

THE EUROPEAN BIOECONOMY IN 2030

*Delivering Sustainable Growth by addressing
the Grand Societal Challenges*

Disclaimer

This White Paper is the result of discussions between the European Technology Platforms (ETPs) that cover different segments of the European Knowledge-Based-Bioeconomy (KBBE) and a series of open meetings with their array of stakeholders. The primary focus of this document is to elaborate on common themes and joint priorities across the widely diverse sectors relevant for the European Bioeconomy. Naturally through the different roles of the sectors and the different stakeholders, each ETP will put specific emphasis on the common goals while following their own specific objectives. Consequently this White Paper does not replace, but complements, the Strategic Research Agendas (SRAs) of each individual ETP.

Full contact and website details for each ETP can be found at the end of this document. This document and more detailed information on the outcome of the open meetings organised with experts from the different sectors of the Bioeconomy can be found at the following weblink: www.becoteps.org.

Acknowledgment:

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Summary and key messages

The Bioeconomy refers to the sustainable production and conversion of biomass into a range of food, health, fibre and industrial products and energy. Renewable biomass encompasses any biological material (agriculture, forestry and animal-based including fish) as a product in itself or to be used as raw material.

Over the coming decades, Europe must ensure a safe, healthy and prosperous environment for current and future generations. Successfully addressing major environmental, social and economic challenges will change the way we live and work. The Bioeconomy will make this a change for the better if its potential for sustainable production and conversion of biological material is fully exploited. The mature, sustainable Bioeconomy will help deliver global food security, improve nutrition and health, create smart bio-based products and biofuels, and help agriculture, forestry, aquaculture and other ecosystems to adapt to climate change.

This White Paper shows how the Bioeconomy can address the grand societal challenges and sets out a vision for 2030 together with a set of policy recommendations needed to achieve it. It is the result of a collaborative effort by experts involved in the nine separate Technology Platforms which cover the various aspects of the Bioeconomy.

Realising the vision across a range of sectors – arable and livestock farming, forestry, food, aquaculture, the chemical industry, materials manufacturing and energy – will create a smart, sustainable and inclusive European Bioeconomy.

Individual sectors will be mutually dependent on each other for raw materials and energy, together forming the Bioeconomy web. Creating this also needs concerted development across all sectors; if one is left behind then the inter-connectedness means that the entire web is weakened.

The successful Bioeconomy needs coherent and integrated policy direction, with key areas being:

- Investment in relevant research areas, both within each of the sectors and by encouraging multi-disciplinary programmes;
- Encouraging innovation to make sure that more of the knowledge developments reach the commercialisation stage;
- Making entrepreneurship within the Bioeconomy a desirable career option;
- Providing a skilled workforce by making the various sectors of the Bioeconomy attractive career options through secondary and tertiary education;
- A streamlined and innovation-friendly regulatory framework which balances both risks and benefits;
- Good two-way communication with the public embedded in R&D projects to ensure societal appreciation of research and innovation.



An introduction to the Bioeconomy

Europe, in common with the rest of the world, faces a number of major environmental, economic and social challenges which have to be properly addressed if future generations are to enjoy a safe, healthy and prosperous future. The solutions we arrive at will change the way we live and work and – if we make the right choices – these changes will generally be for the better. The transition from a dependence on fossil fuels to a situation where agriculture not only will continue to provide food security but also biomass as a renewable raw material for industry will be the basis of the coming integrated Bioeconomy.

Although a transition to an integrated Bioeconomy is the way to secure a sustainable future, the origins of bio-processing are as old as human society. Baking, brewing, making cloth from wool and cotton and tanning leather were all established thousands of years ago and the use of wood for fires and construction dates back even further. But recent and continuing progress in the life sciences now makes the Bioeconomy one of the most dynamic sectors of the European economy and it is also one of the largest employers. The capacity to meet today's challenges has given even more momentum to its development.

The Bioeconomy is already making substantial contributions to sustainable development and this contribution will increase in the future: higher quality, renewable raw materials will be produced sustainably, and food security and a healthy environment will continue to be assured. Conversion to a wider range of end products, whether food, feed, fuel, fibre or a other healthcare or industrial products, is also sustainable,

being efficient, producing little or no waste, and often using biological processing. Developing all sectors of the Bioeconomy in concert will provide global food security, improve nutrition and public health, make industrial processing cleaner and more efficient and make a significant contribution to the effort to mitigate climate change.

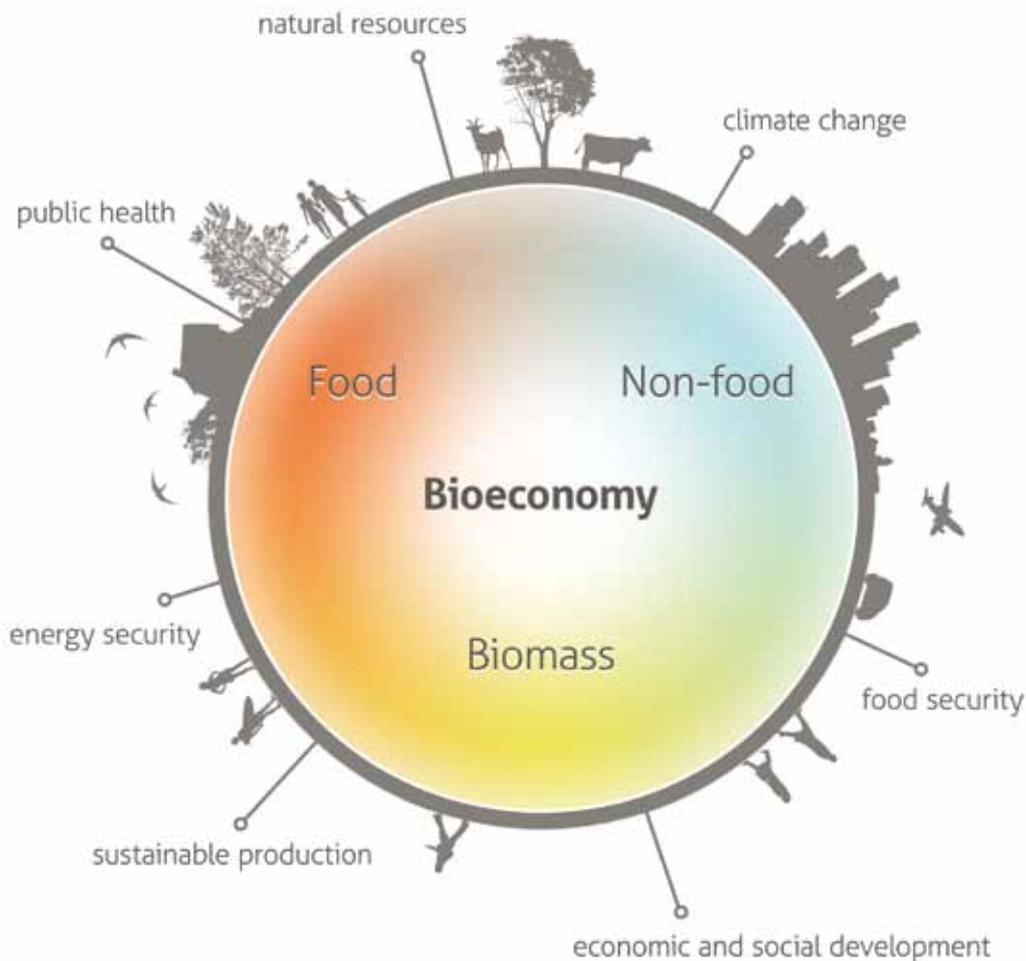
The integrated Bioeconomy we envisage is not simply about science, but is rather an integration of science with business and society. The dynamics of this are shown in figure 1. In the EU, it is already worth more than €2 trillion annually and employs over 21.5 million people, predominantly in rural areas and often in SMEs (see figure 2 for a breakdown). As the Bioeconomy develops, some parts will become more efficient and employ fewer people, but this will be more than compensated for by new jobs that are created by other emerging segments, so making the integrated Bioeconomy a sustainable provider of employment.

Although Europe is one of the largest economies in the world, most activities aimed at supporting the development of the Bioeconomy have until now been conducted at a national level. While they may have been individually successful, a lack of coordination has not enabled synergies and economies of scale to be exploited. The result is that Europe is at a competitive disadvantage compared to other major economies and is in danger of falling behind in terms of basic research, education, innovation and investment. A more cooperative approach must be taken if a strong Bioeconomy is to grow, capable of addressing the societal grand challenges.

The Bioeconomy refers to the sustainable production and conversion of biomass into a range of food, health, fibre and industrial products and energy. Renewable biomass encompasses any biological material as a product in itself or to be used as raw material.

An introduction to the Bioeconomy

Figure 1.
The European Bioeconomy



For maximum benefit, the various sectors of the Bioeconomy must also be properly linked, since they are all interdependent. Concerted action across Europe will not only create strong individual sectors, but strong and effective links are needed to create a Bioeconomy web. This inter-connectedness means that all sectors must be equally strong; one weak link could significantly reduce the overall effectiveness of the web and limit European competitiveness.

Such a transformation will not happen overnight. Established businesses will have to undergo significant

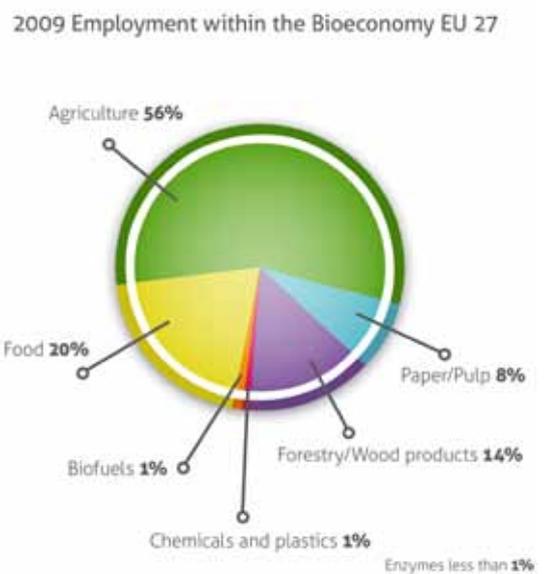
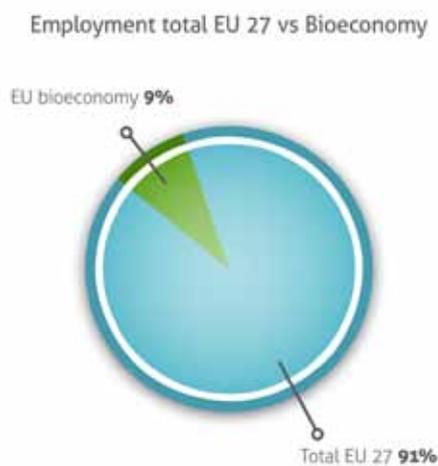
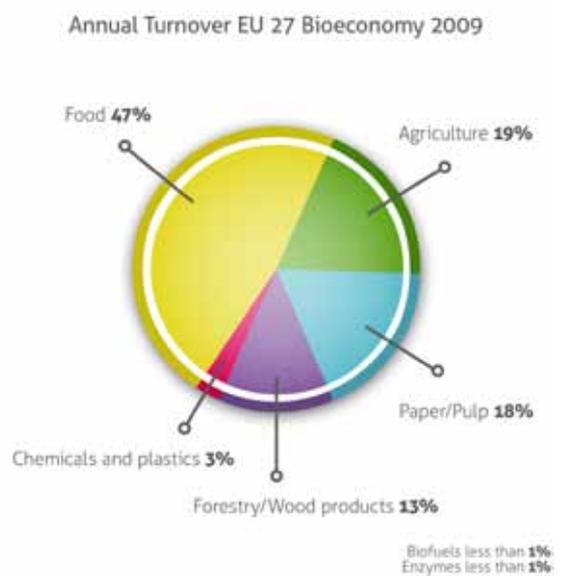
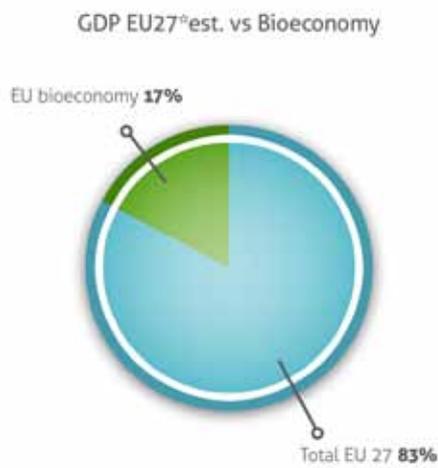
change if they are to compete successfully in the future Bioeconomy against new companies being formed in the sector today. Such transformations can be uncomfortable and carry a higher risk in the short term. It is important for strong policies to be in place to encourage and support traditional businesses in making the shift. Unless they are given assistance to move from their comfort zone, they risk becoming uncompetitive as the Bioeconomy develops around them.

This White Paper is the result of a collaborative effort by experts involved in the nine separate Technology

Platforms which cover the various aspects of the Bioeconomy. It analyses the present state of the Bioeconomy and makes recommendations which will strengthen and develop it to enable Europe to tackle the grand societal challenges facing the world and turn Europe into a smart, sustainable and inclusive economy. Common objectives have been identified which will need to be achieved to improve long-term

competitiveness, with sustainability, energy security and public health being key. These and others have to be addressed with the needs of all stakeholders in mind and the entire effort has to be underpinned by effective research and implementation funding mechanisms and a concerted communications effort.

Figure 2.
The contribution of the Bioeconomy to the EU as a whole.



How the Bioeconomy can meet the Grand Challenges

There are six Grand Challenges currently identified that the world faces at present. These must be tackled and overcome to ensure a peaceful and healthy future for all. They are:

1. Sustainable management of natural resources
2. Sustainable production
3. Improving public health
4. Mitigating climate change
5. Integrating and balancing social developments
6. Global sustainable development

Underlying all human societies is the need for food security. The modern Bioeconomy has its roots in providing both food and non-food products from managed agricultural, aquaculture and forestry ecosystems. Based as it is on continuously renewable resources, it provides an ideal platform from which to tackle 21st Century challenges. Properly implemented, the integrated Bioeconomy can result in major progress, including increasing the efficient production of enough safe, high-quality food and feed for a population not set to plateau until mid-century, providing raw material for existing and new industrial and energy uses and addressing climate change and energy security.

But it is not enough to provide solutions for the current population; the challenges must be addressed sustainably to provide a secure future for succeeding generations in a way that makes economic sense. To achieve this, major issues such as water usage, land management, efficient use of nutrients like nitrogen and phosphorus, maintaining carbon sinks and socio-economic development must be tackled in a systematic and holistic way across all the interconnected sectors. Before 2100, the Bioeconomy will have to double its output of raw material while halving its environmental impact. This will require not just smart science and technology but due attention will have to be given to shaping societal behaviour and adapting to changing economic realities.



Challenge 1

SUSTAINABLE MANAGEMENT OF NATURAL RESOURCES

On a global level, natural resources both on land and in water are subject to steadily increasing demands from a growing population. Not just more and higher quality food is needed, but renewable feedstocks for energy and other industrial uses are increasingly in demand. At the same time, productive land is being lost to erosion, salinisation, desertification and urban development. To meet the demand, forests and other virgin land are being cleared in developing countries, while overproduction and economic pressures lead to good quality land in other countries lying fallow. Water management is equally important as is the proper stewardship of natural resources, including biodiversity.

Addressing this challenge properly first requires an understanding both of biomass needs at global, regional and local level and of the drivers and dynamics of land and water use change. Increasing and maintaining the productivity of existing farmland – what the Royal Society has called ‘sustainable intensification’ – is important in restricting both the amount of new land taken into production and further exploitation of water resources, and so preserve natural habitats. The development of mixed production systems and optimising the use of genetic diversity to breed improved crops, trees, animals and fish will make a major contribution to this, alongside better management systems.

Particular examples include:

- Minimising soil compaction and maximising cropping area via the use of new technologies such as controlled traffic and lighter machines.
- Novel plant varieties adapted to a range of stresses will maintain yields, provide greater soil coverage under poor growing conditions and reduce irrigation needs. Productivity will be optimised and soil erosion and salinisation reduced.
- Reducing water use throughout the food supply chain.
- Improved spatial planning to help adapt to climate change.

Challenge 2

SUSTAINABLE PRODUCTION

Managing natural resources sustainably is a vital start, but the whole supply chain must also be sustainable, to ensure food security, supply sufficient quantities of renewable raw materials and energy, reduce environmental footprints and promote a healthy and viable rural economy. Beyond this, it is also important to avoid unnecessary waste and to recycle unavoidable waste in useful and efficient ways. The ideal is to have closed loop systems of production and by-product reuse. The Bioeconomy already does this adequately, but the ambition is always to use by-products from one sector in another part of the web if they cannot be used directly.

Specific opportunities include:

- Biotechnology and other modern technologies, including long-term selection programmes, give new ways to improve productivity, efficiency and robustness in the arable, livestock and aquaculture sectors, while at the same time reducing their environmental footprints.
- The forestry sector provides great potential for the cascading use of renewable raw materials to produce a wide range of innovative value-added products.
- The development of more diverse sectors, such as algal biofuels, gives opportunities for evaluating by-products as alternative sources of animal and fish feeds, so making less demand on food crops. The Bioeconomy web gives many such opportunities to balance and improve resource use efficiency.
- Integrated multi-trophic aquaculture, cultivating a number of species in a managed environment.
- Unavoidable waste streams whether from agriculture, forestry or the domestic sector can be used to produce biogas or as a source of other value-added biomaterials.

Challenge 3

IMPROVING PUBLIC HEALTH

The safety and quality of human food and animal feed in Europe today is very high, but there is no room for complacency, particularly when striving to make healthy daily diets affordable for all. The improvement of plants and the development of other functional food ingredients can help to produce high quality food, thus helping to achieve a healthy diet for the whole population in a sustainable way, while more efficient food processing and distribution can help to make high quality products available at an affordable price. In addition to the long-term effects of diet on health, threats to human health may also arise from zoonoses (animal-borne diseases) and the Bioeconomy provides the tools to minimise this hazard.

Areas where the Bioeconomy will have an impact include:

- Developing new foods that contribute to improved nutrition and health. In particular, foods that promote healthy aging or 'adding life to years' will be of major importance. In addition, consumer trust in such health promoting products will be developed by encouraging better communication between scientists and consumers and constructive engagement with the public throughout the process of developing new foods and processes.
- Improving animal resistance to disease via breeding, optimised farm management and feeding systems and using epidemiology as a basis for the development of prophylactic vaccination programmes and to allow the better prediction and handling of disease outbreaks.
- Reliable and extensive data gathering and traceability in the livestock sector can help to anticipate the need for early intervention and thus reduce the overall burden of diseases and infections.
- Tailoring plants to produce specific pharmaceuticals can be an efficient way of making high quality and valuable materials and products such as vaccines for both human and animal healthcare.



How the Bioeconomy can meet the Grand Challenges

Challenge 4

MITIGATING CLIMATE CHANGE

The agriculture sector manages a significant amount of available land in Europe. It also makes a large contribution to emissions of greenhouse gases (GHGs) in the form of methane from ruminant production, nitrous oxide from breakdown of nitrogen fertilizers and carbon dioxide from fossil fuel use. On the other hand, it provides the essentials of human life and makes a large contribution to GHG capture via crop cultivation. The forest-based sector plays a significant role in capturing carbon in sustainable managed forest ecosystems and its products. There is also considerable energy use in the food chain beyond the farm gate, in preparation, processing, distribution and storage. The rural biorefinery concept can allow for greater integration of a range of activities and more efficient use of energy, water and transport between farms and other sectors of the local economy.

The resources of the Bioeconomy can make a major contribution to minimising GHG emissions in the overall context of a sustainable economy. New products can be created from biomass to replace those based on fossil fuels, while sustainable intensification of agriculture and forestry can protect carbon stocks in soils and forests. A beneficial side-effect of the drive to reduce emissions is the use of bio-based products as alternatives to currently-used toxic organic solvents. Plant breeding and other technologies can also help to increase the resilience of the sector in the face of climate change.

Particular ways in which the Bioeconomy can help meet this challenge include:

- Downstream processing which uses bio-catalysis or fermentation to replace chemical processing can save a billion tonnes or more of CO₂ emissions across a wide range of industrial sectors. Partial replacement of petrol and diesel by biofuels can add significantly to that.
- Improved upstream processing to reduce the large amount of energy needed to make high digestibility livestock feed.

- Human society is dependent on a range of staple crops (including trees) and domesticated animals. Their genetic base and the available genetic diversity need to be maintained and widened by setting a range of broad, balanced breeding goals to allow flexible and adaptable production systems and increase the security of the supply chain.
- Moving to the next generation of bio-energy systems, based on agricultural and forestry residues and waste, offers great potential for GHG reduction.

Challenge 5

INTEGRATING AND BALANCING SOCIAL DEVELOPMENTS

In contrast to the Industrial Revolution, which depopulated the countryside, the evolving Bioeconomy will be a major driver of rural and coastal development. Agricultural, aquaculture and forestry development will be boosted and high-skilled jobs will be created in economically disadvantaged rural and coastal areas. Patterns of employment in the Bioeconomy will alter as some areas become more efficient and employ fewer people. At the same time, new jobs will be created in other sectors, so overall employment is expected to stay steady. The Bioeconomy will be a growing part of the global economy, feeding and providing bio-products and energy to an increasing population.

As well as specifically helping the rural and coastal economies, the Bioeconomy will play a key role in helping Europe become the world's most innovative society. However, since it is still at a relatively early stage, it is important that its growth is facilitated and supported and entrepreneurship encouraged.

Other important social factors to take into account include:

- Use of the latest developments in engineering, power train and sensor technology will facilitate efficient production of high-quality, safe and traceable end products consistent with high social standards.

- The changing demands of European consumers can be met by increasing research in plant and animal varieties with improved nutritional balance, together with milder processing techniques and identification or incorporation of additional functional ingredients.
- Clear communication of the benefits and risks of new developments will help build societal trust in the Bioeconomy.

Challenge 6

GLOBAL SUSTAINABLE DEVELOPMENT CHALLENGES

More than a billion people remain chronically malnourished, are prone to disease and have reduced life expectancy. This is partly due to lack of calories but also because some staple foods in developing countries, including rice and cassava, are poor sources of some vitamins and minerals. European scientists working on new technologies and better production systems must also be helped to work in cooperation with developing countries to adapt these advances for local crops, animals and growing conditions. Europe also traditionally played a key role in training agronomists and breeders from developing countries and it is essential that the decline in recent years is urgently reversed.

Developing countries also face most of the same challenges which we do in Europe, for example maintaining a healthy food chain and increasing crop and animal genetic diversity. Some challenges – particularly food security and climate change – will have their greatest impact in less developed countries. Helping them improve their own agriculture is of course important, but so is giving them the opportunity to export biofuels and bio-energy carriers. There is also an important wider trade and distribution issue. Already there is theoretically enough food produced to feed the global population adequately, but part of the challenge is to get this to the people who need it and also to allow free trade in agricultural surpluses for the benefit of developing countries.

Other important contributions which can be made by the Bioeconomy include:

- As animal protein consumption increases, improved breeding programmes and understanding of animal nutrition will allow more efficient production and minimise the amount of grazing land, water or feed required.
- Advances in plant breeding will allow plants to photosynthesise more efficiently, so capturing more carbon dioxide. As well as the positive effect on climate change mitigation, yields and nutritional qualities would increase and less pressure would be put on land.
- Sustainable Forest Management (SFM) seeks to balance economic, social and environmental factors and can create a wide range of economic activities in the same area of woodland. Income created along the value chain is important in supporting and developing rural economies.
- Good education and knowledge transfer are key requirements for successful innovation in developing countries, as in Europe.



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The Bioeconomy vision

By 2030, by integrating and strengthening all the key component sectors of the Bioeconomy, a Bioeconomy web will have been created, capable of delivering sustainable growth while addressing the grand societal challenges.

The Bioeconomy, including food and non-food products across a range of industries, will continue to be a major driver of innovation in Europe. The success factors are:



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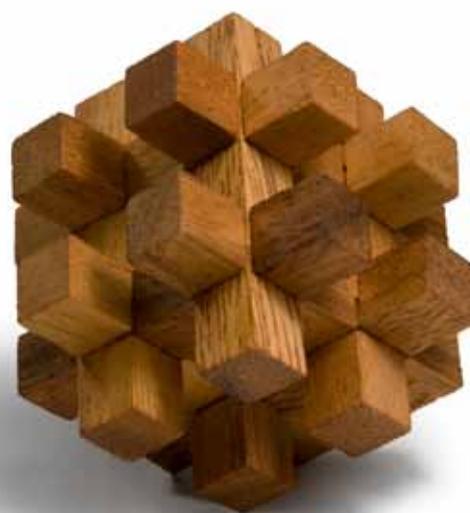
The potential for the emerging European Bioeconomy is certainly there, but making it a reality requires coordinated action across all areas. A transition from a dependence on fossil fuels to full use of renewable raw materials can only be achieved if science, industry, governments and civil society work together constructively and effectively to:

- **Accelerate the development of basic knowledge and new technologies by intensifying research and development efforts:** Research, while having launched and boosted the concept of the Bioeconomy by recent rapid advances, needs to be further intensified. But both academic and industrial research is an increasingly specialised business and it is important now that barriers between different disciplines are overcome by, for example, establishing joint research programmes and actively looking for synergies. The research sector must also play its role in better bridging the gap between knowledge and innovation.
- **Encourage and facilitate the successful setting up of appropriate economic structures to support cooperation between the different sectors:** Since energy use and by-products/raw materials will be shared between sectors, the economics will be driven by the cyclic and interdependent nature of Bioeconomy processes and the need to minimise overall energy, water and nutrient use and carbon footprints. The aim is to provide new products and processes which are competitive with fossil fuel-based ones on both price and quality.
- **Build a strong underpinning capacity for continued progress by structuring research, innovation, market conditions and education to support the Bioeconomy:** Clear policy support is needed. For the academic sector, this means supporting institutions which can overcome bottlenecks in doing enabling research and building bridges with the commercial world. Regulatory changes are needed to remove barriers and help bio-products become fully competitive, while eliminating any existing advantages enjoyed by fossil fuel-based products. Politicians also have a role to play in supporting the appreciation of a balanced approach to the opportunities, benefits and risks of bio-

based technologies. Last but not least, the future needs for skills and training must be addressed by national education authorities to provide the next generation of talent for the sectors.

- **Achieve the consent and support of broader society to complete the transition to the integrated Bioeconomy, which is still in its early stages:** The general public are not passive consumers of products. Instead their attitude encourages or hinders innovation in particular areas. Existing concerns about generation and use of biological and genetic information need to be addressed and overcome for the Bioeconomy to achieve its potential. This also needs to be seen in a global context, since useful biological resources are distributed very differently than the fossil fuels on which we currently depend.

An integrated and coordinated approach is needed to make the Bioeconomy a reality, but the Bioeconomy itself needs to be highly integrated to be successful and sustainable. This is the reason for the Bioeconomy web, via which former waste streams from one process will be the residues streams and thus the raw materials for another. Closed-loop processes, as are common in nature, are the ideal. This philosophy requires flexibility and open-mindedness from all stakeholders from academic researchers to industry, policymakers, regulators and investors.



Making the vision a reality

To achieve this Bioeconomy vision by 2030, we make a set of recommendations, which are explored in more depth later in this section:

RESEARCH

1. Knowledge-Based: Research at the Heart of Innovation to Inspire, Drive and Sustain the Bioeconomy

INNOVATION

2. Support Innovation: From Innovation Hurdles to Innovation Support Measures – Appropriate and Feasible Regulations
3. Framework Conditions for Boosting Entrepreneurship
4. International Standards: Development in Parallel with Research
5. Assess Risks and Benefits: Open and Balanced Assessment

EDUCATION AND TRAINING

6. Young People and Professionals attracted to the New Integrated Bioeconomy

GOVERNANCE AND PUBLIC DIALOGUE

7. Integrated Governance for the Bioeconomy Web
8. Communication with Society: Transparency, Openness and Clarity

As for the Bioeconomy, so for these recommendations: it is essential that they be implemented as an integrated package in every sector if the vision is to be achieved. In some cases, pan-European actions are needed, but some other activities may be highly localised. The point is that ultimately all stakeholders jointly benefit from the outcome.

If one or more of the recommendations were not to be carried out properly, then the Bioeconomy would be seriously weakened. So, for example, if all else was implemented perfectly but public engagement was neglected, the risk is that market acceptance of bio-products would be much lower than expected. In a

similar way, if too little attention was paid to education, a successfully growing Bioeconomy could be stifled by lack of skills.

The need for a coherent and integrated programme might seem to need a top-down approach from the centre, but this would be wrong. Coordination is certainly essential, but implementation of the Bioeconomy will happen via an integrated pattern of activities at all levels: European Union, Member State and various local levels. The recommendations set out will provide the essential framework to allow the integrated Bioeconomy to flourish, but the details of implementation will vary with level, between countries, between sectors and with time.

To effectively address the grand societal challenges, all stakeholders in the Bioeconomy need to explore the full potential offered by biological resources and the ways in which their utilization as primary raw materials can be embedded in policymaking, industry's ways of working and society's expectations. The key point of understanding must be that the Bioeconomy is based on an integrated web of systems and networks which use biological resources, maximise value creation and, as far as possible, work in closed loops (in terms of raw materials, water, nutrients, by-products and energy).

Networks are needed to enable and support the development of scientific, technological and managerial excellence. This can be achieved by:

- Efficient and effective maximisation of value added, by optimising flows of materials and energy within and between processing systems, minimising losses and re-using waste;
- Optimisation of both product and process quality;
- Setting realistic and sustainable pricing levels to ensure the value generated can be equitably shared through the supply chain;
- Sustainable resource use to ensure the continued availability and affordability of land, water, raw materials, nutrients and products;
- Interdisciplinary and inter-sectoral collaboration to ensure cross-fertilisation and identification and exploitation of synergies;

- Providing adequate support for entrepreneurs and providers of risk capital;
- Ensuring individual sectors and the whole Bioeconomy web are resilient and adaptable to change.

We now move on to the recommendations themselves in more detail.

RESEARCH

Recommendation 1: Knowledge-Based

Research at the Heart of Innovation to Inspire, Drive and Sustain the Bioeconomy

The Bioeconomy is **knowledge-based** and thus dependent on productive and relevant research as an essential first step. The level of research funding for areas which support the Bioeconomy must therefore be increased if a steady stream of innovation is to take place and enable the grand societal challenges to be addressed both in Europe and globally. As well as supporting various specific branches of science, interdisciplinary research (which can be highly productive and is particularly relevant to the needs of the Bioeconomy) must be actively encouraged. In particular, we call for:

- The setting up of strong programmes in both individual and collaborative, intra- and interdisciplinary research. In each case, they should cover both basic and applied research at national and European levels;
- The encouragement and facilitation of multi-disciplinary research programmes between different institutions and administrative sectors across countries and Europe as a whole;
- Simplification of funding schemes, which are complex and difficult for all participants, particularly SMEs, to use;
- Adequate time spans should be set for funding schemes to take account of diverse research needs, particularly when important long term goals are to be addressed;

- Improved collaboration between Member States and across the European Research Area to make international projects and joint programming more effective;
- Development of the Cooperative Research Centre model across Member States, both within and between sectors;
- Support for the development of knowledge nodes of all sizes, including SMEs and niche industries which may be a particularly fertile source of innovative ideas;
- Improved efficiency of communication and dissemination, including early stage feedback, to demonstrate progress and allow more resources for next stage financing and development of promising and agreed activities.

First Actions

Bioeconomy enabling research must be supported at all levels and should include both strong sectoral and multi-disciplinary components. This will ensure that the knowledge-based Bioeconomy will answer the societal challenges and support a sustainable European economy. Institutes and companies should be encouraged to work together as an aid to integration. The participating ETPs intend to work closely together to address these topics. Three FP7 Large Collaborative Pilot Projects (on the food chain, the non-food chain and sustainability) would form a perfect place to start, to be followed by appropriate FP8 projects that address some of the grand challenges. Support activity from the European Union (EU) to integrate a greater number of stakeholders in all Technology Platforms, which have just started to work together, would be useful. While the ETPs themselves do not do research, they are vital in building bridges between the research and business communities. Strengthening communication between these sectors will facilitate effective multi-disciplinary approaches to priority issues and provide the necessary support activities to make them successful.

Making the vision a reality

INNOVATION

Recommendation 2: Support Innovation

From Innovation Hurdles to Innovation Support Measures –

Appropriate and Feasible Regulations

A more business friendly European culture which encourages and fosters innovation is essential if the Bioeconomy is to be strengthened. Time to market must be reduced and opportunities for profitable new product development need to be maximised. The research and innovation process has to be aligned with the needs of specific sectors if the strong knowledge base is to be translated into commercial reality.

The needs of the various steps in the **innovation chain** are explained below:

Knowledge and technology transfer. In this primary phase, successful transfers may be as proof of concept (from research to business), between different Bioeconomy sectors, from business to business (B2B) or as joint developments (which can be B2B, open innovation, contract research or consultancy). In all cases:

- Bottlenecks to innovation (such as legal barriers, time constraints, costs and lack of information, knowledge or skills) must be identified and structures and procedures changed to overcome them;
- The research and innovation process has to be aligned with the specific needs of the sector and its customers;

- International, and in particular European bottom-up technology transfer networks must be established and encouraged.

Experimental production facilities

- Experimental farms: testing and developing concepts for the agricultural sector means that they must be evaluated under realistic farming conditions. So that farmers are not discouraged from running them, they should be eligible for the same benefits as any other working farm, including participation in the Common Agricultural Policy (CAP). Such farms should be used not just to evaluate new crops or management methods but also novel integrated systems such as agro-forestry and agro-aquaculture.
- Demonstration and moving to commercial scale: innovation in Europe has been constrained in part because it is difficult to obtain public sector funding or tax breaks for public-private partnerships and demonstration projects, so increasing time to market. This can be improved by:
 - Business-friendly management of intellectual property;
 - Providing easy access to flexible, research-oriented pilot plants;
 - Increasing public funding for demonstration projects such as bio-refineries or off-shore aquaculture prior to scale-up for commercialisation;
 - Developing public-private partnerships and other funding schemes to support innovative, high-impact technologies;
 - Developing similar funding mechanisms for private sector consortia to build innovative demonstration/industrial-scale plants, following the model of the European Industrial Bio-energy Initiative (EIBI) under the EU SET-Plan.

Access to market. This can be hindered by regulatory requirements, lack of appropriate standards or specific skills, as well as the usual difficulties of creating a new market and gaining acceptance for a new technology. It is therefore important that:



- Incentives are put in place for marketing of new products and processes;
- An innovation-friendly regulatory framework is put in place and regularly reviewed;
- Standards are developed in parallel, with the process started at the research phase;
- Market distortions such as legislative and other barriers to entry, the lack of a level playing field for new entrants, or tougher regulatory hurdles for European manufacturers compared to imports, are removed.

For companies – particularly smaller ones – to succeed, regulatory requirements and procedures must be both streamlined and coherent. Time to market can be considerably reduced by adopting an innovation-friendly approach which not only minimises uncertainties and bottlenecks but cuts costs. Particularly important issues include:

- Reducing the overall administrative burden to encourage greater participation of Small and Medium-Sized Enterprises (SMEs).
- Bridging the funding gap between public financing of pre-competitive research and the commercialisation of the end-product or process.
- Taking account of the costs incurred in developing and submitting project proposals before projects are agreed and started.
- Setting up and implementing innovation-friendly regulatory frameworks for the overall Bioeconomy and all sectors of the Bioeconomy web;
- Streamlining and simplifying procedures (for example having a simple two-stage evaluation process for proposals) and using them only where necessary;
- Regularly reviewing and updating the frameworks to ensure they remain optimised;
- In addition to the Lead Market Initiative (LMI) on Biobased Products, setting up a further one to cover the whole food chain.

First Actions

Support for innovation must be improved by strong encouragement for public and private sector cooperation. There should be a variety of mechanisms, including funding for demonstration projects, specific sector-based research and innovation funding schemes and schemes to encourage knowledge transfer between companies and industries. In parallel, new and existing regulatory frameworks should be made as innovation-friendly as possible and be regularly reviewed. For example, in the field of GMOs, large companies could take the lead in getting approval for a certain family or species, with SMEs then having fewer hurdles to overcome when bringing related products to market. More generally, access to specialised advice on intellectual property and licensing issues is needed. To aid market development, it is also recommended that in addition to the initiative on Biobased Products, one more LMI is introduced, covering the whole food chain.



Making the vision a reality

Recommendation 3: Framework conditions for boosting entrepreneurship

Structures adapted for scale and sector/niche

Companies of all sizes participate in the Bioeconomy, and entrepreneurship structures are different at the various scales. Although continuous knowledge development is still crucial to successful innovation for all companies, **novel cooperation models** are needed to allow different business models to be used collaboratively to boost the development of the Bioeconomy.

Enabling factors. There are various factors which seem all too often to be lacking in Europe, so stifling entrepreneurship. Their development can be encouraged by:

- Making entrepreneurship more attractive for young people, via education and the social environment. Setting up small projects for children and students to run themselves will develop awareness and skills and make entrepreneurship a more desirable career path.
- Providing a support framework for budding entrepreneurs, including mentoring networks, opportunities to meet venture capitalists, administrative support from incubator staff and using media networks to highlight start-ups and success stories.
- Setting up a European Innovation Council.
- Establishing competitions to reward innovative ideas with help on starting up.

Combining a boost in entrepreneurship with the responsible corporate identity of established European companies, supported by representative networks, will form the backbone of the private sector in the integrated Bioeconomy.

Small- and Medium-sized Enterprises. High-tech SMEs spun off from research institutes play a key role in innovation. They are typically quite short lived, as the successful ones are often bought by established companies, while others are vulnerable to failure for a variety of reasons. There is still a clear financing gap which must be addressed, to ensure that a higher

proportion of these companies achieves success. In contrast, there are many established SMEs in the agriculture, forestry, aquaculture and food sectors, which are equally important for the Bioeconomy. They generally do not have the capacity to absorb and commercialise innovations at the cutting edge but are essential for the dynamics and commercial success of most new products development.

Midsized companies (from €50m to €750m annual turnover). There are many companies of this scale in the agriculture, aquaculture and forestry sectors, including co-operatives and umbrella organisations at various points in the supply chain. They can play a leading role in the commercialisation of knowledge, particularly in specialised areas where knowledge is expensive to develop. Although products and processes close to market are well protected, the underlying concepts are quite accessible. These companies are important in leading commercialisation of innovative technologies which SMEs can then follow.

Large-scale companies. Many major businesses already operate globally and are subject to fierce competition. To maintain their market position, they must place even more emphasis on technological innovation and providing their services and products in innovative ways. Legal and regulatory frameworks need to facilitate the transition of these established companies to also secure their positions as major players in the global Bioeconomy. Risk-sharing in the setting up of demonstration or pilot-scale facilities should be increased via public-private partnerships.

First Actions

Appropriate strategies must be developed to suit the structures and capabilities of different sized companies, and this has to be done in cooperation between policymakers and industry. To encourage entrepreneurship, a European Innovation Council (EIC) is needed, similar in scope to the European Research Council. The EIC would work closely with the European Investment Bank to support promising ideas, encourage risk-taking and develop more young entrepreneurs. The Bioeconomy ETPs could collaborate to help to develop these concepts further within a clear policy of developing and providing the framework for this approach.

Recommendation 4: International Standards *Development in Parallel with Research*

Establishment and development of high quality and safety standards are an essential prerequisite for consumer confidence in the Bioeconomy. Transparent, industry-led development and implementation of codes of good practice and standards for each sector are highly recommended, since such standards need to be continually revised and adapted to reflect continual improvements. Systematic and reliable data recording is now common across many areas in Europe, but it is increasingly important that standards are developed and applied internationally to avoid distortions in national and regional markets as well as the global Bioeconomy. Not only should **standards** always be developed on a basis of sound science, but they should have the support of industry, policymakers and society.

Inevitably, the best operators provide the push for the highest standards. The effect is to pull the aspects of quality, efficiency and acceptability of the sector concerned to higher levels. It is essential not only to identify such contributors but also to engage these players in the process of developing and reinforcing such standards.

First Actions

There must be continued development of European and international standards and Codes of Practice both for good business development and to reinforce public trust. As well as addressing safety and quality, standards should also play a positive role in promoting sustainability and innovation. They must not favour one sector of the Bioeconomy over another, nor imports over local production; overall, they should support the continued development of the entire Bioeconomy and be devised and managed equitably.

Recommendation 5: Assess Risks and Benefits *Open and Balanced Assessment*

In today's risk-averse culture, a highly precautionary approach to policymaking has often reinforced the concept of potential and hypothetical risk in people's minds, and this is all too infrequently offset by a consideration of benefits. To make properly informed choices, consumers are entitled to **full and transparent information on both risks and benefits** for traditional and novel products. Clarifying and communicating this information properly needs good cooperation between researchers, policymakers, industry and consumers. A successful example of assessing the risks and benefits and communicating them to consumers is cheese made from unpasteurised milk, where clear procedures for production and labelling allow consumers to make their own choice, but in other areas the real risks are not yet always so well quantified and unsubstantiated opinion can counter development.

First Actions

There should always be an opportunity to submit a benefit assessment at the same time as the necessary risk assessment. This would enable rational decisions to be made on the basis of sound scientific evidence, taking account also of economic, environmental and health issues and both short- and long-term impacts of alternatives, and allow all information to be properly communicated to consumers. The stakeholders in the Bioeconomy ETPs have a role in the effective communication of this information.



Making the vision a reality

EDUCATION AND TRAINING

Recommendation 6: Education and Training

Young People and Professionals attracted to the New Integrated Bioeconomy

Many companies in the Bioeconomy have trouble **recruiting appropriately skilled people**, in particular at middle management level, partly due to a poor image of the sector and the opportunities available among young people. If not addressed, this will seriously hinder the growth of the Bioeconomy. Employers need people with university education and/or appropriate sector specific training but they also value, for example, those who can work across disciplines and want to continue to develop and expand their knowledge. Special attention is needed for these areas:

- Education at a range of levels, to produce the next generation of good technicians and other skilled manual workers, researchers, entrepreneurs, managers and traders;
- Encouraging the mobility of researchers, young entrepreneurs, students and skilled staff from industry;
- Cross-recognition of qualifications between Member States;
- International training and education programmes which:

- Encourage development of experience across Bioeconomy sectors;
 - Encourage movement between, and mutual understanding of, different stakeholder groups, including academia, industry, media, politics, retailers etc. Moves from industry into academia are as important as the more common moves in the other direction;
 - Start in schools and continue through university and the working life;
 - Encourage the participation of Bioeconomy professionals.
- Lifelong learning with short modules leading to recognised European qualifications.

First Actions

A coherent Education Action Plan covering all sectors should be developed with the input of all relevant stakeholder groups, to inform national education authorities and universities of the future needs of the Bioeconomy for a well-qualified workforce. Successful programmes such as the Marie Curie fellowships should be continued and built on, with greater encouragement for those moving from universities to industry to return to academia. Similar exchanges should be encouraged across other areas, particularly into and between academia/industry and the media, and academia/industry and policy/regulatory bodies. Meanwhile, schools and universities should promote the concepts of being inventive and taking justified risks in order to stimulate entrepreneurship.



GOVERNANCE AND PUBLIC DIALOGUE

Recommendation 7: Integrated governance for the Bioeconomy web

The Bioeconomy provides a wide range of public goods, in particular rural and coastal jobs, sustainable future food and energy supplies and conservation of natural environments and biodiversity, as well as contributing to economic growth while providing investors with a financial return. However, the provision of social goods must be balanced against the needs to both remain globally competitive and retain public support. This requires the implementation of a public strategy for research and innovation in which all the recommendations of this report are included in an integrated way to meet the **Bioeconomy web** criteria.

First Actions

Full cooperation and alignment of strategies across the Bioeconomy landscape is needed. This should be at all levels; between relevant ministries in national and regional governments, between Member States and between and within EU institutions. As necessary, the alignment should go beyond national and European levels to be on a global basis. Where there are areas of global competition, there should be a framework in place to pool national funds to enable Europe to participate in major global initiatives and retain competitiveness.

Recommendation 8: Communication with Society *Transparency, Openness and Clarity*

It is not enough just to carry out the other recommendations; **effective communication with the general public** is also essential. All research, education, innovation and business communities must be transparent, open and clear about all Bioeconomy developments if the sceptical and negative feelings of some parts of society to novel products and processes are to be overcome. In particular:

- We need to listen as well as talk and to make the most of new channels of communication;
- Scientists and technologists need to become more aware of societal perspectives and both understand and address these throughout their work;

- Proper, balanced communication on the risks and benefits both of commercialising processes and products or not – including the impact on sustainability – is essential;
- Communication needs to be with members of the public with all levels of education, rather than just an elite;
- Attention is also needed for communication on the implications of Bioeconomy developments for the various sectors and stakeholders;
- Overall, better communication can support the improvement of the public image of the Bioeconomy (and hence help make it a success) by both improving public understanding of the science and technology and increasing awareness among scientists, technologists and industrialists of what the public is really concerned about;
- Engaging young people in the debate can be encouraged via use of popular social media ranging, for example, from Twitter to YouTube.

First Actions

All those involved in Bioeconomy commercialisation, R&D and education must include open and accurate communication with the public as part of their roles and take account of public perception in planning and carrying out their work programmes. Coordinated action on specific topics could usefully be undertaken by the Bioeconomy ETPs.



Glossary

Bioeconomy: The Bioeconomy refers to the sustainable production and conversion of biomass into a range of food, health, fibre and industrial products and energy.

Biomass: Renewable biomass encompasses any biological material (agriculture, forestry and animal-based including fish) as a product in itself or to be used as raw material.

Figure 2 on page 7: these figures are based on input from ETPs, EUROSTAT and EU27 GDP is estimated (<https://www.cia.gov/library/publications/the-world-factbook/geos/ee.html>).

Sustainability: This is an economic, social, and ecological concept. A sustainable (bio)economy is one that meets the economic and social needs of the present while minimising the impact on the environment, and without compromising the ability of future generations to meet their own needs.

Food security: Food security encompasses sufficient, nutritious, safe and affordable food.

The Cooperative Research Centre model: A concept initially developed by the Australian government to bring end-users and researchers together to build critical mass to work on key strategic projects.

Knowledge nodes: Remotely accessible collections of shared knowledge of specific topics.

European Technology Platform (ETP): These provide an industry-led framework to define R&D and innovation priorities and plans for strategically important sectors.

Small and Medium Enterprises (SMEs): Small enterprises have fewer than 50 employees. Medium enterprises have fewer than 250 employees and have an annual turnover not exceeding 50 million euro. In the enlarged EU-25, some 23 million SMEs provide around 75 million jobs and represent 99% of all enterprises.

A top-down approach from the centre: Addressing problems via centralised target setting and planning, compared with a bottom-up approach in which individual enterprises, either individually or collaboratively, make and implement their own plans to meet broadly defined targets for the whole EU.

ETPs and EUFETEC contact details

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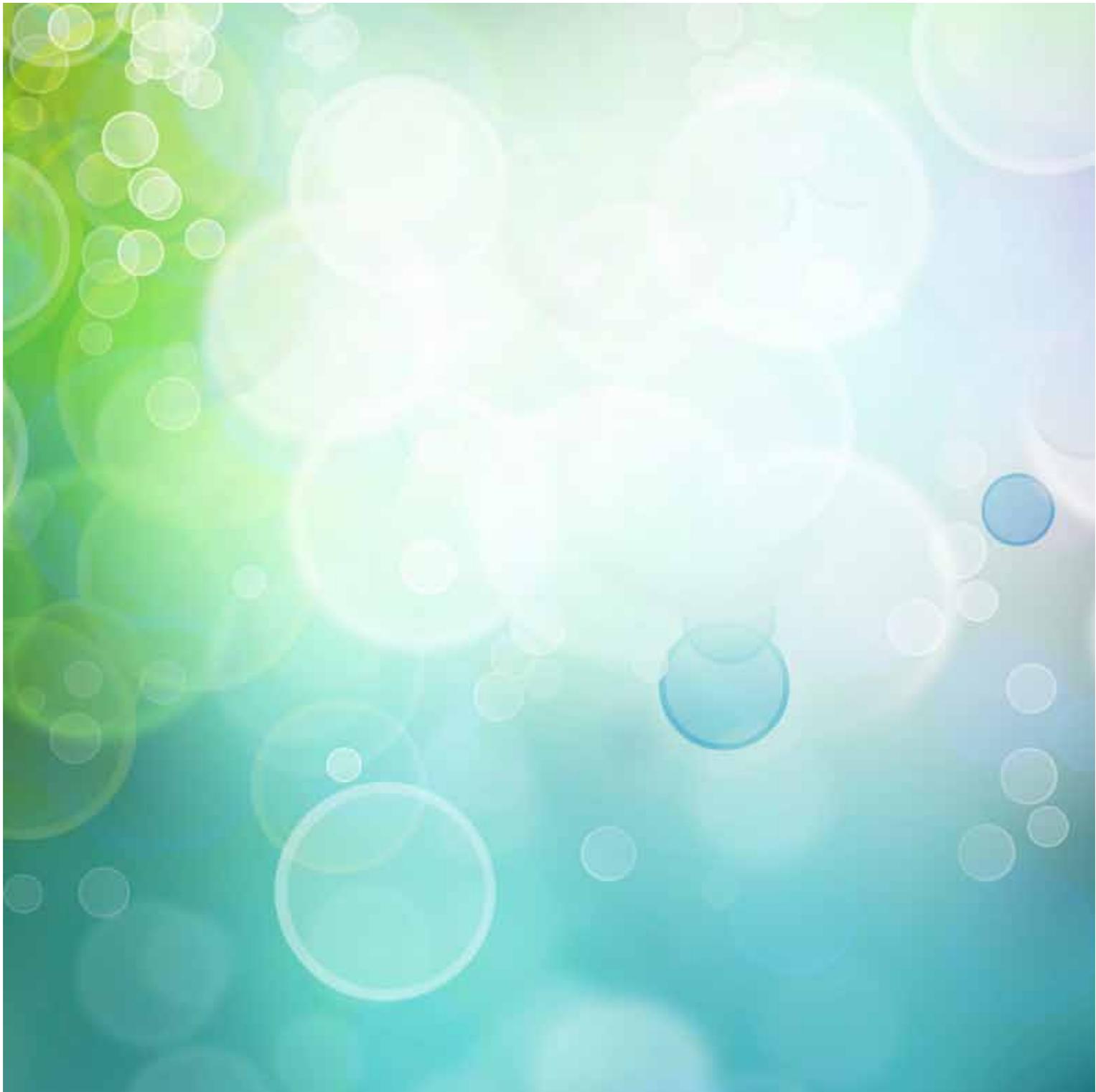
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the Grand Societal Challenges*