorefineries at pilot plant or demonstrator scale in Europe[59] has shown that there are a large number of pilot plants already, but only a very limited number of demonstrators. Increased investments into demonstration plants will therefore be needed, possibly through PPPs, financial instruments, regional funds, etc.

Networks, clusters and logistics

Supply of sufficient quantities of good quality renewable raw materials at a competitive price is critical for the success of biorefineries. A supply chain for feedstock needs to be developed across Europe that allows compensating fluctuations in one feedstock, by using another. This includes improving infrastructures for storage and transport, and developing the necessary logistics. Cascading use of biomass should be possible at regional, national and European level. Supply chain and logistics should be linked to a wide network of integrated and diversified biorefineries. Where appropriate, a cluster approach could be applied

1.3.3.2. Waste as an alternative biomass source

Every year, more than 300 million tonnes of biodegradable household and household-like wastes, industrial wastes and other wastes are generated in the EU and remain largely unexploited. The bioeconomy offers a wide range of added value solutions for the prevention and management of biodegradable waste streams in line with the Waste Framework Directive

[58] Nova Institute (2010) The development of instruments to support the material use of renewable materials in Germany (Summary)

[59] FP7 project Star-COLIBRI (2010) http://www.star-colibri.eu/files/files/Deliverables/D2.3.1-Mapping-of-Research-Projects-main-report.pdf

(WFD)[60]. The Directive includes the use of by-products and secondary raw materials, but not that of agricultural and forestry residues.

Many sectors are starting to recognise the potential economic value of biodegradable waste (e.g. the agricultural, chemical and energy sectors). For certain types of biodegradable wastes, too many sectors are already competing for a limited resource, for example in the pulp and paper industry. At the same time, differences in national implementation of waste legislation (e.g. on landfilling) and in the classification of certain waste streams exclude many of them from being used for biotechnological conversion, e.g. wood from construction/demolition sites, animal by-products, composts, etc. While protecting human health and the environment should always be a priority when exploring potential uses of waste, end-of-waste criteria that could make restricted wastes more accessible for re-use need to be considered.

Using waste efficiently

As with biomass, waste may not always be directed to the most efficient and highest value uses. Life cycle thinking and prospective studies will be critical in determining which use of a waste will be the most efficient in a given context. It will assist in assigning a waste to its optimal use through a cascading approach in line with the waste hierarchy of the WFD (e.g. measuring the added value of bio-based products against that of biofuels and incineration), but also to justify any deviation from this waste hierarchy (e.g. when distance makes transforming a waste into biofuel or energy more efficient than other uses).

Guidance on the development of life cycle thinking in bio-waste management is being developed by the Joint Research Centre (JRC) and the Directorate-General for Environment. This initiative should be extended to other waste streams that could undergo biological transformation in order to ensure their optimal use. It should also take into account factors, such as waste fluctuations, logistics and transport.

Future waste streams

While priority should be given to investigating major existing waste streams and their potential uses, it will also be important to anticipate, which biodegradable waste streams are likely to gain significant volumes in the future (e.g. bioplastics) and to predict future waste streams. Life cycle thinking should be an intrinsic part of any product development. Furthermore, the likely shifts in waste and by-product quantities and distributions as a consequence of the waste hierarchy implementation should be assessed in future scenarios and associated socio-economic and environmental assessments. Some work on the environmental impacts associated to Member States' waste management systems is ongoing at the JRC for the Directorate-General for Environment.

1.3.3.3. Biotechnologies

Industrial biotechnology can contribute to making production processes more resource efficient and environmentally friendly. Bio-based processes can substitute individual production steps or entire production processes. They convert carbon sources more efficiently (both fossil and renewable), use less solvents and have a lower water and energy intensity,

[60] Directive 2008/98/EC

which also results in significant cost savings. Bio-based processes in some cases can be used to eliminate or substitute process steps involving particularly hazardous substances[61].

Environmental biotechnology can contribute to the development of more sustainable bio-based products and processes and the cleaning and preventing environmental pollution, including hazardous substances (e.g. through bioremediation and biological water treatment).

Synthetic biology is highly likely to influence a wide range of areas of our economy and society. Designing and constructing artificial micro-organisms for a given application could have a huge potential for biotechnological applications, such as protein design and production, metabolic engineering, carbon fixation, biomass production, biocatalysis, biofuels and bioremediation.

Systems biology aims to understand the operation of biological systems rather than its component parts. Combined with systems engineering it can assist product and process development, for example through virtual or *in silico* set-ups that predict process conditions. This reduces the need for experiments and saves cost and time.

Nanobiotechnology develops nanotechnology products with the basic components of biomolecules and living cells. This provides innovative scientific and technical approaches to address existing or to create new applications, especially in the area of biocatalysis, which will contribute to the development of innovative and cost-efficient bio-based products and solutions.

1.3.3.4. Bio-based products

Bio-based products are wholly or partly derived from materials of biological origin, excluding materials embedded in geological formations and/or fossilised[62]. The advantages of these products over conventional products range from more sustainable production processes, to improved functionalities (e.g. enzyme-based detergents that work more efficiently at lower temperatures, save energy and replace phosphorus) and characteristics (e.g. better biodegradability, lower toxicity).

Standardisation and certification

The EU is taking an active role in driving the development of clear and unambiguous standards for bio-based products at European and international level (e.g. on bio-based content, biodegradability, sustainability and functionalities) and ensure their consistency across sectors. Standards are also central for the development of labels for bio-based products.

To be comparable and reliable, sustainability assessments for bio-based products need to be standardised and be certifiable. Sustainability criteria for bio-based products and biofuels should be comparable and take into account factors, such as the calculation of GHG emissions and criteria for sustainable biomass production. Life cycle assessments (LCAs) can contribute to improving the sustainability of products and processes. They should be clear, objective,

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61 Regulation (EC) 1907/2006

62 Note: This definition refers to the well-known short-cycle of carbon, i.e. the life cycle of biological materials (e.g. plants, algae, marine organisms, forestry, micro-organisms, animals and biological waste from households, agriculture, animals and food/feed production). The bio-based product is normally characterised by the bio-based content. CEN- Report on Mandate M/429.

science-based, easy to handle and implement[63] and do not add significant costs to the development of innovative products or hinder market access for SMEs. Guidance on good practice in LCAs is being prepared by the JRC. The LCA approach is also being further developed towards a sustainability assessment in the FP7-funded PROSUITE[64] and Global-Bio-Pact[65] projects.

Labelling

Labelling can play an important role for the commercialisation of bio-based products. They provide consumers with clear information on the environmental performance of the products and guide their purchasing behaviour towards sustainable choices. Labels can also be critical for the uptake of bio-based products by green public procurement.

In view of the proliferation of national and international labelling schemes, there are benefits in associating bio-based products to a successful existing scheme with a harmonised and standardised approach across the EU, such as the European Ecolabel[66]. Although its criteria are not fully congruent with those of a sustainability assessment under the European industrial policy, it already includes products with renewable carbon content under various product groups (e.g. lubricants and detergents). Creating additional product groups covering bio-based products could be considered, as well as the further development and improvement of the Ecolabel criteria.

Advisory and support services

Bio-based products create entirely new markets or enter markets dominated by well-established petro-chemicals suppliers. This implies specific challenges both for start-ups and mature companies wanting to enter a bio-based market either as a supplier or a customer.

A specialised support infrastructure for SMEs across the EU would be beneficial. It could advise interested stakeholders on the strategic use of instruments (e.g. standards, labels, certificates) and assist with specific LCA and sustainability tools, bio-based eco-design aspects, access to demonstration, testing and certification facilities, or mediate investments. An EU wide approach bringing together suppliers and potential users downstream in the bio-based products value chain would increase chances to alleviate market failures and earn societal benefits earlier, contributing to a lead market advantage. The BIOCHEM project[67] funded under the EU Competitiveness and Innovation Programme (CIP) serves as a pilot for such services.

1.3.4. Food chain

With a turnover of € 954 billion, and 4.2 million people employed in over 310,000 companies, the food and drink industry is the EU's single largest manufacturing sector. SMEs represent 99.1% of food and drink companies and generate almost half of the industry's turnover. In

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63 Ad-hoc Advisory Group for Bio-based Products in the framework of the European Commission's Lead Market Initiative (2009) Taking bio-based from promise to market: Measures to promote the market introduction of innovative bio-based products.

64 FP7 project PROSUITE: http://www.prosuite.org/

65 FP7 project Global-Bio-Pact: http://www.globalbiopact.eu/

66 Directorate-General for Environment: http://www.ecolabel.eu

67 CIP project BIOCHEM: http://www.europe-innova.eu/web/guest/eco-innovation/eco-innovation-platform/biochem/about

terms of turnover, R&D expenditure is quite low at 0.37% - the lowest of developed countries.[68]

The combined pressures of an ever-increasing global population, climate change impacts, limited natural resources, complex socio-economic and culturally influenced dietary choices and an increasing demand for meat, pose significant and unprecedented challenges in ensuring future food security and safety. Over recent years, food consumer retail prices have risen at a higher inflation rate than all other items and the prices of agricultural commodities have shown an extreme volatility.[69]

The central goal of the Commission's food safety policy is to ensure a high level of protection of human health and consumers' interests in relation to food, taking into account diversity, including traditional products, whilst ensuring the effective functioning of the internal market. The White Paper on Food Safety[70] provides guiding principles for applying an integrated approach from farm to table covering all sectors of the food chain, including feed production, primary production, food processing, storage, transport and retail sale.Over the last three decades obesity levels in the EU have risen dramatically, particularly among children. This is indicative of a worsening trend in poor diets and low physical activity levels across the EU population which can be expected, in turn, to increase future levels of a number of chronic conditions. In the long term, this will result in a negative impact on life expectancy in the EU, and a reduced quality of life for many. Tackling this important public health issue entails the integration of policies across the board; from food and consumer, to sport, education and transport. The Bioeconomy Strategy sets out concrete actions to help ensure that consumers have access to sufficient, safe, nutritious and affordable food at all times while decreasing the burden of diet-related diseases, including obesity by promoting healthier diets and by facilitating sustainable and value-based consumption patterns.

1.3.4.1. Resource efficiency

The food industry is a very large consumer of water, energy and packaging materials. Water is used throughout the processing chain, not only as an ingredient, but also in processing for cleaning, heating and cooling. Reductions in water usage by up to 20 % in Europe should be achievable by improving the efficiency of existing processes and by applying new technologies and processing methods. Likewise, a more efficient use of energy in food processing, transport and distribution will increase the industry's competitiveness by lowering costs and have a positive impact on the environment. Alongside improvements to traditional processes, new technologies should be applied more widely and novel technologies should be developed in order to maximise recycling and minimise energy usage and waste at all stages of the food supply chain.

1.3.4.2. Food waste

An estimated 90 million tonnes of food, (approximately 180 kg per capita) goes to waste in Europe each year, with up to 80% of that waste coming from the manufacturing and household sectors alone[71]. Worldwide, approximately 1.3 billion tonnes or one third of all

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68 CIAA (2011) Data & trends of the European Food and Drink Industry 2010.

69 CIAA (2011) Data & trends of the European Food and Drink Industry 2010.

70 Com(1999)719 final

71 Bio Intelligence Service (2010) Preparatory Study on Food waste across EU 27. DG ENV, 2009

food produced for human consumption is lost or wasted annually[72]. Food waste also contributes to global carbon emissions and is ethically unjustifiable in a world where close to 1 billion people remain undernourished. Urgent, global and integrated measures are urgently needed to prevent avoidable food waste together with strong public engagement as a prerequisite in moving towards sustainable and equitable food systems.

The Commission is already addressing the issue actively and is cooperating closely with all relevant stakeholders to explore how to minimise food waste. It works with retailers in the framework of the EU Retail Forum on sustainability, with the EU Sustainable Consumption and Production Food Round Table, with the High Level Forum for a Better Functioning Food Supply Chain and with the Member States. Food waste is also a topic under analysis by the Commission and other EU members of the OECD, in the context of the recently formed Food Chain Analysis Network. The forthcoming proposals for the reform of the Common Fisheries Policy will also address the issue of eliminating discards of edible fish.

It is essential that consumers are provided with the information necessary to enable them to make informed choices and to avoid throwing away food that is still edible. Current education and consumer education tools such as The Europa Diary[73] and Dolceta[74] touch already upon the reduction of food wastage and the European Commission is currently undertaking an evaluation of its consumer education actions although further actions are still urgently needed.

1.3.4.3. Packaging

Food packaging plays a critical role in ensuring food safety, enhancing shelf-life, preserving taste, protecting goods, providing information to consumers and providing convenient portion sizes but also generates large quantities of waste and poses a significant environmental burden. The development of new, biodegradable, thinner and/or lighter packaging materials that can be fully re-used, recycled or recovered as energy sources, while ensuring food safety, are urgently needed in order reduce heavy environmental footprint currently brought to bear. While sustainable packaging must be considered against the background of food safety and economic sustainability, innovative advances in this field would have significant positive impacts on the competitiveness of the European food and packaging industries while paying a key role in reducing environmental impacts of this sector

1.3.4.4. Food safety

Over recent years there has been an alarming increase in food safety incidents which have increased consumer concern worldwide. In industrialised countries, the percentage of the population suffering from food borne diseases each year has been reported to be up to 30%. In the USA, around 76 million cases of food borne diseases, resulting in 325,000 hospitalisations and 5,000 deaths, are estimated to occur each year[75]. Complex food production chains and the globalisation of food markets have further increased potential food safety risks. The very heavy socio-economic burden caused can not be underestimated and, in light of increasing food demand, is likely to increase in the short-term. Innovative approaches, integrated policy developments and further investment in research and innovation aimed at enhancing food

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72 Global Losses and Food Waste (2011) Gustavsson, J., Cederberg, C.,Sonesson, U. Swedish Institute for Food and Biotechnology, Gothenburg Sweden – Report commissioned by the FAO

73 The Europa Diary: http://ec.europa.eu/consumers/europadiary/docs/europa_diary_uk.pdf

74 Dolceta: http://www.dolceta.eu/

75 WHO Fact Sheet N° 237, March 2007

safety, from production to consumption, are urgently needed. Research and innovation should also address the social aspects of the seafood sector which is essential for the cohesion of the social tissue in European coastal areas.

It will be essential that "fit-for-purpose" and effective food safety regulations are in place to protect consumers and consumer confidence while ensuring food safety and reducing wastage. Measures should be taken to reduce, where possible, mitigate the cost of compliance with regulation and the possible negative effects of compliance on innovation should also be carefully assessed and reviewed.

1.3.4.5. Nutrition and dietary choices

Adequate nutrition is fundamental for normal growth and development, health, prevention of disability and disease and well-being. In Europe, the burden of disease due to poor nutrition is related primarily to food choices that lead to the excessive intake of energy-dense, nutrient-poor foods.

There is a need for more dialogue between governments, public health groups and industry in raising consumer awareness of the link between food and health, and in creating incentives for informed food choices. This includes possible reformulation programmes to reduce nutrients associated with health risks, including sodium, sugar, saturated fat and energy, and increasing the fibre, wholegrain, fruit and vegetable content of commonly consumed processed and pre-prepared foods. These activities should be supported by strategies to standardise and reduce portion sizes. Consumer demand is driven by readily available, affordable, convenient and safe foods, however consumers are showing an increasing interest in environmental issues (where and how food is produced, transport distances including carbon printing) and social values (fair trade) which are increasingly influencing food purchasing decisions.

Sustainable consumption patterns and healthy diets are key drivers for Europe's growth and prosperity and the synergies between "healthy" and "environmentally friendly" food must be further explored at political level in Europe. Appropriate measures to improve the health of citizens, when acceptable to society and beneficial to the environment, can result in significant environmental and socio-economic benefits as well as improvements in competitiveness. The food sector is currently experiencing an increasing demand for meat at the same time as a steady increase in the world population and ever increasing competition for resources. The transition towards increased sustainability, equitability and security in food supplies will need to reconcile a complex range of factors that include economic viability, environmental protection together with societal needs and expectations.

2. THE BIOECONOMY ACTION PLAN FOR EUROPE[76]

The Bioeconomy Strategy includes a set of objectives and actions to be taken at EU and Member States levels. This accompanying Staff Working Document presents a detailed Action Plan whose implementation will allow meeting the objectives of the Strategy. The sub-actions of the action plan include, where relevant, the corresponding time frame, actors involved, and funding instrument to be used. The execution of some of these actions and sub-actions will require dedicated impact assessments.

The detailed Action Plan below describes the Commission's actions for the implementation of the Bioeconomy Strategy objectives, building on the Seventh Framework Programme for Research and Technological Development (FP7), Horizon 2020 and other relevant existing policy initiatives, such as the European Innovation Partnerships (EIPs). It also invites Member States and stakeholders to engage.

2.1. Investment in research, innovation and skills

N°	Action	Timeframe[77]	Actors[78]
A1	**Ensure substantial EU and national funding as well as private investment and partnering for bioeconomy research and innovation. Develop further JPI and ERA-Net activities in order to strengthen coherence and synergies between public programmes. Support bioclusters and KICs under the EIT for partnering with the private sector. Outline the main research and innovation concepts and priorities for food, sustainable agriculture and forestry and for marine and maritime activities under Horizon 2020.**		
A1.1	Increase EU public funding for research and innovation related to the bioeconomy, with dedicated and enhanced efforts on food security, sustainable agriculture, forestry, fisheries and aquaculture, and bio-based industries (e.g. FP7 and Horizon 2020). Encourage sufficient national public spending on bioeconomy research and development.	Short- to long-term	EU, MSs
A1.2	Strengthen coherence and synergies between EU and national/regional programmes that support research and innovation relevant to the bioeconomy, through EIPs and specific public-public partnering initiatives (e.g. ERA-Nets, Joint Programming Initiatives).	Short- to long-term	EU, MSs, Regional authorities
A1.3	Boost the bio-sciences knowledge base, related emerging technologies and biological research infrastructures, through relevant activities in FP7 followed by Horizon 2020 "Excellent Science Base". Support research and innovation to address bioeconomy-related challenges in FP7 and then Horizon 2020, particularly under "*Food security, sustainable agriculture, marine and maritime research, and the bioeconomy*" and parts of other relevant societal challenges. Establish close interactions among the respective activities in Horizon 2020.	Continuous: Short- to long-term	EU

[76] Note: Actions are not placed in a priority order

[77] In the context of the detailed action plan, and if not specified otherwise, "short-term" stands for 2-3 years, "medium-term" for 5-6 years, and "long-term" for anything beyond 2020

[78] Acronyms used for different actors: 1) European Union (EU); 2) Member States (MSs)

A1.4	Cooperate with the EIT and relevant KICs in the area of the bioeconomy, including entrepreneurship promotion activities.	Continuous: Short- to long-term	EU
A1.5	Establish close interactions between the relevant parts in Horizon 2020 and other related EU programmes in areas such as education, technology and knowledge transfer and acquisition, competitiveness and SMEs, development aid as well as structural funds - Cohesion policy Funds, Rural Development funds, Regional funds, European Fisheries Funds, etc.	Continuous: Short- to medium-term	EU
A1.6	Outline the main research and innovation concepts and priorities for sustainable agriculture and forestry and for marine and maritime activities under Horizon 2020.	Short-term	EU
A2	**Increase the share of multi-disciplinary and cross-sectoral research and innovation in order to address the complexity and inter-connectedness of societal challenges by improving the existing knowledge-base and developing new technologies. Provide scientific advice for informed policy decisions on benefits and trade-offs of bioeconomy solutions.**		
A2.1	Continue the co-operation with and ensure the sustainability of European Technology Platforms relevant to the bioeconomy.	Continuous: Short- to long-term	EU
A2.2	Support knowledge acquisition and technology exchange, advisory and support services, cooperation and training opportunities among all actors of the supply chain and end-users of bioeconomy research and innovation, for example new businesses in the bio-based product market with particular attention to first users in applying sectors downstream in the value chain. Reinforce rural and coastal advisory services.	Continuous: Short- to long-term	EU, MSs
A2.3	Develop further an EU SME support infrastructure advising producers, businesses and stakeholders, for example on strategic use of instruments (e.g. standards, labels, certificates) and for assistance with specific sustainability tools, access to demonstration, testing and certification facilities, or mediate investments.	Short-term (2014)	EU, MSs, Industry
A2.4	Reinforce the dialogue between bioeconomy research and policy making and ensure EU funding of research in support to bioeconomy-related policies, in order to ensure that public research results provide a sound scientific basis and promote responsible political decisions.	Continous: Short- to long-term	EU, MSs
A2.5	Boost the development of technologies related to bio-based industries and to the bioeconomy at large - including biotechnologies, nanotechnologies, ICT, advanced materials, manufacturing and processing - through FP7 and then Horizon 2020 “Industrial Leadership and Competitive Frameworks”.	Continuous: Short- to long-term	EU
A3	**Promote the uptake and diffusion of innovation in bioeconomy sectors and create further feedback mechanisms on regulations and policy measures where necessary. Expand support to knowledge networks, advisory and business support services, notably through EIPs and bioclusters.**		
A3.1	Identify barriers and work out solutions to promote the uptake if knowledge and innovation in different bioeconomy sectors.	Continuous: Short- to long-term	
A3.2	Provide a level playing field for patent development and improve patent law related to the bioeconomy.	Medium-term	EU, MSs
A3.3	Enhance the role of SMEs, primary producers and end customer servicing industries in the novel bioeconomy supply chains, in EU research and innovation programmes. Support "Innovation in SMEs" and provide "Access to risk finance" for innovative companies in the bioeconomy (Horizon 2020).	Continuous: Short- to long-term	EU
A3.4	Organise on an ad-hoc basis meetings of leading scientists, which will provide a platform for discussion and uptake of	Continous: Short-	EU

	scientific evidence for policy making as well as for pointing out missing elements in the knowledge base.	to long-term	
A4	**Build the human capacity required to support the growth and further integration of bioeconomy sectors by organising university fora for the development of new bioeconomy curricula and vocational training schemes.**		
A4.1	Promote EU talented researchers training, mobility, career development and exchange opportunities and enhance the development of an open European market for researchers across borders and public and private sectors in the bioeconomy areas. Increase the role and visibility of Marie Curie Actions (FP7 and Horizon 2020) and the European Research Area (ERA).	Continuous: Short- to long-term	EU
A4.2	Stimulate the development of bioeconomy skills in higher education by encouraging interaction with bioeconomy sectors, creating more academic posts in relevant scientific and technological disciplines, adjusting higher education curricula, and providing realistic prospects and career opportunities. Where appropriate consider financial subsidies or other incentives. Promote bio-literacy in school curricula.	Short- to medium-term	EU, MSs
A4.3	Establish a *Life Science, Marine and Agricultural Universities Forum*, to foster the development of the bioeconomy throughout academic excellence and networking in education, training and research.	Short- to medium-term	EU

2.2. Reinforced policy interaction and stakeholder engagement

N°	Action	Timeframe	Actors
A5	**Create a Bioeconomy Panel that will contribute to enhancing synergies and coherence between policies, initiatives and economic sectors related to the bioeconomy at EU level, linking with existing mechanisms (by 2012). Encourage the creation of similar panels at Member State and regional level. Foster participation of researchers, end-users, policy-makers and civil society in an open and informed dialogue throughout the research and innovation process of the bioeconomy. Organise regular Bioeconomy Stakeholder Conferences.**		
A5.1	Establish an EU-wide bioeconomy interaction system to strengthen coherence and synergies across sectors, policies and activities, through a Bioeconomy Panel involving relevant European Commission services, Member States and stakeholders, and building where possible on existing structures.	Short- to medium-term	EU, MSs
A5.2	Engage with civil society and promote informed public debates on bioeconomy issues, research and innovation activities and societal implications, through stakeholders discussion platforms involving scientists, entrepreneurs, policy makers and civil society at large. Organise regular Bioeconomy Stakeholders Conference to facilitate and promote communication activities on a yearly basis at EU level from 2012-2017. Encourage similar conferences at national level.	Continous: Short- to long- term	EU, MSs
A5.3	Improve availability and quality of information on bioeconomy products and processes, and on their socio, economic and environmental impacts, to facilitate informed societal choices. Raise awareness with and involve local authorities and stakeholders in the building of the bioeconomy and in reaching out to the general public. Promote "zero-waste" campaigns.	Continous: Short- to long-term	EU, MSs
A5.4	Promote further stakeholders involvement in the discussion of research priorities, in research activities and uptake of research results; promote best use of available scientific knowledge to underpin the development of national strategies and guidelines.	Short-term	EU, MSs, EATIP
A6	**Establish a Bioeconomy Observatory in close collaboration with existing information systems that allows the Commission to regularly assess the progress and impact of the bioeconomy and develop forward-looking and modelling tools (by 2012). Review progress and update the Strategy at mid-term.**		

A6.1	Establish a Bioeconomy Observatory to follow the evolution of bioeconomy markets and the impacts (socio-economic, scientific technological, market and legislation) of policies, where such mechanisms do not yet exist, as well as research and innovation activities affecting the bioeconomy in Europe and beyond. Support existing databases and develop new databases and indicators for bioeconomy impacts analyses, EU and global models integrating economic both macro and sectors levels, environment, technological development and territorial dimensions. Link the system to a global monitoring system to follow the world-wide developments and impacts of the bioeconomy, with a focus on strategic third countries partners and also to guide international co-operation strategies (including in Horizon 2020). Review regularly the progress and delivery of EU and national/regional bioeconomy strategies, including research and innovation by Horizon 2020.	Continous: Short- to medium-term	EU
A6.2	Produce regular foresights and forecasts and updates of ex-ante impacts assessments for the bioeconomy, contributing to policies' orientations as well as research and innovation directions.	Continous: Short- to long-term	EU, MSs
A6.3	Contribute to the mapping of EU, national and regional bioeconomy policies, research and innovation capacities, activities and infrastructures, as well as public and private investments in research and innovation. Produce regularly Capacities Maps, Technology Maps, Policies Maps and Projects Maps for the bioeconomy in Europe.	Short- to medium-term	EU, MSs
A7	**Support the development of regional and national bioeconomy strategies by providing a mapping of existing research and innovation activities, competence centres and infrastructures in the EU (by 2015). Support strategic discussions with authorities responsible for rural and coastal development and Cohesion Policy at local, regional and national level to maximise the impact of existing funding mechanisms.**		
A7.1	Contribute to national and regional bioeconomy strategies by supporting discussions with authorities responsible for rural and coastal development and Cohesion Policy.	Medium- to long-term	MSs
A7.2	Enhance short chain, local economic activities and urban-rural and coastal interlinkages to cater for the increasing demands for regional and diversified food and non-food products (e.g. through support in regional development programmes).	Continous: Short- to long-term	EU, MSs, Regional Authorities
A8	**Develop international cooperation on bioeconomy research and innovation to jointly address global challenges, such as food security and climate change, as well as the issue of sustainable biomass supply (from 2012). Seek further synergies between the international cooperation efforts of the EU and Member States and reach out to international organisations.**		
A8.1	Foster international policy dialogues (including monitoring and foresight) and joint S&T international cooperation actions in the area of bioeconomy in Horizon 2020 research and innovation to efficiently address global challenges related to the bioeconomy, such as food security, sustainable agriculture and fisheries, and greening the industry. Continue work with established fora, such as the International Knowledge-Based-BioEconomy Forum, the EC-US Task Force on Biotechnology Research, etc. Contribute to the development of global standards for bioeconomy sectors.	Continous: Short- to long-term	EU, strategic third countries partners
A8.2	Promote international cooperation and synergies among R&I programmes related to the bioeconomy in the EU, Member States and strategic third countries, also through the expansion of existing fora such as the Strategic Forum for International Cooperation (SFIC).	Continous: Short- to long-term	EU, MSs, third countries

2.3. Enhancement of markets and competitiveness in bioeconomy sectors

N°	Action	Timeframe	Actors
A9	**Provide the knowledge-base for sustainable intensification of primary production. Improve the understanding of current, potential and future availability and demand of biomass (including agricultural and forestry residues and waste) across sectors, taking into account added value, sustainability, soil fertility and climate mitigation potential. Make these findings available for the development and review of relevant policies. Support the future development of an agreed methodology for the calculation of environmental footprints, e.g. using life cycle assessments (LCAs).**		
A9.1	Develop tools to aggregate data on biomass and biowaste availability and their use in bio-based industries, bioenergy and food sectors in order to examine the use of available resources and the need for imports from third countries. Ensure that the developed knowledge base is communicated to the different sectors to revise the strategy if appropriate. Determine the sustainable biomass trading potential with third countries, taking into account the findings of the observatory to the GEOSS (Global Earth Observing System of Systems) of the Group on Earth Observations (GEO).	Medium-term	EU, MSs, Industry
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.	Medium-term	EU, MSs, Industry
A9.3	Contribute to the development of an agreed methodology for the calculation of environmental footprints, e.g. using LCAs	Medium-term	EU
A9.4	Develop the knowledge base for carbon balance and for assessment of sustainable uses of biomass	Medium-term	EU
A9.5	Provide data, tools and models to examine potential trade-offs between various types of land uses in agriculture and increase capacity to analyse complex scenarios (e.g. on trade or food security versus biofuels issues)		EU
A9.6	Support the development of appropriate diagnostic tools, reference material and coordination mechanisms to tackle quarantine pests along with support to relevant authorities	Continous: Short- to long-term	EU, National Plant Health Authorities
A9.7	Provide extension services and farmers/foresters with (predictive) tools on pests and disease outbreaks as well as with comprehensive information on measures for integrated pest control	Continous: Short- to long-term	EU, MSs, Regional and extension services
A9.8	Improve the knowledge base for the implementation of policy actions under the Common Agricultural and Fisheries Policies (CAP and CFP), the Integrated Maritime Policy and many environmental (including biodiversity, resource efficiency and waste), industrial, employment, energy and health policies.	Short- to long-term	EU, MSs
A10	**Promote the setting up of networks with the required logistics for integrated and diversified biorefineries, demonstration and pilot plants across Europe, including the necessary logistics and supply chains for a cascading use of biomass and waste streams. Start negotiations to establish a research and innovation PPP for bio-based industries at European level (by 2013).**		
A10.1	Promote the launch of a public private initiative for bio-based industries involving research and innovation supporting the sustainable use of renewable resources for the production of bio-based products. It will embrace the entire value chain from crop development, biomass production and collection to industrial conversion into a range of biobased products, notably biochemicals and biomaterials.	Short-term (2013)	EU
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.	Medium-term	EU, MSs

A11	**Support the expansion of new markets by developing standards and standardised sustainability assessment methodologies for bio-based products and food production systems and supporting scale-up activities. Facilitate green procurement for bio-based products by developing labels, an initial European product information list and specific trainings for public procurers. Contribute to the long-term competitiveness of bioeconomy sectors by putting in place incentives and mutual learning mechanisms for improved resource efficiency.**		
A11.1	Contribute to the development of methodological standards for bio-based products (e.g. using LCAs) with regard to, e.g. bio-based content, biodegradability and functionalities.	Medium-term	EU, CEN, ISO
A11.2	Improve the accessibility to existing and invest into additional pilot plant infrastructures and activities in order to support the up-scaling of bio-based products and processes. Increase investments in demonstration infrastructures and activities in order to support the up-scaling of processes for the manufacturing of bio-based products.	Medium-term	EU, MSs
A11.3	Better integrate research projects with the use of pilot and demonstration activities and advice to further the development of new products, technologies and production systems ("Spread Best Practice")	Continous: Short- to long-term	EU , MSs (through extension services)
A11.4	Develop the knowledge base for certification schemes and labels (e.g. Eco-label) for bio-based products in order to promote their uptake in consumer markets and green public procurement.	Medium-term	EU
	Launch a study in 2013 to assess different labelling options for bio-based products, in particular whether bio-based products are adequately covered by existing EU labelling criteria (e.g. Eco-label) and possibly to create a bio-based product category if necessary.	Short-term (2013)	EU
A11.5	Contribute to the creation of an initial European product information list for bio-based products to promote uptake in consumer markets and green procurement.	Short-term (2013)	EU
A11.6	Develop new technologies and processing methods aimed at reducing both energy and water consumption in the food processing industry. Stimulate the development of new, biodegradable, thinner and/or lighter packaging materials that only can be fully re-used, recycled or recovered as energy sources, while ensuring food safety.	Medium-term	EU
A11.7	Boost the development of innovative production systems, products and services deriving from the exploitation of aquatic living resources and the management of their environment to stimulate blue growth.	Medium-term	EU, MSs
A11.8	Develop innovative production and management systems and technologies to improve aquaculture competitiveness while consolidating the position of the sector at the forefront of technological development.	Medium-term	EU, MSs
A11.9	Explore the possibilities of more demanding process and efficiency criteria in food processing and manufacturing. A consultation forum will be set-up and convene during 2012/2013 to deliberate on first draft implementing measures and possible self-regulatory initiatives.	Medium-term	EU, MSs
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.	Medium-term	EU, MSs
A12	**Develop science-based approaches to inform consumers about product properties (e.g. nutritional benefits, production methods and environment sustainability) and to promote a healthy and sustainable lifestyle.**		
A12.1	Improve consumer awareness of healthier food choices in order to promote a dietary shift towards healthier diets and	Medium-term	EU, MSs

	encourage sustainable consumption patterns across Europe.		
A12.2	Promote research and innovation activities to further our understanding of the complex factors affecting food choices and their impact on the environment, and to develop new process technologies to enhance the functionality, quality and nutritional value of food and responding to consumers medical needs.	Medium-term	EU, MSs
A12.3	Analyse new and existing policy and economic incentives to encourage industry to reformulate their products to reduce nutrients associated with health risk, including sodium, sugar, saturated fat and energy, and to increase the fibre, wholegrain, fruit and vegetable content of commonly consumed processed and pre-prepared foods.	Medium-term	EU, MSs
A12.4	Establish and communicate to the society scientific evidence about environmental and social services provided by agriculture and by fisheries and aquaculture, as well as evidence on positive effects of seafood consumption.	Medium-term	EU
A12.5	Offer full transparency to authorities and consumers on the origin of seafood products "from net/cage to plate" and promote the consumption of safe, nutritious and healthy European seafood.	Medium-term	EU

Section B - Estimating the impact of EU level research funding and better policy interaction in Bioeconomy

1. THE JUSTIFICATION FOR EU ACTION

Europe has an important role to play at two levels, firstly in ensuring necessary policy coherence and enhancing market development in the bioeconomy sectors, but also facilitating the new knowledge and innovations that can loosen constraints and define a new frontier for the bioeconomy. The EU's right to act in Research and Innovation policies is set out in the Treaty on the Functioning of the European Union under Articles 179 to 181. Articles 38 to 44 (for agriculture and fisheries), Article 173 (for the competitiveness of industry), and Articles 191 to193 (for the environment) give basis to define a Strategy of interaction between these sectoral policies.

1.1. A common view and a global answer for the main challenges

The bioeconomy encompasses sectors of the economy that are interrelated across the European geographical, economic, social, environment policy levels. It has become obvious in the recent past that the most effective way to address new global issues such as climate change, global trade, food security, energy security, is to build global answers for the main regions of the world. No one European country would be able to answer alone; no one sector can be isolated from the other interrelated ones. The EU policies of the Treaty, in particular for agriculture, research and the environment, particularly climate change, have a direct interface with the bioeconomy. Interaction between these policies is necessary as is also the case for innovation and knowledge interrelations.

The legitimacy of EU and Member States' intervention was strongly recognized in the public consultation already mentioned in this Staff Working Document[79]. 93% of respondents agreed that action is needed to realise the potential of the bioeconomy, and 81 % thought initiatives should be taken at both EU and national levels.

1.2. Overall economic added value in a single market

The benefits of the grand market and the elimination of institutional barriers as described in the "Cecchini report"[80] apply also to the bioeconomy. This supposes *inter alia* a standardisation of the specification of manufactured products, healthcare, food additives, and various other products. A grand European market for the bioeconomy will provide a clear playing field for economic actors, and enterprises will be subject to greater competition and will be prone to invest more in R&I in order to reduce costs, improve product quality and develop new products to maintain market positions. Measures to reduce market failures will be in particular significant for the bioeconomy because its activities both produce and are constrained by significant positive and negative externalities.

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79 Public consultation by the European Commission (open from 22 February to 2 May 2011) "Bio-based economy in Europe: state of play and future potential". Full reports available at: http://ec.europa.eu/research/bioeconomy/news-events/news/20110926_en.htm

80 P Cecchini et al, (1988) The European Challenge 1992: the benefits of a single market

1.3. A stronger EU commitment

Global and societal challenges need global answers and shared views. European Union has a long tradition of organising consensus and common policies; in addition, its capacity of promoting scientific knowledge is bigger compared to individual Member States. This is particularly true for bioeconomy which represents an important part of the world trade; this theme is also more and more debated in the international conventions or initiatives (food security, climate, development). There are also common positions to take at the EU level. Better monitoring and policy interaction is useful at two levels: between Member States and European Institutions; between stakeholders, including policy making, consumers, industry, etc.

1.4. The benefits of EU research and innovation

Research and innovation can help to resolve some societal challenges; it can also advance the technological frontier as defined by the trade-offs between different metrics (costs, performance, environmental and social impacts). The bulk of research in bioeconomy is implemented at a national level; but a European research policy, based on European funding is necessary; this conclusion follows from the application of the subsidiary principle.

Secondly, specific characteristics of the bioeconomy, the process and the products that are concerned also indicate an important role for Europe. Some aspects of the bioeconomy represent rather "young" research activity so the uncertainty of outcome and therefore the risks are high and this impedes the necessary efforts; a common effort can reduce perceived risk. A European effort is justified thirdly by the contribution that these technologies can make to the grand societal challenges identified as issues that require a European response. Lastly, the role of bio-technologies will be wide spread amongst all the productive activities; it is desirable therefore that research is coherent across Europe and that the benefits of "knowledge spillovers" are maximized; this can be assisted by specific European level interventions.

The integration of research and innovation at European level comprises:

- Interaction of the different countries research. Avoidance of overlapping and duplication of research;
- Increase of the spillovers of research and promotion of the transfer of best practices, while protecting intellectual property;
- Increase of the volume of R&I in order to reach the critical mass when compared to other countries, for instance USA.

All these measures increase the knowledge spillovers, the productivity of '"knowledge" and therefore the leverage effect.

Risk can also be reduced by demand-side measures. The European institutions for research and the associated actions are mainly "supply side" measures that take little account of demand driven by the market, but recently, there has been a clear policy shift to create

effective supply-demand[81] matching in research and for the particular role of demand driven innovation for growth, welfare and well-being. One way to increase demand driven innovation is the creation of lead markets. The lead marked initiative[82] for bio-based products launched by the European Commission (Directorate-General for Enterprise and Industry) is exemplary. Public procurement is another effective way to create demand for new innovative products.

The leverage effect describes the multiplier effect of subsidies on R&I expenditures. Analysis of results and impacts of FP funded projects in the food, agriculture, fisheries and bio-technology areas show that participation in FP funded projects had leverage effects and facilitated access to additional funding sources such as national agencies or private foundations. Stronger links between research and innovation encourage the private sector to invest more in R&I as it has been described in previous studies about the Framework Programme.

For FP7, the "institutional effect" of EU finding is 0.33 (projects are funded at 75% by EU and € 1 from FP is followed by € 1.33 R&D Iexpenditures), but a greater leverage has been in fact observed. The Impact Assessment of Horizon 2020 retained € 2.1 for private and € 1.6 for public research as effect of € 1 R&D expenditure. Greater leverage could be expected in the bioeconomy with specific stimulating actions and support to innovation policies.

2. SCENARIOS

Four Scenarios (SOs) have been considered to assess how to best unlock the innovation and employment creation potential of Bioeconomy research. The analysis of the social, economic and environmental impacts of the four scenarios will allow for identification of the most efficient one to achieve the objectives, while respecting the principles of subsidiarity and proportionality.

SO1: The bioeconomy under "business as usual" conditions: SO1 is the baseline scenario described in Section 2.3.

SO2: A Non-EU coordinated Research and Innovation in bioeconomy: In this option, EU research efforts in the bioeconomy are discontinued, but are undertaken by Member States. Coordination of research and innovation efforts between Member States is very limited. However, policies related to the bioeconomy continue under present arrangements at both EU and national levels, on a sectoral approach and with minimal coordination.

SO3: The bioeconomy is supported by enhanced efforts in research and innovation: In this scenario, the bioeconomy research benefits from a new approach supporting the implementation of the Innovation Union through the Horizon 2020 programme: research is performed under an integrated research and innovation approach specifically aiming at tackling societal challenges, and in an effort to support innovation to allow a better deployment of products and processes on the market and to enhance social innovation. It is also supported by instruments to foster excellence in the science base and create industrial

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81 E. Mann, L. Soete, F. Gannon, A. Hibon, E. Nowotny and C. Vela (2010) Mid-Term Evaluation of the Risk-Sharing Financial Facility (RSFF) – Final draft of the Group of Independent experts

82 Lead Market Initiative for Bio-based Products Ad-hoc Advisory Group– Brussels, 2011 February.

leadership and competitive frameworks. The different policies related to the bioeconomy continue to work on a sectoral approach at both EU and Member States' levels. As stated in the Multiannual Financial Framework Proposal[83] (MFF), Research and innovation in the bioeconomy benefit from an increased funding compared to FP7: € 4.5 billion for the 2014-2020 period.

SO4: The bioeconomy supported by reinforced policy interaction and enhanced efforts in research and innovation: In this option, the bioeconomy is given a coherent interaction framework of supportive public policies that aim at reconciling competing activities and overlapping initiatives. Research and Innovation is structured so as to match societal challenges and policy objectives. This scenario links with the CAP and CFP, as well as industry, environment and energy related policies, due to the potential of innovation in these sectors. The future European Innovation Partnership (EIP) on "Agricultural Productivity and Sustainability" as proposed in the reform package for the CAP post 2013 and the Communication "Innovation Union" will, for example, become a key tool for inducing innovation in agriculture. Regional policy contributes to the development of new innovative businesses and infrastructures in Europe. Provision of appropriate human capital requires coordination with training and educational policies. As in SO3, the bioeconomy research benefits from a new approach supporting the implementation of the Innovation Union through the Horizon 2020 programme: research is performed under a new cross-disciplinary approach specifically aiming at tackling bioeconomy societal challenges, and in an effort to support innovation in order to allow a better deployment of products and processes on the market. Research and innovation in the bioeconomy benefit from an increased funding compared to current level, as stated in the MFF.

3. COMPARING THE POLICY SCENARIOS

3.1. How the options were compared

The four scenarios identified and presented in Chapter 2 were compared according to a range of criteria, chosen to identify the extent to which the various options contribute to the solution of the problems. The selected criteria have been grouped into four sets covering the policy interaction model, innovation, public goods and sustainability. The groups include within them a variety of sub-criteria including: strengthening the policy interaction model of the bioeconomy; improving the efficiency of research and innovation through spillovers and leverage effect, contributing to innovation in the bioeconomy, providing EU added value, stimulating high skilled jobs; contributing to the supply of public goods; contributing to positive environmental, social and economic impacts.

The approach draws on the public consultation already summarised in this Staff Working Document, various consolidated sources of expert opinion, evaluation studies of FP6 and FP7 funded projects and specially commissioned economic modelling. Scientific evidence provided by the JRC publications or FP6/7 projects from “Agriculture, Fisheries and Biotechnologies” has also been taken into account.

[83] COM(2011) 500/I final and COM(2011) 500/II final

3.2. Comparison by criteria

3.2.1. Policy interaction potential

In SO1 and SO2, no positive improvement of policy interaction was projected. SO3 will contribute significantly to the coordination of research in the bioeconomy through the deployment of ERA activities[84]. It will not however facilitate the provision of a sufficient knowledge base for polices, nor for coordinated actions. Benefits brought to the bioeconomy from sectoral and horizontal policies at EU and national levels will not be enhanced by a specific coordinated approach. This scenario will go some way towards reducing perceptions of risk through the Risk-Sharing Finance Facility (RSFF). SO3 has little direct impact on product standards, market failures or the consistency and effectiveness of regulation, although it can provide scientific evidence on which to base intervention policies.

It is among the main aim of SO4 to improve informed dialogue by the establishment of EU-level bioeconomy platforms and by the development of national and regional bioeconomy development strategies inspired by a common European approach. In particular, a reinforced interaction can (1) reconcile potentially overlapping policies and measures, taking into account trade-offs; (2) reinforce the impacts of supporting policies and measures; and (3) facilitate the removal of market failures in a coherent manner across the EU and the introduction of effective and appropriate regulation. Research can contribute strongly to a better informed dialogue by improving forward-looking analytical tools that represent the bioeconomy satisfactorily and by further development of assessment methodologies such as life cycle analysis and multi-criteria analysis. SO4 has the potential fully to exploit the opportunities of European level monitoring and interactions along the paradigms of resource efficiency and green growth.

Coherence of research policy with other policies under SO4 will strengthen the impacts of research in whichever direction policy may lead and can inform sectoral decisions. For example, the longer term impacts of bioenergy on agricultural forestry will largely depend on the rules, standards and incentives introduced for the production of biomass and the effectiveness of their implementation[85]. The integration between the biomass utilisation for bio-based products and bioenergy by multi-product use and cascading is expanding which leads to improved resource efficiency, optimised environmental benefits and waste reductions.

International cooperation is essential to ensure that bioeconomy-related global challenges are well addressed at the appropriate level, and to develop common standards, coherent surveillance and control and consistent regulations that do not impede trade.

3.2.2. Innovation performance of scenarios

The non-Europe option SO2 envisages that the EU would withdraw from research in the field and that policy cooperation with Member States and among sectors would evolve without any guiding strategy. There would be negative impacts for this option. Innovation potential for

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[84] European Commission (2011) Impact Assessment accompanying the European Commission proposal for "Horizon 2020, the Framework Programme for Research and Innovation CSF Impact Analysis"

[85] Standing Committee on Agricultural Research (2011) The 3rd SCAR Foresight Exercise; Sustainable food consumption and production in a resource-constrained world

agriculture would remain largely unused. The impacts from overcapacity in fishing and overexploitation of stocks would worsen as the lack of publically funded EU-wide research would prevent adoption of optimal policies. Both SO3 and SO4 are conducive to high levels of innovation as a consequence of the improved research funding. SO4 can be expected to be more successful in ensuring that innovations are adopted because of the greater involvement of stakeholders and encouragement of local and regional initiatives. In SO4, enhanced interaction within research activity and with other policies, promotion and exploitation of research results, acting on both supply and demand of bio-based products will strengthen the so-called "externalities", in particular spillovers, both sectoral and international ones. The additional benefits, or spillovers will be strengthened in SO4 compared to the BAU and SO3; in particular the international spillovers through a better dissemination of results and intensification of exchanges. The inter-sectoral spillovers would be potentially more important in SO2 through for example regional policies and development of competitiveness poles, but at the detriment of the international spillovers.

The development of competitive bio-industries would be delayed in SO2 as a consequence of continued problems of access to markets, finance and knowledge and conflicting regulations and standards across the Union. In option SO3 the enhanced research into second and later generation bio-refineries and the extension of the product range will provide the basic scientific underpinning of a broadly-based bio-based industry, in particular chemical industry. Under SO4, public policy will be informed to better reflecting external costs, allocating risk rationally, providing financial support for demonstration plants and creating a long-term strategy to stimulate demand through incentives and public procurement. Innovation variables will have an important impact, in particular in SO4 aiming at promoting strongly further private investment.

For the food chain, the non-Europe option SO2 will be similar to SO1, but exacerbated by a lack of underlying scientific knowledge and poor coordination of research. The underlying structural tensions in the food-chain will continue. The potential health benefits from coordinated European interventions in regulations and practices based on publically-funded scientific research would be lost or delayed. SO3 will make a substantial contribution to an improved food chain and will have beneficial impacts through improved predictive risk assessment, effective control measures, global surveillance systems, new food safety technologies and detection methods, microbial and chemical hazards and their control, inclusion of biosensors in food packaging, intelligent packaging with embedded information, a better understanding of obesity, satiety, dietary requirements of the elderly and the epidemiology of environmental and chemical risks.

The link between research and innovation with education and skills is emphasized in Innovation Union; it is particularly relevant for the bioeconomy, and SO4 will be able to address this characteristic. The fact that multidisciplinary approaches are needed will imply development of innovative systems of formation and dissemination of knowledge. Furthermore, many social innovations could take place within the food chain in relation for example to the distribution of food, lifestyles changes, food and health. These forms of innovation can be encouraged both by SO3 and SO4, but it is likely that they would flourish better under SO4 because of the greater involvement of stakeholders from beyond the conventional research community. A particularly strong support can be expected from the post 2013 CAP which, through its rural development pillar, will put in place specific tools to enhance innovation.

3.2.3. Strengthening "public good" policy

Bioeconomy sectors provide and support a wide range of public goods – i.e. goods that cannot be provided efficiently by private market activities – in the fields of education, knowledge and Research and Innovation (R&I), health, land infrastructures, water, environmental quality, protection of nature. Many of them are characterised by spillovers and cross-border effects that make EU action particularly relevant.

The lack of incentives for private producers means that there is an inadequate provision of public goods associated to the bioeconomy. This is one of the challenges that have to be considered in the evaluation of scenarios. SO3 is likely to stimulate the provision of public goods only modestly, to the extent of the additional funding of public R&I efforts that could be devoted to activities in the public domain such as those listed above.

SO4 addresses the public good question better. The creation of a sound knowledge base for coherent policies – enhanced by SO4 would contribute to achieving the objectives of increasing efficiency, production and jobs in market activities of the bioeconomy as well as improving health, social and environmental conditions, expanding the provision of non-market services and related employment. The nature of R&I supported by EU policies would take into account in a more systematic way the co-existence of such different objectives; innovations introduced in products and processes would give consideration to improvements in knowledge, nutrition, wellbeing, resource savings and environmental sustainability, as well as to economic factors. A wide range of activities could result, both in market and non-market spheres. The outcome would be a greater ability to satisfy non-market needs, with more effectiveness and efficiency.

3.2.4. Sustainability

3.2.4.1. Environmental impacts

Under SO2 the negative environmental impacts of SO1 will remain insufficiently addressed by research, relevant data and improvements in existing models. The impacts of SO3 on the environment will be generally positive, as it links greening economic activities and integrated environmental protection with resource efficient production and economic performance. Emerging risks of new production and consumption systems may be identified that could not be considered in solution-oriented, short-term research designs. From this perspective, public research on environmental systems is particularly important to complement private research.

The European level concerted approach of SO3 is especially important for fisheries and aquaculture, because the marine environment is international in most cases. Management measures contained within the reformed CFP and required by the Marine Strategy Framework Directive would reduce environmental impact from aquaculture and help achieve Good Environmental Status over the next decade.

In SO4, the increased utilisation of waste and by-products and share of dedicated perennial crops and integrated cropping systems could increase the efficiency of land-use, enhance carbon storage and reduce water pollution. A more favourable commercial and financial environment and improved regulation and standards will promote bioenergy, chemical and materials manufacture.

In the food chain, changes towards a more environmentally friendly diet and a reduction in food spoilage and greenhouse gas emissions in households will be aimed at. In addition, well-informed, mature and independent consumers will reduce environmental impacts of the food chain, particularly with regards to resource use and GHG emissions and waste reduction[86]. Bio-diversity will benefit from an increase of sustainable farming practices, if it is assured that within the supporting measures for farming also the obligation to maintain (or create) diverse land structures is included.

3.2.4.2. Social impacts

The impact of bioeconomy research funding and improved policy interaction on employment is potentially significant. The pre-requisite for job creation is that skilled entrepreneurs and project managers can develop and implement business models creating new value chains and value-added bio-based products that are successful in the global marketplace. Creating high-skilled jobs within the bioeconomy depends on success in creating competitive bio-industries. For this reason neither SO1 nor SO2 are likely to create many jobs in the area.

Under SO3 the number of jobs created in the bioeconomy increases substantially as a consequence of the economic growth following the stimulus to innovation provided by the increase in research funds; 120,000 jobs would be created in the bioeconomy by 2025 (gross increase). For SO4, 11,000 more jobs than for SO3 are expected by 2025. This is fewer than the incremental employment generated in moving from SO1 to SO3 because the main economic benefits of SO4 appear as productivity gains rather than as employment. SO4 will generate new jobs particularly in those sectors which will invest in the non-food applications of biomass, e.g. energy, chemicals, eco-innovation.

SO4 contributes to achieving a diverse multifunctional European agriculture that will provide ecosystem services as coproduction with support from a strong and more targeted CAP[87]. Technology, social and management innovation will make a strong contribution to rural development and open new non-food markets for the farmers. The closer interaction of research and policy under SO4 can be helpful here also not least in the promotion of bioeconomy uptake in rural development strategies.

Foreign investment in agricultural land could be spurred by the expanding market for biofuels in SO4. The expansion of bioenergy production and bioenergy and biofuel use in Europe may have profound impacts in global environmental aspects, particularly land use changes in Brazil[88]. This is a potential negative aspect of SO4; it may be partially alleviated by main-streaming the bioeconomy into the technical cooperation policy of the EU.

Food availability, safety and quality will get strong support by SO4 as a result of an increase in improved knowledge, helping the variety of both food products and channels, which will also bear positively on consumer choice. Understanding long term consumer behavior will be more developed in SO4. Confidence and consumer acceptance are known to correlate

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86 Standing Committee on Agricultural Research (2011) The 3rd SCAR Foresight Exercise; Sustainable food consumption and production in a resource-constrained world

87 European Commission (2011) The CAP towards 2020: Assessment of Alternative Policy Options (SEC(2011) 1153)

88 A.G. Prins, B. Eickhout, M. Banse, H. Meijl, W. Rienks, and G. Woltjer (2011) Global impacts of European agricultural and biofuel policies, in Ecology and Society 16(1)

strongly with the stringency of the regulatory framework. The prospects for poverty alleviation are rather moderate in all options, with however a slightly rosier picture for SO4, notably as a result of the generalized efficiency increase and the increases in food availability, and the expected rise in the share of local food supply characterizing this option.

The current crisis could affect these results, but not in a dramatic way. Recent statistics show that investments into research and innovation have remained at the same level of GDP real growth (%) even in the 2008 crisis.

3.2.4.3. Economic impacts

The Actions envisaged in the different scenarios have been subject of simulations with the European econometric sectoral model NEMESIS. For SO1, SO2 and SO3, the same general assumptions for research and innovation variables have been used as for the Horizon 2020 Impact Assessment. The budgets of € 80 billions dedicated to the whole "Horizon 2020" and € 4.5 billions for "food security, the bio-economy and sustainable agriculture" as indicated in the Multi-annual Financial Framework[89] have been introduced into SO3. Compared to the reference scenario SO1, the impact of Horizon 2020 on the value added of the bioeconomy activity alone would be an increase of 0.61% (€ 9 billion), with the creation of 120,000 jobs by 2025 when the full impact of the "Horizon 2020" will have taken place.

SO4 has then been simulated through sensitivity analysis of SO3 relative to the main variables characterizing innovation economics, e.g. research productivity, spillovers, subsidies, leverage effect (see Table 2). It is obvious that the impact of such variables is less important than the impacts of the budgets which are considered in SO3, even if these variables would also induce in SO4 some additional R&I expenditures from private and public sectors (due to the increase of leverage effect). According to a scenario where the economic performance of innovation variables is increased by 40% due to successful implementation, the impact of SO4 on the bioeconomy activity in 2025 would represent 0.14% of its value added (€ 2.4 billion) compared to SO3; this impact would come in addition to the € 9 billion generated by SO3; this would correspond to 11,000 additional jobs to the 120,000 jobs creation in SO3 by 2025. In cumulated terms, over 12 years from 2013, the SO4 option would then generate employment of 790,000 jobs-year and € 45 billion of value added. It should be underlined that these increases correspond to direct impacts of research funding on the bioeconomy sectors. Indirect impacts on the rest of the economy would also be important.

The SO2 scenario relative to a renationalisation of European research would have negative impacts on bioeconomy value added which would fall about -0.27% compared to the SO1 level in 2025.

[89] COM(2011) 500/I final and COM(2011) 500/II final

Table 1: Summary of comparative economic impacts of scenarios in 2025

	SO2/SO1	SO3/SO1	SO4/SO3	SO4/SO1
Added value created (bioeconomy only, %)	- 0.27 %	+ 0.61 %	+ 0.14 %	+ 0.75 %
Added value created (bioeconomy only)	- € 4 billion	€9 billion	€2.4billion	€11.4 billion
Employment created (bioeconomy only)	-	+ 120 000	+ 11 000	+131 000

3.3. Comparing and choosing the Scenarios

Scenario characterisation, mechanisms at work, simulation model and overall effects are the different steps to consider for the Policy Options economic comparisons. The comparison of the impacts on some possible key aspects of the innovation and market variables is presented in Table 2.

Table 2: Synopsis of scenarios, Main Key Actions related to Innovation and mechanisms of change

		Coefficients of the simulation model						*Potential market effects*					*Non-market effects*		
Policy Option	**Actions**	**R&I Fund. & Subsidy**	**Leverage Rate of Private R&I**	**Spillov. Coeff. of Knowl.**	**Skills**	**Market behav.**	**Producti v. of Knowl. & Diffus. Effects**	**New Product markets**	**New Process, Lower Prices**	**New Priv. Invest.**	**Higher Producti v.**	**Hig h. GD P and emp l.**	**Higher provision of public goods**	**Social Well-being**	**Envir. Quality**
SO2	Non-EU	+		+											
SO3	Enhance support to "bioeconomy"	+++			+			+++	+	++	++	+++	+++	++	++
SO3	Use instruments of European Research Area		+	+++	+		+	++	++	++	++	++	+	+	+
SO3	Strengthen links between different funding instruments	++	++	++	+		++	+	+	+	+	+	++	++	++
SO3	Coordinate public/private research		+++	++			+	++	+	++	+	++	++	+	+
SO4	Foster product and agriculture process innovation	++	+	+	+	+	+++	+	+++	++	+++	++	+	+	+
SO4	Market organisation and demand driven		++	+		+++		++	+	++	++	++	+		
SO4	Education and Training policies			+	+++		+	+	+		++	++	++	++	+

Table 3 shows how each scenario compares to BAU according to the selected criteria.

Table 3: Impacts of Policy Options compared to BAU option

Option / Criterion	SO2	SO3	SO4
Interaction	--	+	++
Building knowledge base for regulation	--	+	++
Knowledge base for remedying market failure	--	+	++
Supporting International cooperation	-	=	+
Promoting innovation	-	+	++
Providing EU added value	--	+	++
Sustaining primary production	=	+	++
Building knowledge base for sustainable and competitive bio-based industries	=	+	++
Building knowledge base for sustainable and productive food chain	=	+	++
Stimulating high skilled jobs	=	+	++
Promoting "public goods"	-/+	=	+
Environmental impacts	-	+	++
Social impacts	-	+	++
Economic impacts	=	+	++

The selection of a preferred scenario is simple as SO3 is superior to SO2 in every way, recognising the clear advantages brought by European research programmes for the Bioeconomy; and SO4 is superior to SO3 in every respect as it not only benefits from all the advantages of SO3, but also from a supportive policy, regulatory and market environment. The Strategy "Innovating for Sustainable Growth: a Bioeconomy for Europe" has been developed according SO4, the most advantageous Scenario.