



SUN-to-LIQUID II Overview: Solar-Thermochemical Fuel Pathway

Andreas Sizmann, Bauhaus Luftfahrt e.V.

BioTheRos Technical Expert Workshop

WIP Renewable Energies, Munich, 06.10.2026



Funded by
the European Union

Funded by the European Union under GA No. 101122206. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

Project funded by



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs,
Education and Research EAER
**State Secretariat for Education,
Research and Innovation SERI**

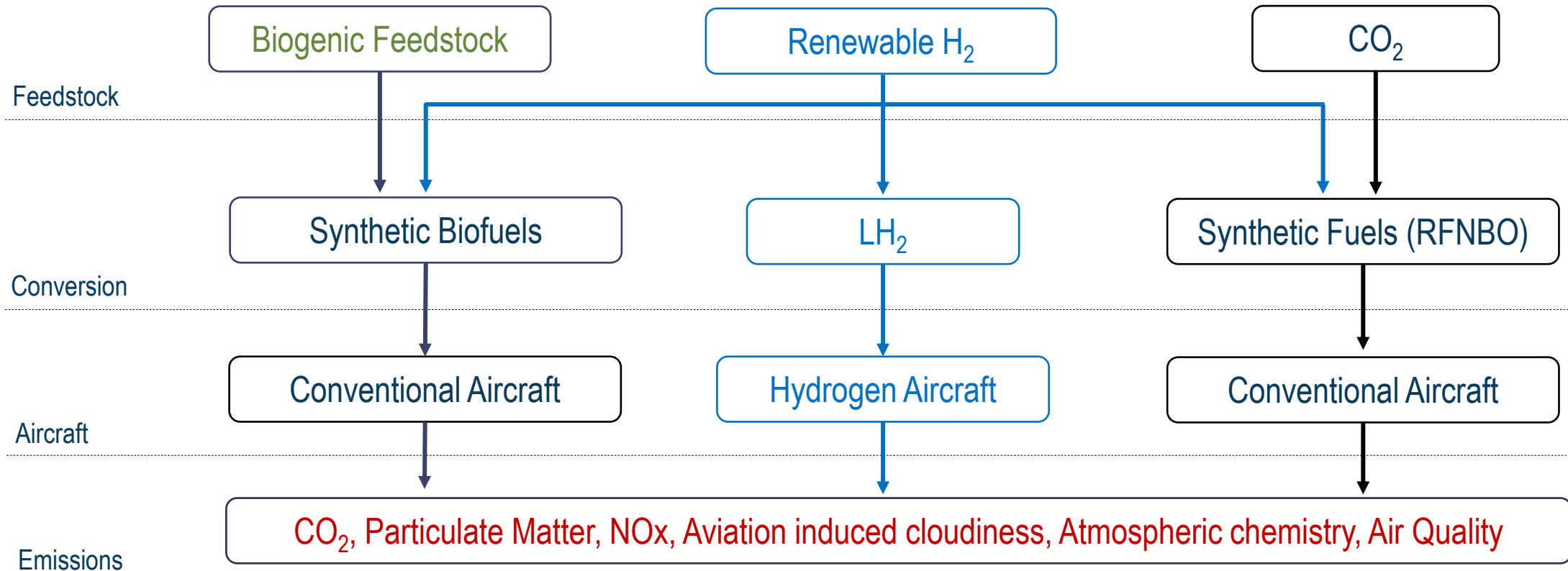


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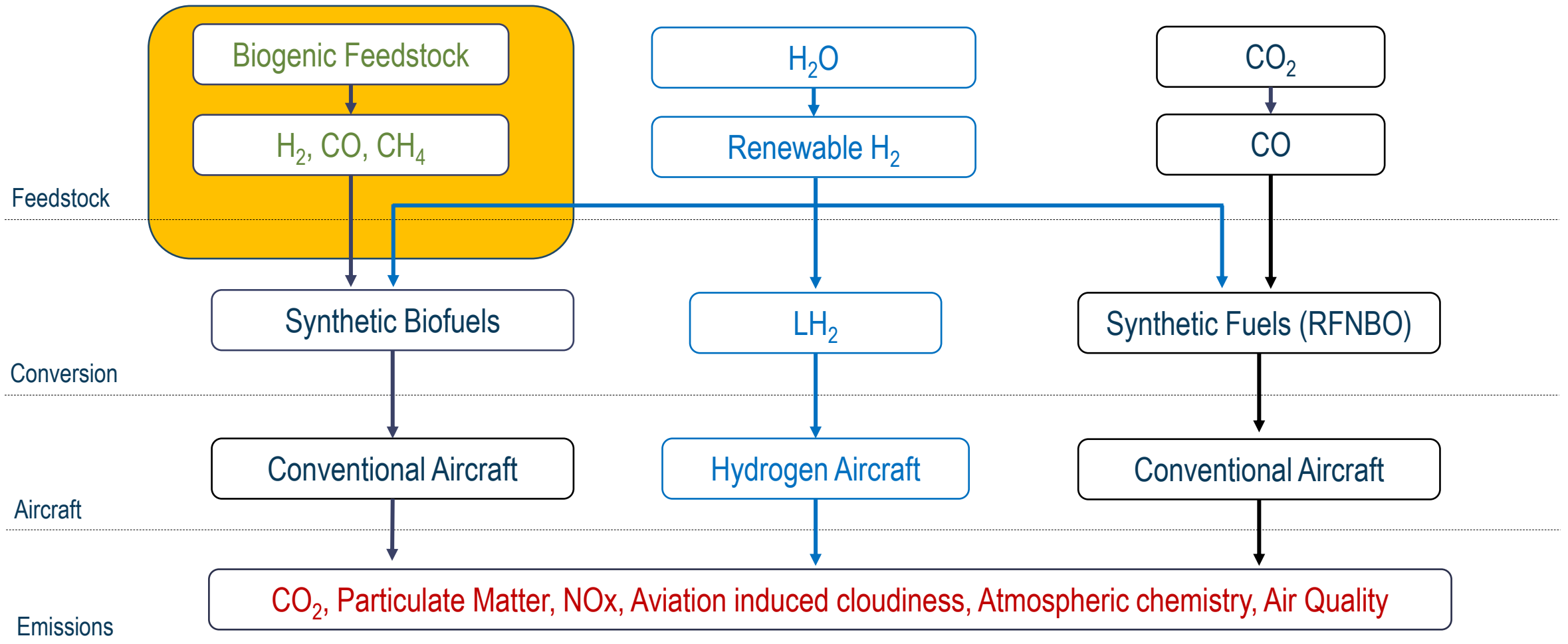


Sustainable Aviation Fuel Pathways

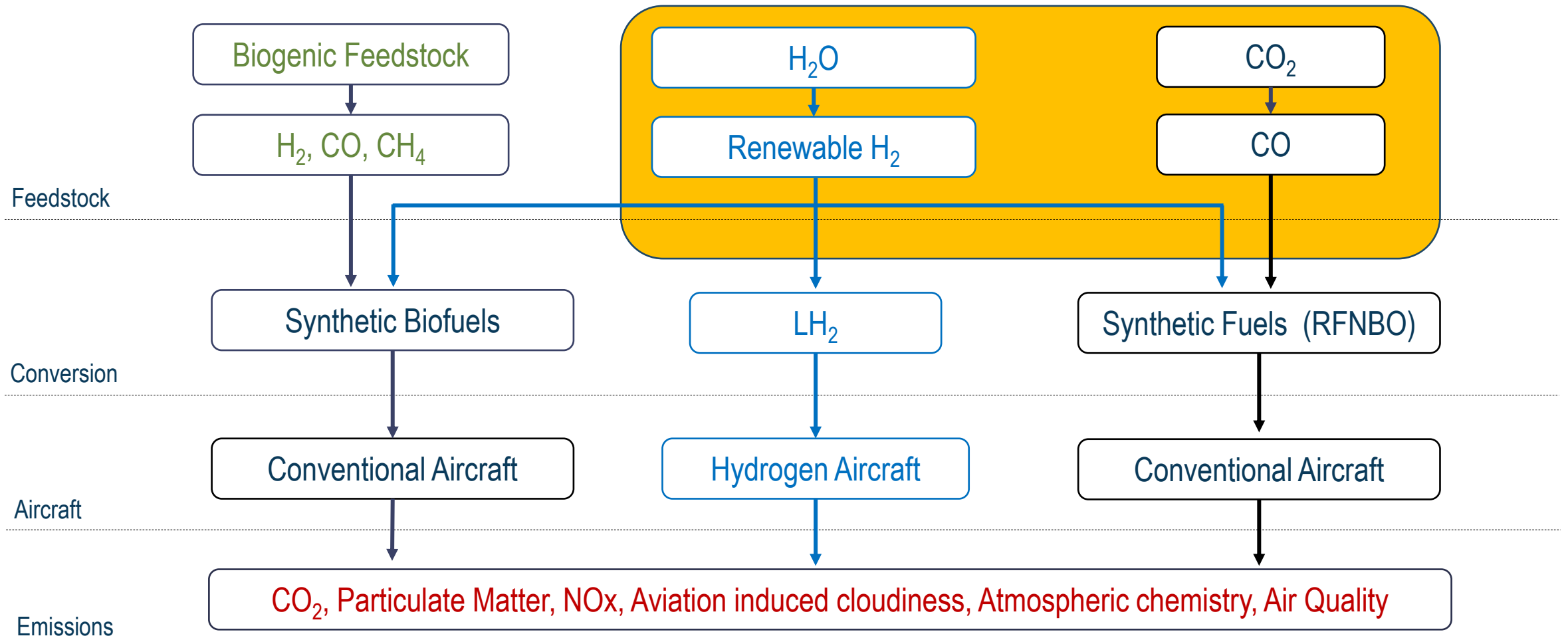


Source: Penke, *Pathways and environmental assessment for the introduction of renewable hydrogen into the aviation sector*, Progress in Life Cycle Assessment 2019. Sustainable Production, Life Cycle Engineering and Management. Springer

Solar-Thermochemical Pathways



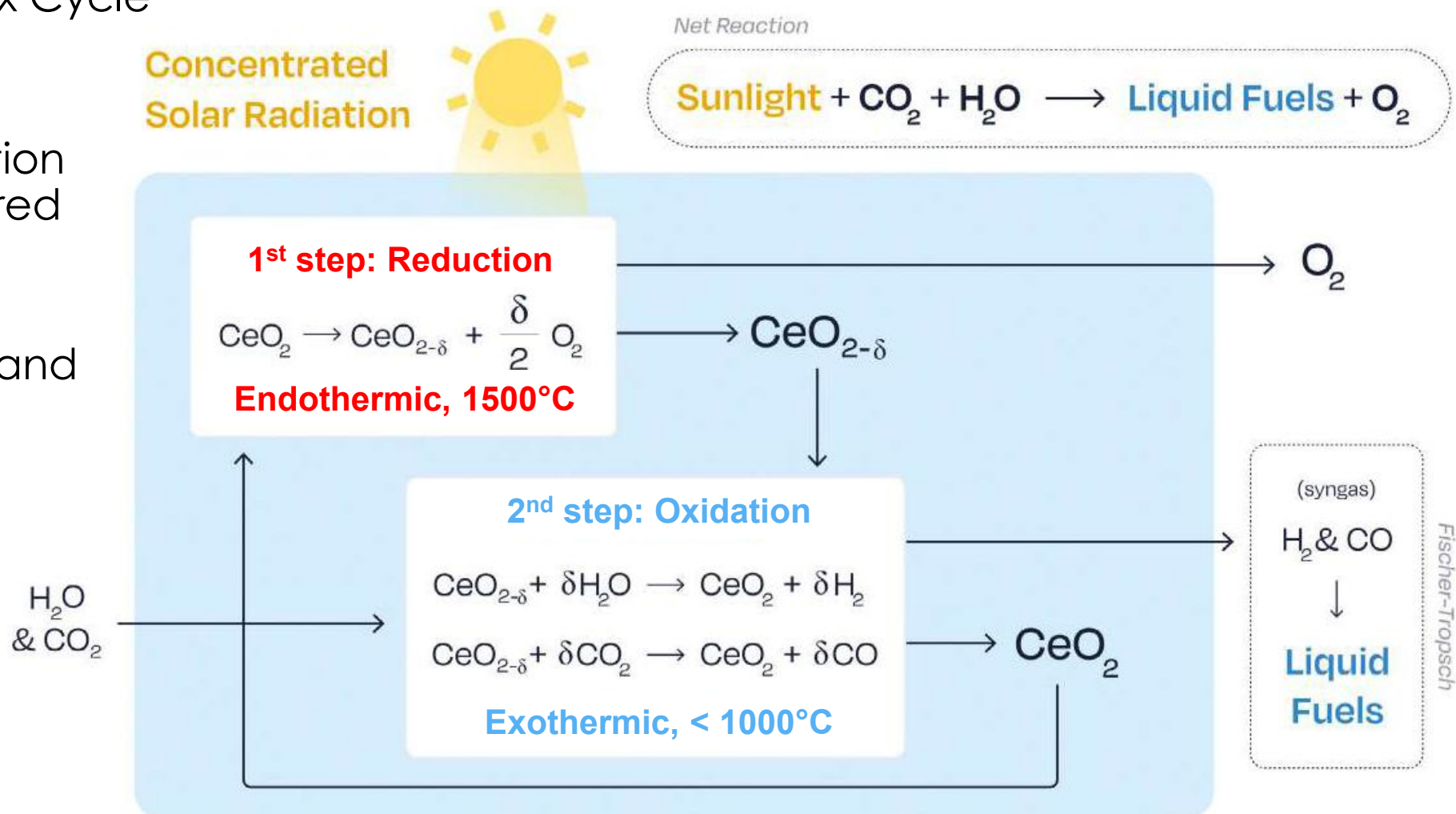
Solar-Thermochemical Pathways



Solar-Thermochemical Pathways

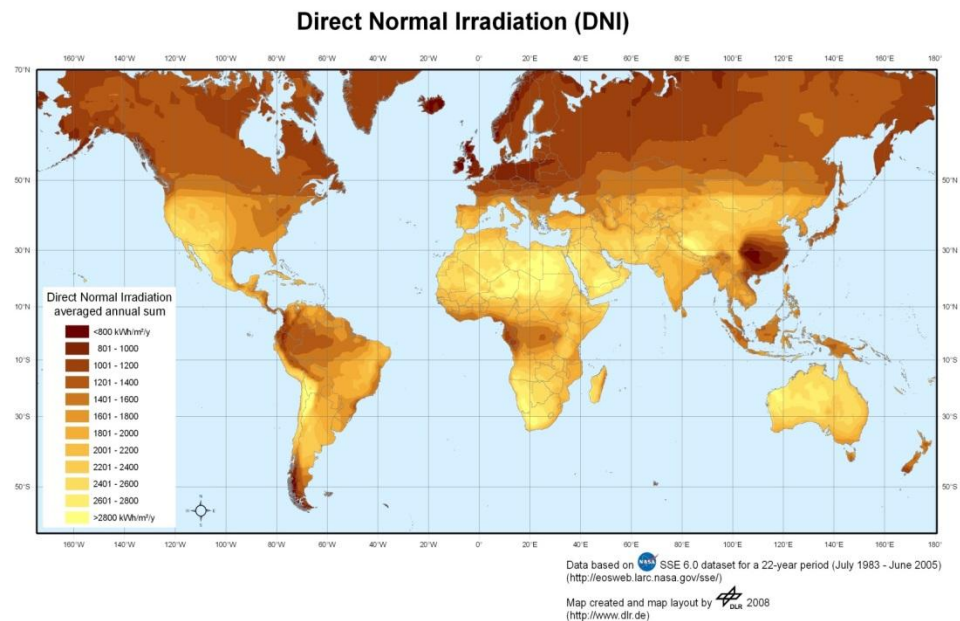
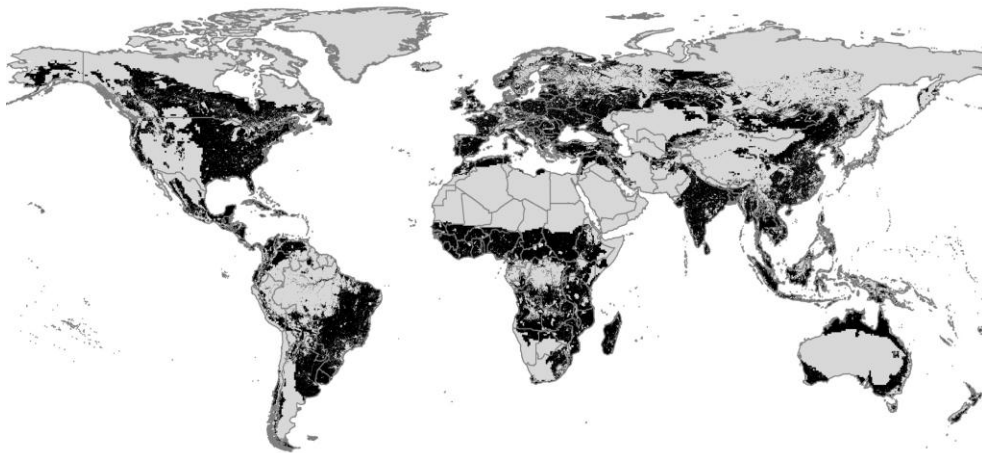
Thermochemical Redox Cycle

- Simultaneous production of H_2 and CO in required ratio
- Two-step reaction separates O_2 from H_2 and CO



Solar Fuel Potential

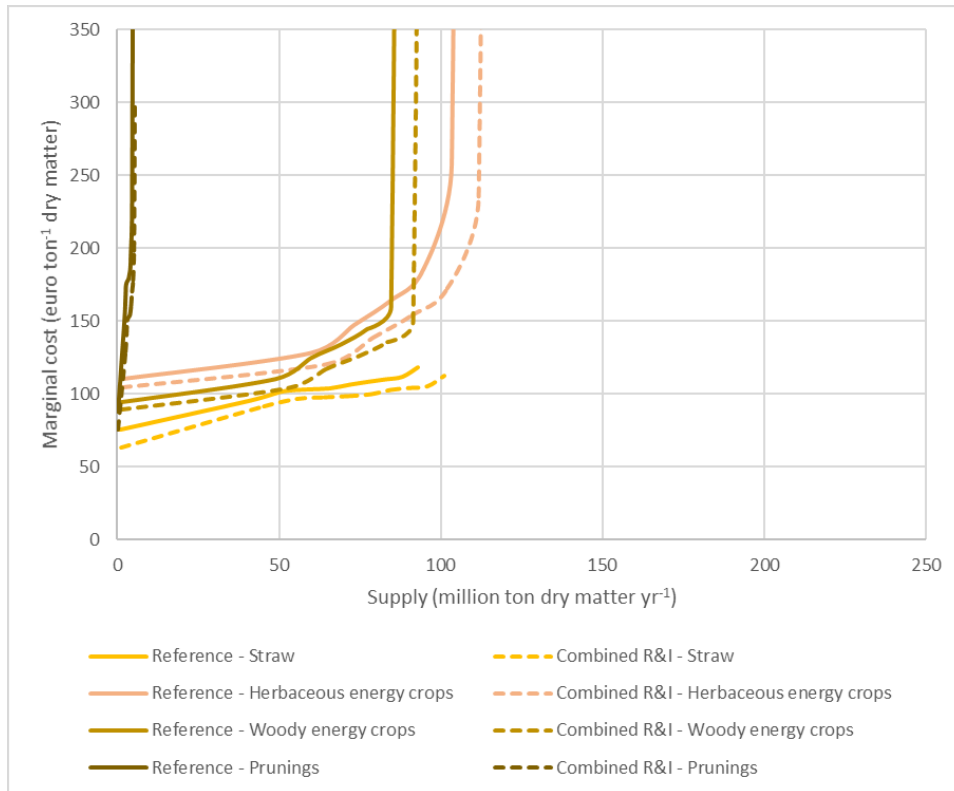
- “Solar Fuel” production potential: Largely complementary to biofuels
 - High direct normal irradiation (DNI) requires low level of humidity
 - Little overlap with arable land, high population density and rich biodiversity
- Solar aviation fuel potential surpasses global demand around 50 times



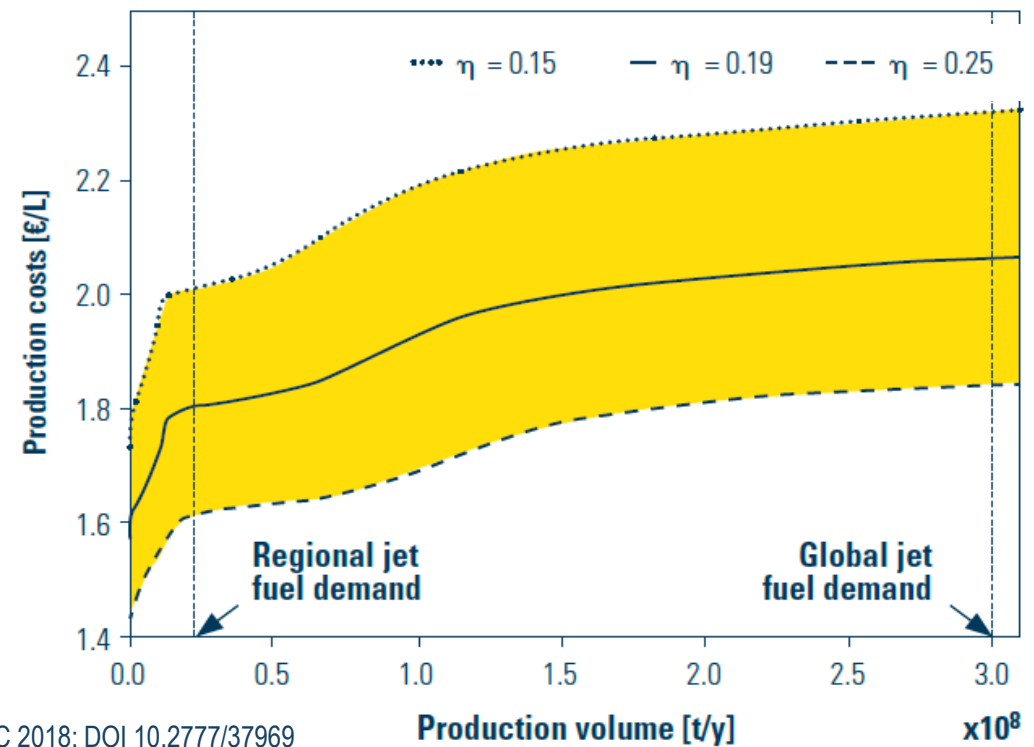
C. Falter, N. Scharfenberg, A. Habersetter, "Geographical Potential of Solar Thermochemical Jet Fuel Production", Energies 2020, 13, 802

Cost and Supply of Biofuels and Solar Fuel

- Limitations of agricultural biomass



- StL fuel costs are driven by reactor efficiency, cost of CO₂, cost of capital

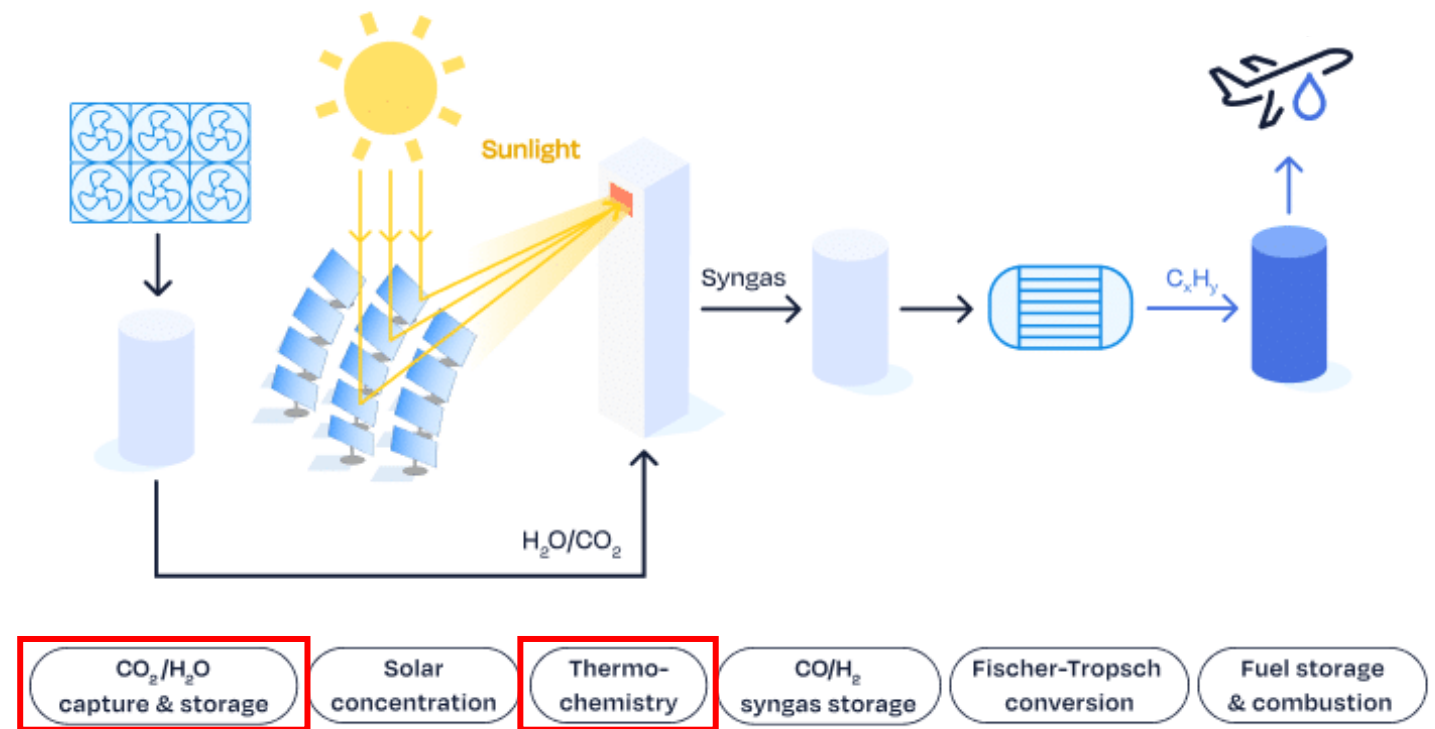


Research and innovation perspective of the mid-and long-term potential for advanced biofuels in Europe, EC 2018; DOI 10.2777/37969

Falter, Scharfenberg, Habersetzer (2020), Geographical potential of solar thermochemical jet fuel production, Energies, Vol 13(4)]

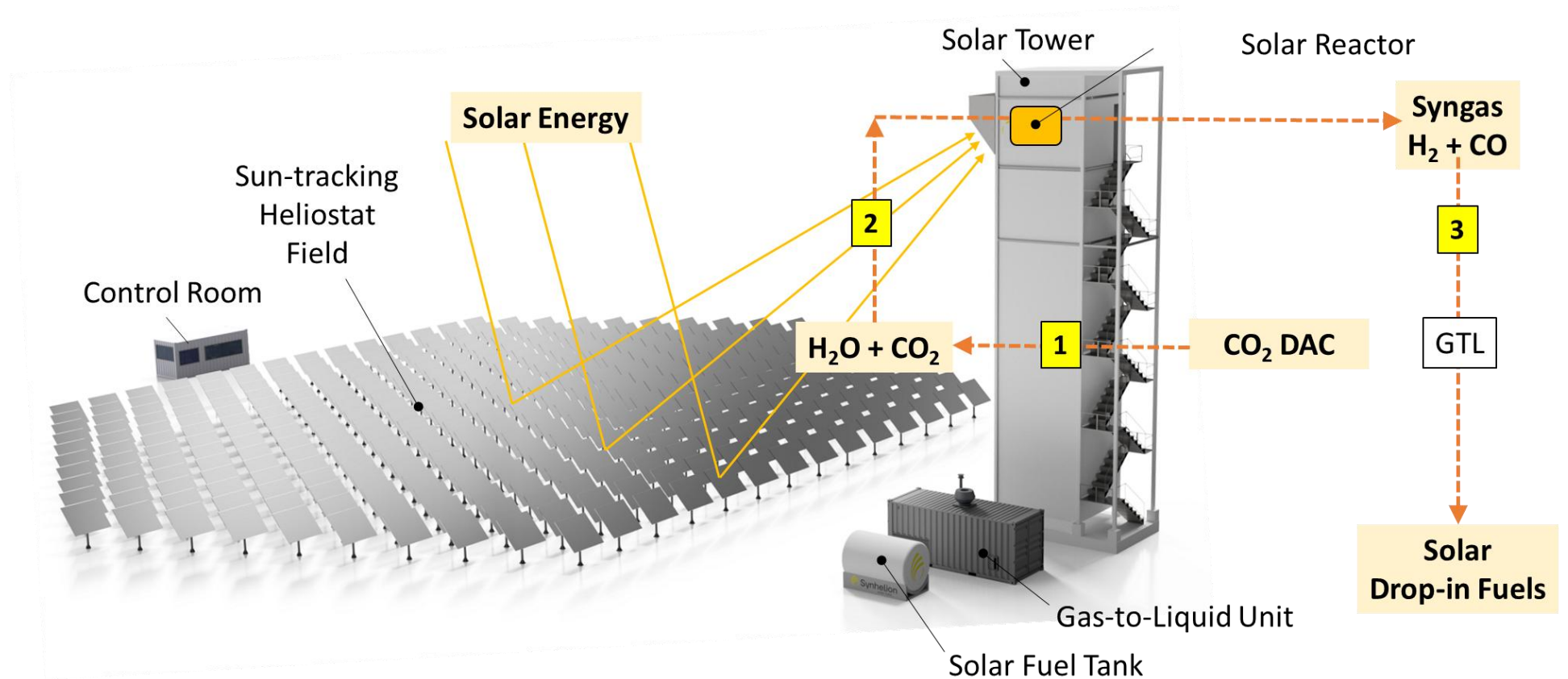
SUN-to-LIQUID II Overview

- Building on EU-funded RIA projects (SolarJET, SUN-to-LIQUID)
- Direct path from H_2O + CO_2 and sunlight to drop-in fuels
- Carbon-neutral 'closed' cycle
- Wide availability of most components
- Low TRL for DAC and the thermochemical reactor



SUN-to-LIQUID II – Overview

SUNlight-to-LIQUID - Efficient solar thermochemical synthesis of liquid hydrocarbon fuels using tailored porous-structured materials and heat recuperation



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SUNlight-to-LIQUID - Efficient solar thermochemical synthesis of liquid hydrocarbon fuels using tailored porous-structured materials and heat recuperation



SUN-to-LIQUID II Overview



HORIZON-CL5-2022-D3-03-07 - Development of algal and renewable fuels of non-biological origin

SUNlight-to-LIQUID - Efficient solar thermochemical synthesis of liquid hydrocarbon fuels using tailored porous-structured materials and heat recuperation

Funding Scheme

Research and Innovation (RIA)

**Start TRL 2-3
End TRL 4-5**



Starting date

01/11/2023



Duration

48 months



Total budget

5.7 M€



EU grant

4.88 M€

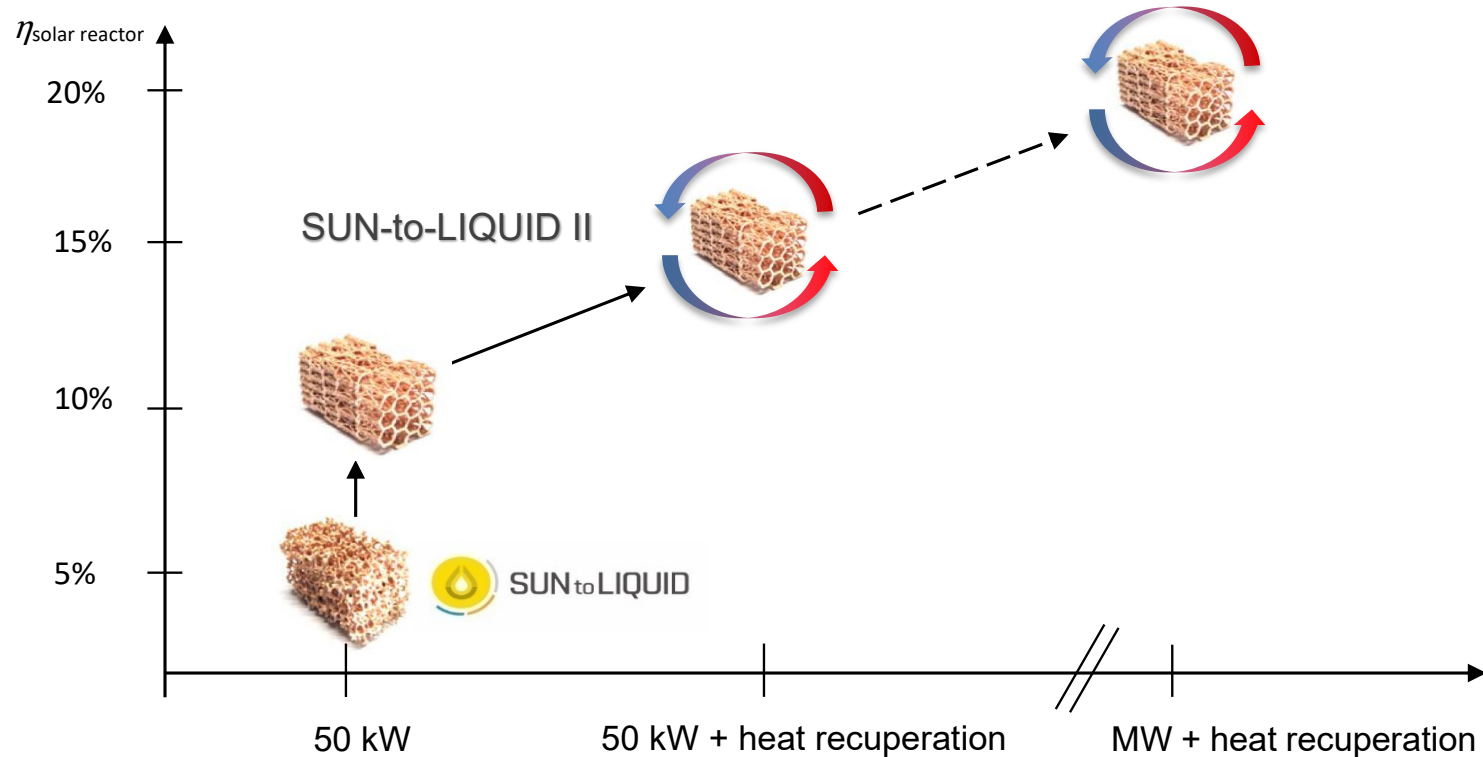


Grant from SERI
Swiss State Secretariat for
Education, Research and Innovation

0.84 M€

<https://sun-to-liquid-2.eu/>

SUN-to-LIQUID II Objectives



The primary objective is to achieve a record-high energy conversion of 15%
- a 3-fold increase of the state of the art - by bringing novel concepts (TRL 2) and lab-scale developments (TRL 3) to the field (TRL 4-5).

- Optimization & enhancement of a **high-flux solar concentrating heliostat & tower system:**
- Enhanced yield from **novel 3D structured chemically active redox materials**
- **Advanced solar reactor with integrated high-temperature heat recovery**
- **Preparing commercial exploitation of solar-thermochemical fuels**

Current Status, Work in Progress

1. **Solar concentrating facility:** near 50 kW, $>2500 \text{ kW/m}^2$, stability 1-3 mrad;
2. **3D reactant design** tested in 5-kW reactor
3. **Recycling of reactant:** viability confirmed
4. **Model of dual heat storage configuration** achieves 31% recuperation effectiveness
5. **GtL system** adapted and **catalytic upgrading system** developed
6. **Process model** for the complete fuel path for a future commercial plant developed



Developments in Progress

1. **Integration in one plant**, complete in 2026
2. **On-sun testing** of the integrated StL plant
3. **Long-term performance** evaluation (50 kW)
4. **System model** evaluation for future commercial plant (Multi-Mega-Watt scale)
5. **Business case study**, parametric analysis



Key Messages

- 1. Solar thermochemical fuels are technically scalable beyond future aviation demand.**
Economic viability is the goal.
Key: reactor efficiency, cost of renewable carbon.
- 2. SUN-to-LIQUID II ambition:**
15% energy efficiency (solar-to-syngas) with integrated plant ops for solar fuel production
Demonstrating key developments up to TRL 5:
 - enhanced concentrating facility
 - innovative reactant 3D-structure,
 - advanced heat recuperation design.
- 3. System model for scale-up and business case**
Create a roadmap towards commercialization.

Consortium:



SUNtoLIQUID II

FUELS FROM CONCENTRATED SUNLIGHT

Contact:

Andreas Sizmann
Bauhaus Luftfahrt

andreas.sizmann@bauhaus-Luftfahrt.net

www.sun-to-liquid-2.eu



Funded by
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Project funded by



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Life-cycle Emission Reduction Potential

Renewable CO₂ decisive for environmental performance

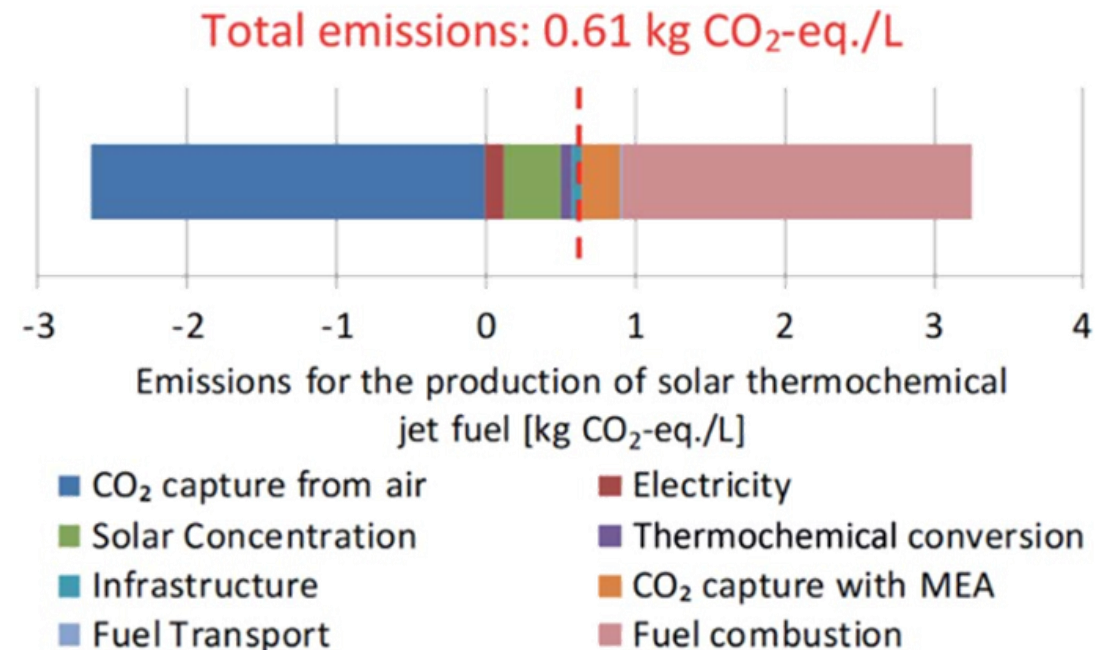
Drivers of emissions:

- Combustion of product
- Solar concentration infrastructure
- Thermochemical efficiency

Further leverage

- Higher optical efficiency or less material requirements
- Higher solar irradiation

→ **Reduction of GHG by 80%**
Conventional jet fuel: 3.0 kg/L



Falter et al., Sustainable Energy and Fuels, 4, 2020