ICAO

# INNOVATION

## EUR/NAT WORKSHOP

Paris Office

#FUTUREAVIATION

# Christoph Falter

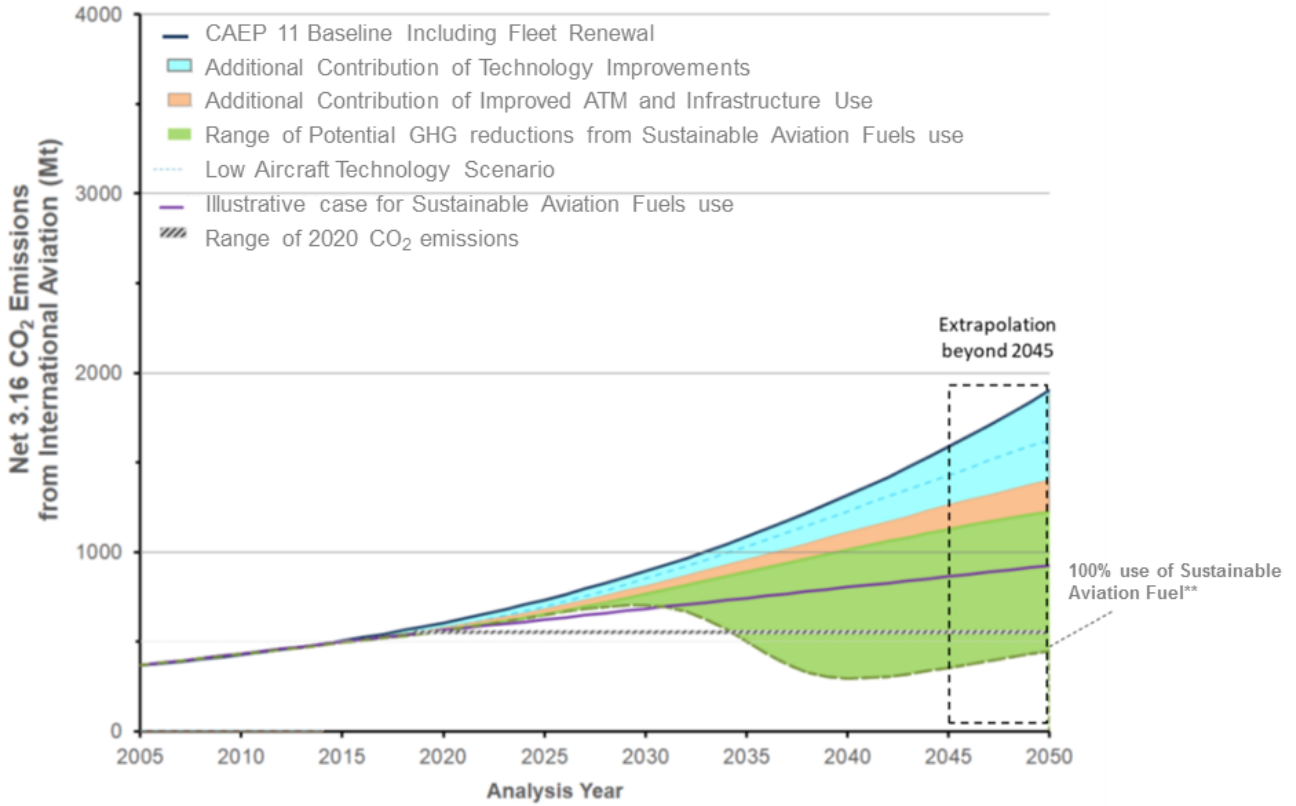
Head of Strategy, Synhelion

# Agenda

- Introduction
- The Sun-to-Liquid pathway
  - Fundamentals
  - Construction of and experimental experience with demonstration plant in Jülich, Germany
- Perspectives of the technology
- Conclusions

# Introduction

- Wide consensus: Renewable fuels are required to achieve GHG emission targets
- Increase in transportation demand outpaces efficiency improvements in aviation
- Sustainable fuels:  Wide substitution and low specific GHG emissions required




Source: https://www.icao.int/environmental-protection/pages/climatechange_trends.aspx

# Introduction

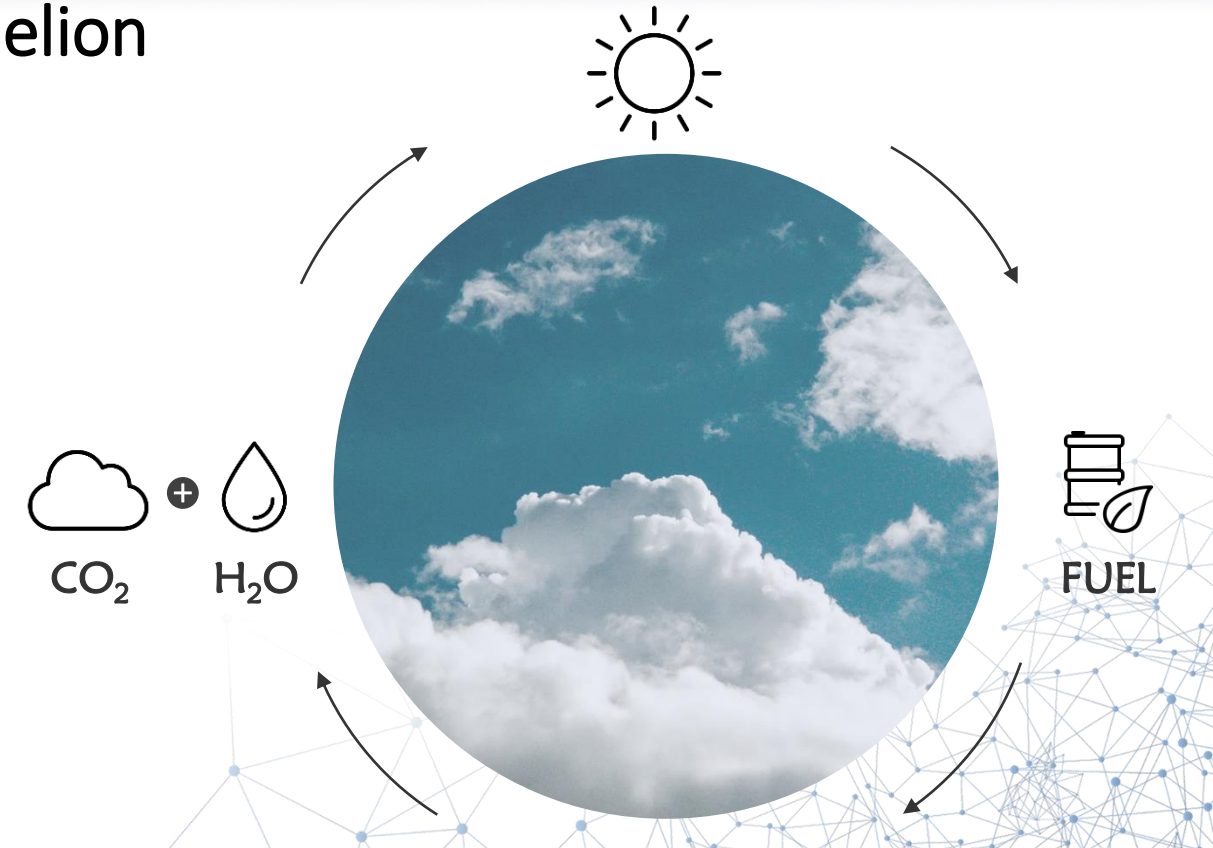
- Aviation will rely on liquid hydrocarbons for decades
  - Electric flight limited by battery specific energy (E/M)
    - E.g. Bauhaus Luftfahrt Concept Study Ce-Liner
    - Task: Cover 80% of air traffic (900 NM range)
    - Would require specific energy > 1 kWh/kg
  - Hybrid electric aircraft concepts still rely on liquid fuel
    - Potential efficiency benefits are still subject of current research
  - Liquefied gasses ($LH_2$ and LNG)
    - Feasible concepts but change of energy carrier requires new aircraft and new infrastructure



Sources: M. Hornung, *Ce-Liner – Case Study for eMobility in Air Transportation*, Aviation Technology, Integration and Operations Conference. Los Angeles. 12.8.2013
EU-H2020 Project Centreline: http://cordis.europa.eu/project/rcn/209713_en.html; M.K. Bradley, *Subsonic Ultra Green Aircraft Research: Phase II N+4 Advanced Concept Development*, 2012. doi:2060/20150017039, Tupolev Tu-155 experimental aircraft: wikipedia

# The Sun-to-Liquid pathway at Synhelion

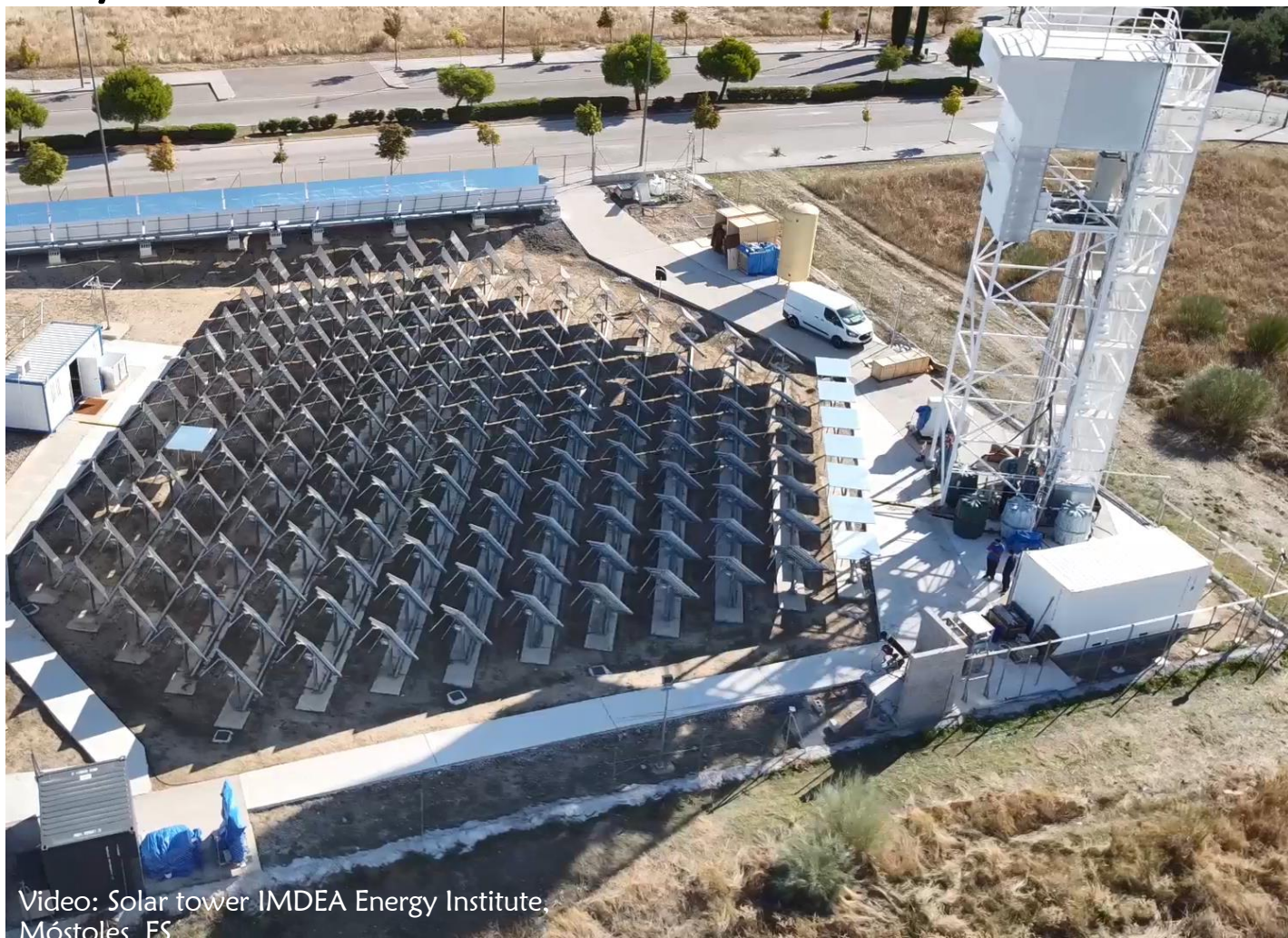
- Our aim is to produce liquid fuels for the transport sector that are fully compatible with our infrastructure and can be used by airplanes, ships, and cars.
- To this end, we close the carbon cycle by using $CO_2$ captured from the atmosphere and combine it with $H_2O$ in a chemical process to produce liquid hydrocarbons.
- The $CO_2$ that is emitted during combustion is balanced by the $CO_2$ captured from the atmosphere, which closes the carbon cycle.



# The Sun-to-Liquid pathway at Synhelion

## Overview

- Concentrated solar system deliver high-temperature process heat

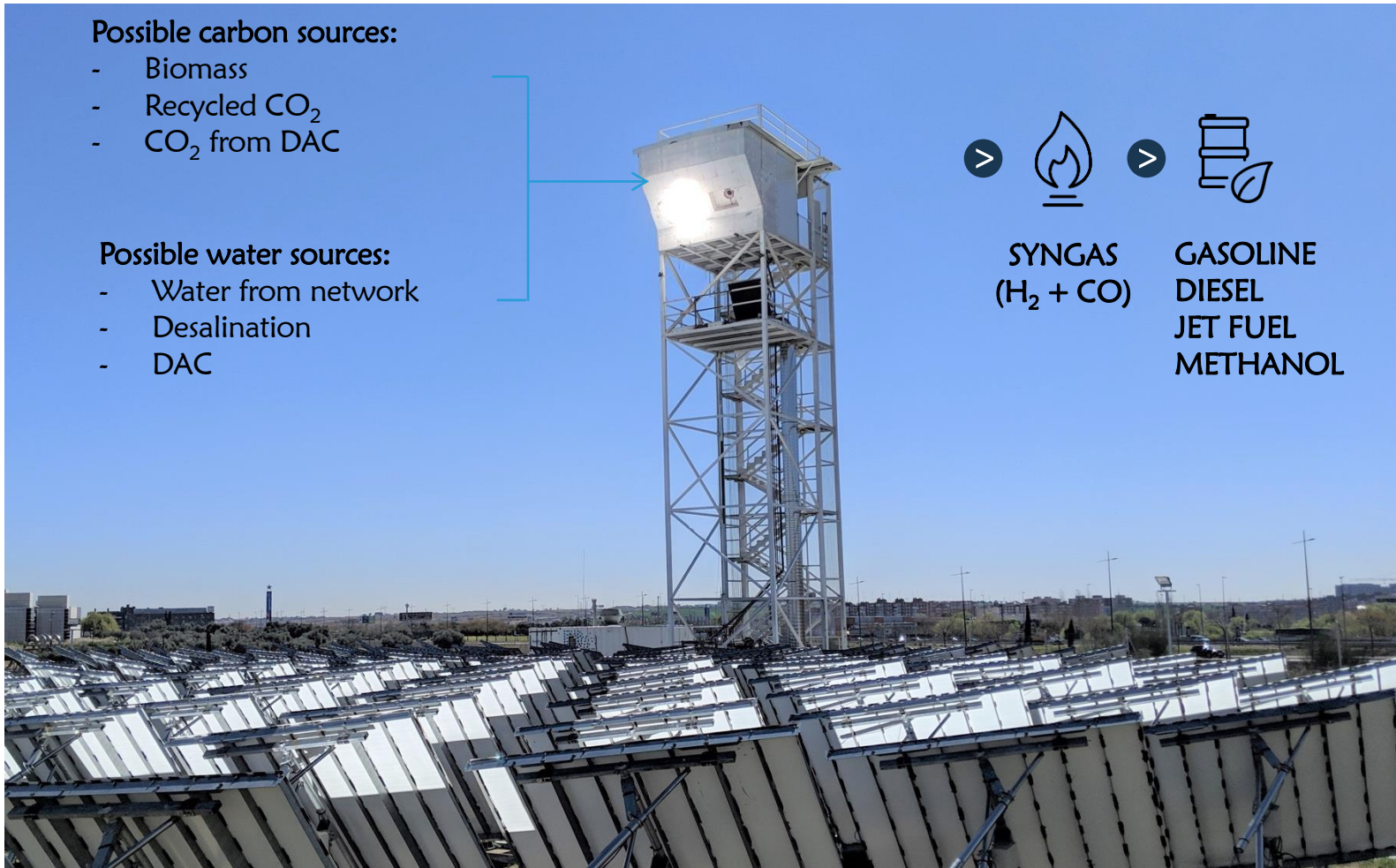


Video: Solar tower IMDEA Energy Institute, Móstoles, ES

# The Sun-to-Liquid pathway at Synhelion

## Overview

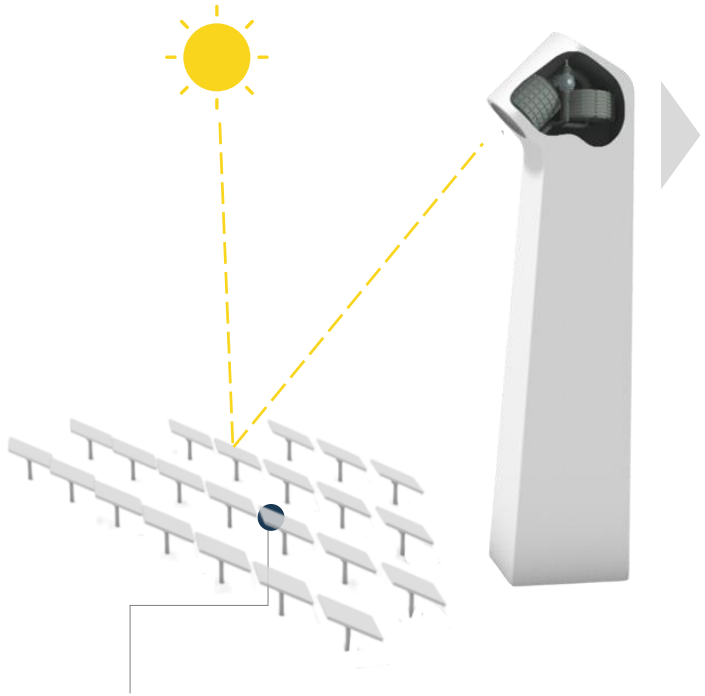
- Synhelion uses solar heat to convert $CO_2$ and $H_2O$ into synthetic fuels – so-called solar fuels.

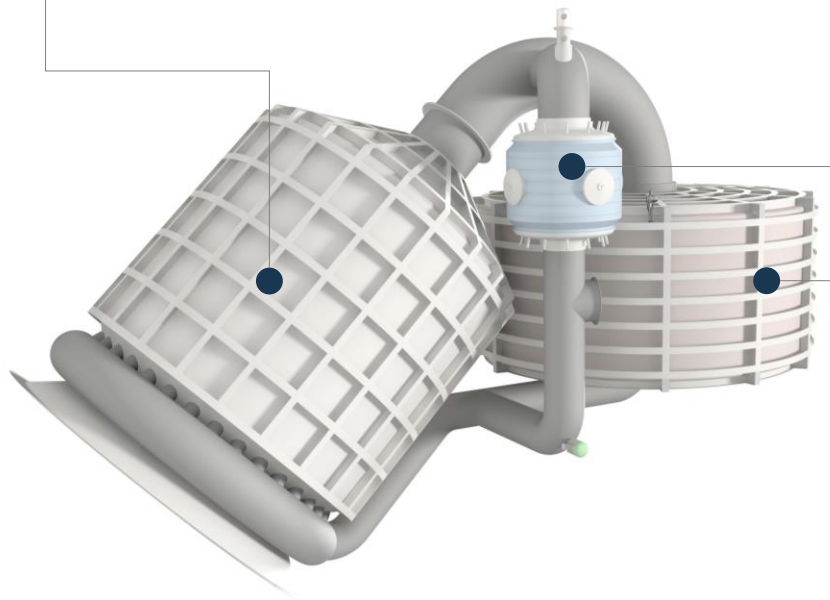


# The four innovation fronts

## SOLAR RECEIVER
High-temperature process heat

## THERMOCHEMICAL REACTOR
Syngas production

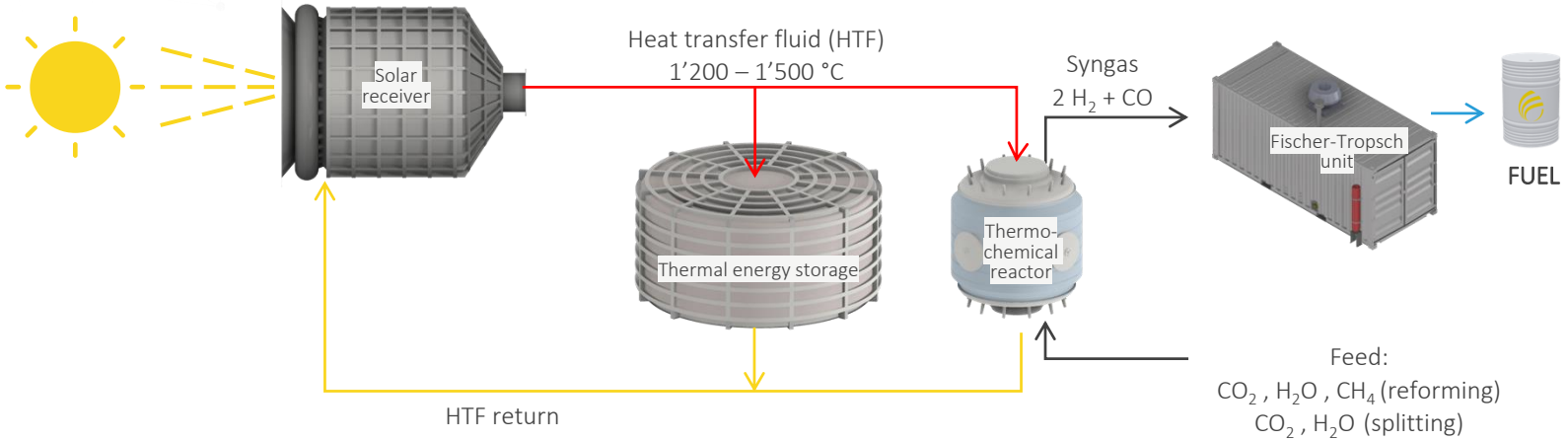


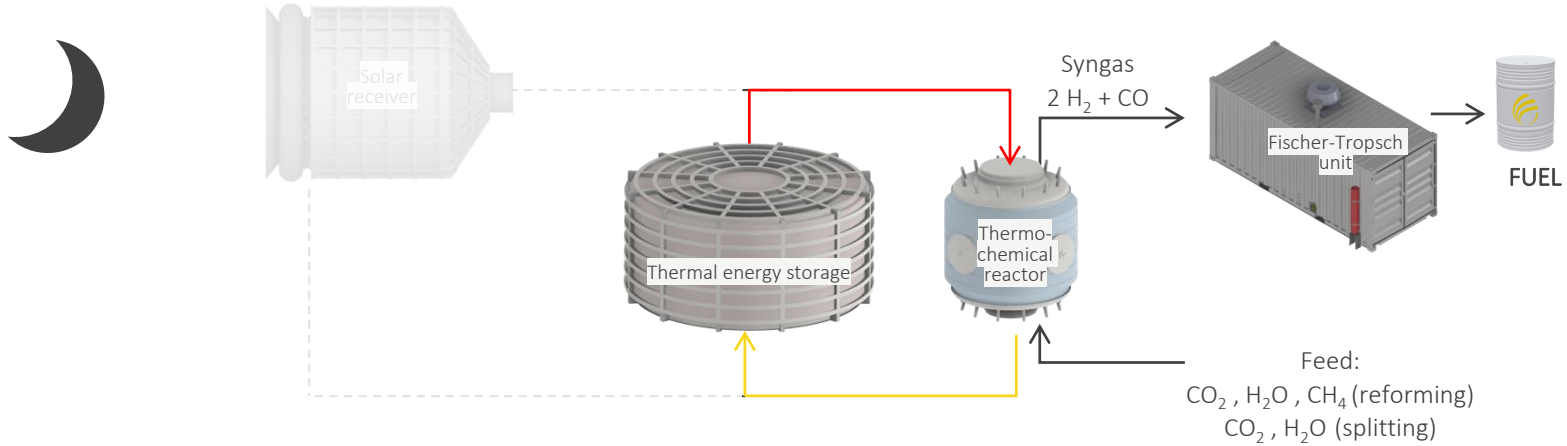


## HELIOSTATS & CONTROLS
Concentrated sunlight

## THERMAL ENERGY STORAGE
24/7 heat delivery

# The process in a nutshell



# A record-breaking path to market


World's first solar jet fuel from $H_2O$ and $CO_2$ in the lab


World's first carbon-neutral fuels from air and sunlight


Medium-scale demonstration under real field conditions


Full-scale demonstration of key components

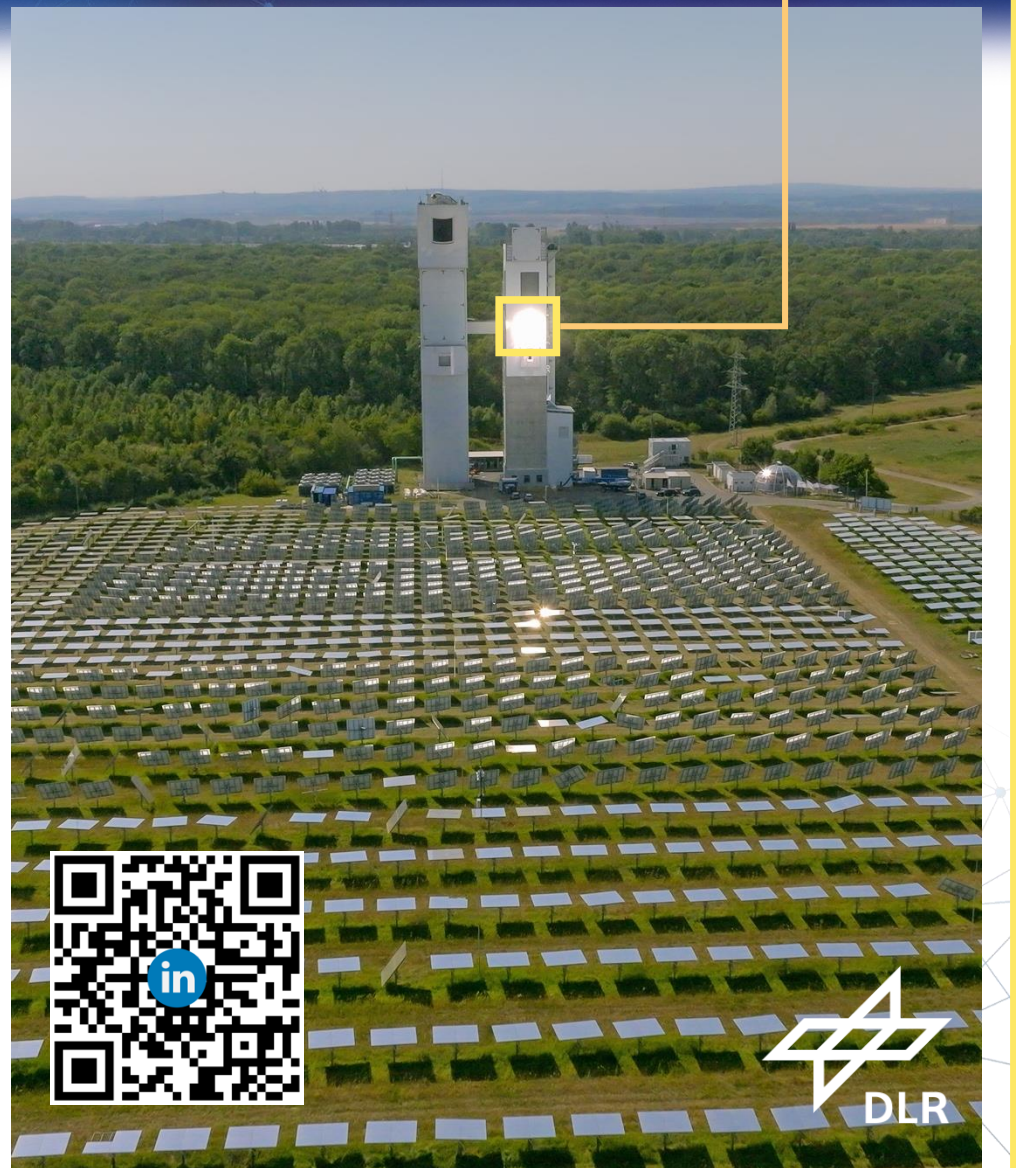
# INNOVATION

EUR/NAT WORKSHOP

#FUTUREAVIATION

ICAO

In 2022, we coupled the receiver and the reactor on industrial scale and produced the world's first solar syngas, reaching the last decisive technological milestone to start the industrial production of solar fuels.



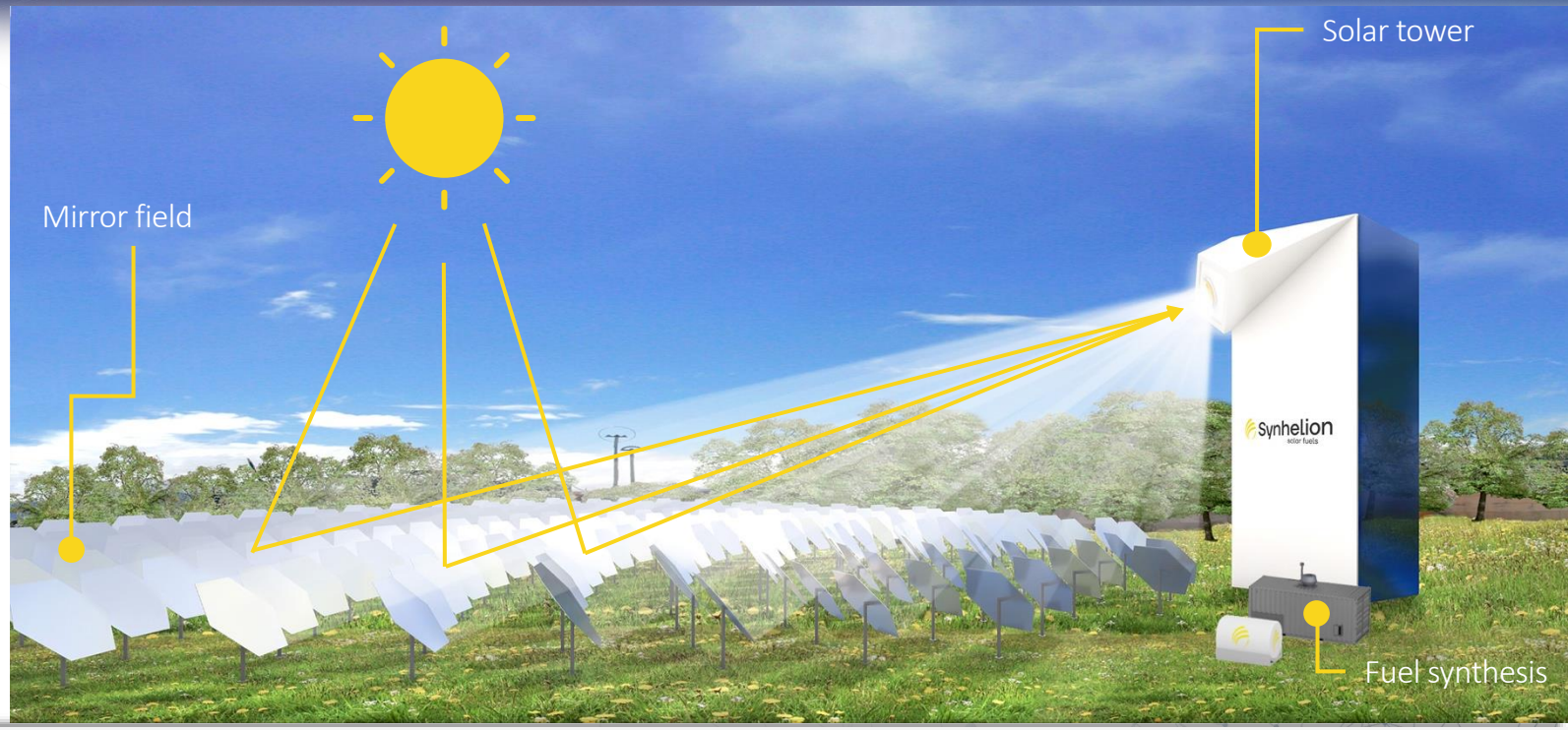


# SPATEN STICH

## SOLARTREIBSTOFF-ANLAGE


ICAO INNOVATION

# 2023: Industrial plant DAWN




## Main specifications

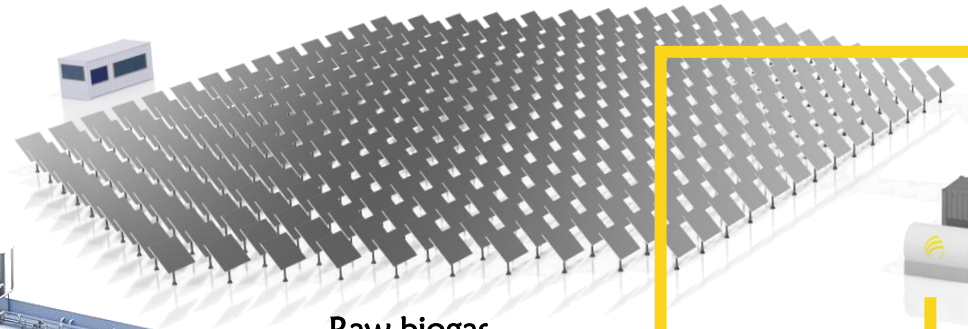
- 1'500 m² mirror area
- 600 kW solar input power
- 10'000 l/y fuel demo batches
- Commissioning: 2023
- Customers: Swiss / Lufthansa Group, AMAG and other key customers

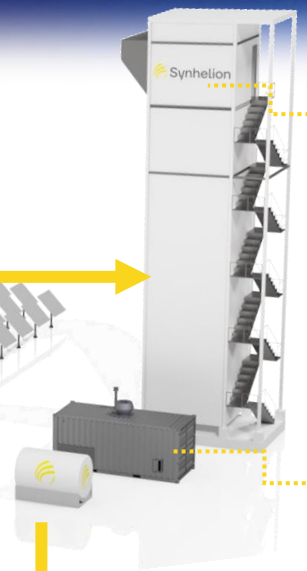
Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

# Renewable fuels the Synhelion way



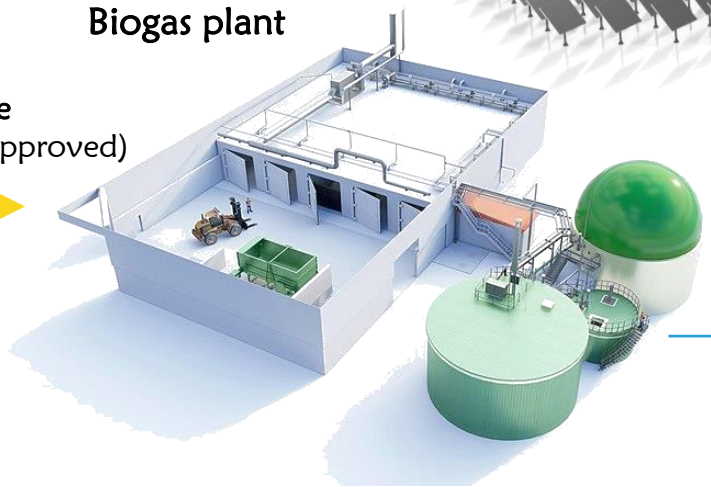



Synhelion thermochemical solar fuel process

Fischer-Tropsch synthesis

Biogas plant

**Bio-waste**
(RED II approved)



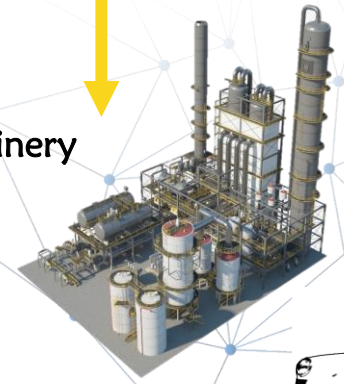
**Raw biogas**
(50% $CO_2$, 50% $CH_4$)

Digestate

**Syncrude**

Trucking

**Local refinery**



**JET A1**

**Gasoline and other products**

**Local Airports**

amag

# Synhelion roadmap

= 50% of Switzerland's jet fuel consumption

= 50% of European jet fuel consumption

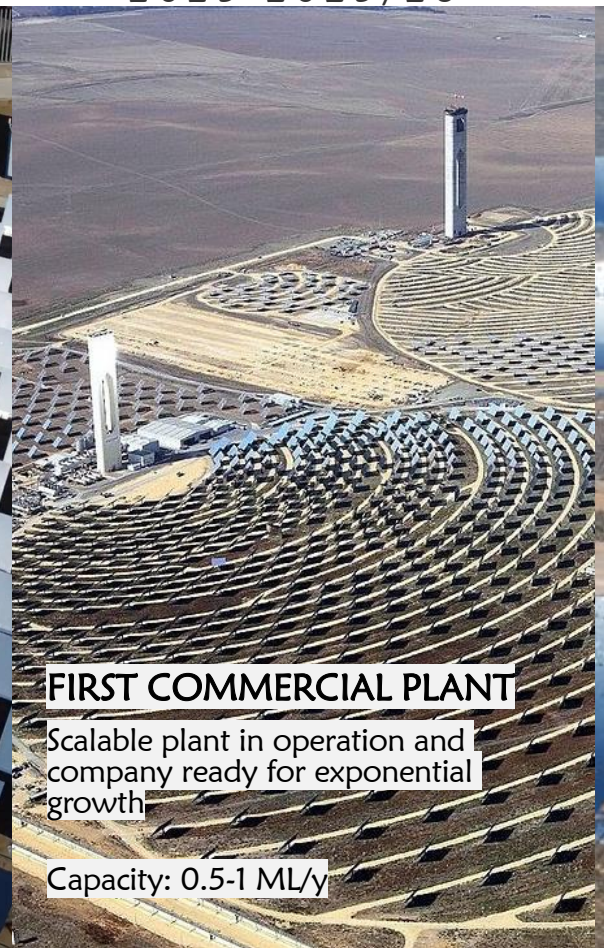
2021-2023/24

## INDUSTRIAL DEMONSTRATION

Full-scale industrial demonstration and first fuel batches to key customers

Capacity: ~10'000 L/y

2023-2025/26

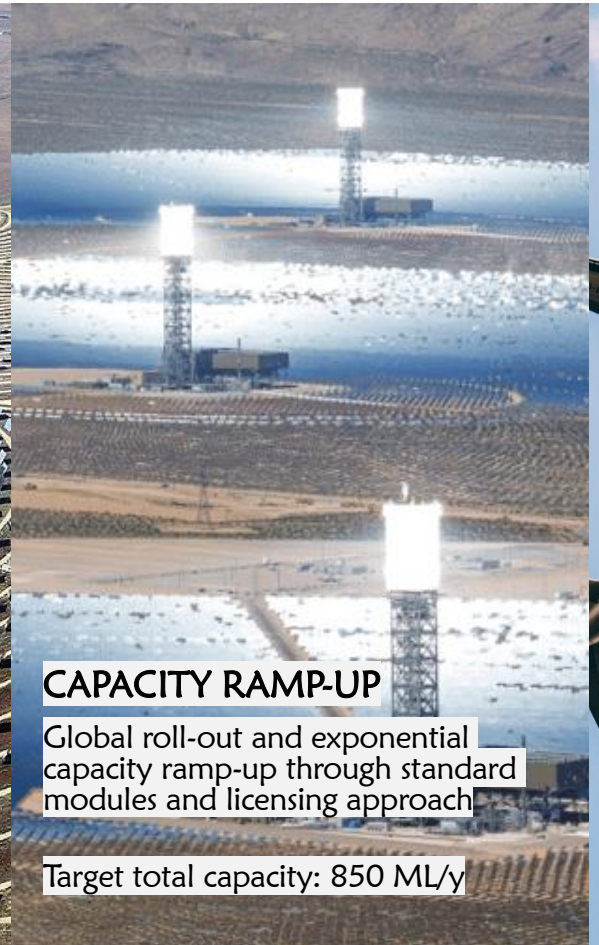


## FIRST COMMERCIAL PLANT

Scalable plant in operation and company ready for exponential growth

Capacity: 0.5-1 ML/y

2025-2031



## CAPACITY RAMP-UP

Global roll-out and exponential capacity ramp-up through standard modules and licensing approach

Target total capacity: 850 ML/y

2040

## TOWARD NET ZERO

Target total capacity: 50 BL/y

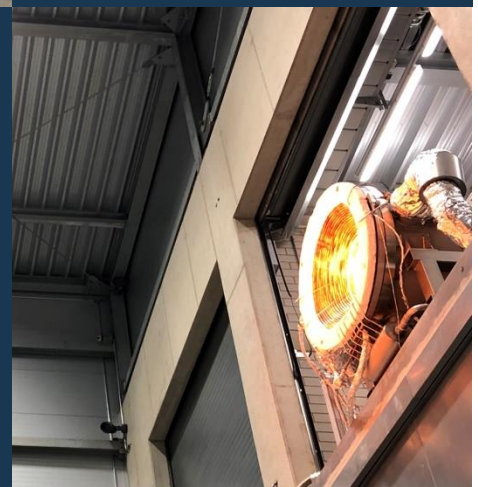
Total: 36 FTEs and growing

Spinoff

ETH zürich

SOLAR IMPULSE EFFICIENT SOLUTION LABEL

TURNING SUNLIGHT INTO FUEL.



# Partners & key customers

eni

CEMEX

wood.

SMS group

Lufthansa

SWISS

edelweiss

Zurich Airport

amag

ETH zürich

YORK UNIVERSITÉ UNIVERSITY

institute IMdea energy

Scuola universitaria professionale della Svizzera italiana SUPSI

UF UNIVERSITY of FLORIDA

DLR

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

**Office fédéral de l'énergie OFEN**

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

**Federal Office of Civil Aviation FOCA**

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bun[illegible]estag

INNOVATION
WORKSHOP

ICAO

# THANK YOU!