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

Deliverable 3.4
Minutes of telephone conferences of stakeholder working groups

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Johannes Michel
- Coordinator-
Fachagentur Nachwachsende Rohstoffe e.V. (FNR)
j.michel@fnr.de
Tel.: +49 (0) 3843 – 69 30 – 250
Fax: +49 (0) 3843 – 69 30 – 102

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CORE-JetFuel

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Submitted Version 1.0

Document authors and contributors: Christoph Jeßberger (BHL), Andreas Sizmann (BHL), Rainer Janssen (WIP), Dominik Rutz (WIP), Arne Roth (BHL)

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Work Package Leader:	Wirtschaft und Infrastruktur GmbH & Co Planungs AG (WIP)
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PROJECT PARTNERS

FNR – Fachagentur Nachwachsende Rohstoffe e.V., Germany

BHL – Bauhaus Luftfahrt e.V., Germany

SENASA – Servicios y Estudios para la Navegación Aérea y la Seguridad Aeronáutica SA, Spain

IFPEN – IFP Energies Nouvelles, France

WIP – WIP Renewable Energies, Germany

AGI – Airbus Group Innovations France

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INTRODUCTION

For a number of environmental and economic reasons, the aviation industry is in great need for alternative fuels. Highly ambitious goals for the reduction of the sector's overall greenhouse gas emissions (cf. ATAG and ICAO) imply sustainable alternative fuels as a major contribution. To meet the high expectations research and innovation efforts are required in order to develop efficient and effective pathways for an environmental friendly as well as technologically and economically feasible large-scale production of such fuels for aviation.

However, at the current state of development, none of the current production pathways offers a vision of fulfilling all three high-level criteria of suitability, sustainability and scalability. In fact, several alternative fuel production pathways are being investigated, developed and certified as "drop-in" capable fuel technologies to best meet the "suitability" criterion which guarantees the lowest implementation barrier into the aviation system. But yet a credible scenario for a sufficiently large supply of sustainable feedstock and an economically efficient way of implementation with well-functioning market mechanisms remain major challenges.

Within Working Group 2 of the CORE-JetFuel project specific focus will be placed on the following topics:

- *Radical concepts and conversion technologies of biogenic feedstock into fuels*
- *Renewable and biomass-independent fuel production pathways*

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LIST OF ABBREVIATIONS

Abbreviation / acronym	Description
ATAG	Air Transport Action Group
BMUB	Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety
BMWi	German Federal Ministry of Economic Affairs and Energy
BtL	Biomass-to-Liquid
CAAFI	Commercial Aviation Alternative Fuel Initiative
DFG	German Research Funding Organization
EIBI	European Industrial Bioenergy Initiative
EROI	Energy Return On Investment
FRL	Fuel Readiness Level
GHG	Green House Gas
GtL	Gas-to-Liquid
HTL	Hydrothermal Liquifaction
HTP	Hydrothermal Plant
HEFA	Hydroprocessed Esters and Fatty Acids
ICAO	International Civil Aviation Organization
KPI	Key Performance Indicator
LCA	Life Cycle Analysis
MAC	Minimum GHG Abatement Costs
MRL	Manufacturing Readiness Level
NGO	Non-Governmental Organization
PtG	Power-to-Gas
PtL	Power-to-Liquid
PtX	Power-to-X(any other liquid)
R&D	Research and Development
R&I	Research and Innovation
RED	Renewable Energy Directive
SIP	Synthesized Iso-Paraffinic
StL	Sunlight-to-Liquid
TCI	Total Capital Investments
TCO	Total Cost of Ownership
TDC	Total Direct Costs
TIC	Total Indirect Costs
TRL	Technology Readiness Level
UCO	Used Cooking Oil
VDI	Verein Deutscher Ingenieure
WG	Working Group

1 Background - The CORE-JetFuel Project

1.1 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

1.2 Stakeholder Involvement

CORE-JetFuel will ensure cooperation with other European, international and national initiatives and with the key stakeholders in the field. The expected 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

2 Working Group 2 Telephone Conference Timing, Organisation and Participants

Telephone conference timing

5 August 2016, 10:00 – 12:00

Telephone conference topic

Conversion technologies and holistic assessment of production pathways

Telephone conference organisation

Stakeholder:

- FRANZISKA MUELLER-LANGER, Deutsches Biomasseforschungszentrum gGmbH, Germany
- PATRICK BILLER, Aarhus University, Department of Chemistry, Denmark

Moderation:

- ANDREAS SIZMANN, Bauhaus Luftfahrt e.V., Germany
- CHRISTOPH JESSBERGER, Bauhaus Luftfahrt e.V., Germany

Participant:

- DOMINIK RUTZ, WIP Renewable Energies, Germany

3 Topics and Questions as Guideline for the Discussion

1. Technology monitoring and future potentials of alternative fuel production pathways

Well defined performance indicators are essential for technology monitoring and for quantification of technology potentials. In the domain of alternative fuels, such indicators are the state of development (TRL), economic competitiveness (cost of production) and specific GHG emissions (carbon intensity) as well as total GHG reduction potential. Further indicators of interest are, e.g., the energy return on invest (EROI) and the minimum GHG abatement costs (MAC).

➔ **Which performance indicators do you consider most relevant when evaluating and comparing conversion technologies and production pathways of renewable fuels?**

2. Balance of effort in basic science and technology development

In alternative fuels research, there is a need for both technology development and basic science. A certain balance in funding as well as the linking of basic science and technological innovation should be achieved.

In the long term, today's basic research might play an important role for the product-oriented research priorities of tomorrow. In the short term, the technology development effort should integrate existing knowledge to bring alternative fuels to the marketplace, clearly showing the importance of a well-balanced approach.

➔ **What are the priorities and key challenges in R&I activities, both in basic science (advancing our basic understanding) as well as in technology development for alternative fuels?**

➔ **What is the right balance of funding between basic and applied research? How should a well-balanced distribution of R&I efforts (in terms of relative allocation of resources, funding) between basic science and technology development be defined and achieved?**

➔ **How can we better link basic science and technological innovation, and integrate new knowledge in innovative solutions?**

3. Risk-and-reward correlation of technology development

Research and development come with some probability of success and failure and with potential benefits of incremental to substantial magnitude. Of particular interest is the relation of risk to potential rewards: If R&D funding is solely spent on easy-to-attain objectives ("low-hanging fruits"), the technology development will probably succeed, but scientific leadership and long-term technological innovation in a competitive environment is at stake. High-risk long-term R&D projects therefore have a place in pro-active aggressive innovation. In a well-balanced distribution of high and low-risk technologies, the magnitude of the acceptable risk (technical risk, commercial risk) will depend on the magnitude and quality of the potential reward (e.g. European socio-economic benefits, global climate impact).

➔ **Considering the risk of failure to reach technical maturity and economic competitiveness with certain production technologies, and potential rewards their development promises:**

- **Which technologies do you see as candidates in the "high reward / high risk" domain, i.e. yet uncertain to succeed technically and/or commercially but potentially very rewarding?**
- **Which technologies do you see as "low-hanging fruits" with sufficient benefits in the "low risk" domain?**
- **Are there any candidate technologies with both "low risk" and "high reward" expectations?**

4. Coordination of future R&I

There are certain needs for future research to better support fact-based decision making. For example, CORE-JetFuel has identified the need for a comprehensive and coherent analysis of realistic European energy/feedstock potentials.

➔ **Which gaps in the current research landscape do you see and which capabilities need to be developed to empower the EU to implement its alternative fuel strategy?**

4 Stakeholder Statements

Franziska Müller-Langer, DBFZ

- The use of the performance indicator Fuel Readiness Level (FRL) developed by CAAFI is recommended. This performance indicator takes into account the following aspect of alternative fuels: If the TRL of each technology of a fuel pathway is above 6, but the amount of feedstock (or an intermediate product) is too low to be compatible with the next process step and the respective technology, then the overall FRL of that pathway is reduced. The overall FRL would thus be lower than 6 even though each single technology has a TRL above 6.
- An important performance indicator may also be the Manufacturing Readiness Level (MRL). There could be a relation of the amount of funding or the number of projects within a certain fuel pathway and the size and financial power of the companies developing that fuel pathway. The MRL would control for a situation in which many small start-ups do not have the financial power to sustain a long period of capital lock-up with no or very low revenues as their business and, thus, their revenue structure is not as diversified as the one of an established market player.

Patrick Biller, Aarhus University

- Coming beyond the pilot project stage is often an issue, for example in the field of micro algae, HTL, and pyrolysis.

Franziska Müller-Langer

- An important aspect to be analysed is the allocation of alternative fuels among different transport modes (road, aviation, etc.), the allocation among different sectors (transport, energy or chemistry), and the allocation with respect to energy-based and material use.
- Further important aspects include the flexibility of a fuel pathway, namely its potential use in different sectors, as well as the feedstock flexibility of a single fuel pathway.

Patrick Biller

- It would be interesting to also depict the risk and reward diagrams without combining a fuel pathway with one single feedstock. This could give an answer to the feedstock-flexibility question. For example:

  - HEFA (microalgae, Camelina,. UCO, …)
  - BTL (lignocellulose, waste, …)
  - HTL (microalgae, lignocellulose, …)

Franziska Müller-Langer

- The reference value used for Jet-A1 (i.e. Stratton et al. or EU-RED) could influence the results of the assessment.
- The energy mix for power generation is shifting more and more towards renewable sources, thereby improving LCA results of bio-based alternative fuel pathways.
- It needs to be indicated in CORE-JetFuel reports that the list of fuel pathways, conversion technologies, R&D projects and feedstocks is not exhaustive and depends on the investigation and current data availability.
- The technology pathway Bio-GtL (bio-gas to liquid) and the hybrid pathway of PtG (Power-to-Gas) and HEFA should be included in the analyses.
- DFG (German Research Foundation) research projects should be investigated to find more projects focusing purely on basic research (Bohr's quadrant).

Further information on the discussion topics and questions discussed in this WG2 telephone conference was provided by Franziska Müller-Langer, DBFZ by email.

1. Technology monitoring and future potentials of alternative fuel production pathways: Performance indicators

- Even though there are many relevant factors, key performance indicators should be in line with technological development against current and future time horizons as well as target oriented. In the EU context the EIBI (European Industrial Bioenergy Initiative) KPI provide a good starting point, cf. https://setis.ec.europa.eu/system/files/Key_Performance_Indicators_EIBI.pdf
- Technology maturity: independent of the resource-to-fuel-route, overall concepts/routes can be divided into comparable functional units (e.g. resource pre-treatment, core conversion steps, final fuel treatment, by-product handling etc.) that can be assessed by known TRL. In addition also MRL (Manufacturing Readiness Levels) can be considered as an indicator for companies and their background (start-ups to companies with long history and many references) in manufacturing and

operating technical components. The overall resource-to-fuel-route should additionally be assessed at least by FRL (Fuelk Readiness Level) (such as the CAAFI approach with dedicated fuel amounts).

- Costs: An overall cost assessment (e.g. related to TCO (Total Cost of Ownership) approach or VDI) is mandatory, normalized to the same baseline year. For capital related investments this includes total direct costs (TDC) and total indirect costs (TIC) which together with land and working capital are total capital investments (TCI). Additionally also all fixed and variable costs should be analysed, at least for used resources and operation-related materials/auxiliaries. Especially for TCI also learning and experience curve approaches could be considered in order to simulate potentials for cost reduction in future time frames. Other cost parameters should be analysed by sensitivity analyses. Regarding fuel production costs EIBI KPIs should be used as benchmark.
- GHG and other impact parameters: with regard to the main driver for alternative fuels (i.e. climate change) GHG is of priority. Here also EIBI KPI or benchmark set in RED (of at least 60% GHG reduction) is binding. Esp. with regard to GHG also the development scenarios of background systems (e.g. energy/electricity mix with huge impact to different products) and conventional/fossil reference systems have to be taken into account.
- GHG abatement costs are an indicator that helps with one factor to compare different options.

2. Balance of effort in basic science and technology development

- A technology-open funding is important. Beginning with early TRL/FRL an accompanying assessment is necessary to develop the process/technology/overall concept into the “right” direction (sustainable, market-competitive etc.).
- Improving target oriented networking / accompanying projects like done in Germany for the programme “Energetic biomass use” (BMUB, BMWi) with project-overlapping methodologies for process assessments and measurement methods in order to make processes/projects comparable and learn from each other.
- For advanced fuels, there are lots of quite innovative and interesting processes at technical lab stage, but only few of them could be realized as pilots – and in the next steps – as demo followed by commercial plants. One of key issues is that funding of

investments in pilots and demos is required, but also funding of expensive test campaigns that are urgently required to improve the process and overall concept.

3. Risk-and-reward correlation of technology development

- “High reward / high risk”: for wet biomasses: algae based technologies and HTP processes, for “dry” biomasses/lignocellulosic: BTL and PTL/x. Synergies of smart biofuel and PTx should be considered and investigated.
- “Low-hanging fruits”: clearly HEFA based on different “oils and fats”, as niche application: SIP

4. Coordination of future R&I - Gaps in the current research landscape

- Comprehensive analysis on “lessons learned” along the value chains in the different alternative fuel sectors.
- Improvement and further development of assessing systems according to different TRL/FRL levels, like identifying realistic TRL/FRL specific parameters and details for required and reliable data to assess KPI and expected KPI along the value chain (e.g. eco-efficiency analyses).
- Improvement of methodology for assessing “residues”, esp. when strongly linked to the agricultural and forest sector or food/fodder industry (link to the “circular economy”).
- Scenario based modelling of target-oriented required fuel amounts and qualities (e.g. for transport) and available resources (e.g. biomass and electricity) for different time horizons in order to estimate e.g. typical number of required plant sizes/capacities to fulfil demands (and required investments, expected GHG mitigation, typical lifetime etc.).
- Developing alternative fuel strategies as learning strategy including also comprehensive monitoring systems (how market segments develop under the set frame conditions and how to deal with flexible elements).