Closing the gap between sustainable aviation fuels and fossil-based fuels

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Criteria for SAFs

What are SAFs?

Sustainable aviation fuels (SAFs) are synthetic liquid fuels for commercial aviation that are produced from a variety of feedstocks of non-fossil origin and thus can potentially reduce CO_2 emissions significantly. [1]

- achieve net greenhouse gas emission reductions of at least 10% compared to the baseline emissions values for aviation fuel on a lifecycle basis.
- not be made from biomass obtained from land with high carbon stock.

[1] ICAO document, 2022: CORSIA Sustainability Criteria for CORSIA Eligible Fuels

Standards for defining SAFs

- **Aviation Turbine Fuel (JET A1)** is compliant with **ASTM D1655** and **fossil based**.
- Individual **synthetic blending components** e.g., FT SPK, HEFA SPK, etc and their **blends with Jet A1**, must be compliant to **ASTM D7566** (equivalent to ASTM D1655).
- Compliance mandatory so that the blends can be handled by conventional infrastructure and safely used in aircraft designed for ASTM D1655 compliant Jet A1.

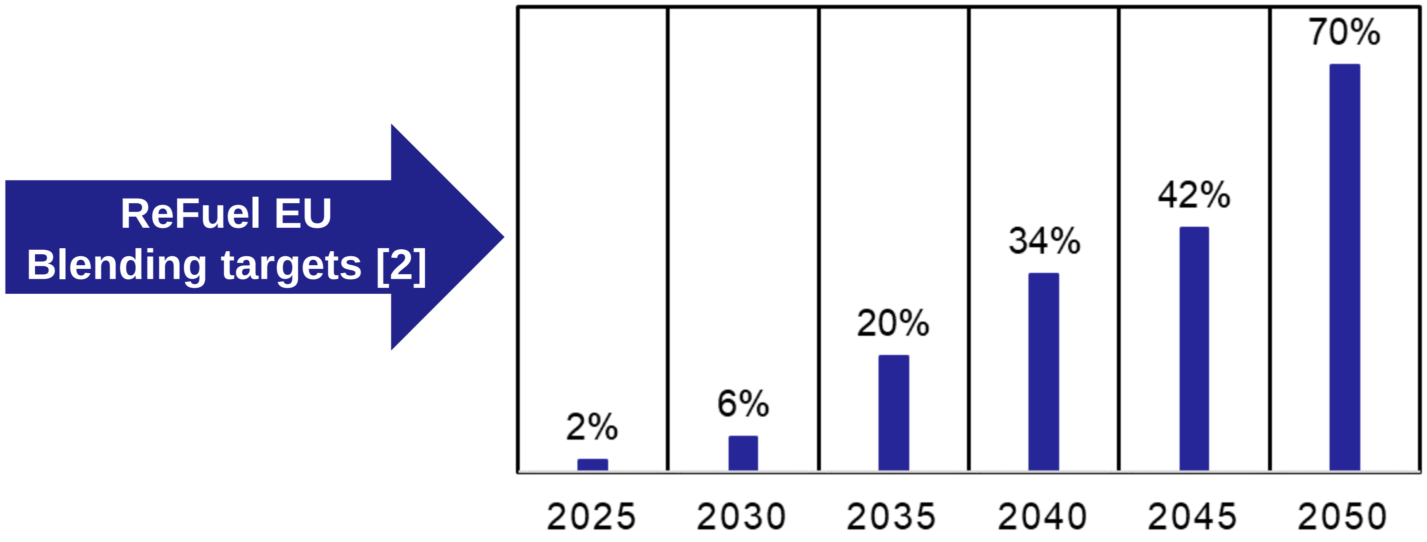
Regulatory framework for deployment of SAFS

Renewable Energy Directive (RED III)

sets the EU's binding renewable target for 2030 to a minimum of 42.5% aiming for 45% to support the drive to decarbonise its economy [1].

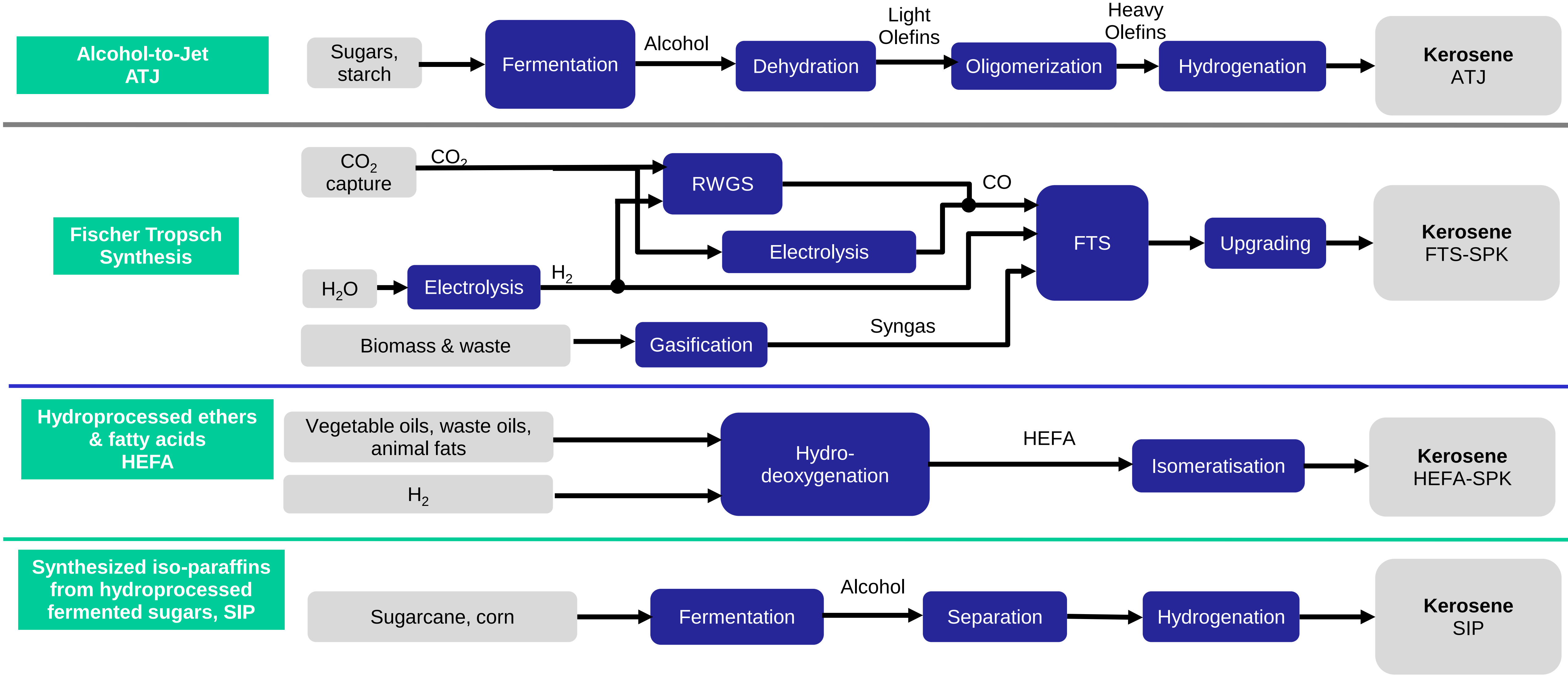
Green Deal

29% of the energy mix for transport must be covered from renewable energy to enable a 14.5% reduction of greenhouse gas emissions in the sector including aviation by 2030 [1].



[1] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_2061.| [2] Adapted from: https://www.consilium.europa.eu/en/infographics/fit-for-55-refueleu-and-fueleu/

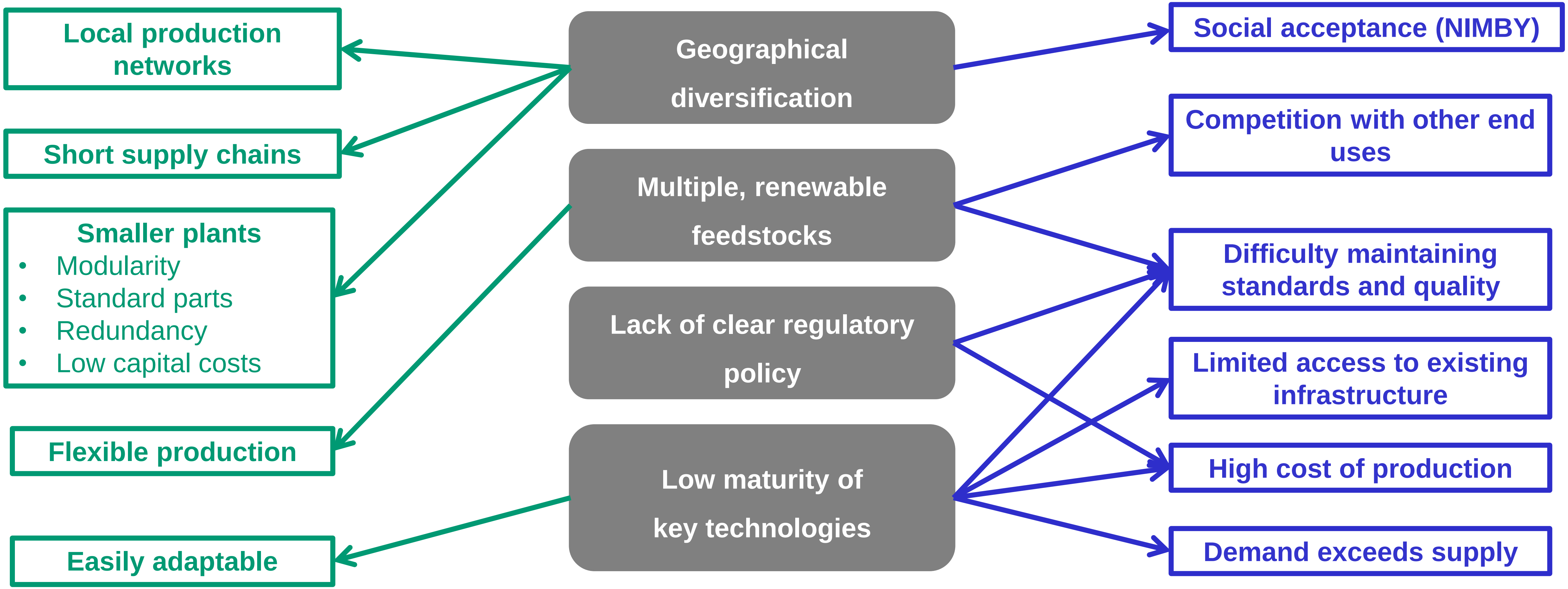
Certified Technological Pathways for SAFs



SAFs versus fossil aviation fuel

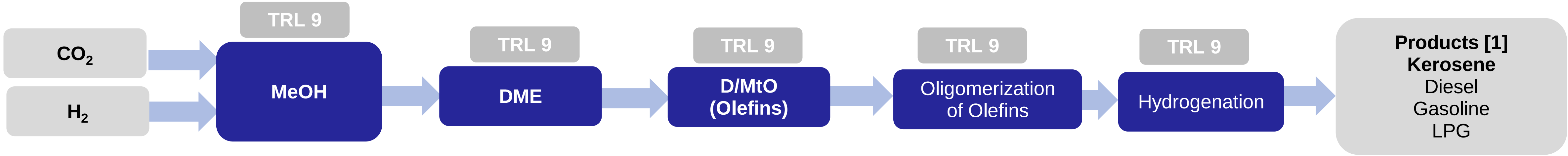
SAFS	Characteristics	Fossil aviation fuel
50-90% reduction in CO_2, NO_x, particles	**Green house gas emissions**	High
Low to medium	**Environmental impact**	High
• Nascent with high potential for technological progress • Low efficiency	**Technology base**	• Mature with limited scope for technological progress • High efficiency
Variable renewable feedstocks	**Source**	Single nonrenewable feedstock
Developing	**Standardisation**	Highly advanced
Production, processing and storage are distributed	**Geographical distribution**	Production, processing and storage are centralised
Various possibilities e.g., multiple suppliers, production for self-consumption	**Supplier model**	Typically single supplier

Resilience of SAFs

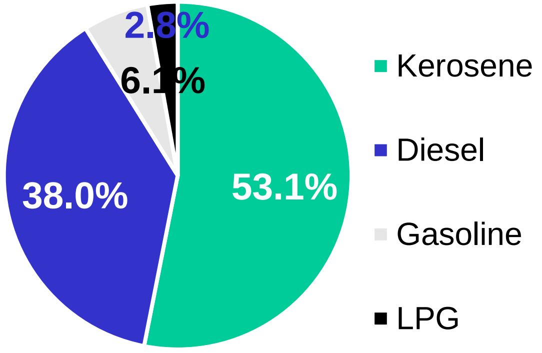


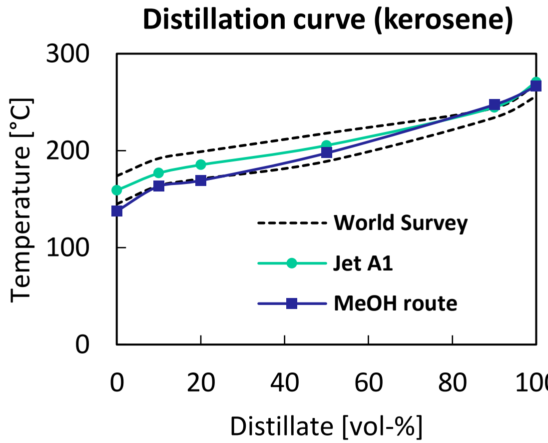
Safeguarding a reliable, regular supply of SAF and having appropriate contingency measures in place in the event of a disruption from external forces.

#FZJ | Methanol to Kerosene (MtK) pathway



- Study proving competitiveness of the MtK pathway over the Fischer-Tropsch pathway [1]
- Methanol is more economical and can be imported from regions with high renewable energy resources like Saudi Arabia or Patagonia [2].
- Methanol-based kerosene and its by-products are produced with a combination of process steps with **high Technology Readiness Level (TRL) of every single step** [3,4]
- Around 50% of the product spectrum is in the kerosene fraction [3]
- Adjusting operating conditions can yield kerosene with a **8% aromatics fraction** and thus **fulfilling ASTM7566** [5]
- ….however **MtK pathway is not yet licensed** for the use in aviation sector





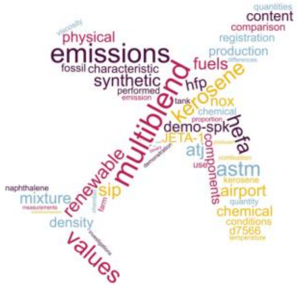
[1] Weiske, et al., Konzepte und Potenziale von Demonstrationsanlagen für die Produktion von erneuerbarem synthetischen Flugzeugtreibstoff als Beitrag zur Transformation der Reviere in NRW, ed. 580. 2022, Jülich: Forschungszentrum Jülich GmbH Zentralbibliothek, Verlag.|**[2]** Schorn, et al., Advances in Applied Energy, 2021. 3.|**[3]** Schmidt, et al., Power-to-Liquids Potentials and Perspectives for the Future Supply of Renewable Aviation Fuel. 2016, German Environment Agency/ Umwelt Bundesamt: Dessau-Roßlau| **[4]** Liebner, & Wagner, Kohle, 2004. 120(10) pp. 323-326. **[5]** ASTM D7566-16b, Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons. ASTM International, 2016

#DBFZ | Key results DEMO-SPK project

Supported by:
Federal Ministry of Transport and Digital Infrastructure
on the basic of a decision by the German Bundestag

www.mks-dialog.de

2016 - 2020



More than 20 international partners from industry and science

First of the kind project:

- **Supplied** nearly **600 tons of multiblend JET A-1**
- **Used** multiblend JET A-1 in **flight operations** at Leipzig/Halle airport
- **Quantified** benefits of use of multiblend JET A-1 in aircraft instead of pure fossil-based JET A-1 fuel
  - **reduced particle emissions** in ground runs by 30 to 60 %
  - **reduced CO_2 equivalent emissions** by about 35%
- **Produced** FT-SPK using PTL (power-to-liquid) that **met key requirements of the ASTM specifications**
- **Developed** three different approaches for **SAF sustainability verification** and **SAF accounting** aspects in GHG regulation systems like the EU ETS
- **Recommended** improvements to the **operational supply chain**

TanQuid Tanklager Speyer (all pictures © DEMO-SPK 2018)

Tank storage DHL/EAT Leipzig (©DHL)

Multiblend JET A-1 fuelling (© DEMO-SPK 2018)

Further information on DEMO-SPK : https://www.dbfz.de/news/ergebnispraesentation-demo-spk ; https://onlinelibrary.wiley.com/doi/full/10.1002/ceat.202000024 ; https://www.mdpi.com/2076-3417/12/7/3372
https://www.sciencedirect.com/science/article/pii/S0016236120326028

CARE-O-SENE will enable the highly efficient production of SAF

CARE-O-SENE
Catalyst Research for Sustainable Kerosene

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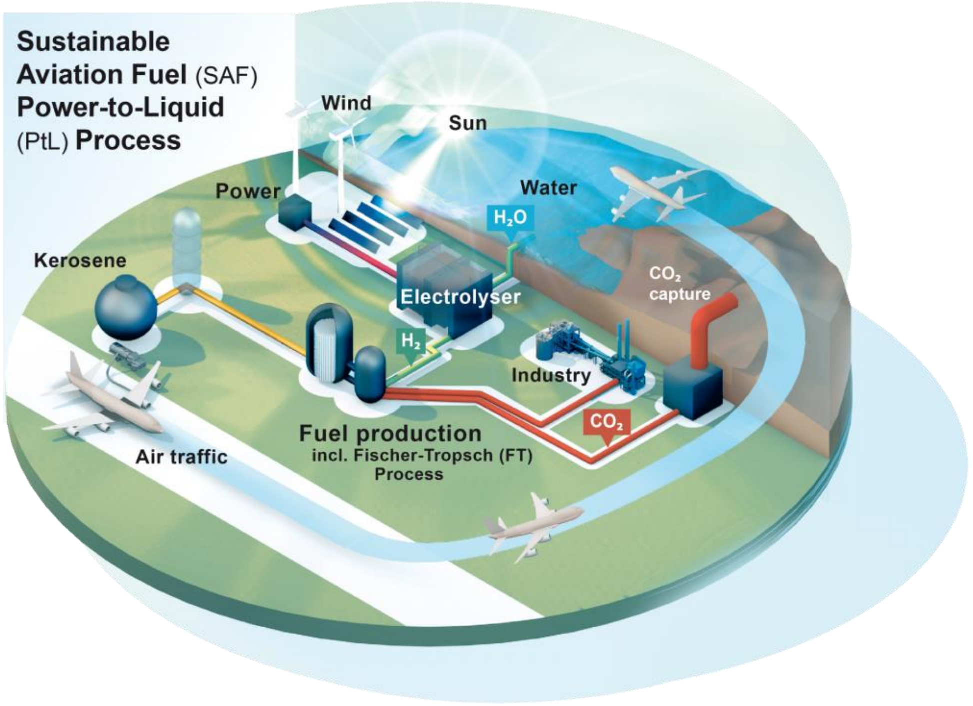
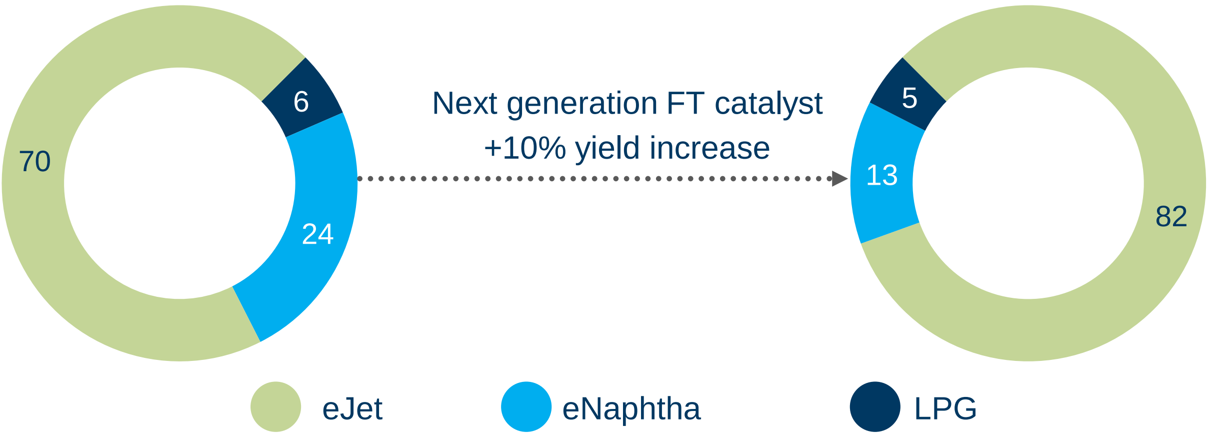
2022-2025

Power to Liquids process: production of sustainable aviation fuels (SAF)

Power from renewable sources → Production of green hydrogen → Carbon dioxide e.g. from industrial processes or direct air capture → CARE-O-SENE Fischer-Tropsch-Synthesis → synthetic sustainable aviation fuels (SAF)



Accelerated and knowledge-based development of Fischer-Tropsch (FT) catalysts for the **highly efficient and production** of Sustainable Aviation Fuels (SAF) in **relevant volumes for the transformation** of the aviation sector



CARE-O-SENE |Workpackages & partner involvement

CARE-O-SENE Catalyst Research for Sustainable Kerosene

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HZB Helmholtz Zentrum Berlin, SASOL, University of Cape Town, KIT Karlsruher Institut für Technologie

WP1

CATALYST SYNTHESIS

Lab scale synthesis and testing

WP2

CHARACTERISATION AND MODELLING

Advanced Structural characterisation and modelling

KIT Karlsruher Institut für Technologie, SASOL, HZB Helmholtz Zentrum Berlin, University of Cape Town

SASOL, Fraunhofer IKTS, HZB Helmholtz Zentrum Berlin, KIT Karlsruher Institut für Technologie

WP4

IMPACT ANALYSIS

Assessment of the benefits of the FT catalyst

WP3

SCALE-UP AND DEMONSTRATION

FT catalyst production at larger scale and testing

SASOL, INERATEC, HZB Helmholtz Zentrum Berlin, Fraunhofer IKTS

2022-2025

Selection of other SAF projects with contributions from Germany

Gefördert durch:
Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages

KEROSyN 100	Power to liquid plant using wind energy and the Methanol to Kerosene route	https://www.kerosyn100.de/ 2018 - 2022
GLAMOUR	GLycerol to Aviation and Marine prOducts with sUstainable Recycling using CO_2 removal and Fischer Tropsch Synthesis	https://www.glamour-project.eu/ 2020-2024
FLITE	Sustainable Aviation Fuel Produced From Waste-Based Ethanol Resources	https://flite.eu/about/ 2020-2024
eCOCO2	Direct electrocatalytic conversion of CO_2 into chemical energy carriers (e.g. SAF) in a single stage co-ionic membrane reactor	www.ecoco2.eu 2019-2023
KEROGREEN	Kerogreen CO_2: Demonstration of SAF production from renewable electricity, captured CO_2 and water to kerosene via Fischer Tropsch Synthesis	https://www.kerogreen.eu/ 2018-2022

Conclusion

Status Quo	• 50% SAF: Currently certified maximum SAF blend • 70% SAF: ReFuel EU aviation fuel blending target by 2050 • Multiple renewable feedstocks possible for SAFs • Relatively high cost of SAFs with low production volumes
Related Projects	• Proof of lower CO_2 equivalent emissions for SAFS than Jet A-1 (100% fossil) • Increasing the kerosene yield in the Alcohol to Jet technology • New catalysts to increase kerosene fraction of Fischer Tropsch from syngas • New technologies e.g. single stage hydrogenation, carbon capture, etc. • New processes in value chain for SAFs to reduce costs
Needs for Resilience	• Enabling standards and specifications • Advances in processing technologies: higher efficiency & less complex • Increased production levels: scaling

Thank you for your attention

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HELMHOLTZ
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