The bioeconomy enabled





Introduction

Despite being able to tackle some of today's global societal challenges including climate change, dwindling fossil fuel resources and the need for the development of a more sustainable and resource-efficient industry, several hurdles continue to hamper the full exploitation of Industrial Biotechnology's (IB) potential today.

The BIO-TIC project was a solutions-centred approach that comprehensively examined the innovation hurdles in IB across Europe and formulated action plans and recommendations to overcome them. Three roadmaps have been developed, based on literature study, more than 85 interviews with experts and on the information collected through several regional and business case workshops.

The *market roadmap* relates to current markets for five IB business cases across Europe, and market projections extending to 2030. It aims to obtain a comprehensive overview of the market potential for industrial biotechnology, the current and potential future value chain composition and stakeholders, including segmented market opportunity assessment and projections. The "market roadmap" provides an important focus for the other two roadmaps.

The *research and development roadmap* revolves around the setting of R&D priorities and identifying needs for research, pilot and demonstration plant activities. This is centred on obtaining a clear overview of R&D related hurdles for realising Europe's IB market potential. The analysis focuses on the identification of R&D bottlenecks and required breakthroughs across a broad range of technological domains. It seeks to identify key areas of research to focus on, and to selectively highlight those areas that can be best aligned with current and foreseen end user market requirements. The technology roadmap also seeks to identify the relative strength of research areas in different European countries and gathers evidence where a duplication of resources exists.

The *non-technological roadmap* identifies regulatory and non-technological hurdles that may prevent IB innovation from taking advantage of market opportunities. The roadmap proposes solutions for key market entry barriers, going beyond recommendations already formulated by other initiatives and projects on biobased products.

The BIO-TIC roadmaps show how the various stakeholders can work together to overcome the major issues that hamper the huge potential of IB in Europe. The integrated roadmap, entitled '*The bioeconomy enabled: A roadmap to a thriving industrial biotechnology sector in Europe*' shows the relationship between potential market developments, R&D needs, regulatory and non-technological aspects impacting on IB innovation.

This short document provides a concise overview of the main hurdles and solutions collected during the BIO-TIC multi-stakeholders iterative process. The solutions highlighted in **GREEN** boxes are discussed in more depth within the research and development roadmap, whilst the solutions highlighted in **RED** are discussed in more depth within the non-technological roadmap.

All of the BIO-TIC roadmaps can be downloaded from the project website at <u>http://www.industrialbiotech-europe.eu/</u>.

		Hurdles	Recommended Solutions
	Feedstock availability	Costs of feedstock produced in Europe are too high compared to other regions	Improve yields of annual and non-food perennial crops by developing higher yielding crops;
			Investigate uses for under-utilised forestry resources;
			Investigate waste and residue biomass as alternative feedstocks;
			Investigate the best way to utilise coproduct streams (e.g. lignin);
Feedstock			Recover abandoned and marginal lands for cultivation of biomass;
			Install a win-win scheme for farmers and processors;
		Pellets are heavily subsidised (bio-energy subsidies) which may contribute to price fluctuations	Introduce a level playing field for all biobased applications;
		Seasonability of biomass cropping versus need of continuous feedstock supply is a major problem	Develop storage possibilities that conserve the biomass in a better way;
		Logistics: inefficient transport and distribution of biomass	Reduce transport needs by decentralisation;
		(High) import costs for certain types of feedstock	Global free trade of biomass;
		Fluctuating feedstock quality and price which has the potential to affect the whole value chain	Value chain quality certification;

		Hurdles	Recommended Solutions
	Bioconversion and Downstream Processing	The yield, productivity and robustness of many (bio) conversions is still too low to make processing economically competitive	Develop new strains to improve residence time, management and yield;
			Develop mixed-culture systems to help improve conversion efficiency;
			Develop anaerobic conversion systems;
			Develop feedstock-agnostic microbes;
			Develop more economical conversion processes with higher yields and less wastage;
		Genetic engineering has proven to be a costly and time-consuming process	Map the most wanted chemical steps;
vology		Water removal in (bio)conversion process is still very costly and not fully optimized	Develop new water management systems;
Fech		Advanced bioreactor equipment is often lacking hindering process integration and CAPEX	Develop and improve <i>in-situ</i> product removal methods;
F			Develop novel reactors and promote process integration (integration of DSP ¹ and UPS ² equipment;
		Lack of integration of (bio)conversion, product recovery and downstream processing together	Aim for the integrated optimisation of process intensification, <i>in-situ</i> product recovery (ISPR), continuous fermentation and downstream processing systems, and make more funding available for research on this;
		Lack of continuous fermentation systems hamper the economics of the bioconversion processes	
		Lack of predictive models to aid scaling up	
		Difficult to produce product, by-product and waste streams with consistent and uniform quality when utilising second generation feedstocks with wide ranging specifications	Develop microbes resistant to impurities in different feedstocks and with more narrow and robust production features;

¹ Downstream Processing ² Upstream Processing

		Hurdles	Recommended Solutions
Markets	Lower cost-competitiveness versus fossil products	Limited availability of low-cost feedstocks	Encourage the coproduction of high value chemicals;
			Focus on the production of high-value products;
			Integrate IB within the conventional chemical industry , e.g. using existing facilities, and improving the competitiveness of IB by maximising cost effectiveness of GHG emissions savings;
			Reform CAP ³ import quotas and tariffs, allocating a minimum amount of sugar to the bio-based economy;
			Enhance collaboration within the agricultural value chain to minimise biomass loss;
			Enhance collaboration with waste chains;
			Develop international agreements on sector specific emission reductions;
	Investment barriers and financial hurdles/capital requirements	Lack of mechanisms/incentives compensating for poor cost competitiveness	Cluster capital-intensive infrastructures;
			Develop off-take agreements (such as the Dutch aviation sector agreement);
			Introduce a voluntary bioproduct scheme based on the "mass- balance" approach to kick-off market demand;
		Untapped potential of IB in developing new functionalities	Enhance collaboration between academia, producers and end- users. Increase the focus on applications testing;
		Long time to market because of regulatory constraints	Simplify the registration and permits for bioproducts within REACH;
		Different understanding of definition "bioproduct" across regions and stakeholders	Encourage efforts to harmonise definitions on a global level (following the publication of CEN ⁴ TC 276 definitions);

³ Common Agricultural Policy
⁴ European Committee for Standardization

		Hurdles	Recommended Solutions
Markets	Definition of bioproduct is unclear which makes it difficult to communicate the benefits	Lack of common agenda for bioproducts development - incoherent policies and regulations	Develop a common strategy for IB in the EU;
			Introduce specific legislation for products where biobased has distinct advantages over fossil-based alternatives;
	Poor public perception and awareness of biobased products	Negative messages in the media on GMO and biofuels may influence the perception of IB	Introduce information campaigns to provide facts about GMM ⁵ and their use in IB and open the discussion with NGOs ⁶ and public authorities;
			Revise GM ⁷ rules. Currently no GM yeast or GM bacteria are approved in the EU for use in food/feed;
		Advantages of biobased products are not visible enough/ unclear definitions	Develop information campaigns to promote bio-based products. These should focus on safety, environmental benefits and the added value of bio-based products;
			Harmonise biolabels B2B ⁸ , B2C ⁹ ;
			Create mechanisms to kick-off market demand: Public procurement with periodic reporting;
			Develop EU standards for biobased products;
			Develop international standards for assessing the carbon footprint of CO ₂ based products;

 ⁵ Genetically Modified Microorganisms
⁶ Non-Governmental Organisations
⁷ Genetic Modification/Genetically Modified
⁸ Business to Business
⁹ Business to Consumer

		Hurdles	Recommended Solutions
Innovation System	Investment barriers and financial hurdles/capital requirements	Limited availability of public R&D funding for demonstration and commercial plants	Increase R&D funding at EU, national and regional levels for pioneering public research in collaboration with the industrial sector in a co-funding scheme;
		Limited access to finance for spin offs and start-ups	Develop technology and science parks, and bio clusters covering the entire value chain. Partners in the cluster should be able to collaborate in the innovation process until market phase;
		Limited access to finance for SME	Share R&D facilities and attract joint and alternative routes for funding and demonstration projects and scale-up facilities (public private investors, private foundations etc);
		Limited financial support for new production facilities	Implement R&D funding programmes for pilot and demonstration scale projects as proof of concept with industrial partners at 50% joint funding;
			Promote and give financial support for interregional pilot and demonstration projects within the framework of a joint strategic bioeconomy agenda;
			Start specific national/regional PPP ¹⁰ for projects at demo phase;
		Limited financial support for new production facilities and too long return on investment time	Implement funding for feasibility studies for start-ups and special grants for product development and commercialisation such as the small business investment company programme;
			Allocate funding for the construction of large scale facilities and improvement of pilot facilities at interregional/national and EU level;
			Attract foreign VCs ¹¹ and other private investors through capital fiscal incentives;

¹⁰ Public Private Partnership(s) ¹¹ Venture Capitalists

		Hurdles	Recommended Solutions
ovation System	Investment barriers and financial hurdles/ confidence requirements	Lack of visible tangible products and blockbusters	Implement tax reduction measures or tax bonuses;
			Create a stock option market for green (biobased) or environmental technology companies at EU and national level;
		Lack of investor confidence	Develop a new long-term vision business models for the production of biobased products to attract new venture capital and large corporate investments, private foundations etc;
			Develop demonstration projects as a proof of concept. Flagship projects that cover the whole product value chain will minimise the risk and install confidence;
			Develop a communications strategy with branch associations and companies involved to positively influence the image of IB. For instance, publication of reports and studies on successful case studies will amplify the confidence gained;
	Human resources	Lack of HR with right skills and curricula	Promote the development of chemical engineers with biosciences training;
Inn			Develop and retain scale-up expertise;
			Governments should implement new strategies to motivate children and high school students to follow technical studies;
			Introduce modern technologies and innovation processes in the curricula of secondary schools and academia, apprenticeships, regional training centres; training for SME;
			Introduce cross-disciplinary programmes at M.Sc. and Ph.D. level combining different fields of expertise e.g. chemical engineering with life sciences, synthetic biology and chemical engineering;
			Promote the involvement of M.Sc. and Ph.D. students at the industrial level from the very early stages of their study through the creation of scholarships in frame of a joint research program;

		Hurdles	Recommended Solutions
	Inefficient collaboration	Insufficient cooperation and knowledge exchange between the parties in the value chain	Set up specific R&D programmes to build supply chains in certain cross- disciplinary domains;
			Organise value-chain specific workshops to exchange knowledge;
			Organise "Communities of Practice" to exchange knowledge and lessons learned in best and bad practices;
			Create industrial 'value chain' platforms and consortia, including farmers associations, forest owners etc.;
Innovation System			Develop an open database listing all possible players in different biobased value chains (governments, companies, research institutions, branch associations etc.), and an inventory of all projects in the field of IB coupled to a forum to share experiences and best practices;
			Stimulate cooperation between the different industrial sectors through branch associations, umbrella organisations, consortia;
		Difficulties to establish operational alliances between industry and academia	Organise science/industry matchmaking events to support the building of relations between industry and academia/RTO ¹² s;
			Promote Public Private Partnerships by regional authorities;
			Change the rules for R&I ¹³ calls (cfr. Horizon 2020) to enhance cooperation; 1) minimum number of partners from certain amount of countries/regions in a project; 2)Obligation/requirement to bring, on a regular basis, "new" partners in a project call (not always bringing the same partners together); 3) The full value chain needs to be brought together to obtain funding;
			Set-up clusters bringing different sectors together cross-sectorial dating), or improve/stimulate collaboration between clusters;

¹² Research Technology Organisations ¹³ Research and Innovation

		Hurdles	Recommended Solutions
	Inefficient collaboration		Stimulate knowledge and technology exchange between different countries and centres of excellence through mobility schemes and knowledge partnership programmes;
		Regional funding conditions hinder establishment of international networks	Promote international multidisciplinary platforms and networks consisting of multiple stakeholders from different industrial and public sectors;
			Promote public-private ownership stages for alternative biobased companies;
m	Intellectual property (IP)	High patent costs hinder start-ups and SME.	Simplify and harmonise patent procedures in Europe;
Innovation Syste		Lack of harmonised IP regulation	Create an open patent environment (following to the US model) through patent disclosure of innovative research done at universities (or elsewhere) by technology agents;
		Difficulties in implementing the sustainability agenda and life cycle thinking in policies, and lack of coherent policy framework for sustainability	Ensure requests for sustainable certification of biomass are linked to certain incentives (like in the RED) to avoid further market distortion: If all sectors have to fulfil sustainability criteria for biomass, while only some sectors receive incentives, the other sectors will suffer from additional hurdles;
	Sustainability barriers	No general consensus on important definitions of the bioeconomy	Develop standardised systems to obtain feedstock that correspond to certain sustainability criteria, e.g. drying technologies, thermos- physical processes (cfr the "Biobased Raw Materials Platform" in the Netherlands);
		No commonly accepted "sustainability" certification system	Streamline certification schemes for the determination of biomass sustainability, taking into account cost effectiveness, resources and time scale at EU level (cfr. Bioeconomy Panel, CEN, etc.);

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