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KEROGREEN

"Production of Sustainable aircraft grade Kerosene from water and air powered by Renewable Electricity, through the splitting of CO₂, syngas formation and Fischer-Tropsch synthesis"

Project No: 763909

Deliverable D1.3 Glossy brochure for Policy makers

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Dissemination level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Deliverable Nature

Nature of Deliverable		
R	Report	x
P	Prototype	
D	Demonstrator	
O	Other	

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1 Introduction

The deliverable 1.3 reports on the production of a glossy brochure for policy makers. This brochure has been produced by DIFFER based on the KEROGREEN Corporate Identity (logo, picture with plane and fixed green colour). It also includes the previously used infographic showing the “Circle of KEROGREEN”, from CO₂, water, and renewable electricity to green kerosene in 12 steps. This brochure has been submitted to the coordinator for reviewing and to all project partners for approval for dissemination and use. The brochure will be available in hard copy and also on the project website.

2 Glossy brochure for Policy makers

The purpose of the brochure is to heighten awareness amongst policy makers about the results achieved in the project to increase the influence of the project and to enable next steps. Therefore besides the description of the ‘Circle of KEROGREEN’, the main achievements and key figures are mentioned. In addition by answering some frequently asked questions the brochures gives a comprehensive overview of the reasoning behind the project in comparison with other developments and what is next. The brochure also invites companies and policy makers to contribute where possible to take green kerosene to the next level.

Each partner will be able to disseminate the brochure as often as required.

3 Annex

KEROGREEN

Making green kerosene out of CO₂, water,
and renewable electricity



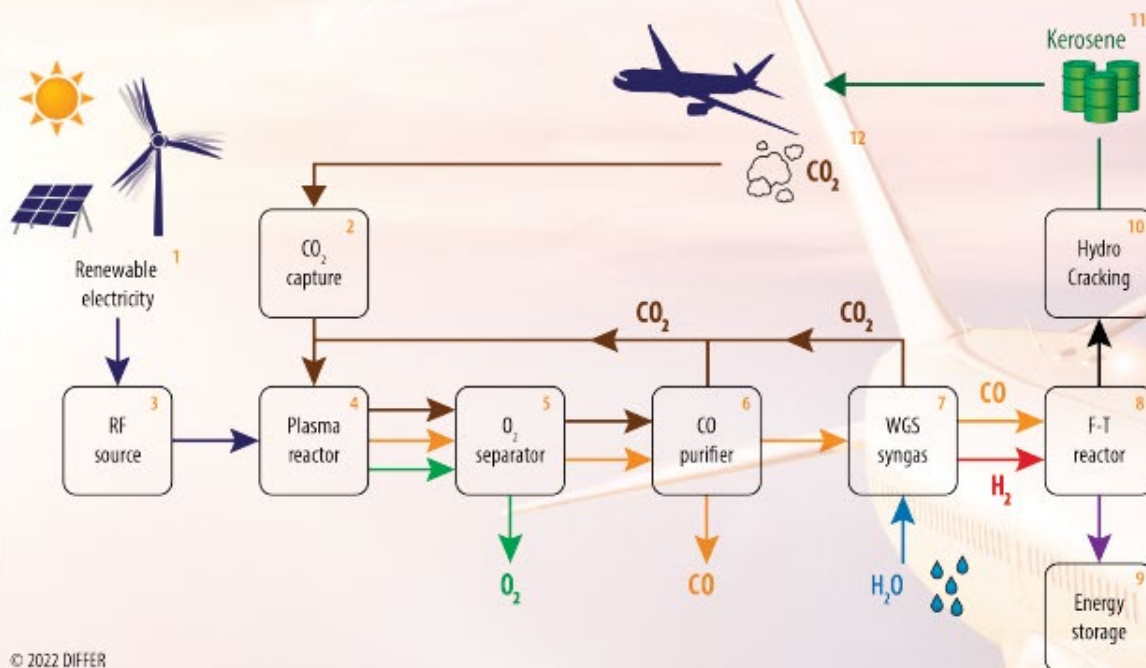
We integrated the individual, separate processes and
installed it into a shipping container!
Will you fly with us to the next level of technology readiness?



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THE CIRCLE OF KEROGREEN FROM CO₂, WATER AND RENEWABLE ELECTRICITY TO GREEN KEROSENE IN 12 STEPS



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Step 1: The 12 steps to produce kerosene cost a lot of energy. To produce green kerosene, the energy source has to be renewable. Good sources are solar energy and wind energy.

Step 2: CO₂ feedstock is to be (re-)captured from ambient air for the fuel cycle to become CO₂ neutral.

Step 3: The energy from step 1 drives a so called RF source, a kind of microwave-oven.

Step 4: A plasma reactor uses the microwave radiation and splits CO₂ in CO and O₂. This so called plasmolysis has been proven at small scale by DIFFER.

Step 5: To remove the oxygen (O₂) VITO and CERPOTECH produced oxygen permeable membranes. DIFFER demonstrated that oxygen is removed from the mixture. CO and CO₂ go to the next step.

Step 6: In the CO purifier, made by HyGear, undesired gases are removed to supply clean CO for the next step.

Step 7: The integrated water-gas shift and CO₂-removal is built by KIT. CO and H₂ go to step 8.

Step 8: The Fischer-Tropsch synthesis by INERATEC is a collection of chemical reactions that converts a mixture of carbon monoxide and hydrogen into liquid hydrocarbons, mainly alkenes to serve as a basis for clean diesel or kerosene, amongst others.

Step 9: An excess fraction, for example molecules that do not fit the kerosene specification, could be stored for later use as CO₂ storage.

Step 10: The molecules which have passed the hydrocracking step (by KIT) and fit to the kerosene blend, a mixture of carbon molecules with 8 to 14 carbonatoms, are sent to final upgrading for aviation.

Step 11: Kerosene can be stored in barrels and tanks.

Step 12: The aircraft is fueled by the synthesized kerosene propelling its jet engines, whilst emitting CO₂. This CO₂ is recaptured and re-used to feed the KEROGREEN synthesis system. The circle is closed.

FREQUENTLY ASKED QUESTIONS

Why green kerosene?

Green kerosene is a carbon-neutral fuel. It provides long-term, large-scale energy storage. This is important if you want to bridge periods in which the sun does not shine or there is no wind. Furthermore, green kerosene is a high-energy-density fuel. It enables long-range transport and mobility. And, last but not least: it does not increase the atmospheric CO₂ concentration.

Why not make electric planes or use hydrogen?

In 2016, when the KEROGREEN project started, sustainable aviation hardly figured in public debate. To date, green kerosene looks like the only solution for sustainable aviation. Not-yet-existing planes on hydrogen need enormous fuel tanks. Potential electric planes carry heavy batteries. A great benefit of green kerosene is that it uses existing infrastructure. The planes, the airports, and the fuel terminals; they do not need to be modified.

How much kerosene do we need?

The demand for kerosene is overwhelming. As of today, the world uses approximately 1 million tons of kerosene per day or 5 million barrels of kerosene per day. If you were to put those barrels in a square, you would have about a kilometre by a kilometre of barrels of kerosene. Each day. Usually, the demand is calculated in millions of tons per year. The demand for kerosene is nearly 300 million tons per year. The prospect of replacing kerosene with sustainable fuels is daunting.

How much produces the KEROGREEN project?

First, this project was not about producing enormous amounts of green kerosene. The project aimed to connect existing technologies and bring them to a higher level of technology readiness. Having said that, KEROGREEN produces 0,1 kg of kerosene per hour. If you would extrapolate that to a year, that would amount to 876 kg of kerosene, which rounds up to 1 ton of the 300 million tons needed. So, we are clearly not there yet.

How about the technology readiness levels?

The project objective was to reach technology readiness level 4. That means technology is validated in the lab. All elements, except the oxygen separator, reached this desired level of 4 or higher. In addition to that, the integration in one container actually corresponds to level 5: technology validated in a relevant environment.

What's next?

Unlike any other Synthetic Aviation Fuel (SAF) approach, KEROGREEN uniquely departs from air-captured CO₂ and is therefore worth pursuing. The picture below shows the impressive machinery presently installed on-site at KIT-IMVT, ready for further system development. This includes upscaling the oxygen separator and testing and characterization of the fully integrated system. After that, energy efficiency is to be improved by a system engineering approach. Followed by upscaling for demonstration in an industrial relevant environment.

Photo: KIT / Amadeus Bramsiepe

KEROGREEN container with the integrated system



KEROGREEN: FOR GREEN KEROSENE

Main achievements

- Individual elements have been demonstrated at lab-scale
- Individual elements have been integrated in a container sized system

Key figures

Plasma Reactor (step 4)

- Up to 0.7 kg CO/h production rate
- Typical energy cost: 0.12 kWh/kg CO

CO purification (step 6)

- Up to 98% purity (on single step)
- Up to 95% CO yield

Fischer-Tropsch and Hydrocracking modules (steps 8 and 10)

- In-line recycling (and cleaning) of residual wax
- Wax conversion > 50%
- Required isomer content of > 30% for kerosene obtained

Challenges

- Upscaling of the oxygen separator (step 5) from lab scale to system level is work in progress
- To produce 0.1 kg/h kerosene with a fully integrated system

What's next?

- We would love to get into contact with investors, policymakers, companies and airports
- Do you take green kerosene with us to the next level?

What can the EU, countries, or companies do?

The next steps to achieve a profitable product depend on several factors. It helps if the EU and countries or companies globally, provide funding or loans to enable the next steps. More important however, will be regulation to make e-kerosene cost competitive.



Photo: KIT / Pfeifer



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