Mobility and Fuels Strategy
of the Federal Government (MFS)

Workshop “Sustainable Aviation Fuels – From Principle to Practice
Insights from DEMO-SPK and other Projects”

26 April 2018

Berlin, 21. Juni 2018
The Mobility and Fuels Strategy of the Federal Government

The Federal Government's Mobility and Fuels Strategy (MFS) is the key instrument for shaping the transformation of the energy system in the transport sector and thus for achieving the Federal Government's energy and climate change policy objectives. The MFS was developed in 2013 based on a broad dialogue with experts and adopted by the Federal Cabinet. The Federal Ministry of Transport and Digital Infrastructure has thus created a platform for a cross-modal information and reference framework on technologies, energy and fuel options plus innovative and modern approaches to mobility and modal shift. It consolidates the knowledge that exists and actively progresses the generation of new knowledge.

Key parameters of the MFS

In Germany, the transport sector currently accounts for around 30 percent of total final energy consumption and is responsible for around one fifth of domestic greenhouse gas (GHG) emissions. The Federal Government’s 2010 Energy Strategy sets out the basic energy and climate policy objectives of the Federal Government. According to this document, GHG emissions are to be reduced by 40 percent by 2020 and by 80 to 95 percent by 2050 (against 1990 levels) across all sectors. Furthermore, in the transport sector, final energy consumption is to be reduced by around 10 percent by 2020 and by around 40 percent by 2050 against 2005 levels. In the December 2015 Paris Agreement, the international community undertook to limit global warming to significantly below 2° C above preindustrial levels and – if possible – to limit it to just 1.5° C. To achieve the longterm temperature objective, greenhouse gas neutrality is to be established in the second half of the century. The 2050 Climate Action Plan, which was adopted by the Federal Government in November 2016, confirms and fleshes out the existing national climate change targets in the light of the outcome of the Paris Climate Change Conference. In the 2050 Climate Action Plan, the national greenhouse gas reduction target for 2030 (reduce GHG emissions by 55 percent against 1990 levels) is allocated to the action areas addressed. Accordingly, GHG emissions from the transport sector are to be reduced by 40 to 42 percent by 2030 against 1990 levels. The measures necessary to achieve this are to be designed such that they have an impact as quickly as possible and have become fully effective by 2030. In addition, action is to be taken today to progress developments that will help to almost totally decarbonize transport by 2050. With the MFS plus the “2020 Climate Action Programme” and the “National Energy Efficiency Action Plan”, the Federal Government has already adopted measures for meeting the 2020 target. In addition, within the scope of the 2050 Climate Action Plan, specific options for action are currently being identified. By 2018, a programme of action is to be developed that is designed to ensure that the 2030 target is met.
Workshop at the Innovation and Leadership in Aerospace Fair (ILA) in Berlin

Environmental and climate-friendly renewable jet fuels for aviation have to contribute decisively to reduce air traffic emissions. Various manufacturing processes (HEFA-SPK, AtJ, FT/BTL, FT-PTL, SIP) are already approved and certified according to ASTM D7566, while others (e.g. HEFA diesel) are within the approval process. In the medium term, it is to be expected that airports in Germany will be supplied with Jet-A1 that also contains renewable fuels of various types in variable proportions. As part of the Mobility and Fuels Strategy of the Federal Government (MFS) the German Federal Ministry of Transport and Digital Infrastructure (BMVI) has implemented a comprehensive international research and demonstration project regarding the use of renewable jet fuel at airport Leipzig/Halle (DEMO-SPK).

The DEMO-SPK project is internationally unique: The main objective is to examine the behavior of different multi-blends of fossil and renewable jet fuels under realistic conditions within the general fuel supply infrastructure of an airport. Impacts on the reliable and safe operation of the airport infrastructure as well as determination of necessary technical adjustments are of great interest. Various renewable jet fuels are to be used and tested from different manufacturing processes, concentrating on the jet fuel blends approved according to ASTM D7566. The workshop is the first opportunity to gain scientific insights in the field of multi-blends.

Objectives of the workshop are to understand the big challenges behind sustainable and renewable aviation fuels, to see progress and gain insights into selected lighthouse projects in Europe and Germany, to take part in the objectives and first results of the project DEMO-SPK as well as to actively discuss lessons learned and upcoming to do’s to fly with renewable fuels.
<table>
<thead>
<tr>
<th>Time</th>
<th>Session Title</th>
<th>Speaker(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.00</td>
<td>Welcome Address</td>
<td>Silke Rittgerott, Federal Ministry of Transport and Digital Infrastructure</td>
</tr>
<tr>
<td>14.10</td>
<td>Introduction on International Initiatives, Targets and Progress on Flying with Renewable Fuels</td>
<td>Joachim Buse, Aviation Initiative for Renewable Energy in Germany e.V. (aireg)</td>
</tr>
<tr>
<td>14.30</td>
<td>HEFA for Aviation – Lessons Learned</td>
<td>Tarja Myllymäki, Neste Oil</td>
</tr>
<tr>
<td>14.50</td>
<td>Sustainable Fuels for Aviation – Insights From the burnFAIR Project</td>
<td>Alexander Zschocke, Lufthansa Group</td>
</tr>
<tr>
<td>15.10</td>
<td>High Biofuel Blends in Aviation</td>
<td>Sebastian Schuermann, Bundeswehr Research Institute for Materials, Fuels and Lubricants (WIWeB)</td>
</tr>
<tr>
<td>15.30</td>
<td>Operating Renewable Fuels for Aviation - Lessons Learned in the US</td>
<td>Steve Csonka, Commercial Aviation Alternative Fuels Initiative (CAAFI)</td>
</tr>
<tr>
<td>15.50</td>
<td>Coffee break</td>
<td></td>
</tr>
<tr>
<td>16.10</td>
<td>Research and Demonstration Project on the Use of Renewable Kerosene (DEMO-SPK)</td>
<td>Franziska Müller-Langer, DBFZ Deutsches Biomasseforschungszentrum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Christian Marquardt, Bundeswehr Research Institute for Materials, Fuels and Lubricants (WIWeB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tobias Schripp, Institute of Combustion Technology at the German Aerospace Center (DLR)</td>
</tr>
<tr>
<td>16.50</td>
<td>Panel</td>
<td>Michael Kyriakopoulos, European Commission</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bill Hemmings, Transport &amp; Environment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Harry Lehmann, German Environment Agency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Philippe Marchand, TOTAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Joachim Hugo, Federal Ministry of Transport and Digital Infrastructure</td>
</tr>
<tr>
<td>17.50</td>
<td>Conclusion</td>
<td>Silke Rittgerott, Federal Ministry of Transport and Digital Infrastructure</td>
</tr>
<tr>
<td>18.00</td>
<td>Informal Networking Session</td>
<td></td>
</tr>
</tbody>
</table>

**Moderator:** Lena Judick, IFOK GmbH
Introduction on International Initiatives, Targets and Progress on Flying with Renewable Fuels

Joachim Buse, Aviation Initiative for Renewable Energy in Germany e.V. (aireg)

- Aireg was founded on 8 June 2011 in Berlin, together with Dr. Peter Ramsauer (Federal Minister of Transport), Airbus Industries, Lufthansa German Airlines and Munich Airport. It is a non-profit association currently bringing together 32 members in 5 working groups on core areas from crop to tank. Airegs’ mission is to cover 10 percent of Germany’s aviation fuel demand in 2025 by climate friendly alternative fuels. Therefore, its main objective is to foster and promote the use of renewable fuels in aviation.

- Certain renewable fuels have been certified since 2008, e.g. Alcohol to Jet (AtJ) (GEVO), Biomass to Liquids (BtL-FT) (UOP, Red Rock Biofuels). Numerous different pathways are in development and already present y a great variety of alternative fuels. Each choice has its own roots and its own price.

- Some pioneering airlines have been using biofuels since 2011, first of them was KLM. Today using synthetic fuels does not present any technological problem and first steps to market implementation have been made. But the progress is slow and long term agreements for alternative fuels between producers and airlines are still in negotiation.

- Development of oil prices is connected to the market implementation of alternative fuels. When the price of the conventional fuel drops, renewable fuels become relatively more expensive. Especially NGOs, which are massively opposing against biomass-based synthetic fuels, address the role of crude oil prices and emphasise the fact, that airlines prefer a less costly alternative and the lack of constant subsidies for green jet fuels. The U.S. has made moves to address this issue by implementing policy measures that allow airlines to buy renewable fuels without having to take the full burden of the higher prices.

- ITAKA (Initiative Towards sustAinable Kerosene for Aviation) and AVINOR (financing Biofuels at OSLO Gardermoen) are examples for the EU efforts in supporting renewable fuels in aviation. While CAAFI (Commercial Aviation Alternative Fuels Initiative) was the first institution to pave the way for significant collaboration between parties supporting renewable fuels commercialization, NISA (Nordic Initiative for Sustainable Aviation) was founded to bring the parties together and to enable biofuel producers and consumers to use the initiative as a platform to develop the market.

- The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) (ICAO) is a voluntary system but will get mandatory over the years.
The German government has included green jet fuels in its Mobility and Fuels Strategy (MFS) to reduce emissions in the transport sector. MFS also funds the DEMO-SPK project, which advance on the outcomes of the burnFAIR project, which had been funded by the Federal Ministry of Economic Affairs and Technology in 2011.

**Outlook:** The aireg member Clean Carbon Solutions (CSS) is supported by the State of Lower Saxony for the construction of a pilot plant of bio-methane based GtL-FT green jet fuel. The project named Green Gas to Liquid (GG2L) might be the catalyst for Germany’s first step towards a continuous supply of renewable jet fuel. The production will start in May 2019 and will cover all steps from feedstock preparation, to gas clean-up and syngas production, the Fischer-Tropsch-Synthesis until product upgrading and distribution. The potential is up to 8,000 biogas plants in Germany alone.

**HEFA for Aviation – Lessons Learned**

**Tarja Myllymäki, Neste**

- Neste’s production capacity is 2.6 million tons per year, mainly sold in Europe and North America.

- ITAKA (Initiative Towards sustAinable Kerosene for Aviation) was founded by the EU 7th Program for Research and Technological Development (2012 to 2016). The initiative’s target was to develop a full value-chain in Europe to produce sustainable drop-in HEFA at large scale to test its use in existing logistic systems and in normal flight operations in the EU. Neste was one of 16 partners. Overall cost have been 16 million euro. The EU contributed 9.4 million euro.

- The feedstock used by ITAKA was camelina oil, which can be produced in Europe without competing with other crops or land use in dry areas. Its sustainability is EU-RED certified. For the ITAKA project four camelina plantations in Spain have been used, which were complemented by smaller plantations in Romania. An important lesson learned was that the availability of sustainable European feedstock can become a bottleneck since it can be hard to cultivate a big quantity of new crops. Getting the necessary amount of crops was part of why the project was delayed.

- HEFA was produced at the Neste refinery in Porvoo in Finland in late 2015. The fuel was analyzed and certified to ASTM D7566 and then shipped to Gävle, Sweden. There the fuel was blended with conventional jet fuel (50 percent) and transferred to Oslo by trucks. The lesson learned in production is that the upscaling of the production from batches to continuous production and developing logistics solutions requires collaboration among a multitude of stakeholders, since the whole value chain is involved.
For the first time, HEFA distribution was done via the existing distribution system (hydrant) at Oslo Gardermoen Airport (with max. 3 percent blend). The fuel was used by KLM, Lufthansa and SAS with excellent results. In total 60,000 flights have been made and 6 million passengers transported. A lot of data could be collected to demonstrate that there are no concerns related to the logistics and commercial use of HEFA. There are no real obstacles for the production besides the economics and in this respect incentives would be needed.

Findings from the discussion:

• To implement renewable jet fuel and to compensate the higher prices, incentives and regulations will be needed.

• There are many challenges in starting the production of considerable volumes of new crops, e.g. securing the necessary amount of land, making contracts with the farmers, arranging the logistics, and increasing the yields.

Sustainable Fuels for Aviation – Insights From the burnFAIR Project

Alexander Zschocke, Lufthansa Group

• The burnFAIR project was initiated by Lufthansa in 2011. The operation was a joint research activity of 12 universities and industry partners. It was partly financed by the Federal Ministry for Economic Affairs and Energy.

• Until burnFair, experience with ASTM approved synthetic fuels were rare, whilst ASTM 7566 produced biofuel blends had already been tested by ASTM members and considered safe to use, since they are very similar to conventional kerosene. Therefore, Lufthansa decided to conduct an evaluation of synthetic kerosene under controlled circumstances.

• Lufthansa tested HEFA Biofuel on scheduled passenger flights on four daily roundtrips HAM-FRA-HAM with A321 for six months. One engine was operated on 50 percent blend of HEFA kerosene, one on standard fuel. During the project a total of 1187 flights were performed. No operational issues were reported by the flight crews. Even in a prior test of non-normal situations (without passengers), such as in-flight engine relight or gravity feed of the fuel the flight was smooth and no issues where observed. In total 1.557 tons of bio kerosene blend have been consumed in the project.

• The behavior of the engine was monitored during the evaluation via Engine Condition Monitoring (ECM). For this purpose, the frequency of ECM downlinks was increased. The messages were
evaluated by MTU using proprietary software. This was done by first calculating of variances between predicted and actual parameters for both the bio kerosene and the reference engine, then calculating the difference between the two engines. There was no significant difference found between the engines, and no problem occurred. The data showed that there were no flight operational limitations initiated using bio kerosene.

- It had been expected that the fuel consumption (in tons) would be slightly lower, since the engines are unchanged (means the energy requirement is the same) and biofuel has no aromatics (means that the energy density of biofuel is slightly higher). Fuel consumption was expected to be ca. 1 percent lower than the average consumption without the use of biofuel. Fuel flow (kg/sec) during take-off and cruise (through the bio fuel test campaign) was reduced by approx. 1.2 percent, confirming the expectations.

- The fuel behavior in the storage tanks was monitored over the time of six months. No changes were observed during the monthly tests. The density was tested at top, middle and bottom of the tank and was found to be consistently at 0.783 throughout the tank. The fuel supplied to the airport was inspected every nine days. There were no adverse findings and no microbiological issues. A full ASTM D-1655 analysis was performed after the end of the evaluation, all parameters were found to be on-spec. There was also normal behavior of running sample conductivity.

- The post flight-evaluation borescope inspection showed no changes. The engine was checked before, during and after the trial. The blades were found clean and no damage to the coating could be found.

- The fuel bearing parts were removed from the aircraft after the end of the flight evaluation program for detailed inspection. They showed a yellow discoloration on the bio kerosene side, which could be traced back to sulfur content of blending fuel. There was visibly less fuel pump cavitation impact on the pumps powered by bio kerosene blend. This could be traced back to a higher vapor curve of bio kerosene blend. This was the only difference that could be traced to the properties of the bio kerosene. However, this difference is not a problem as the effect is beneficial (less wear and tear). Overall, the removed parts were in a good condition.

- The emissions of the bio-blend engine were measured and compared to the findings from a reference engine. But since all fossil fuels differ, quantifying the reduction effects is complicated. The reference engine must use the same fuel as it is used for the blending. It has been found out that the parameters of conventional kerosene must be known. The kerosene properties have been found to be highly heterogeneous in Germany and there is not one conventional kerosene to be compared to bio kerosene. The measurements of relative emissions are also influenced by the properties of the fossil fuel.
The effect of bio kerosene is measured best by using unblended fuel. This avoids the distorting effect of fossil kerosene used for blending. This is not permitted for engines in commercial aviation use, as bio kerosene is only approved as blends. It was tested in HBBA and airegEM projects, using a special testbed engine operated by Lufthansa Technik.

Findings from the discussion:

- DEMO-SPK is a logical next step after the burnFAIR-project. Mixing several bio kerosenes is new, before the DEMO-SPK project there have been only binary blends using one bio kerosene. DEMO-SPK takes the research to the next level.

High Biofuel Blends in Aviation

Sebastian S. Scheuermann, Bundeswehr Research Institute for Materials, Fuels and Lubricants (WIWeB)

- In the study *High Biofuel Blends in Aviation (HBBA)* physico-chemical properties of binary fossil/synthetic fuel blends with a synthetic fuel content > 50 percent were investigated.

- The fuels used were second generation synthetic fuels, like hydrotreated vegetable oil (HVO), Fischer-Tropsch-fuel, here: from coal, as a placeholder for any Fischer-Tropsch synthetic fuel), Alcohol-to-Jet (AtJ) and fuels generated by fermentation. Fuels from the first generation (biodiesel or ethanol) are not suitable for aviation and differ chemically from conventional fuels. The fuels from the second generation only contain classes of chemical compounds also present in fossil fuel. However, they may lack certain compounds, e.g. aromatics or cycloalkanes. Blending with fossil fuels is therefore necessary to obtain fit-for-purpose aviation fuels similar to conventional fuels.

- The Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons, ASTM D7566 includes the requirements of ASTM D1655 (Standard Specification for Aviation Turbine Fuels), defines an upper limit for synthetic fuel content (depending on type) and stipulates some additional parameters, for example a minimum content of aromatic compounds of 8 percent or distillation curve gradients.

- The research program included blending a set of conventional fuels with a set of relevant synthetic fuels to yield a variety of binary mixtures with varying synfuel content (normally 50-90 %w/v) and analyze their properties.
• Fuel analysis yielded 17 physico-chemical parameters per fuel blend and together with assessment of chemical composition of the synfuels database was obtained from which trends in properties vs. synfuel content could be observed and properties that undergo critical changes were spotted.

• One important result was that a broad variety of fuel properties can be calculated from values of the neat blend components and the blend ratio. If the neat blend components themselves meet the requirements for a certain fuel property, the respective blend will do so as well. However, since some requirements, like distillation curve gradients only apply for synthetic fuels, an unfit fossil blend component might curtail achievable blend ratios.

• Freezing points of blends may exhibit an anomaly which leads to a depression of the freezing point for certain blend ratios. This depression is the more pronounced, the more similar the freezing points of the neat blend components are. Depression of freezing point leads to an improvement of fuel quality. As a rule of thumb, the component with the lower freezing points exerts a pronounced influence on the property only if its present in considerable amounts (e.g. > 40 %v/v)

• The lubricity of fuel blends is not predictable from the values for the neat blend components and therefore needs to be determined for every blend. However, as a rule of thumb, the better lubricity of the two blend components prevails in the blends.

• In summary it can be said that maximum synfuel content depends on properties of fossil and synthetic fuel. On the one hand, the fossil component must compensate for deficiencies of the synthetic component. On the other, synthetic fuels can have favorable properties such as low freezing points or advantageous burning characteristics, which improve the quality of blends. Most blend properties can be calculated based on values for neat blend components and blend ratio. This works also for blends of blends. On-spec binary blends can be blended in any ratio to give on-spec multiblends, which has a special importance for the DEMO-SPK project.

• Conclusion for HBBA and DEMO-SPK: Fuel blends can be designed in theory with good accuracy prior to blending.

Operating Renewable Fuels for Aviation - Lessons Learned in the US

Steve Csonka, Commercial Aviation Alternative Fuels Initiative (CAAFI)

• The industry is still counting on the execution of Sustainable Alternative Jet Fuel (SAJF) commensurately with the progress on other pillars. Technically, SAJF and co-products are viable and
slowly commercially developed with expanding opportunities. The feedstock availability is pacing on some parts, but not an ultimate constraint.

- The most important challenge is the price, which must be competitive to petroleum. Right now, there is a full range of activities ongoing to try to bring down the cost, reduce the risk, incentivize production and develop feedstocks. Especially the price of the feedstock is too high and can make up to 80 percent of the full price. Crude oil price and policy mechanisms will be the key determinants.

- There are many SAJF offtake agreements and numerous demonstration programs. These offtakes and efforts represent over 250 million gallons per year (gpy) and account for the total production slate of the first several commercialization efforts CAFFI uses a goal/metric of 300 to 400 M gpy being needed to close CNG2020 gaps in North America, but those agreements are hard to execute, especially on first-of-kind facilities.

- SAJF has several qualification statuses. Right now, there are five approved fuels, and several others are moving through the process (Tier 1 & 2 results in the Phase 1 ASTM Research Report, followed by Tier 3 & 4 which result in the Phase 2 ASTM Research Report and the final FAA Review, the ASTM Balloting Process and the ASTM Specification).

- There is a significant “pipeline” of new production pathways. The industry continues to develop bio-chemical, thermo-chemical, and other hybrid approaches for converting non-petroleum hydrogen & carbon sources to jet fuel. To be successful, feedstocks from locations around the globe and from multiple conversion pathways should be used in production, e.g. fats, oils, lignocellulose, sugars and starches, various H&C waste streams and industrial slip-streams.

- The producer must work collaboratively with customers, suppliers, and the distribution network to define access to petro-jet, blending and logistic concepts. Almost every case needs a unique approach. At the point of delivery, the SAJF is treated as any other jet fuel, compliant with ASTM D1655, and indistinguishable from petro-jet.

- A capacity of 1 billion gallon per year (gpy) or more by 2021 can be achieved but needs serious engagement on expansion of multiple oilseeds, as well as F.O.G. (fats, oils and greases) development and expansion. The market opportunities are huge and the policy is in favor to achieve those goals at present.

Findings from the discussion:

- The competition between transport on the road and aviation with the mandate is not seen as relevant, since it is a long way until the SAJF will be used in aviation. For however long, fossil fuels will be used. This is not the case in ground transport.
The work on Fischer-Tropsch coprocessing has just started in the US. There will be a lot of research and improvement within the next few years.

The competition between transport on the road and aviation with the mandate is not seen as relevant, since it is a long way until the SAJF will be used in aviation in large quantities, while the future need for ground transport fossil fuels appears to be very uncertain, but with a declining expectation.

The work on Fischer-Tropsch coprocessing (in existing refineries) has just started in the US. There will be a lot of research and improvement within the next few years.

Research and Demonstration Project on the Use of Renewable Kerosene (DEMO-SPK)

1. Franziska Müller-Langer, DBFZ Deutsches Biomasseforschungszentrum

- The DEMO-SPK project has been implemented on hindsight to the IATA targets (CO$_2$ neutral growth from 2020 and a 50 percent reduction of CO$_2$ emissions in 2050 compared to 2005) as well as the aireg target (10 percent renewable jet fuel in 2025). To achieve those goals there is a tremendous amount of renewable fuel is required. The project started in November 2016 and will end in April 2019.

- DEMO-SPK investigates different renewable jet fuels that are usable according to ASTM. It also wants to show under controlled conditions that multiblend Jet A-1 can be implemented into practice as a starting point of increasing its shares of renewable jet fuel. DEMO-SPK is internationally unique and provides a decisive contribution towards a more sustainable and climate friendly air traffic.

- There are ten different tasks which are divided to three main project pillars: pre-investigation/R&D, Demonstration (will take place this summer at the airport Halle/Leipzig) and Accompanying R&D:
  1. Specification and procurement of renewable jet fuel and Jet A-1
  2. Jet fuel blending and preliminary test on storage behavior
  3. Analysis of the behavior of multi-blends
  4. Verification of compatibility of multiblends and supply infrastructure
  5. Investigation of local non-CO$_2$ emissions at the airport
  6. Lifecycle assessment for the used jet fuels and multiblends
  7. Development and practical application of a sustainability documentation in a certification system
8. Conceptual design of a credit methodology in emissions trading
9. Operational and legal aspects
10. Project coordination and external presentation (during the whole project)

• First results of the lab scale study on processing Power-to-Liquid (PTL) middle distillate to synthesized paraffinic kerosene (SPK) with the aim to meet the requirements of ASTM D7566. This included an investigation of different processing conditions to evaluate the effort of SPK production from the PTL middle distillate in comparison to the upgrading to diesel fuel. It was the first examination of the conversion of non-fossil Fischer-Tropsch / PTL derived material to a kerosene fraction with cold properties suitable for aviation applications. The first results showed promising fuel properties.

2. Christian Marquardt, Bundeswehr Research Institute for Materials, Fuels and Lubricants (WIWeB)

• Aviation Turbine Fuel blends containing synthetic hydrocarbons have to meet the requirements of ASTM D7566. About 20 physico-chemical properties have to be determined. For DEMO-SPK all blends should possess a maximum amount of synthetic compounds and must conform to requirements of ASTM D7566.

• Insights from previous studies allow the prediction of a majority of those properties. After analysis of the neat synthetic fuels, possible binary blend ratios have been calculated. The binary blends are based on conventional fossil fuel (Jet A-1) and either HEFA-Kerosene or SIP Kerosene or ATJ-SPK.

• On-spec binary blends can be blended in any ratio. One multiblend containing all three synthetic fuels and three multiblends containing each two synthetic fuels are produced based on these binary blends. The multiblends are mixed at lab-scale first to verify that they meet all requirements according to ASTM D7566 and finally at 1 m³-scale. After blending as well as after storage time of 6 months all multiblends are tested according to ASTM D7566. Selected properties of the blends are tested periodically during the storage phase.

• The fuels have arrived and samples were taken. The neat fuels were analysed in the laboratory and possible binary blend ratios have been calculated. The binary blends and the multiblends were produced at lab-scale and have been analysed. The multiblends have been produced at 1 m³-scale and the studies on their storage stability are currently in progress.
Climate chamber tests are performed to prove that high and low storage temperatures have no effect on the fuel properties. At the beginning and at the end of the climate chamber test the physico-chemical properties are determined to study the influence of temperature. It shows that an increase of the HFP-HEFA-content affects the low temperature properties. However, mixtures up to 20 percent v/v meet the ASTM-criteria for freezing point and viscosity at -40°C.

Climate chamber tests are performed to prove that high and low storage temperatures have no effect on the fuel properties. At the beginning and at the end of the climate chamber tests the physico-chemical properties are determined to study the influence of the storage temperatures. An increase of the HFP-HEFA-content affects the low temperature properties. However, mixtures up to 20 percent v/v comfortably meet the ASTM-criteria for freezing point and viscosity at -40°C.

3. Tobias Schripp, Institute of Combustion Technology at the German Aerospace Center

The co-benefit of many alternative fuels is lower soot release from jet engines. Field studies with ASTM certified fuel blends showed an emission reduction of soot mass up to 70 percent. Beyond the fuel parameters, soot emission is additionally affected by the type of the engine its maintenance status / age. Due to the extensive effort of field studies, models for the estimation of fuel impact on soot emission was developed.

The soot formation from aviation fuel is complex and can be studied in lab scale experiments in combination with field experiments. The lower aromatic content (associated with a higher hydrogen content) produces less soot precursors during combustion. Estimation of the soot emission reduction may be achieved via soot precursor quantification in flow reactor measurements (part of DEMO-SPK).

The aromatic content of reference Jet A-1 (16 percent) and multiblend (12 percent) are in a narrow range. The alternative fuels used for blending are of paraffinic nature and are expected to reduce the soot emission stronger than anticipated from the aromatics (precise measurement of H-content follows)

Based on the preliminary “fuel composition correction model” the expected reduction in soot emission for the multiblend will be in the range of 15 - 20 percent. This estimation will be experimentally confirmed by ground measurements at the LEJ airport.
1. Michael Kyriakopoulos, European Commission

- The European Union took a number of initiatives on sustainable aviation fuels over the last 20 years. This period included times were market forces were not favorable and a global financial recession acted as drag.
- The European Commission, Airbus, and high-level representatives of the Aviation and Biofuel producers industries, launched in 2011 the European Advanced Biofuels Flightpath. This action aimed to achieve 2 million tons of sustainable biofuels used in the EU civil aviation sector by the year 2020.
- The European Union has also funded numerous research projects and studies on aviation alternative fuels, for example the FP7 ALFA-BIRD and the SWAFEA study.
- Finally, in 2016, the European Union launched the Strategic Transport Research and Innovation Agenda (STRIA) towards contributing to the realization of the Energy Union. One of the 7 roadmaps was dedicated to alternative fuels.
- The European Commission supports the ICAO initiative towards developing an ICAO Vision on Aviation Alternative Fuels and the discussions that took place in the second ICAO Conference on Aviation and Alternative Fuels (CAAF2) in Mexico in October 2017.

2. Bill Hemmings, Transport & Environment

- To meet Paris targets use of renewable fuels is a key option with major impact.
- Price and availability are problems. But policy and subsidies prevent renewable kerosene from entering the market. An alternative product cannot enter the market if the component – fossil fuel – is subsidized so much.
- Technology/design will not get us anywhere near decarbonisation.
- In the road sector, first generation renewables are far worse than diesel. This must not happen in aviation and NGOs will work hard against it. If you come up with good sustainable products, the NGOs will support it but if your product is not sustainable in the first place then you don’t have a product.
- The technological bases for production of sustainable alternative fuels and e-fuels exist. The low ETS price means it will take a very long time to support such fuels.
- We need either a fuel tax with a minimum of 33cts/l, or a low carbon fuel standard.
- In sea shipping we now see a shift with the recent IMO commitment to decarbonization. This must happen in aviation as well.
- The sooner regulations take place, the sooner PtL and sustainable biokerosene industry can prosper.
3. **Harry Lehmann, German Environment Agency**

- Two problematic sectors have been detected in the climate protection strategy: agriculture and aviation.
- A sustainable path for the aviation sector is not biomass based. With the growing population of the world and the need to feed them this will not work.
- A solution is Power to Liquid (PTL) based on renewable energies. The use of PTL is necessary to meet and cope with the climate protection goals of the aviation sector.
- Only Biomass Residues and CO$_2$ from the air should be used as CO$_2$ sources for the production of PTL. The necessary wind and photovoltaic must be built up as fast as possible.
- We need to define a roadmap: Industries needs a clear framework.
- A quota for sustainable renewable fuel (PTL) for 2020 and 2030 should be defined. PTL as a “drop in” fuel could be produced everywhere.
- We cannot stop and wait until everyone follows. Willing countries must join their forces and take the topic forward. Europe is big and strong enough to start this and to be an example. Europe can be faster than ICAO.

4. **Philippe Marchand, TOTAL**

- All the ASTM certified pathways to-date can be part of the solution to reduce the carbon footprint of aviation. Biomass is available everywhere in the world but in different forms – e.g. sugar in Brazil, agricultural products in Western Europe or forestry products in Scandinavia –, thus solutions, combining feedstock with technology, will be essentially local.
- Solutions will only be produced and used if they are sustainable and economical.
- Regulations are needed in all parts of transport to reduce GHG emissions, and they need to be sensible, based on solid evidence.
- Aviation is a world-wide activity, thus difficult to regulate to protect competitiveness, but it is possible to act at a local or national level.
- Regulations need to be stable to give certainty to investors.

5. **Joachim Hugo, Federal Ministry of Transport and Digital Infrastructure**

- MFS is the Federal Government’s tool to achieve the goals in energy transition in the transport sector. Aviation plays a crucial role in achieving those goals. Therefore, MFS initiated several studies researching solution for decarbonizing the aviation sector (e.g. Drop in fuels for aviation, Renewable
jet fuels for future aviation – from theory to pilot as well as Feasibility of PTG-HEFA hybrid refinery). The ongoing demonstration project DEMO-SPK is based on these works.

- Further research, development and demonstration is needed. For example, the improvement of the technology readiness level and fuel readiness level need to be addressed, for innovative jet fuel production technologies.
- Furthermore, a regulatory framework for aviation fuels on EU-level is needed, as regulation on national level is not enough.
- We need pilot- and demonstration projects to generate experiences with renewable kerosene in the field. Only demonstration projects can improve the knowledge regarding compatibility of renewable fuels and aircraft combustion systems.
Impressions of the Workshop
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