Coordinating research and innovation in the field of sustainable alternative fuels for aviation

WP3: International Expert and Stakeholder Exchange
Deliverable 3.10: Report on Strategy Workshop

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Coordinating research and innovation in the field of sustainable alternative fuels for aviation

Deliverable 3.10:
Report on Strategy Workshop

SUBMITTED VERSION 1.0

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Work Package 3: International Expert and Stakeholder Exchange
Work Package Leader: WIP Renewable Energies

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EXECUTIVE SUMMARY

The CORE-JetFuel Strategy Workshop on “Policies and Value Chains for Large-scale Deployment of Alternative Aviation Fuels” was organized on occasion of the IEA Bioenergy Conference in Berlin on the 29th of October 2015.

At this event preliminary results obtained from the assessments conducted in the CORE-JetFuel project were presented and discussed with the invited experts. The focus of the panel discussions was placed on the development of supportive policies and regulations as well as the establishment of sustainable value chains that have the potential to lead towards a large-scale market up-take of alternative aviation fuels at reasonable fuel production costs.

The first panel discussion on ‘polices and deployment’ mainly addressed means to overcome high fuel prices in order to trigger deployment of alternative jet fuels as well as the question, which policy measures are needed to incentivize the use of bio-kerosene while considering lessons learnt from the road transport sector.

The establishment of supply chains by involving all relevant stakeholders and sharing the (additional) costs between them as well as establishing Private-Public-Partnerships (such as the BioPort Holland) were seen as important steps to overcome the price barrier mentioned above. In addition, the panelists considered stable and long-term policy frameworks that ensure good Greenhouse Gas emission balances of advanced biofuels and the implementation of integrated biomass policies that address competing uses, prioritization as well as cascading uses of the sustainably available biomass as crucial policy actions for paving the way for the (commercial) deployment of alternative aviation fuels.

The second panel on ‘feedstock, sustainability and conversion technologies’ discussed the availability of sustainable feedstock in Europe as well as potentially promising roadmaps for renewable fuel production pathways.

With respect to sustainable feedstock availability the panelists agreed that competing uses of biomass in established industries pose a major challenge for sourcing alternative aviation fuels from renewable feedstocks, particularly as feeding the world must have priority and indirect land uses changes, the accompanying emission of Greenhouse Gases as well as other negative impact of feedstock production must be minimized.

As far as promising production pathways are concerned, the panelists agreed that HEFA technologies will remain the only viable option to produce significant quantities of bio-kerosene in the near term. In addition, cooperation with the petrochemical industry should be established in order to co-process biogenic feedstock in efficient bio-refineries. In addition, the potential of Power-to-Liquid technologies based on renewable electricity further explored.

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
ATAG	Air Transport Action Group
CAAFI	Commercial Aviation Alternative Fuels Initiative
CAEP	Committee on Aviation Environmental Protection
C-JF	CORE-JetFuel - Coordinating research and innovation in the field of sustainable alternative fuels for aviation
CO_2	Carbon Dioxide
DBFZ	Deutsches Biomasseforschungszentrum
DG	Directorate General
EC	European Commission
ETS	Emission Trading Scheme
EU	European Union
FT	Fischer-Tropsch
GHG	Green House Gas
HEFA	Hydro-processed Esters and Fatty Acids
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ILUC	Indirect Land Use Change
LCA	Life Cycle Assessment
MSW	Municipal Solid Waste
NGO	Non-Governmental Organization
R&D	Research and Development
RED	Renewable Energy Directive
RES	Renewable Energy & Sources
RFS	Renewable Fuel Standard
RIN	Renewable Identification Number
RSB	Roundtable on Sustainable Biomaterials
RTD	Research and Technological Development
SUSTAF	Sustainable Alternative Fuels

Background - The CORE-JetFuel Project

For a number of ecologic and economic reasons, the aviation industry is highly interested in alternative fuels. Highly ambitious goals for the reduction of the sector's overall greenhouse gas emissions set from industry and politics imply sustainable alternative fuels as an important contribution. To meet the high expectations research and innovation efforts are required in order to develop pathways for an economically feasible large-scale production of such fuels for aviation.

The transformation of its energy base from fossil fuels to a secure supply of renewable, climate-friendly, sustainable and sufficiently scalable alternative fuels represents a tremendous challenge for aviation. Many different types of renewable feedstock, most prominent biogenic materials (biomass), and various kinds of conversion technologies can be utilised for the production of alternative jet fuel.

Objectives

The CORE-JetFuel project supports the European Commission in its dynamic and informed implementation of research and innovation projects in the field of sustainable alternative fuels for aviation. It links initiatives and projects at the EU and Member State level, serving as a focal point in this area to all public and private stakeholders. CORE-JetFuel addresses competent authorities, research institutions, feedstock and fuel producers, distributors, aircraft and engine manufacturers, airlines and NGOs. The project is aimed to set up a European network of excellence for alternative fuels in aviation that brings together technical expertise from all across this complex thematic field and helps to coordinate R&D as well as implementation efforts.

More information can be found on the CORE-JetFuel official website: www.core-jetfuel.eu

Stakeholder involvement

CORE-JetFuel ensures cooperation with other European, international and national initiatives and with the key stakeholders in the field. The benefits are enhanced knowledge of decision makers, support for maintaining coherent research policies and the promotion of a better understanding of future investments in aviation fuel research and innovation.

In order to ensure efficient involvement of international experts and stakeholders in the coordination of research and innovation throughout the duration of the project, four stakeholder working groups are established on the following topics.

- WG1: Feedstock and sustainability
- WG2: Radical concepts and conversion technologies
- WG3: Technical compatibility, certification and deployment
- WG4: Policies, incentives and regulation

Introduction – Workshop Background

This event was organised in the framework of the project CORE-JetFuel (www.core-jetfuel.eu) supported by the European Commission in the 7th Framework Programme. The CORE-JetFuel project supports the EC in its dynamic and informed implementation of research and innovation projects in the field of sustainable alternative fuels for aviation. CORE-JetFuel addresses competent authorities, research institutions, feedstock and fuel producers, distributors, aircraft and engine manufactures, airlines and NGOs. The project is aimed to set up a European network of excellence for alternative fuels in aviation that brings together technical expertise from all across this complex thematic field and helps to coordinate R&D as well as implementation efforts.

At this event preliminary results from the CORE-JetFuel project were presented and discussed with focus on the **development of supportive policies and regulations** as well as the **establishment of sustainable value chains** that promise (from preliminary assessment) to lead towards a large-scale market up-take of alternative aviation fuels at reasonable fuel production costs.

This workshop took place on the occasion of the **IEA Bioenergy Conference 2015** on 27-29 October 2015 in Berlin, Germany (https://ieabioenergy2015.org/).

1 Opening Session

The CORE-JetFuel Strategy Workshop "Policies and Value Chains for Large-scale Deployment of Alternative Aviation Fuels" in Berlin on 29 October 2015 was opened by **Rainer Janssen**, WIP Renewable Energies. This CORE-JetFuel event is a follow-up on two successful CORE-JetFuel workshops, namely the Sustainable Aviation Fuels Forum (SAFF) in Madrid on 20-22 October 2014 and the CORE-JetFuel Stakeholder Workshop "Sustainable Alternative Aviation Fuels - Innovative conversion technologies and deployment" in Vienna on 1 June 2015.

Johannes Michel, coordinator of the CORE-JetFuel project, Fachagentur Nachwachsende Rohstoffe e.V. (FNR), Germany presented an overview of activities and results of the CORE-JetFuel project. Mr. Michel first introduced to the auditorium the main objectives of the project, namely to:

- Develop and implement a strategy for sharing information, for coordinating initiatives, projects and results
- Identify needs in research, standardisation, innovation and policy measures at European level
- Evaluate the research and innovation “landscape” with collection of the lessons learned in order to support decision makers in setting priorities for the European funding strategy.

The CORE-JetFuel working methodology consists of ***collection*** (information gathering), ***mapping*** of data and results from identified projects, as well as ***analysis/evaluation*** of

gathered information and mapped projects/technology pathways. Thereby, the analysis of alternative fuel technologies requires a multiple-criteria approach applying three key ("high-level") criteria for alternative aviation fuels: Suitability (e.g. "Drop-in" capability), Scalability (e.g. production potential), and Sustainability (e.g. GHG Emission reduction potential).

After presenting intermediate project results with respect to the four thematic domains (feedstock & sustainability, conversion technologies, deployment & certification, policies & regulations), Mr. Michel highlighted the importance of international stakeholder exchange for the success of the CORE-JetFuel initiative. All workshop participants were cordially invited to join the fruitful discussions and contribute to a vivid exchange of ideas and knowledge within the present workshop.

The EU perspective on renewable fuels for aviation was presented by **Remy Denos**, DG ENERGY, European Commission. In his introduction Mr. Denos recalled the targets of the EU climate and energy policy, namely the ***binding targets for 2020***: 20% GHG emission reduction (compared to 1990) and 6% GHG emission reduction in transport (compared to 2010), 20% share of RE in EU energy consumption and 10% RE share in transport, 20% improvements in energy efficiency; and the ***targets for 2030***: 40% GHG emission reduction (compared to 1990, binding), 27% share of RE (binding at EU level only, no sub-target for transport), 27% improvements in energy efficiency.

Recently, the so-called "ILUC Directive" (Directive 2015/1513), amending the Fuel Quality Directive (98/70/EC) and the Renewable Energy Directive (2009/28/EC), was published including the following main issues:

- Renewable transport fuels of non-biological origin
- 1st generation biofuels capped to 7%
- Member States to report about Indirect Land Use Change
- Indicative target of 0.5% of advanced biofuels (advanced biofuels count double)
- Transposition deadline: 10/09/2017
- In the case of suppliers of biofuels for use in aviation, Member States may permit such suppliers to choose to become contributors to the reduction obligation provided that those biofuels comply with the sustainability criteria.
- Installation starting operation after 5 October 2015 shall produce fuels with at least 60% of GHG savings.

The EU Emission Trading Scheme (ETS) was initiated in 2005 with the aim to "cap and trade" GHG emissions. Since 2012 aviation is included in ETS (Directive 2003/87/EC). Due to the present low effectiveness of ETS in reducing GHG emissions, for the time beyond 2020 the overall number of emission allowances will decline at an annual rate of 2.2% from 2021 onwards, compared to 1.74% currently.

Up-coming policy initiatives include the UNFCCC conference in December 2015 in Paris. In summer 2016 the EC will propose legislation to achieve the greenhouse gas reduction target as well as a communication on decarbonisation of transport. By the end of 2016, the EC will propose a new Renewable Energy Package including a new policy for sustainable biomass and biofuels.

In 2012 biofuels consumption in the EU was 14.5 Mtoe (mainly biodiesel and bioethanol) which accounted for 5.3% of transport energy consumption. This total amount represents about 30% of the about 50 Mtoe final energy consumption of the air transport sector. Thereby, GHG emissions from the aviation sector (incl. international bunkers) represent 12.8% of transport GHG emissions or 2.5% of total emissions.Past and on-going initiatives at EU level include coordination projects (BIOJETMAP, CORE-JetFuel and Forum AE), research projects (DREAM, Alfa-Bird, SWAFEA, Solar Jet) and demonstration projects (ITAKA, BIOREFLY, BFSJ). On policy level initiatives include EuroCAEP, ACARE WG3 and the European Advanced Biofuel Flight Path Initiative which is part of the European Industrial Bioenergy Initiative (EIBI) of the EU SET-Plan and specifies a production target of 2 million tons of biofuels blended with kerosene per year by 2020 (i.e. ~4% of current volumes). Until today, however, achievements towards this target are negligible.

Mr. Denos also highlighted opportunities presented in the Horizon 2020 work programme 2016 & 2017, namely under topics LCE-20-2016-2017 “Enabling pre-commercial production of advanced aviation fuels” and MG-1.1-2016 “Reducing energy consumption and environmental impact of aviation”. Furthermore, the EC will publish a tender on “Coordination of renewable fuel stakeholder's strategy in the field of aviation” in the first quarter of 2016.

A comparison of the current status of renewable fuels for surface transport and aviation is presented in Figure 1 highlighting the main differences and pointing out challenges faced by the aviation sector.

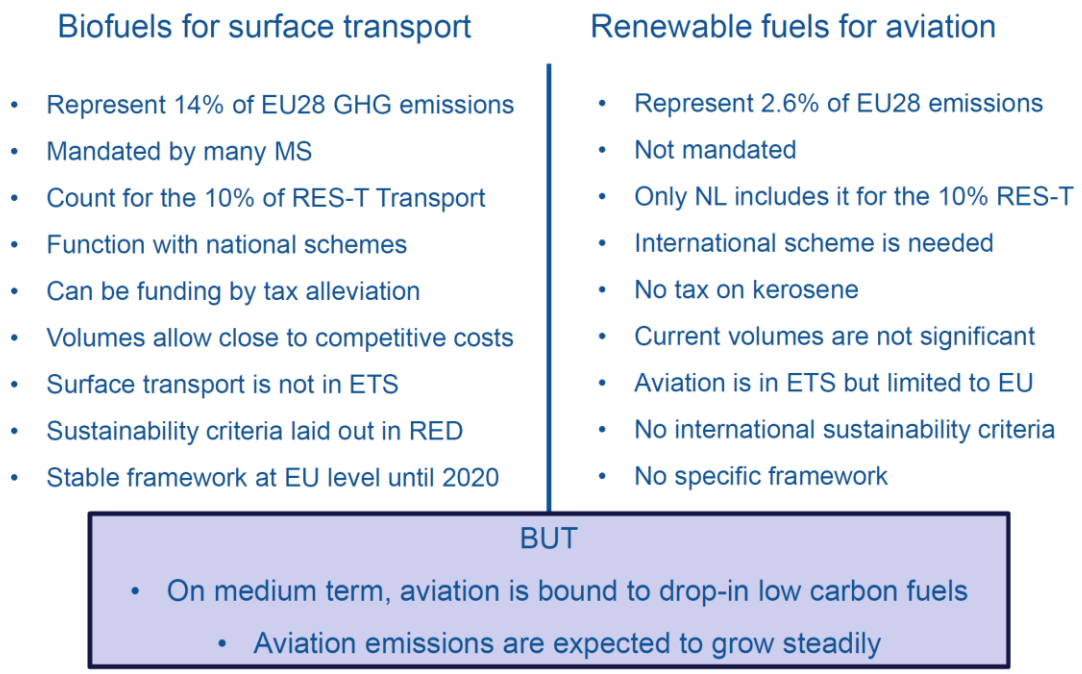

Figure 1: Renewable fuels for surface transport and aviation

In conclusion, for the “way forward” Mr. Denos stated the importance of further activities in the areas RTD, demonstration and scaling-up entire value chains. Additional production pathways for alternative aviation fuels need to be certified and sustainability criteria need to be harmonised at international level. Finally, with respect to economics market based measures are being discussed at ICAO. But in the current period of transition, smart solutions need to be found to fund extra costs of biofuels towards production volumes of >100 000 tons/y.

2 Chapter Panel Discussion on “Policies and Deployment”

Moderation

- Maria de la Rica Jiménez, SENASA
- Alain Quignard, IFPEN

Panelists:

- Remy Denos, European Commission, DG Energy
- Matthias Spoettle, ECOFYS, Germany
- Thomas Roetger, International Air Transport Association (IATA)
- Adam Brown, International Energy Agency (IEA)
- Martin Porsgaard, NISA, Denmark
- Philippe Marchand, TOTAL New Energies, France
- Carlos Calvo Ambel, Transport & Environment (T&E), Belgium

2.1 Introduction

Maria de la Rica Jiménez, SENASA and **Alain Quignard**, IFPEN presented preliminary recommendations derived from the following policy related activities within the CORE-JetFuel project:

- Analysis of existing legislation and their impacts on different regions
- Analysis of policies applied worldwide considering specificities of aviation
- Analysis of the differences between these different legislations (e.g. EU RED and US RFS, and existing barriers to deployment)
- Creation of a data base of the current certification and deployment status
- Identification of most promising pathways
- Elaboration of recommendations on actions to be taken on EU level

The following main differences between RED and US RFS have been identified:

- No consensus on sustainability criteria
- Certification and auditing (RED: independent audit through national/voluntary schemes, other means for enforcement within RFS)
- Both establish minimum amounts of production
- Different LCA methodologies (RFS relies on EPA default value calculations, EU RED allows actual values)
- Differences in the fossil fuel comparator

With respect to certification and deployment, until today three production pathways have been certified (FT-SPK, HEFA, DSHC/SIP) whereas ATJ-SPK and Green Diesel are close to certification. However, there will be no unique production pathway for alternative aviation fuels as all pathways face challenges such as low and regionally specific feedstock availability, low matureness level, high price, environmental impacts as well as use competition with other transport modes. Therefore, within CORE-JetFuel a large variety of pathways will be analysed (see Figure 2).

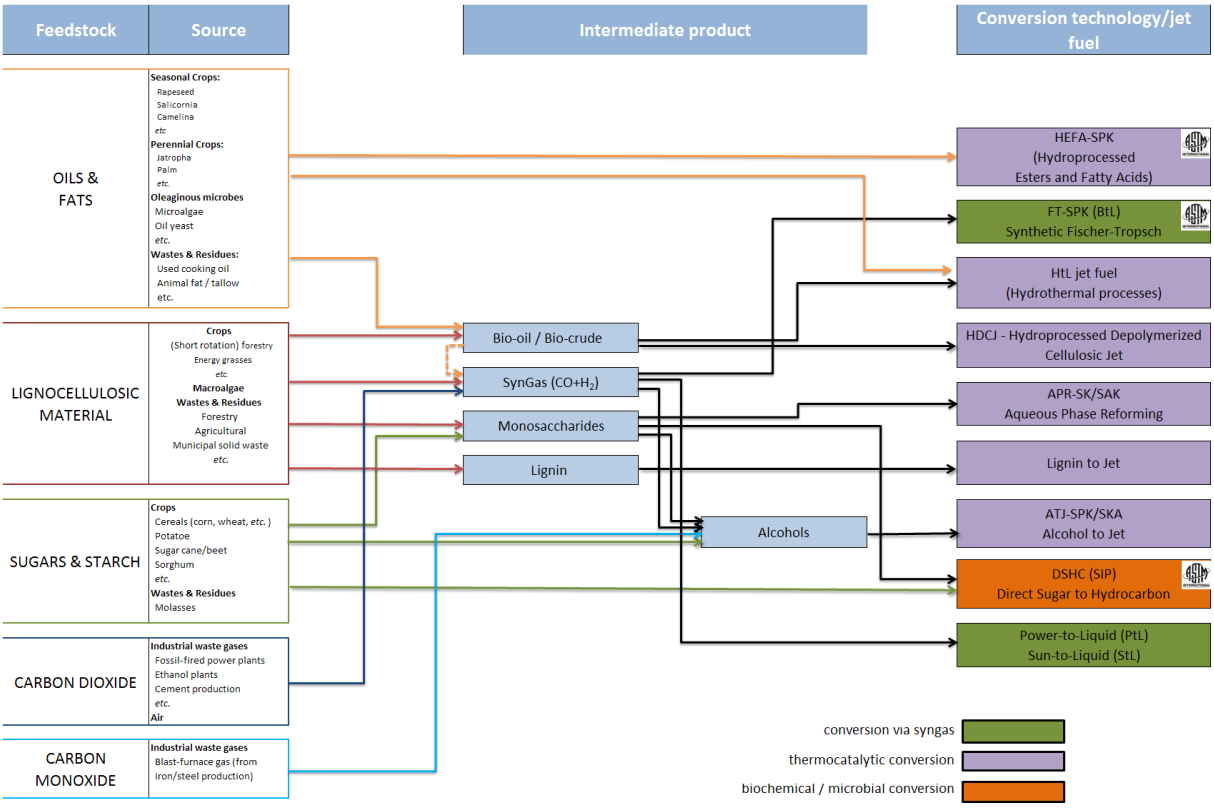

Figure 2: Production pathways for alternative aviation fuels (C-JF representation)

2.2 Background information for discussion panel

To streamline the panel discussion, the following questions/topics have been selected.

Currently there are demonstration projects in Europe, but we need to pass from demonstration level to actual use of the current aircraft fleet and reach a significant percentage of biofuels at the time horizon 2020. Fuel price is currently one of the main barriers.

- *What means do we have to overcome those barriers in the EU? Is it more interesting to consider obligations or incentives from the policies perspective?*
- *Should these actions be specific for aviation?*

Within ICAO it is currently being studied how to credit the use of alternative fuels in a GMBM.

- *When do we believe a GMBM can be realistically put in place on a world-wide basis in the context of this United Nations agency process?*
- *Assuming the CAEP proposal is successful at the 2016 ICAO General Assembly, when is it realistic to have it implemented in 190+ member states (2020, 2025)?*
- *Would the credit obtained for use of alternative fuels in a GMBM be a sufficient incentive to promote use?*

Alternative fuels for road transport and air transport need to be at a level playing field both at level of development and regarding climate change regulations.

- *What political actions are required to reach such a status?*
- *Considering the volumes eventually needed for biojet, will there be enough biomass available for production of the current demand of biofuels in all sectors?*
- *How will the agriculturally-based feedstock restrictions affect the scenario?*
- *What lessons can we learn from the biofuel policy for road transport in the EU?*
- *If a GMBM is implemented and biofuels is a way of reducing emissions in the system, how will we prevent market distortion when biofuels are unequally available in airports around the world?*
- *How important is the logistics aspect? Should there be a more in depth analysis of the logistics implications?*
- *What should the European position be for the near future regarding alternative aviation fuels?*
- *Should we consider the possibility of having some sort of centre of excellence/European network?*
- *In terms of certification, the process is currently slow and expensive. How can we solve this?*
- *Could the EU dedicate more resources to this aspect (since currently we are very dependent on the ASTM)?*

2.3 Panel discussion on Policies and Deployment

2.3.1 Topic I-1: Which means (e.g. policies, incentives, obligations) do we have to overcome the barrier of high fuel price for deployment in the EU?

Thomas Roetger

- Promote the establishment of supply chains by involving all relevant stakeholders (cooperation with initiatives such as AIREG, NISA, CAAFI).
- Promote voluntary off-take agreements (e.g. agreement between Fulcrum Bioenergy and Cathay Pacific Airways on production volume of 270.000 t/a).

Matthias Spoettle

- Public-Private Partnerships: BioPort Holland is the joint initiative of KLM, Schiphol Airport, SkyNRG, Neste Oil, Port of Rotterdam and the Dutch Ministries of Infrastructure and Environment as well as Economic Affairs to strengthen the development and deployment of sustainable aviation biofuels in the Netherlands.

Adam Brown

- Base initiatives on lessons learnt in other RE sectors (e.g. electricity).

- Provide stable policy and market framework.
- Develop smart incentive programmes.
- Ensure integration in the energy system (e.g. drop-in fuels).
- Obligations work well with mature technologies on similar levels of development (cheapest technologies will dominate); for technologies with lower maturity level technology-specific measures are needed to move towards deployment.

Martin Porsgaard

- Focus needs to be placed on feedstock supply and production potentials before cost issues can be addressed.
- Promote a fund for alternative aviation fuels to address higher ticket prices.

Philippe Marchand

- In the long-term (beyond 2020) alternative aviation fuels may indeed reach cost competitiveness (in contrary to the present understanding that they will “always” be more expensive than fossil fuels).

Audience

- Start the establishment of value chains with small volumes to build confidence (supply confidence, technical confidence (ASTM), logistics).
- Spread (additional) costs among many stakeholders.
- Partnerships with e.g. regional airports.
- Costs of bio-based fuels will always remain comparatively high due to the importance of feedstock costs even if technological learning will reduce technology-related costs.

Remark

- Opportunities and challenges of the ICAO MBMs for the future deployment of alternative aviation fuels have not been discussed in the panel.

2.3.2 Topic I-2: Which is the time horizon for alternative aviation fuel deployment?

Thomas Roetger

- Since first test flights in 2008 alternative aviation fuels have seen fast progress.
- For the next phase of development policy support is needed.
- Alternative aviation fuels are not solely a “long-tern option”, actions are needed now.
- More “radical” innovative solutions address long-term options.

Carlos Calvo Ambel

- Actions are needed now to avoid negative impacts and ensure good GHG emission balances of advanced biofuels.

Philippe Marchand

- The ASTM certification process for alternative aviation fuel pathways may be reduced to about 2 years (with costs of <2 million USD) based on good cooperation and mutual trust with the OEM (Original Equipment Manufacturers).

Audience

- Today there is ZERO ton production potential for dedicated alternative aviation fuels as HEFA is also used in other sectors.

2.3.3 Topic I-3: Which policy actions are required?

Thomas Roetger

- More EU countries need to follow the Netherlands to allow alternative aviation fuels to contribute to the 10% target specified in the RED.
- Europe may need to learn from initiatives in the USA focusing on faster market deployment

Remy Denos

- The USA always has strong energy policies focusing on energy security. Europe will need to find its own way.

Christiane Bruynooghe

- Harmonisation of sustainability requirements between USA (EPA) and Europe (RED) is urgently needed.

Adam Brown

- Create a firm initial market (but not too large and too early) to ensure investor confidence.
- Create appropriate support mechanisms also addressing cost of capital.
- Prioritisation of biomass use is a difficult topic as solutions are needed for all sectors.

Martin Porsgaard

- Establish close cooperation links with politicians to bring alternative aviation fuels on the political agenda.

Matthias Spoettle

- An integrated policy on biomass is needed addressing competing uses, prioritisation and cascading use.

Audience

- Do not focus on GHG reduction potential (reducing GHG emissions in transport will always be more expensive than in other sectors), but emphasise other benefits such as regional development, job creation, strengthening the EU aviation sector.
- Specific mandates for alternative aviation fuels can send wrong signals to the market.

2.3.4 Topic I-4: Which is the feedstock availability for alternative aviation fuel production?

Audience

- Availability of feedstock (residues, waste) for aviation fuels is very limited due to other material, chemical and energy uses.
- Decisions need to be taken on prioritizing use of biomass in different sectors.

Remy Denos

- (Aviation) transport sector shall also engage in options for decarbonisation and not solely rely on other sectors. Today, biofuels offer a pragmatic short-term solution to address decarbonisation. Other options such as Power-to-gas have longer time to the market.

2.3.5 Topic I-5: Which are the lessons learnt from biofuels in road transport?

Carlos Calvo Ambel

- Avoid mistakes of biofuels use in road transport by focusing on targets instead of impacts on sustainability.
- Establish a framework for alternative aviation fuels that does not have to be changed after a few years.

3 Panel Discussion on “Feedstock, Sustainability and Conversion Technologies”

Moderation

- Johannes Michel, FNR
- Arne Roth, Bauhaus Luftfahrt

Panelists:

- Franziska Mueller-Langer, DBFZ, Germany
- Maarten van Dijk, SkyNRG, Netherlands
- Dominik Behrendt, FZ Jülich, Germany
- Patrick Schmidt, Ludwig-Bölkow-Systemtechnik GmbH (LBST), Germany
- Jack Saddler, University of British Columbia, Canada
- Manfred Woergetter, Bioenergy 2020+, Austria

3.1 Introduction

As an introduction to the panel discussion, **Arne Roth**, Bauhaus Luftfahrt, Germany presented an overview on the CORE-JetFuel technology assessment methodology and the key questions addressed in the project. The applied assessment framework is based on a selection of relevant criteria for evaluation, the definition of suitable metrics in order to facilitate quantification of results, the comprehensive weighting of criteria, as well as the final multiple criteria assessment.

Relevant questions addressed in the framework of the technology assessment include future production potentials, environmental impacts, production costs, drop-in capability, and the current state of maturity of the technologies. Identified criteria for technology assessment thus comprise ***technical maturity*** (feedstock production maturity, conversion technology maturity), ***technical compatibility***, ***economic competitiveness***, ***global substitution potential***, ***impact on local biodiversity***, and ***GHG reduction potential***, with further criteria currently under discussion.

This Strategy Workshop sets out to discuss the main challenges identified by CORE-JetFuel that hinder the large-scale deployment of alternative aviation fuels and how they could be overcome.

Looking at different production pathways towards renewable fuels, particularly feedstock production and conversion pose several challenges that have to be addressed carefully if the future large-scale deployment of alternative aviation fuels is to be realised in a sustainable and economically viable way. To date, the only industrially developed value chain yielding renewable jet fuel depends on biogenic oils and fats (triglycerides) as feedstock.

3.2 Background information for discussion panel

This panel will therefore focus on renewable fuel options that have the potential of significantly contributing to meet the GHG emissions reduction targets set by the aviation industry, without inducing detrimental environmental impacts.

3.2.1 Renewable energy/feedstock potentials

When developing targets and roadmaps for the utilisation 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.

- Which fundamental bottlenecks do you see with respect to the availability of sustainable feedstock sources in Europe?

Considering a European agenda for renewable aviation fuels:

- Should such an agenda be solely based on European production potentials? Or should the scope be extended to also include production potentials outside of Europe?
- What is your view with respect to Europe's potentials to produce renewable fuels? Which types of renewable feedstock/energy (algae, residues/waste, lignocellulosic energy crops, electricity, etc.) offer the highest potentials in Europe?

3.2.2 Microalgae

Due to their high biomass productivity, microalgae have gained a lot of attention as a promising feedstock in recent years. As a consequence, a series of European R&D activities are concentrating on this particular type of feedstock, its cultivation, further processing as well as its sustainability and economic viability. Progress however, particularly in making the production of this type of feedstock less energy and carbon intensive, seems negligible, with production sites seldom surpassing demonstration level.

- What is in your opinion the main reason for this and what measures would you recommend to make microalgae a viable feedstock for the production of alternative aviation fuels? Please elaborate.
- What are in your opinion the most important milestones in algae research until 2030 and 2050, respectively?

3.2.3 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 utilisation of some types of lignocellulosic feedstock 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 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.

- What kind of measures would you recommend to increase the economic viability of bio-kerosene based on lignocellulosic biomass?
- What are in your opinion the most important milestones in the utilisation of lignocellulose as a feedstock for the large-scale production of bio-kerosene until 2030 and 2050, respectively?

3.3 Conversion Technologies

A broad range of technologies for the conversion of renewable feedstock into liquid fuels is currently under development. Apart from hydroprocessing of oils and fats, essentially none of these technologies is yet commercially mature. In order to develop an R&D roadmap, it is important to understand the potentials of the technologies to substantially contribute to the renewable fuel supply for future aviation. It is also vital to evaluate the individual technology states of development as well as the remaining challenges and bottlenecks on their way to commercialisation, in order to decide when certain technologies could be commercially implemented and in which direction R&D efforts should be supported.

Examples of conversion technologies are:

i. (Thermo)chemical processes (gasification/Fischer-Tropsch, pyrolytic processes, hydrothermal liquefaction, aqueous phase reforming, etc.)
ii. Hydroprocessing of oils and fats
iii. Fermentative technologies (Amyris/SIP, Alcohol-to-Jet, etc.)
iv. Non-biogenic pathways (Power-to-Liquid, Sun-to-Liquid, Solar-to-Fuel, etc.)

- Which conversion technologies offer the highest potentials for producing renewable fuels for aviation in the short-term (2020), medium-term (2035) and long-term (2050) future?
- Which technologies should be especially supported in their development towards industrial maturity?
- Can you specify technical challenges and important milestones to be achieved with respect to the development of these technologies?

3.3.1 Roadmap for Renewable Fuel Production Pathways

A production pathway represents a specific combination of feedstock and conversion technology. To conclude the panel discussion:

- Please state which production pathway offers, from your point of view, the highest potential in terms of quantity (production volume) as well as quality (environmental footprint, economic competitiveness) to satisfy the increasing demand for renewable jet fuel in the short-term (2020), medium-term (2035) and long-term (2050 and beyond) future?

3.4 Panel discussion on Feedstock, Sustainability and Conversion Technologies

3.4.1 Topic II-1: Which fundamental bottlenecks do you see with respect to the availability of sustainable feedstock sources in Europe?

Franziska Mueller-Langer

- According to IPCC the biomass potential accounts for 100-300 EJ (residues: 30 EJ), however biomass potentials are affected by many factors.
- Opportunities to increase the biomass potential may be provided by a reduction of losses in the agricultural sector.
- Biomass resources have competing uses in different sectors.

Manfred Woergetter

- Feedstock competition exists with established industries (e.g. wood industry) which are not happy about this new competitor.
- Competition exists with food and feed production. Feeding the world must have priority.
- Land use change (LUC) always happens, care needs to be taken to ensure high yields/efficiency of land use.
- Focus shall be placed on agricultural feedstock (vs forestry) as land use efficiency is higher in agriculture.

Patrick Schmidt

- The large potential of wind and solar needs to be exploited with “Power-to-Liquid” technologies.

Maarten van Dijk

- Logistical barriers may limit the suitability of biomass resources (e.g. in Eastern Europe) as transport to ports may not be economically viable.
- Biofuels produced from commodity feedstock will hardly be economically viable (even at higher oil prices) as their price is coupled to the price of oil.

3.4.2 Topic II-2: Status quo and potential of algae-based biofuels?

Dominik Behrendt

- Until today algae-based biofuel pathways are still at low TRL and established markets are still small. For future implementation as well as for judging the potential, technology developments for production systems and the algae are still needed on scale-up and transfer out of laboratory scale.
- Today algae cultivation requires more energy than is produced afterwards.
- Large future potential is anticipated (long term), algae may find applications in chemical as well as the energy sector.

Maarten van Dijk

- Algae-based aviation fuels face severe limitations and may thus not be a viable production pathway.

Manfred Woergetter

- RTD on algae is needed for applications on longer timeframes. Algae development exists for about 60 years compared to 14.000 years of human experience in the agricultural sector.

3.4.3 Topic II-3: Status quo and potential of aviation fuels based on ligno-cellulosic material?

Maarten van Dijk

- Until today no viable production pathways based on ligno-cellulosic feedstock exists.
- Several BtL processes to produce syngas and fuels via FT synthesis have experienced major failures in the past years.
- Alcohol-to-Jet pathways using ethanol produced from ligno-cellulosic feedstock do not seem to be economically viable.

Franziska Mueller-Langer

- Lignocellulosic biomass can favourably be included into value chains based on thermo-chemical processes such as BtL or HTP (hydrothermal processes).

3.4.4 Topic II-4: Status quo and potential of "Power-to-Liquid" technologies?

Patrick Schmidt

- Abundant electricity from wind and solar can be used for water electrolysis.
- Produced hydrogen and carbon (i.e. CO_2, no potential restrictions if extracted from the air) can be used for synthesis of fuels (e.g. FT process, methanol route).
- Detail engineering of "Power-to-Liquid" full pathways is still needed.
- Manufacturing capacities for low-temperature electrolysis need to be scaled up, and high-temperature electrolysis has to be brought to higher technology readiness level.

Franziska Mueller-Langer

- Several opportunities exist for synergies of PtX and bioenergy routes (e.g. hydrogen for synthesis, bio-based CO_2 as source).

Audience

- According to a recent study "Power-to-Gas" technologies will not be economically viable within the next 25 years.
- The amount of renewable electricity needed for renewable "Power-to-Gas" pathways is extremely high.

3.4.5 Topic II-5: Roadmap for renewable fuel production pathways?

Franziska Mueller-Langer

- Technology roadmaps need to address different technology maturity levels and different timescales.

Jack Saddler

- Short-term production pathways will be based on oleochemical processes using tall oil and UCO as feedstock. However, competition exists with use in the road transport sector and overall production potential is very limited.
- Mid-term opportunities exist for pyrolysis based pathways.
- Thermochemical production pathways will be more challenging for agricultural raw material than for forest based raw material.
- The oxygen content in biomass feedstock poses a large problem for the production of aviation fuels.
- Hydrogen needed for up-grading processes is currently expensive, cooperation with oil refiners is needed.

Patrick Schmidt

- Renewable hydrogen can be produced via water electrolysis; deployment of wind and solar power plants is important.

Alain Quignard

- According to a project by IFPEN the development of BtL technologies will still need significant time (>2020).

Maarten van Dijk

- The potential offered by highly efficient biorefineries need to be unlocked. Cooperation with refinery operators is needed to investigate the option of using biogenic feedstock.
- Cooperation with the petrochemical industry needs to be established.

Franziska Mueller-Langer

- Even today biomass based feedstock is used in refineries (if economically competitive).
- Co-processing is thus a viable option to benefit from existing refinery infrastructures.

Philippe Marchand

- Refineries need existing markets to get involved in the production of alternative aviation fuels.

Maarten van Dijk

- Short-term production pathways: HEFA.
- Mid-term production pathways: Direct Sugars to Hydrocarbons.
- Long-term production pathways: “Power-to-Liquids”.

4 Workshop Conclusions

The aim of this Strategy Workshop "Policies and Value Chains for Large-scale Deployment of Alternative Aviation Fuels" was to present and discuss preliminary findings of the CORE-JetFuel project with stakeholders from research, industry, authorities and NGOs. The following main conclusions may be drawn from the workshop discussion panels.

(a) Means to overcome the barrier of high fuel price for deployment

- Establishment of supply chains by involving and sharing (additional) costs between all relevant stakeholders (cooperation with initiatives such as AIREG, NISA, CAAFI)
- Establishment of Public-Private-Partnerships (e.g. BioPort Holland)
- Establishment of initial value chains with small production volumes to ensure (investor) confidence
- Implementation of voluntary off-take agreements
- Implementation of funds for alternative aviation fuels to address higher ticket prices

(b) Policy actions needed and lessons learnt from road transport biofuels

- Establishment of stable long-term policy framework ensuring good GHG emission balances of advanced biofuels and avoiding potential negative impacts; the importance of reasonable targets and accountability was highlighted
- Implementation of integrated biomass policies addressing competing uses, prioritisation and cascading use
- Enabling renewable aviation fuels to contribute to the 10% target specified in the RED on Member State level
- Learning from international initiatives (e.g. USA) focussing on faster market deployment
- Harmonisation of sustainability requirements between USA (EPA) and Europe (RED)

(c) Availability of sustainable feedstock in Europe

- Biomass potential figures depend on many factors and show a significant bandwidth
- Competing uses exist in established industries (e.g. wood industry) and for food and feed production. Feeding the world must have priority.
- High yields and efficiency of land use are needed to minimise potential negative impacts of (indirect) land use change
- Logistical barriers may limit the suitability of biomass resources (e.g. Eastern Europe)

(d) Roadmap for renewable fuel production pathways

- Development of technology roadmaps for different technology maturity levels and timescales
- Short-term production pathways: HEFA technologies for the production of road and aviation fuels currently represent the only option to produce significant quantities.
- Establishment of cooperation with the petrochemical industry to co-process biogenic feedstock and renewable hydrogen in highly efficient biorefineries
- Medium-term production pathways: Alcohol-to-Jet, Direct Sugars to Hydrocarbons, FT synthesis, hydrothermal liquefaction
- Potential long-term production pathways: algae-based biofuels, renewable electricity-based fuels (Power-to-Gas, Power-to-Liquid), solar heat-based fuels (Solar-to-Fuel)

5 Annex 1 - Workshop Agenda

Thursday, 29 October 2015 (08:30-14:00)

08:30 *Registration*

09:00 **Welcome to the Workshop**

RAINER JANSSEN AND DOMINIK RUTZ, WIP RENEWABLE ENERGIES, GERMANY

09:10 **CORE-JETFUEL Activities and Results**

JOHANNES MICHEL, FNR, GERMANY

09:30 **The European Commission's Perspective**

REMY DENOS, EUROPEAN COMMISSION, DG ENERGY

Panel I: Recommendations on Policies and Deployment

10:00 **Introduction: Preliminary Recommendations based on CORE-JetFuel Assessment**

MARIA DE LA RICA JIMÉNEZ, SENASA, SPAIN AND ALAIN QUIGNARD, IFPEN, FRANCE

10:30 **Panel Discussion on Policies and Deployment**

MODERATION: MARIA DE LA RICA JIMÉNEZ, SENASA, AND ALAIN QUIGNARD, IFPEN

PANELLISTS:

- REMY DENOS, EUROPEAN COMMISSION, DG ENERGY
- THOMAS ROETGER, INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA)
- ADAM BROWN, INTERNATIONAL ENERGY AGENCY (IEA)
- MATTHIAS SPOETTLE, ECOFYS, GERMANY
- MARTIN PORSGAARD, NISA, DENMARK
- CARLOS CALVO AMBEL, TRANSPORT & ENVIRONMENT (T&E), BELGIUM
- PHILIPPE MARCHAND, TOTAL NEW ENERGIES, FRANCE

11:30 *Networking Lunch*

Panel II: Recommendations on Feedstock, Sustainability and Conversion Technologies

12:30 **Introduction: Preliminary Recommendations based on CORE-JetFuel Assessment**

JOHANNES MICHEL, FNR, GERMANY AND ARNE ROTH, BHL, GERMANY

13:00 **Panel Discussion Feedstock, Sustainability and Conversion Technologies**

MODERATION: JOHANNES MICHEL, FNR AND ARNE ROTH, BHL

PANELLISTS:

- FRANZISKA MUELLER-LANGER, DBFZ, GERMANY
- MAARTEN VAN DIJK, SKYNRG, NETHERLANDS
- MANFRED WOERGETTER, BIOENERGY 2020+, AUSTRIA
- DOMINIK BEHRENDT, FZ JÜLICH, GERMANY
- JACK SADDLER, UNIVERSITY OF BRITISH COLUMBIA, CANADA
- PATRICK SCHMIDT, LUDWIG-BÖLKOW-SYSTEMTECHNIK GMBH (LBST), GERMANY

14:00 **Summary**

DOMINIK RUTZ, WIP, GERMANY

14:15 *Networking Coffee*

6 Annex 2 – List of Workshop Participants – Part 1

Name	Organisation	Country	Email
Johannes Michel	FNR	Germany	J.Michel@fnr.de
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Annex 2 – List of Workshop Participants – Part 2

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