The Knowledge Based Bio-Economy (KBBE) in Europe: Achievements and Challenges

Summary

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All references and background information are available in the complete version of the report.

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SUMMARY

The European Knowledge Based Bio-Economy (KBBE)

The increasing demand for a sustainable supply of food, raw materials and fuels, together with recent scientific progress, is the major economic driving force behind growth of the Knowledge Based Bio-economy (KBBE) in Europe over the last few decades. The bio-economy – the sustainable production and conversion of biomass, for a range of food, health, fibre and industrial products and energy, where renewable biomass encompasses any biological material to be used as raw material - can play an important role in both creating economic growth, and in formulating effective responses to pressing global challenges. In this way it contributes to a smarter, more sustainable and inclusive economy.

It is estimated that the European bio-economy currently has an approximate market size of over 2 trillion Euro, employing around 21.5 million people, with prospects for further growth looking more than promising. In addition to being economically favourable, the KBBE can help to meet the most urgent global challenges improving public well-being in general. Areas that it can benefit include social and demographic development and its impact on agriculture, the growing pressure on water, the threat of climate change, the limited resources of fossil fuel, the need for sustainable development, the impact of changes in lifestyles and eating habits, the demand for safer and healthier foods and the prevention of epizootic and zoonotic diseases.

Major achievements

When the European Commission developed the concept of the KBBE, it was with the aim of developing the European bio-economy so that it could compete on a global level and build on European strengths. These included excellence in science, technology and industry to deliver innovation, world leadership in food technologies and products and animal breeding technologies, and having a strong chemical and manufacturing industry base. Over the last five years, within the Commission, research and innovation have provided the main supporting policies for the KBBE. To support this initiative, 9 KBBE specific **European Technology Platforms** (ETP) were set up, and research in the area of the KBBE has been promoted and financed through the Commission's Framework Programme 7 and several Member State initiatives.

As these ETPs developed, they started to communicate and work together on issues of mutual interest, such as **identifying synergies** in their Strategic Research Agendas (SRAs). The European Commission set up regular meetings with representatives from the KBBE ETPs and invited experts to discuss policy-related issues together. Today the 9 ETPs active in the KBBE sector are joining forces in the BECOTEPS project, funded by the European Commission's Seventh Framework Programme. The objectives of the BECOTEPS project are to achieve closer and more coordinated collaboration between the KBBE ETPs and to develop recommendations for better interaction between the KBBE ETP stakeholders along the product chains. They also focus on the sustainability issue regarding multidisciplinary research, innovation and policy issues, and the goal to encourage dialogue between European and national, public and private and research and innovation initiatives.

At EU level, research in the KBBE area has also strengthened by the implementation of several **ERA-Nets**. The ERA-NETs aim to reduce the fragmentation of the European Research Area (ERA) by improving the coherence and coordination of national and regional research programmes.

In addition to ERA-NETs and ETPs, a third category of pan-European KBBE-related networks consists of European Commission **expert groups**. These include the Advisory Group on Food, Agriculture and Biotechnologies, the KBBE-Net, the KBBE National Contact Point, and the EU Standing Committee for Agriculture Research.

The current and future availability of **biomass feedstock for food, feed, energy and industrial material use** in Europe as well as the question of the available land for food and non-food crops still remains a contentious issue in need of in depth analysis. The impact on food security is one of the core social factors to be considered in the development of the use of renewable resources for biofuels and material use in biorefineries. The growing market (today largely focussed on the production of biofuels but in the future undoubtedly also for biorefineries) represents a new source of demand for agricultural commodities. This demand must be managed appropriately with respect to available land resources and without associated negative impacts on the food and feed sector.

Feedstocks are continually adapting to the needs of the modern (agricultural) industry. A key focus of national and international research concerning the availability of feedstocks for a bio-based economy is the **optimisation of the yields** and materials for different uses. This includes the technological optimisation of agricultural processes as well as the direct optimisation of crops (and wood for short rotation plantations) via conventional breeding, refinements of conventional breeding or biotechnological methods. Today, modern breeding methods offer a wide range of different approaches. In addition to traditional selection procedures and genetic engineering, (green) biotechnology for feedstock optimization receives increasing attention, though some industry sectors, politicians and the general public continue to regard this technology with suspicion. This appears to remain a Europe-specific problem whilst emerging economies such as China, Brazil and India are embracing these techniques as promising and important technology advances for their nations. The potential of this technology is also demonstrated by the fact that in 2009 more than 134 million ha of arable land were planted with transgenic crops by 14 million farmers worldwide.

A second focus is the **optimization of the plant ingredients** such as through a change of the starch molecule for technical uses of the potato or the change in composition of fatty acids in rapeseed, sunflower or crambe oils.

Nutritional improvements of a large range of food products and the development of novel food products and processes, including food packaging technologies are important drivers in realising ambitions for healthy food and healthy lifestyles. Additionally improvements in this area are necessary for minimising the environmental impacts of agriculture by reducing green house gas emissions and energy and water consumption whilst contributing to a more sustainable eco-friendly economy. These research topics tackle some of our key societal challenges such as how to feed almost 9 billon people by 2050 and how to manage the demands of a population that is shifting its food preferences towards a greater consumption of meat. Achievements in the **food sector** in terms of promoting research and market development include the launch of diversified research programmes (from basic to applied research, research infrastructures, training and support to SMEs), reinforcing cooperation and better exploiting research results. They have also involved boosting competitiveness through the active participation of relevant industrial partners in European technology platforms, and integrating strategically focused, trans-national research that will deliver innovative processes, products and tools in line with the needs and expectations of the consumer. Since 2006, 36 National Technology Platforms (NTPs) have been established under the umbrella of the **ETP Food for Life**. The National Food Platforms play a key role in conveying the programme of the ETP to the national industry, especially to SMEs and the research community.

In addition, actors within the food supply chain are united together under the **European Food Sustainable Consumption and Production (SCP) Round Table** initiative in order to face current and future sustainability challenges.

In the area of **bio-based products**, Europe has become the leading region for the development and production of enzymes. Because enzymes play a crucial role for applications in many other industrial sectors, this sector represents significant potential for the EU in terms of escalating global leadership in the area of biobased products and processes. On the other hand, the United States and Brazil are the world leaders in the production of biofuels (mainly bioethanol). Another established sector is the production of biochemicals which find applications in the pharmaceutical industry, the food and feed industry, the production of detergents and cosmetics, and many other sectors. In the

chemical industry, an important step in increasing the share of biobased chemicals is the creation of biotechnological platform intermediates based on the use of renewable carbon sources. Furthermore, although the production of bio-based polymers and plastics are technologies still in their infancy, this industry has been characterised by an annual grow rate of almost 50% due to new synergies and collaborations.

In Europe, there is also a growing focus on **biorefineries**. These use biological matter (as opposed to petroleum or other fossil sources) to produce transportation fuels, chemicals, and heat and power. Because they combine and integrate the technologies necessary to convert renewable raw materials into industrial intermediates and final products, they can straddle the whole value chain. The European Commission has funded several projects under FP6 and FP7 analysing the biorefinery research situation in the European Union. At the beginning of 2010, they then launched three large collaborative projects addressing the entire value chain. Aspects included in these projects were the production of biomass, logistics, intermediary processing steps and conversion into end-products with the feasibility of techniques shown at pilot scale. Moving forward, the Commission will fund the programmes with 52 million Euro over a period of 4 years. 81 partners from universities, research institutes and industry in 20 countries will invest an additional €28 million. In addition, at member state level, we see an increasing number of biorefinery oriented research programmes. More than 300 research projects have been identified in Europe (at EU, national and regional levels), with a total budget of around 1.2 billion Euro, of which more than 808 million Euro comes from public funding.

There is a clear need for a coordinated technology development covering different technologies and parts of the value chain including feedstock development, product development, production optimization and innovative application development. **Cooperation in cluster structures** rather than in single-company partnerships is significantly accelerating the development of processes and their penetration into the industry. Towards the end of 2009, the European Commission published an action plan on **Key Enabling Technologies (KET**), which included industrial biotechnology. The purpose is to develop an action plan with measures to remove obstacles hindering further development and to fully exploit the results of research. These measures include a focus on demo projects and better coordination of the activities between EU and Member States for example through joint calls or joint programming.

SusChem's European Innovation project - **BIOCHEM** - was selected at the beginning of 2010 for funding by the European Commission under its INNOVA scheme. BIOCHEM will define and promote bio-based product opportunities in the chemical sector, and will also facilitate and help finance new bio-based business ideas to proof-of-concept, including facilitating access for organizations to European test facilities.
Specific policies for the development of biobased products are more extensive for bioenergy, including for liquid biofuel use and solid biomass applications, than for biochemicals or biomaterials. Worldwide, many governments support their emerging biofuel industries far more than other KBBE sectors through subsidies, mandates, adjustments to fuel taxes and incentives for the use of flexi-fuel vehicles. In Europe, the **Renewable Energy Directive** of 2009 is calling for a mandatory target of a 20% share of renewable energies in the EU's energy mix by 2020. In addition, by the same date, each Member State must ensure that 10% of total terrestrial transport, such as road transport and train fuel, comes from 'renewable energy', defined to include biofuels and biogas, as well as hydrogen and electricity. Furthermore, in order to stimulate the use of so-called second generation energy sources, biofuels from waste, residues, non food cellulosic material, and lignocellulosic material will count twice towards achieving the renewable energy transport target.

Although Europe plays a leading role in research and science, it is less successful in converting the science-based findings into commercially valuable products. This is why the Commission has developed a so-called demand-based innovation policy, the **Lead Market Initiative** (LMI). One of the areas that this policy focuses on is that of bio-based products. An Ad-hoc Advisory group has developed a series of concrete recommendations and actions, ranging from improving the implementation of the present targets for bio-based products to standardisation, labelling and certification in order to ensure the quality and consumer information on the new products.

In Europe, sustainability it is an important driver for many of our policies, and several of the demand-side regulations include **sustainability aspects** such as 'green' public procurement. But sustainability is not solely about greenhouse gas emissions reductions or climate change, it also concerns waste reduction, minimizing energy consumption and efficient use of resources. Because of the interdependencies between processes involved in growing, harvesting, manufacturing, distributing and disposing of a product, sustainability requires a life cycle analysis encompassing the whole value chain. This includes the production of biomass, evaluating land use, consumption of water, energy, pesticides and fertilizers and the production and use of the final products. Currently, national and international efforts to develop more comprehensive, systems-oriented sustainability frameworks for bio-based products are under development.

Main challenges

Over the next 10 years we can expect a shift in practice from a sectoral approach towards a more **integrated approach** of the KBBE.

In the case of a **sustainable feedstock production,** for food and non-food applications, significant challenges remain to be solved for the future. In Europe, in particular, there needs to be a concise strategy to satisfy the demands of a range of stakeholders for the use for food, feed, fuel and materials. On this basis, "food versus non-food" debates and the biomass competition between energy and material still needs to be resolved. Other challenges concerning the feedstock needed for different applications include the growing demands for food, fuels and materials in the context of an expanding worldwide human population. In addition, the adaptation and optimisation of existing feedstocks for the given land that can be used for agriculture are a key focus. In this field, in particular, the use of advanced breeding technologies and green biotechnology should be discussed and evaluated in the context of new challenges concerning global warming, pressure on natural resources and sustainable agriculture.

Gene transfer between species has now been a reality in plant breeding and selection for two decades. In addition, it has been achieved technically in animal species as diverse as goats, pigs and fish. The debate on the public acceptability of these techniques in **food animals** has already begun in the United States, and is likely to be even more contentious in Europe. In parallel, the cloning of animals is also now technically feasible, though it is still far from becoming commercially viable. Genetic modification (GM) technologies, already applied in over 130 million ha of crops worldwide, have met strong opposition from European consumers. Issues of **public acceptability** are therefore likely to be increasingly important as GM and related technologies, such as (animal) cloning, continue to develop.
Changes in both population demographics and life span demand that European public health policies focus on healthy ageing, which not only includes the prevention of diseases but also on delaying the deterioration of health status. However, the area of **research in health, food and diet-related diseases** is both complex and fragmented. At the same time, there are a number of pressing challenges on a European-scale that can only be tackled through a combination of public policy development, academic research and industry developments in European Member States and Associated Countries. Future efforts should include prevention of chronic diseases through promoting collaborative research and sharing data and results on health impacts of nutrition and lifestyle. They should also incorporate effective interventions, and the creation of a coherent long term, public health research programme on diet related diseases from molecular to population levels by integrating systems including biology, genetics, nutrition, epidemiology and social sciences.

In addition, industry finds it difficult to seek **authorisation for novel food products**, because of the lengthy procedures and the uncertainty of the outcome. The cost factor discourages many from patenting food products or new processing techniques, in particular SMEs.

Although the total amount of agricultural output will have to increase over the coming decades, climate change is expected to have a profound and increasing impact on food production through factors such as rising temperatures, altered rainfall patterns and more frequent extreme events. Moreover, this challenge of delivering **food security in the**

context of climate change also means that it is necessary to find innovative ways of increasing efficiency and reducing waste throughout the food chain in order to make the most of the resources and raw materials available. Another important contribution of the food sector could be the reduction of food losses by introducing modern collection, processing, storage and transportation methods.

The **development of innovative bio-based products is R&D intensive**, and increasing investments in certain technologies will be a major challenge. Although industrial biotechnology has been identified as a key enabling technology, only 2% of biotech R&D went towards developing industrial biotechnology in 2003. This is incongruous with OECD predictions that industrial biotechnology will contribute up to 39% of the biotech industry's gross value added (GVA) by 2030. In addition, member states of the International Energy Agency (IEA) spent 13 times less on R&D in bioenergy (including biofuels) than the amount spent on nuclear fission and fusion R&D and 4 times less than was spent on R&D into fossil fuels. Furthermore, research activities in the EU concerning lignocellulosic bio-ethanol and second generation biofuels in general, are modest when compared with the massive efforts of the U.S. and Brazilian governments.

The initial construction of **bio-refinery pilot and demonstration plants** is not only a costly undertaking but it also involves bringing together market actors along a new and highly complex value chain. Countries like the US, Brazil, China and others are increasing investment into research, technology development and innovation, and are supporting large scale demonstrators in which many European companies already participate. In addition, producing chemicals through bio-chemical routes is currently still more expensive when compared with traditional production routes. It should also be taken into account that existing production facilities for chemical syntheses cannot be converted to biotechnological production without massive new investments.

In contrast to biofuels, there is currently no European **policy framework to support bio-based materials**. As a result, these products suffer from a lack of tax incentives or other supporting regulations. Other demand-driven policies focus on the sustainability agenda (including green public procurement) and are often implemented as a mix of public procurement procedures, legislation and direct financial incentives which is a complex matter in Europe. However, such policy frameworks have been successfully developed in other parts of the world.

Addressing sustainability issues through all segments of the value chain of bio-based products (from biomass production to end-use) in a fair, evidence-based regulatory framework, is a major challenge for biofuels and other bio-based products. In doing so, the sector has to demonstrate that it possesses sustainability credentials in order to gain a strong "license to operate" from governments and consumers, especially if supporting policies have to be developed. Unfortunately the lack of widely-accepted schemes to assess and confirm sustainability is a significant barrier to consumer and government confidence.

Main recommendations

1. Need for an integrated policy for the KBBE

To achieve a competitive KBBE, broad approaches, such as creating and maintaining markets for environmentally sustainable products, funding basic and applied research, and investing in multi-purpose infrastructure and education, will need to be combined with shorter term policies. These include measures such as the application of biotechnology to improve plant and animal varieties, improving access to technologies for use in a wider range of plants, fostering public dialogue, increasing support for the adoption and use of internationally accepted standards for life cycle analysis together with other incentives designed to reward environmentally sustainable technologies.

2. Research and innovation

In order to make a swifter more efficient shift towards more integrated and sustainable production and processing systems, the level of R&D funding in the bio-economy

should be increased through multidisciplinary research programmes at both national and European level. In addition, cooperation between private and public sectors should be a focus for further improvement. Building competence networks between industry and academia could also help to overcome the competence hurdle and knowledge gap that currently exist between these two stakeholder groups. In addition, better interdisciplinary and collaborative research would lead to valuable new business activities.

Special attention should also be placed on specific key areas, such as the development of efficient and robust enzymes particularly for the conversion of lignocellulosic material. This should enable conversion from a variety of feedstock, synthetic biology and metabolic pathway engineering and the combination of technologies such as biochemical and chemical processes as well as applications derived from agricultural and industrial biotechnology. In addition, specific research is needed to improve feedstock yield and/or the composition of biomass involving both plant genomics and new breeding programmes, also incorporating further research into efficient crop rotation, land management and land-use change issues.

Integration of the individual KBBE sectors should support pre-competitive research covering the entire value chain – from feedstock to end-product – as this will help to stimulate innovation and encourage the uptake of its results by the industrial partners involved. In the longer term, we expect not only closer integration of the different sectors of the KBBE, but also between different research areas across food as well as non-food commercial applications.

One of industry's remaining major challenges is to translate research to products, including the development of new product applications. Setting up public-private partnerships would result in a pooling of resources, thus allowing more ambitious goals to be set in terms of reducing the time-to-market. This would also enable industry to adopt longer-term investment plans in the field of the bio-economy, taking into account the market perspective.

Stimulating the construction of demonstrators via public-private partnerships is one of the most important measures that can be taken in the development of the bio-economy, as they are able to close a critical gap between scientific feasibility and industrial application. They dramatically reduce the risk of introducing new technology on an industrial scale and therefore make a biorefinery venture much less risky for investors.

3. Towards economic-sustainable and innovative SMEs

Spin-offs and high-tech SMEs are key for technology and knowledge development, and investing in research and innovation is the only way for these enterprises to survive. It is of critical importance to the success of these SMEs, and hence to the innovation potential of the sector as a whole, to improve their access to finance. However, without larger scale validation, it remains very hard for SMEs to attract the large industrial partners or other private investors that they need to become sustainable. Developing grants for "Proof of Concept" studies could help partially overcome this problem.
One of the weaknesses of the many SMEs in the more "traditional" sectors (such as agriculture, forestry, aquaculture, food sector) is that many of them do not have the in-house technical skills to take up the results of innovation. Supporting tech transfer or stimulating SMEs to participate in "open innovation" programmes could therefore be a way to overcome this problem.

4. Communication and education

To facilitate smooth long-term development and implementation of the different technologies of the KBBE, a strategy for communication and stakeholder involvement is necessary. This would not only help to raise awareness of the technologies but would help ensure that longer term objectives are fixed to provide solutions that reflect societies real needs.

It is of critical importance for the bio-economy to have a multi- and interdisciplinary work force, in order to ensure that it keeps up-to-date with new knowledge and techniques. There is therefore a need for multidisciplinary education, good international training programmes and efficient lifelong learning. In addition, due to a gap in education, biotechnology and chemistry are still too often perceived as "competing technologies" instead of as being complementary.

5. A strong EU common policy for agriculture: the new CAP (post 2013)

It is essential that the new CAP promotes sustainable and competitive agricultural production, and ensures balanced access to raw materials for the food and feed sectors, as well as for industrial applications, without disrupting food supply. The new CAP should ensure the possibility to maintain a competitive supply of raw materials that meets EU standards, notably in the areas of safety, environmental sustainability, and animal welfare. The CAP should also address situations of extreme price volatility, acting as a safety net in order to secure supply by preventing crisis situations and remedying temporary market imbalances. Absolute coherence is needed across all the policy areas driving supply, including food safety, innovation and new technologies, trade, development, the environment, animal welfare, and consumer and public policies. Horizontal policy coherence should result in reduced raw material market disruptions and should also contribute to ensuring competitive EU agriculture.

In order to stimulate the development of local biorefineries and to support rural development, it is important to develop and maintain a reliable upstream supply chain. This should be capable of mobilising a sufficient level of feedstock for conversion without being achieved at the expense of food and land use. For this reason, it is also important to invest in local and regional infrastructures and in logistical capabilities to allow all biomass, including agricultural, forestry and waste-based raw material, to be utilized.

6. Support reconversion towards low-carbon renewable-based production systems

Investments required for building a new bio-industrial facility - especially if it competes with the conventional one - might be a significant barrier to the development of the KBBE. For SMEs, such an investment might represent an even more difficult hurdle to overcome. Governments aiming to support biorefineries for reasons of environmental sustainability, energy security and innovation leadership will therefore need to support market growth, and carefully regulate the industrialization process in order to stimulate and encourage private sector investments.

7. Policies stimulating the market for KBBE products

Decision makers can help provide the necessary motivation by implementing a regulatory framework of incentive based and demand stimulating policies. Mandates, subsidies and incentives are provided by governments all over the world to stimulate the demand of sustainable bio-based products. The European Commission's Lead Market Initiative for bio-based products represents a good example of such a scheme and moving forward, this should be further developed and build upon. In the future, a similar initiative could be developed for the food sector or for the KBBE as a whole.

8. Science based sustainability criteria

Sustainability criteria addressing the different KBBE sectors should aim to measurably reduce the key impacts associated with feedstock production, consumption and use. In addition, implementation of measures involve the active participation of all stakeholders involved in the supply chain. Recent developments in the biofuel sector in the EU will make it possible to use private standards to prove compliance with sustainability requirements. While some schemes have ambitious sustainability criteria going beyond the minimum EU requirements, most of these only address a fraction of the overall concerns. Wider sustainability concerns will need to be addressed by governments in partnership with the private sectors. In addition, feedstock producing

countries - especially in the global South - will need significant technical and financial support to implement adequate safeguards.

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