Mobility and Fuel Strategy (MKS) of the German Government
Research and Demonstration Project on the Use of
Renewable Jet fuel at Airport Leipzig/Halle
(DEMO-SPK)

ILA Workshop "Sustainable Aviation Fuels - From Principle to Practice - Insights from DEMO-SPK and other projects" | Berlin, 26.04.2018

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Content

1. Background, target and task of the project
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Background and target

- Different renewable jet fuels usable according to ASTM
- R&D&D of implementing multiblend Jet A-1 into practice as starting point of increasing shares of renewable jet fuel
- DEMO-SPK is internationally unique => provide a decisive contribution towards a more sustainable and climate-friendly air traffic

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Target 1 IATA:
CO₂ neutral growth from 2020

Target airc:
10% renewable jet fuel in 2025
c(1 Mio t/a HEFA)

Target 2 IATA:
50% reduction of CO₂ emissions in 2050 wrt 2005

Climate protection plan (CPP): 95% reduction of CO₂ emissions in 2050 wrt 1990

* Requirement: renewable jet fuel with 95% GHG reduction on average

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Project task

Pre-investigations / R&D

Task 1 | Specification and procurement of renewable jet fuel and Jet A-1 (DBFZ, fuel supplier, logistics, others)

Task 2 | Jet fuel blending and preliminary test on storage behavior (WIWeB, DLR)

Task 3 | Analysis of the behavior of multi-blends (WIWeB, DLR)

Task 4 | Verification of compatibility of multi-blends and supply infrastructure (AP)

Task 5 | Investigation of local non-CO₂ emissions at the airport (DLR, AP)

Task 6 | Lifecycle assessment for the used jet fuels and multi-blends (DBFZ, TUHH via MKS)

Task 7 | Development and practical application of a sustainability documentation in a certification system (meo, DBFZ)

Task 8 | Conceptual design of an credit methodology in emissions trading (TUHH via MKS)

Task 9 | Operational and legal aspects (Adeptus Green, others)

Task 10 | Project coordination and external presentation (DBFZ, ifok via MKS, aireg)

Duration: 11/2016 – 04/2019
Presentation of the project

“Sustainability – Documentation and Accounting”, April 2017

“CAAFI Biennial General Meeting”, December 2018 (tbd)

2017

2018

2019

“Sustainable Aviation Fuels – From Principle to Practice | Insights from DEMO-SPK and other projects”, April 2018

Final workshop and presentation of the results, spring 2019

Project video

www.youtube.com/watch?v=Ely1HIXNUBU

Website of the BMVI

www.mks-dialog.de

DEMO-SPK is part of the Mobility and Fuel Strategy of the Federal Government.
First results | lab scale study: PTL jet fuel

- Processing of Power-to-Liquid (PTL) middle distillate (origin: **sunfire GmbH**, Dresden) to synthesized paraffinic kerosene (SPK) with the aim to meet requirements of ASTM D7566:
  - 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
  - First time examination of the conversion of non-fossil Fischer-Tropsch / PTL derived material to a kerosene fraction with cold properties suitable for aviation applications
  - First results show promising fuel properties

- Experiments and analytical characterizations carried out by:

**Figure:** General approach of the processing of a PTL middle distillate to SPK, illustration provided by TU Bergakademie Freiberg, 2016
First results | Blending and storage behavior

- Aviation Turbine Fuel blends containing synthetic hydrocarbons have to meet the requirements of ASTM D7566

- ASTM D7566 is based on ASTM D1655 + additional requirements
  - minimum content of aromatic compounds
  - oxidation stability at higher temperatures
  - distillation curve gradients
  - low temperature viscosity

- A total of more than 20 physico-chemical properties have to be determined for Aviation Turbine Fuel blends containing synthetic hydrocarbons

- For DEMO-SPK all blends
  - should possess a maximum amount of synthetic compounds
  - must conform to requirements of ASTM D7566
First results | Blending and storage behavior

- Insights from previous studies at the Bundeswehr Research Institute for Materials Fuels and Lubricants (WIWeB) allow 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
  - HEFA-Kerosene (mixture of $n$- and $iso$-alkanes) or no aromatic compounds
  - SIP Kerosene (farnesane, exclusively one $iso$-alkane) or low density
  - ATJ-SPK (mixture of essentially two $iso$-alkanes) low distillation curve gradient (SIP, ATJ)

  high viscosity (SIP)
  high freezing point (HEFA)

First results | Blending and storage behavior

- On-spec binary blends can be blended in any ratio
- Based on these binary blends
  - one multiblend containing all three synthetic fuels and
  - three multiblends containing each two synthetic fuels are mixed
- The blends are produced
  - at lab-scale to experimentally confirm that they meet the requirements according to ASTM D7566
  - at 1 m³-scale for 6-month storage stability studies

- After blending as well as after storage all multiblends are tested according to ASTM D7566
- Additionally, during the storage samples are taken periodically to track changes and to exclude separation of the fuels
First results | Blending and storage behavior

Step 1:
- shipment of fuels
- sampling

Step 2:
- analysis of neat fuels
- calculation of possible blend ratios
- blending and analysis of binary and multiblends at lab-scale

Step 3:
- blends are produced at 1 m³-scale
- studies on storage stability

Currently in progress

source: http://www.worldbid.com/petroleum/jet-fuel.html  
**First results | Climate chamber tests**

- **Climate chamber test**: prove that high and low storage temperatures have no effect on fuel properties:
  - multiblend with three synthetic fuels
  - mixture of 20 % v/v HFP-HEFA and 80 % v/v fossil Jet A-1

- At the beginning and at the end of the climate chamber test the physico-chemical properties are determined to study the influence of temperature.

- An increase of the HFP-HEFA-content affects the low temperature properties. However, mixtures up to 20 %v/v meet the ASTM-criteria for freezing point and viscosity at -40°C.

![Graphs showing freezing point and viscosity vs. HFP-HEFA content.](image-url)
Biofuel blending reduces particle emissions from aircraft engines at cruise conditions

Richard H. Moore¹, Kenneth L. Thornhill¹,², Berndett Weinzierl³,⁴, Daniel Sauer³,⁵, Eugenio D’Ascoli³,⁵, Jin Kim³, Michael Lichtenstern³, Monika Scheibe³, Brian Beaton¹, Andreas J. Beyersdorf¹,⁶, John Barrick¹,², Dan Bulzan⁷, Chelsea A. Corr¹,⁶, Ewan Crosbie¹,⁹, Tina Jurkat³, Robert Martin¹, Dean Riddick¹, Michael Shook¹,², Gregory Slover¹, Christiane Voigt³,¹⁰, Robert White¹, Edward Winstead¹,², Richard Yasky¹, Luke D. Ziemba¹, Anthony Brown¹, Hans Schlager³ & Bruce E. Anderson¹

- The **co-benefit** of many alternative fuels is lower soot release from jet engines
- Important for reducing **climate effects** (contrail formation) and **human exposure** in airport areas
- Understanding the relevant fuel parameters is important for future **fuel design**

Source: Nature, 2017
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).
Field studies with ASTM certified fuel blends showed an emission **reduction of soot mass up to 70%**

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 were developed.

![Graph showing particle mass emission index vs H/C ratio for different fuels and operating conditions](chart)

*Source: DLR Emission and CLimate Impact of alternative Fuel (ECLIF) campaign, 2015*

*Source: Schripp et al., Environmental Science and Technology, 2018*
First results | Expected soot emission

- The aromatic content of reference Jet A-1 (16%) and multiblend (12%) 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 %**

- This estimation will be experimentally confirmed by ground measurements at the LEJ airport

Data from HBBA-Study, 2012
CFM56-5C4 engine
For further information on DEMO-SPK please see http://www.bmvi.de/SharedDocs/DE/Artikel/G/MKS/demo-spk.html?nn=214182

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