



CAAIFI – CORE-JetFuel Cooperation Workshop

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Discussion Panel I: Supply Chain Development and Deployment of Alternative Fuels

Moderation: Nate Brown, María de la Rica

We have seen a significant number of initiatives and programs to develop the supply chain of biojet which are currently ongoing in the US and the EU. In order to achieve significant levels of deployment all the parts of the supply chain need to be well coordinated so that significant volumes of use are reached.

- *What lessons can we learn from the biofuel policy for road transport in the EU and the US that could benefit deployment of aviation alternative fuels?*
- *Alternative fuels for road, marine and air transport need to be at a level playing field both at level of development and as well as in regulations. What political actions are required to close the gap in terms of development in both regions?*
- *Currently, there are demonstration projects for alternative jet fuels in both regions, but we need to go from demonstration level to regular commercial use with the current aircraft fleet in order to reach goals set for significant use of biofuels. Among other barriers, fuel price is one of the most important. What strategies exist to overcome this barrier regarding the production cost?*
- *Other barriers may concern European or worldwide accepted reference rules for LCA balance calculation or biomass availability in the energy field. What are the barriers beyond production cost and what strategies exist to address them?*
- *What do you think are the main drivers that have helped to achieve the latest developments in terms of certification of new fuels? How important is the role of the governments in this regard? How else can the government contribute to a faster and more efficient deployment?*

- *We have lately seen the promotion of voluntary off-take agreements (such as the agreements between United and Altair; Alaska and Gevo; Southwest, Fedex and Redrock Biofuels; Cathay Pacific Airways and Fulcrum Bioenergy and the flights performed by KLM within the ITAKA project). The existence of these initiatives is an important step towards a higher level of deployment. What circumstances made these possible? What actions can we collectively take so that these and future initiatives will be further encouraged and successful?*

- *Feedstock availability is a very important issue in the Supply Chain. Considering the volumes eventually needed for alternative fuel, what strategies can ensure enough biomass is available for production of the current demand of the biochemical industry and in all sectors?*

- *In order to bring about the creation of a new industry conventional wisdom suggests that an enabling environment needs to be in place that includes public investments and policies, financial and physical infrastructure, and private sector investment and purchasing. How have we done on achieving this enabling environment for alternative jet fuel? What elements of this formula are in place in the EU and the U.S.? What elements are missing in the EU and the U.S.?*

Discussion Panel II: Promising production technologies and value chains

Discussion Topics - DRAFT

MODERATION: ZIA HAQ, U.S. DOE AND ALAIN QUIGNARD, IFPEN / ANDREAS SIZMANN, BAUHAUS LUFTFAHRT

The aviation industry has set ambitious targets to reduce its environmental footprint, the reduction of greenhouse gas (GHG) emissions being the most crucial one.

As future technological and operational improvements, leading to higher fuel efficiencies, are likely to continue to be outpaced by the expected growth in air traffic, large-scale utilization of sustainable fuels is envisioned to play a vital role in the medium- and long-term future in the aviation sector's quest for reducing its GHG emissions. In order to reduce GHG, a lot of routes were and are in development, mainly based on biomass, but not only.

Looking at the complicated production pathways towards renewable fuels in a fast moving world from a lot of feedstock and a lot of primary conversion/refining processes, pose a lot of challenges, with a many scientific, technical, environmental and economic issues. All these issues have to be addressed carefully under the statement that future large-scale deployment of alternative aviation fuels shall be realized **in a sustainable and economically viable way**. To date, the only industrially developed value chain yielding renewable jet fuels depends on biogenic oils (triglycerides), used cooking oils and fats as feedstock, through the Hydroprocessing (HEFA) route. We are still only at the very early commercial stage with several long term production and demo flights since 2011: i.e.:

- the burnFAIR project with the first 6 months A321 flight trial corresponding to 1187 flights using 1560 t biojet by Lufthansa on the Hamburg-Frankfurt-Hamburg route, four times daily, and using a 50/50 blend SPK-HEFA (produced by Neste from jatropha (15%), camelina (80%) and animal fats (5%)) / fossil jet fuel or,
- very recently under the European Union's Itaka project at Oslo airport with 80 biofuel KLM flights over five to six weeks using a Cityhopper Embraer E190 operating from Oslo to Amsterdam and also using a 50/50 blend SPK-HEFA (also produced by Neste mainly from camelina) / fossil jet fuel,

with the very early beginning of true commercial flights for the long term: i.e. March 2016 with the launching by United of multiple daily Boeing 737 flights from LAX a 30% blend of HEFA biofuel produced by Altair and conventional jet fuel.

There are also several pathways (*refer to Annex*) under development close to the industrial development and yet certified, such as the BtL Gasification + FT route (FT-SPK), route using fermentation as a preliminary conversion of the biomass followed by a refining step (mainly based on sugars) such as the certified SIP (Total-Amyris/Synthetic Iso-paraffin from hydroprocessed fermented sugars route or the very recently certified ATJ-SPK route (Gevo) from isobutanol oligomerization to iso-C12 and iso-C16.

Other are on the road to ASTM certification such as Green Diesel /HFP HEFA (yet at industrial level since it may use existing HEFA units) or the catalytic hydrothermal conversion of triglycerides and animal fats followed by an iso-conversion process: BIC process Applied Research Associates (ARA) / Chevron Lummus Global (CLG), producing a renewable jet fuel with a similar chemical structure to petroleum based jetfuel.

For the medium/longer term, there are also a lot of other routes at pilot plant level such as using a 1st biomass to biooil/biocrude step followed by a final refining using hydrothermal conversion (Licella), catalytic/non catalytic fast pyrolysis or hydrolysis. There are also pathway using another 1st step conversion base on Aqueous Phase Reforming or APR –Shell/Virent) with the APR-SK/SAK route under ASTM certification process. There are also fermentation routes that are not based on biomass but on industrial waste gas (rich in CO, CO₂), such as the one proposed by Lanzatech (also under ASTM certification process).

For the long term there are also very innovative routes such as the Power to Liquid (PtL) and Sun to Liquid Pathways pathways.

There are a lot of pathways and it is not easy to get a comprehensive view, as well as to try to choose between all these routes for the future.

Draft list of items and questions for Panel II

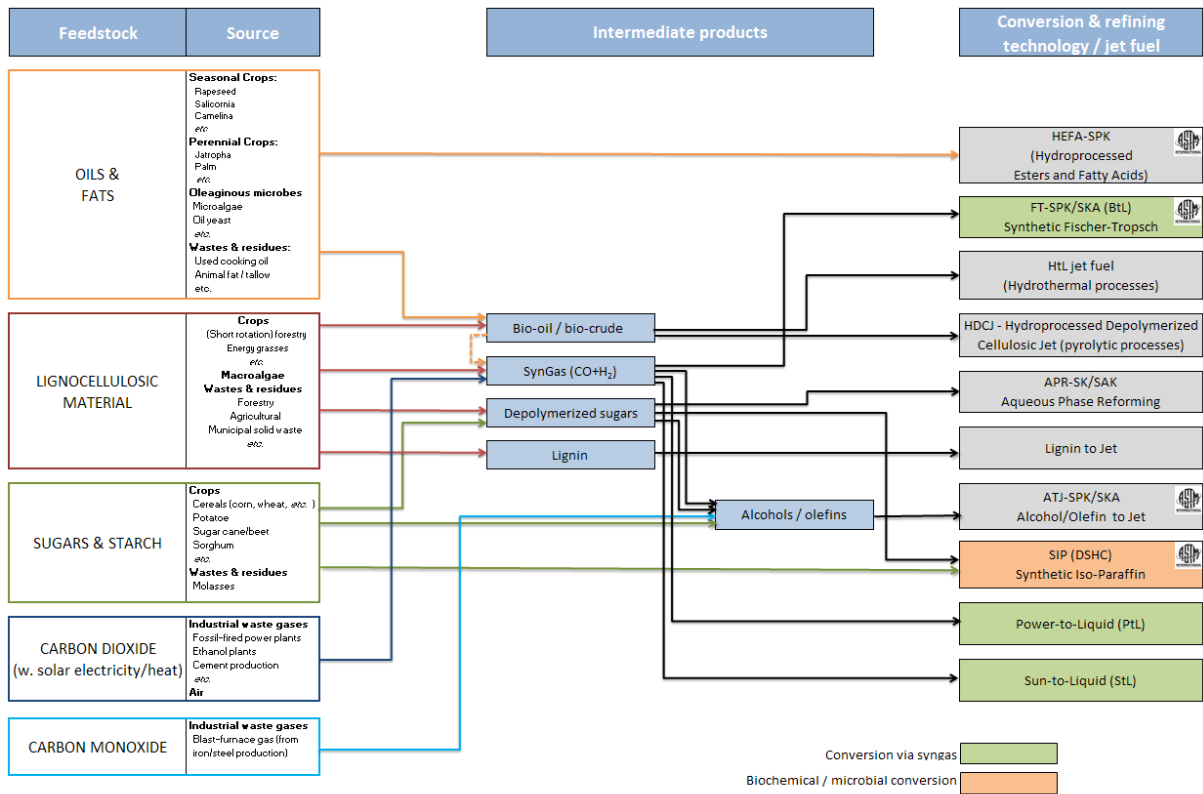
1. ASTM D5054 Certification and alternative fuel chemical structure

- *How make certification shorter and how to decrease the cost, for example by using the feedback of the 5 previous certification (Annex A1 to A of ASTM D7566-16 Standard) ?*
- *What about the maximum alternative fuel allowed in the final blend (50% for FT-SPK; HEFA SPA and FT-SPK/A, 10% for SIP, 30% for ATJ-SPK from isobutanol).*
 - o *How to define the limit ?*
 - o *Why so many different limits ?*
 - o *What about alternative fuels without a continuous distillation curve (SIP, ATJ-SPK) ?*
- *Currently certified alternative fuels are mainly based on isoparaffins: what about fuels mimicking the existing fossil jet fuels with n-paraffins, iso-paraffins, naphthenes and a limited amount of aromatics but without sulfur (such as though the ARA/GLG BIC process) ?*
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- *What about the blending rules and possible advantages/disadvantages, when blending alternative fuels with petroleum based fuel depending on the chemical structure of both component fuels as well as different distillation curves?*
 - o *? Why using it at 100% ?*

2. Conversion + refining pathways to alternative jet fuels

In a perfect world, a very flexible process that could converted any type of feedstock at an acceptable cost and with a high yield into biofuels (even including a high selectivity toward jet fuel) should be a must. But this perfect process does not exist in the real life, so the best routes could be the routes closest to this perfect process and the questions are:

- *When looking at the numerous types of pathways (refer to Annex), could we make recommendations for some families based on technical/scientific, environmental, economic issues as well as biomass availability and sustainability?*
- *How to “classify” these routes regarding risk and rewards?*
 - o *What tools ?*
 - o *What parameters using related to economics, GHG saving, industrial risk, flexibility of the process related to feedstock type and availability, etc...?*
 - o *How to manage and to take into account uncertainty in order to make comparison, taking into account a reasonable level of uncertainty ?*
- *Can we very roughly predict what should be the best routes (in terms of industrial development, blending with petroleum based fuels, economics and GHG emission gain) ? How can we do?*



Discussion Panel III: Sustainability

Discussion Topics

Moderation: Johannes Michel, Nancy Young

The aviation industry has set ambitious targets to reduce its environmental footprint, the reduction of greenhouse gas (GHG) emissions being the most crucial one.

As future technological and operational improvements, leading to higher fuel efficiencies, are likely to continue to be outpaced by the expected growth in air traffic, large-scale utilization of sustainable fuels is envisioned to play a vital role in the medium- and long-term future in the aviation sector's quest for reducing its GHG emissions.

Looking at different production pathways towards renewable fuels, feedstock production and conversion in particular pose several challenges that have to be addressed carefully if the future large-scale deployment of alternative aviation fuels is to be realized in a sustainable and economically viable way. While other alternative jet fuel pathways using a variety of feedstocks are starting up, to date, the only industrially developed value chain yielding commercial quantities of renewable jet fuel depends on biogenic oils and fats (triglycerides) as feedstock.

However, this production pathway is viewed critically by some in terms of its sustainability. Plant oils are valuable feedstocks that can have various competing uses, including food production. Furthermore, cultivation of oil crops can be input-intensive while, in many cases, offering only low to moderate specific yields. Some oleaginous crops, e.g., soy bean and oil palm, have been associated with serious land-use changes. Although these arguments are often countered by the view that feedstocks are not inherently sustainable or unsustainable, but that sustainability is rather a question of the applied agricultural practice, the European Commission will nevertheless stop funding biofuels based on triglycerides post 2020, whereas the United States has not proposed any such restrictions on biofuel funding.

1. Environmental Sustainability Criteria

While the term "sustainability" encompasses environmental, social, and economic aspects according to many frameworks, for purposes of this discussion, we are focusing on environmental sustainability. Obviously, the assessment of GHG lifecycle emissions is a critical environmental sustainability criterion.

- *Recognizing that various countries and regions may have different environmental criteria and priorities, what do you view as the top two environmental criteria in addition to lifecycle GHG emissions that should be addressed for confirming that aviation alternative fuels are sustainable?*
- *How to properly credit the GHG emissions reductions from aviation alternative fuels has been a big area of discussion and work in the ICAO work to develop a global market-based mechanism (GMBM) for international aviation. ICAO's Committee on Aviation Environmental Protection (CAEP) has developed a proposed methodology that all countries would use for determining lifecycle GHG emissions from alternative aviation fuel for purposes of the GMBM. Some in the ICAO discussions take the view that a minimum lifecycle emissions-savings threshold should be established (e.g., 50% or greater emissions reductions) if any credit is to be given. Others take the position that whatever emissions savings are demonstrated under the agreed methodology should be credited. What are the pros/cons of specifying a minimum threshold?*

2. Renewable Feedstock Potentials

When developing targets and roadmaps for the utilization of renewable fuels in aviation, it is crucial to consider the production potentials in order to assure that the targets are not over-ambitious and exceeding the potentials.

In Europe, there is an ongoing scientific and political discourse regarding the sustainable biomass potential that is available for the production of alternative aviation fuels – also taking into account competing uses such as the automotive as well as the heating and cooling sector.

- *Do you think that a diversification of feedstock sources coupled with good agricultural practices in the cultivation stage will be sufficient for meeting the GHG reduction targets of the aviation sector while safeguarding sustainability?*
- *Which types of feedstocks (algae, residues/wastes, lignocellulosic energy crops etc.) offer the highest sustainable potential in the US?*

3. Lignocellulosic biomass

Lignocellulosic biomass ranging from fast growing woody types such as willow and poplar to agricultural and forestry residues are promising feedstock sources for the production of bio-kerosene. The utilization of some types of lignocellulosic feedstocks is already established for bioenergy applications, inter alia for the production of so-called advanced biofuels.

Particularly the fact that production of lignocellulose does in most cases not compete with food production (or the arable land the feedstock is cultivated on) and therefore shows a low risk of inducing indirect land use changes, which is seen as one of the main advantages of this type of biomass compared to conventional energy crops. However, converting lignocellulose in an effective and efficient way is still one of the main challenges both from a technological and economically viable point of view.

- *Are similar challenges noticeable in the US? How is the utilization of lignocellulose as a bio-jet feedstock progressing?*
- *Particularly in the case of lignocellulose, logistical barriers (collection of biomass and transport distances) may hinder the economic viability of utilizing this type of feedstock for bio-jet production. What measures would you recommend to overcome these obstacles?*
- *Agricultural / forestry **wastes and residues** become an increasingly interesting feedstock option for the aviation sector, as making them available is comparably cheap and according to the RED emission-free.*
 - o *Considering the relatively low profit margin bio-kerosene achieves in comparison to other bioenergy applications as well as its demanding certification process, what kind of measures would you recommend motivating feedstock and fuel producers supplying the aviation industry with their respective product?*

4. Sustainability Certification

Stakeholders from politics, industry and academia have often voiced the need for a harmonization of sustainability criteria in the RED and RFS2, for example with respect to the different land conversion restrictions. (Under RFS2, land on which feedstock is cultivated must have been to be cleared prior to Dec 19, 2007 and maintained for this purpose since. RED uses the date of January 2008 for its land conversion restriction).

- *Are there relatively easy measures (such as agreeing on a common reference date for a land conversion restriction provision) that could help foster trade of sustainable feedstocks and therefore positively impact on the deployment of alternative fuels, both in the US and the EU?*
- *In which (additional) areas of alternative aviation fuels would you recommend stronger cooperation / where would it make sense in your point of view?*

Discussion Panel IV: Stakeholder Initiatives for Alternative Aviation Fuels – Progress and Perspectives

Discussion Topics

Moderation: Steve Csonka, Rainer Janssen, María de la Rica

Stakeholder initiatives, both at coordination level and at specific deployment level are proving to be a fruitful source of information sharing, source of new projects and ideas for future off-take agreements and actual deployment of alternative fuels at small scale. The state of maturity of the market is currently low, and therefore Stakeholder Initiatives will still have a key role in discussing how to achieve a higher level of market maturity.

At European Level, the European Advanced Biofuels Flightpath was created with the objective of getting sustainably produced biofuels to the market faster through the construction of advanced biofuels production plants and to get the aviation industry to use 2 million tons of biofuels by 2020. Currently, the policy status in alternative fuels in Europe is under transition, with the objective of moving towards renewable fuels that minimize land use change. This will require an update to the objectives set in the Biofuels Flight Path and therefore the continuation of the Stakeholder collaboration.

In addition to initiatives at European level, national initiatives in Europe have a strong weight in promoting specific projects. Initiatives such as Bioport Holland and Lab'Line for the Future in France help to gain experience in actual value chain deployment and are fundamental to understand how the value chain can be improved to get higher levels of efficiency. Additionally, initiatives like Aireg in Germany, Biokeroseno in Spain or Nisa in the Nordic countries have also contributed to provide the means for networking and coordination that have contributed to produce and carry out demo flights.

Future of the European Flightpath and CAAFI initiatives

The European 2030 framework for Climate and Energy sets a binding target of 27% of renewable energy in the European energy mix by 2030 and a 40% greenhouse gas emissions reduction target to which the aviation community wants to contribute. No specific alternative fuel use objectives are set for transport, meaning that the R&D and demo support will probably have a bigger weight in incentivizing deployment for alternative fuels at European level. For this reason, the HORIZON 2020 - Work Programme 2016 – 2017 will launch a new call for tender to provide an update and renewed approach to the 2011 Biofuel Flight Path. This will require to set-up a framework involving key stakeholders in the field covering production, distribution and use of renewable fuels that will cover topics such as R&D, sustainability, industrial production, legal framework and financing mechanisms.

- *How are the current low oil prices affecting the initiatives within the stakeholder groups?*
- *What should be the priorities of both stakeholder initiatives in the near future? What should be considered as a key element in the renewed approach to the European Biofuel Flight Path? What about CAAFI?*
- *Price gap is currently the main barrier to deployment but other factors such as feedstock availability and sustainability assurance are issues that for which the final users, the airlines, are concerned. Which means do we have to overcome the barrier of high fuel price for deployment in the EU and the US?*
- *The establishment of Public-Private-Partnerships was seen as one of the fundamental ways forward to create small local value chains and learn about the barriers to overcome. Are there any exemplary experiences in the US in this regard? In Europe, how important are the national initiatives? How important is institutional support to achieve these agreements?*
- *Stakeholders have generally agreed that a stable policy framework that creates market stability is fundamental to incentivize investments. What lessons can be learnt in the US and in Europe in this regard from the RFS and the EU RED?*