Overcoming hurdles for innovation in industrial biotechnology in Europe

Aviation Biofuels

Summary

Funded by
the European Union

The BIO-TIC project aims to identify hurdles and develop solutions to the large scale deployment of Industrial Biotechnology in Europe. Advanced biofuels are one of five product groups which we have identified to have significant potential for enhancing European economic competitiveness and introducing cross-cutting technology ideas.

This document is a summary of the findings related to aviation biofuels at the mid-way stage of the project and it has been produced as a discussion piece in order to collect stakeholders' thoughts on the hurdles within this sector, and ideas for how these hurdles can be overcome to capture the full potential of aviation biofuels.

Aviation biofuels can be produced either from oils (e.g. plant oil) or biomass (e.g. agricultural residues or the biobased fraction of municipal solid waste). The raw material is processed into aviation biofuel, which is then traded and transported to end-use markets. In this value chain, it is the end users, i.e. the airlines, which are the key decision makers. There are several routes by which aviation biofuels could be produced. These differ in their stage of development, feedstock and the degree to which the final product can be used in blends with conventional fuels. All aviation biofuels must be 'drop-in' replacements for conventional kerosene as the development of new engines, aircraft and infrastructure is very expensive and the existing infrastructure has a long lifespan. IB and non-IB routes to aviation biofuels exist and are these are explained briefly in the table below. The technologies in blue type could employ IB processes to a greater or lesser extent in some or all of the production chain as explained in the footnotes.

Technology	Product	Feedstocks	Characteristics	Use in Aviation (volume)	Commercial Status
Hydroprocessed Esters and Fatty Acids (HEFA)/ HRJ[1]	HEFA Synthetic Paraffinic Kerosene (HEFA-SPK)	Vegetable and algal oils, tallow and waste cooking oils	Drop-in fuel, straight alkanes	Approved for commercial use by ASTM in a 50% blend with conventional kerosene	Commercial production, economics are challenging. Used currently in road transport.
BTL using Fischer Tropsch step	Fischer-Tropsch Synthetic Paraffinic Kerosene (FT SPK)	Lignocellulose and waste biomass	Straight alkanes, no aromatics	This fuel is approved by ASTM in a 50% blend with conventional kerosene.	Commercial using fossil fuel feedstocks. Biomass and waste-based FT processes are at the pilot and demonstration stages.
Alcohol to Jet (ATJ)[2]	Synthetic Paraffinic Kerosene (SPK) or Synthetic Aromatic Kerosene (SKA)	Alcohols (ethanol, isobutanol, methanol etc.)	SPK – alkane mixture SKA - aromatics	SPK and SKA not yet certified for use SPK- possibly certified to 50% SKA – ?	Currently at demonstration stage.
Direct Sugars to Hydrocarbons (DSHC)[3]	Depends upon technology.	Sugars (starch, cellulosics etc.)	Straight hydrocarbons	Farnesene approved as a blending component at 10% only due to technical limitations	Mostly at an early stage of development. Farnesene is most well developed and at commercial scale
Direct liquefaction pyrolysis	Hydrotreated Depolymerised Cellulosic Jet (HDCJ)	Lignocellulosic biomass	Aromatic hydrocarbons	Not yet approved	Pilot to demonstration stage.

[1] IB could be used to produce oils with a specific composition, for example using algae or yeasts.

[2] Alcohols (e.g. ethanol, methanol, butanol etc) are dehydrated to alkenes (olefins) then oligiomerised to longer chain hydrocarbons. These are then hydrogenated. The product is then distilled into gasoline, jet and diesel fractions. Alcohols may be produced through IB routes by fermentation of biomass or carbon rich waste gases. Alternatively, thermochemical routes to alcohols may be used.

[3] DSHC may use thermochemical or IB routes. IB routes include the use of GM yeast cells to ferment sugars to hydrocarbons to be used as a fuel directly (i.e. farnesene), and the use of microorganisms to ferment sugars to hydrocarbons that may be hydrogenated to produce the fuel.

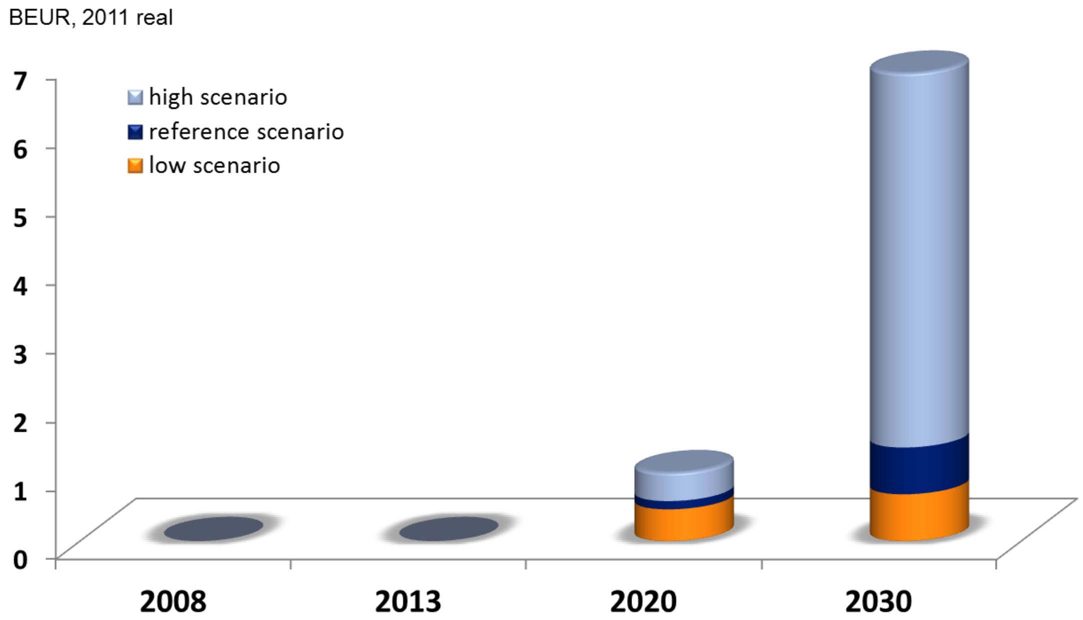
The degree of integration along the value chain depends on both the company and the maturity of a specific technology (early stage development is often focused only on fuel production). Close cooperation and integration throughout the value chain is perceived to be necessary for economically viable production, either through a joint venture or specific project agreement, because then all players share the risks and rewards.

During the past few years, the aviation and biofuel producing industries have been heavily involved in development, testing and standardisation activities related to aviation biofuels. The aviation sector has set ambitious targets for the future. Amongst them, the International Air Transport Association is committed to a 50% reduction of CO_2 emissions by 2050 compared with 2005 levels, and the European Advanced Biofuels "Flightpath" aims at using 2 Mt/year of advanced biofuels in aviation by 2020 (see below).

Flightpath 2050

In 2011, the European Commission and aviation and biofuel producing industries published a Flightpath document on the introduction of advanced aviation biofuels in Europe. The roadmap is a non-binding technical document aiming at setting targets and enhancing co-operation to promote production, distribution, storage and use of sustainably produced and technically certified biofuels. In the roadmap, e.g. the following actions are scheduled to achieve 2 million tons of sustainable biofuels used in the EU civil aviation sector by the year 2020:
1. Facilitate the development of standards for drop-in biofuels and their certification for use in commercial aircrafts;
2. Work together with the full supply chain to further develop worldwide accepted sustainability certification frameworks;
3. Agree on biofuel take-off arrangements over a defined period of time and at a reasonable cost;
4. Promote appropriate public and private actions to ensure the market uptake of paraffinic biofuels by the aviation sector;
5. Establish financing structures to facilitate the realization of 2G biofuel projects;
6. Accelerate targeted research and innovation for advanced biofuel technologies, and especially algae;
7. Take concrete actions to inform the European citizen of the benefits of replacing kerosene by certified sustainable biofuels.
Source: www.ec.europa.eu/transport/modes/air/doc/flightpath2050.pdf

According to recent estimates regarding EU energy, transport and GHG emissions trends to 2050, the EU energy demand for aviation is expected to grow from 52Mtoe in 2013 to 59Mtoe in 2030. However, it is unclear which part of this demand will be supplied through biofuels. Assuming 1%, 2% and 10% biofuel blends in a low, reference and high scenario respectively, the aviation biofuels market could reach between 0.7 BEUR and 6.8 BEUR in 2030.



<u>Vision for aviation biofuels in 2030</u>

In 2030, diverse sustainable feedstocks will be available on a large scale and there will be an established biofuels supply chain in Europe and globally. The EU governments will have supported the scaling-up of aviation biofuels production capacity. Thanks to major efforts in reducing the price for feedstocks (and the concurrent increasing cost for fossil kerosene); the biofuel cost disadvantage will have diminished. However, the cost for CO_2 in EU ETS is not likely to fully cover the price gap compared to fossil kerosene. Therefore, only an international agreement on CO_2 emission reductions in aviation will make it possible to progress towards the goals set in Flightpath 2050. Without such an international agreement (and with severe international hub competition in place), it will be difficult for the market to grow except on a voluntary basis, relying on air passengers' willingness to pay for additional biofuel costs in their ticket prices. Much will depend upon the member states' strategies on transport decarbonisation and allocation of incentive regimes between aviation and road transport.

Drivers for the emerging aviation biofuels market include:

- the growth in demand for air travel,
- the rising cost and cost volatility of kerosene,
- the EU Renewable Energy Directive,
- the inclusion of aviation in the EU emission trading scheme,
- air quality
- airlines' corporate social responsibility policies.

The most important factor appears to be the need to overcome dependency on fossil kerosene both from an economic and environmental perspective. Aviation fuels account for some 40-50% of airline operating costs, and operators in the EU, with higher fuel and operating costs compared to the rest of the world, typically have lower profit margins. Thus the impact of price changes on airline profitability is huge and the identification and use of a more stably priced feedstock is hugely attractive.

Aviation biofuels have the potential to have a superior quality compared to conventional, fossil-derived aviation fuels, for example their better energy/fuel ratio could bring particular advantages in long-haul flights, and the need for engine servicing could be reduced due to cleaner fuels.

Currently, aviation biofuels are substantially more expensive than fossil-based jet fuels, for example HEFA is 2-3 times more expensive than fossil-derived kerosene. In the longer term, aviation biofuels must achieve price parity with conventional aviation fuels. The principal reason why aviation biofuels are so expensive is due to the cost of feedstock. Feedstock costs make up between 50-90% of product costs, and as a result, fluctuations in biomass price can significantly impact upon the final product price. Increasing demand for biomass for chemicals, fuels and energy purposes will potentially increase feedstock prices further.

Aviation biofuels are high volume commodity products requiring very large amounts of feedstock. There is an urgent need to develop better logistics systems for feedstock production and collection in order to provide sufficient biomass for production. Incentives for using straw and other residues are needed to help access these large feedstock reserves or new feedstocks need to be accessed or developed. The ongoing debates on food versus fuel and indirect land use change along with the generally low public acceptance for biofuels are perceived to be barriers to the uptake of aviation biofuels. In addition, demonstrating compliance with sustainability schemes adds further costs.

Aviation fuels must comply with the requirements of ASTM D1655 - 12a Standard Specification for Aviation Turbine Fuels. The specifications can be reached today only by aviation fuels using BtL-FT (biomass-to-liquid via Fischer-Tropsch synthesis), HEFA (hydroprocessed esters and fatty acids process) and renewable Farnesene (Direct Sugars to Hydrocarbons) processing routes. Other aviation biofuels exist, but are not yet commercially available or validated for compliance against ASTM standards.

Several technology hurdles persist. Consistently achieving the high quality requirements needed for use in aviation fuel markets entails a significant cost impact. Many technologies are in development, and innovative new feedstocks and conversion routes have the potential to develop intermediates which need less processing. Algae and yeast can, for example, be genetically modified to produce oils with specific carbon chain lengths and characteristics, and thus potentially reduce the need for downstream processing steps. Support is needed to overcome technology challenges and enable scale-up and process optimization while reducing costs. In particular, new production technologies need to be scaled-up from batch processes to continuous processes, whilst still allowing the final product to meet stringent safety standards. The environmental benefits associated with different aviation biofuels need to be assessed across the production chain in order for development and scale up to be worthwhile.

Additional R&D and funding is needed for aviation biofuels scale-up, and to reduce the overall cost of production. Innovative biofuel projects entail high investment costs. There is little government support for financing large scale plants in Europe and other sources of finance, for example from banks and venture capitalists, have become increasingly difficult to secure, especially for 'first of a kind' plants which carry high financial risk, long payback times and distant exit points. This is compounded by the fact that an unstable political environment and volatile markets do not give certainty to investors. Indeed, some stakeholders even question whether the European Commission is still committed to supporting the European Advanced Biofuels "Flightpath". Strong financial or policy support for scaling-up innovative technologies, along with long-term support for aviation biofuels would be a significant boost for the sector in terms of developing investor confidence. Concerted action between Government and industry in securing product off-take agreements (and hence a finance stream) for projects is deemed crucial for success.

Although aviation is a global business, there are no global regulations and mandates in place promoting the use of biofuels, nor is there an international consensus on regulations that relate to their commercialization. International harmonization is needed to avoid distortions in specific elements of the supply and utilization chain. In particular, it has been suggested that incentives currently given to support alternative fuels for ground transport should be extended to the aviation industry and that the development of electric forms of ground transport could be beneficial as liquid fuels capacity could be then used for aviation as no other alternative fuels exist for the aviation sector.

The table below summarizes the hurdles and some solutions that can be envisaged to overcome the bottlenecks related to aviation biofuels. The hurdles that are highlighted in green apply to aviation biofuels specifically, but are also an issue for IB in general. The white cells apply only to aviation biofuels. The cells that have been left blank indicate that no solution has yet been formulated with regards to that barrier.

Stakeholder engagement is crucial in ensuring that actions are developed which best fit the needs of this sector. The BIO-TIC project would greatly welcome any comments you might have on this document, hoping that your valuable input will contribute to setting the groundwork for a targeted workshop dedicated to advanced biofuels which will be held on 23rd October in London. We are particularly interested in your views on the market projections to 2030, whether we have missed any key hurdles and on any solutions which you could envisage to overcome these hurdles. Please send any comments to bio-tic@europabio.org by end of October 2014.

Short term hurdles	Solution proposed	
	R&D	**Non technological**
Production costs/ Cost, availability, quality and sustainability of feedstock	*-More economical conversion processes with higher yields and less wastage* *-Development of logistics for agricultural feedstocks in order to get biomass to processing plants* *-Increasing the density of agricultural feedstocks on the field* *-Research organisations need to focus their research on new feedstocks and new processes* *-A wider feedstock base would improve feedstock availability and price flexibility*	*-Supply chain certification against the Roundtable on Sustainable Biofuels (RSB) EU RED standard* *-Liberalisation of feedstock markets (leveling the playing field between different end uses)* *-Sustainability and availability of feedstock utilization will require international cooperation*
Low profitability of larger unit operations due to increased logistics costs of sourcing raw material from large areas		
Little governmental support for financing demo and large-scale facilities in Europe		*-Public-private initiatives and co-funding to provide seed capital to overcome financial risks, and enhancement of cooperation between the public and private sector e.g. through PPPs* *-Implementation of more incentives in favour of the feedstock supply chain (e.g. Renewable Transport Fuel Certificates; incentives for farmers and the forestry industry to collect material; incentives to support biomass production on non-agricultural land e.g. willow)*
Food versus fuel utilization of biomass		*-Joint fact finding with NGOs and researchers can contribute positively to the food vs. fuel debate (e.g. Dutch food-fuel debate document signed by 32 organisations)*
High feedstock prices as a result of regulatory framework		*-Simplification of procedures to lower the costs to bring product on the market e.g. biobased kerosene* *-Implementation of global regulation and standards for the*

		feedstock *-Implementation and harmonization of blending requirements*
Customer base limited due to high price	*-Lower production costs, lower feedstock costs*	*-Government subsidies* *-Fuel tax for fossil kerosene* *-level the playing field on incentives between ground and aviation fuels*
Insufficient infrastructure for collection of agricultural residues		*-Use rural development funds to support access to machinery and infrastructure* *-Development of Public Private Partnerships to upscale biorefineries* *-Implement better conditions for loans* *-Development of infrastructure for the logistics of the supply chains* *-By-products and waste from (second generation) ethanol production can be used for the production of secondary and potentially high value added products. This would solve part of the logistics problem (feedstock and use of waste).*
Underdeveloped markets		*-Encourage off take agreements between producers and end users. This will also encourage investment.* *-Optimization of broad spectrum product to yield highest value*
Lack of incentives/legislation pushing aviation biofuels		*-EU needs to create concrete policies to support aviation biofuels e.g. subsidies* *-Aviation biofuels could be included in the road transport biofuel mandates* *-Creation of synergies between mandates and classifications on biofuels* *-Global actions* *-Promotion of public support and aggregated demand e.g. Corporate Biofuel Program where companies can choose to fly on sustainable biofuel*

Lack of R&D funding	*Increasing R&D funding at EU, national and regional level for pioneering public research in collaboration with the industrial sector in a co-funding scheme*	*-Implementation of a public and private funding scheme*
Heavy EU regulations and certifications, especially regarding feedstocks		*-Simplified procedures*
Lack of IB knowledge		
Lack of R&D for scale up		

Medium term hurdles	**Solution proposed**	
	R&D	**Non technological**
Lack of financing/High capital investments		*-Government support for scaling up and deployment*
Lack of long term stable policy framework		
Acceptance of GM		*-Develop a communications strategy addressing:* *1/Mobilization of intermediary associations (e.g. NGOs, umbrella organisations) to promote biobased products based on scientific fact finding.* *2/Involvement of all stakeholders (including the media & consumers) in innovation projects from the beginning*
Lack of public acceptance for biofuels		*-Organization of communication and dissemination activities to the public at large on the benefits biofuels and disadvantages of fossil fuels to raise awareness and to change the opinion and the cultural behavior.* *-Implementation of educational programmes, and specific educational activities targeted at the secondary school level.*

Long term hurdles	**Solution proposed**	
	R&D	**Non technological**
Limited capacity of plants in the future	*Address R&D challenges*	