Comparison between simulation results and on-sun tests of a secondary concentrator exposed to high-flux solar irradiation on a solar tower

15.06.2023

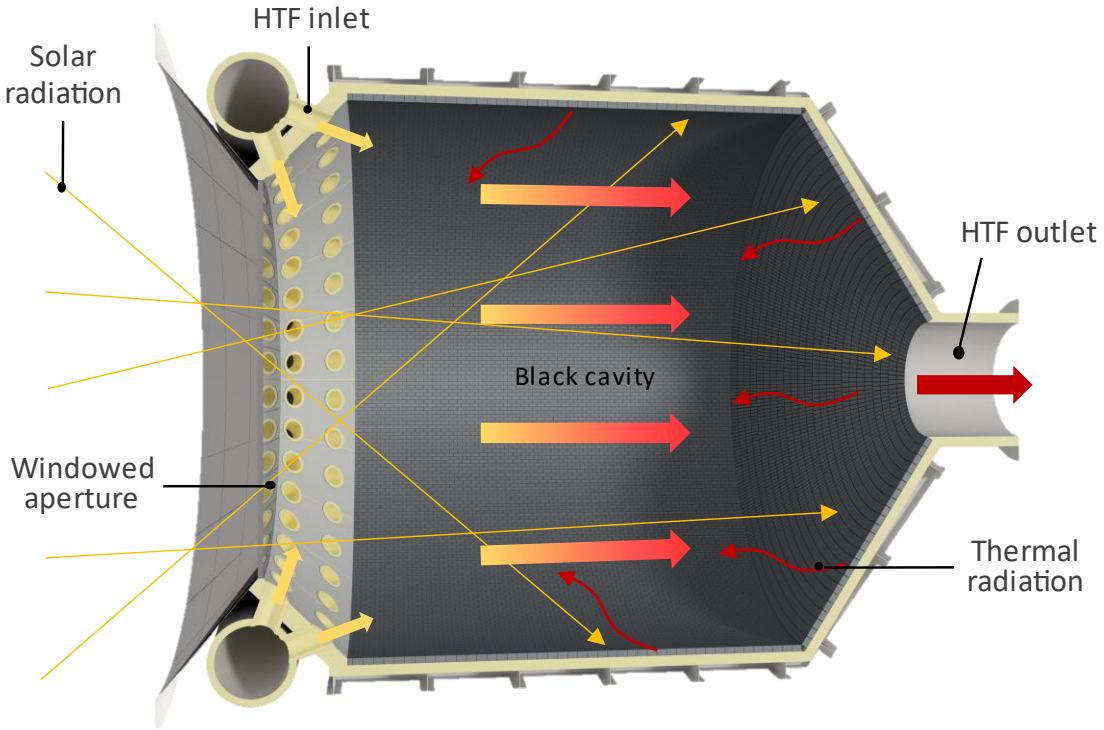
David Rutz

Synhelion technology

TURNING SUNLIGHT INTO FUEL.

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

Synhelion solar receiver



The absorbing (greenhouse) gas is heated by the thermal radiation of the receiver walls and acts as heat transfer fluid (HTF). Temperatures in excess of 1’500°C can be reached.

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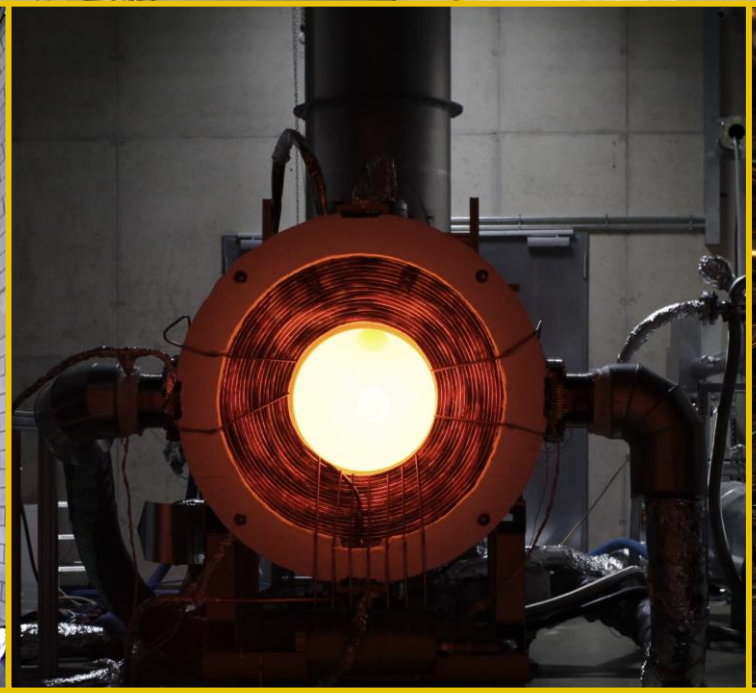
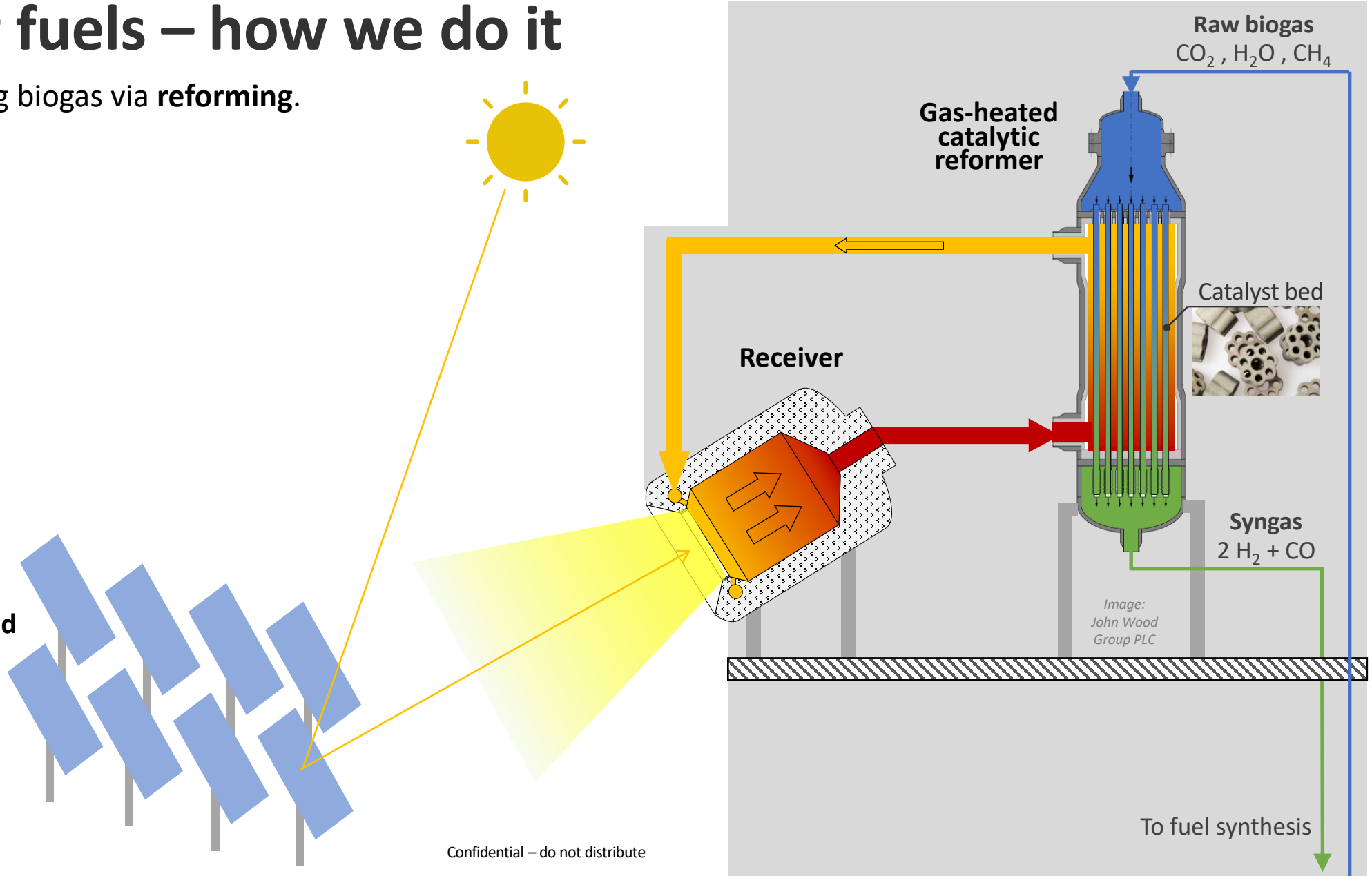
RECEIVER PILOT AT SYNLIGHT



Solar fuels – how we do it

Upgrading biogas via **reforming**.



TURNING SUNLIGHT INTO FUEL.

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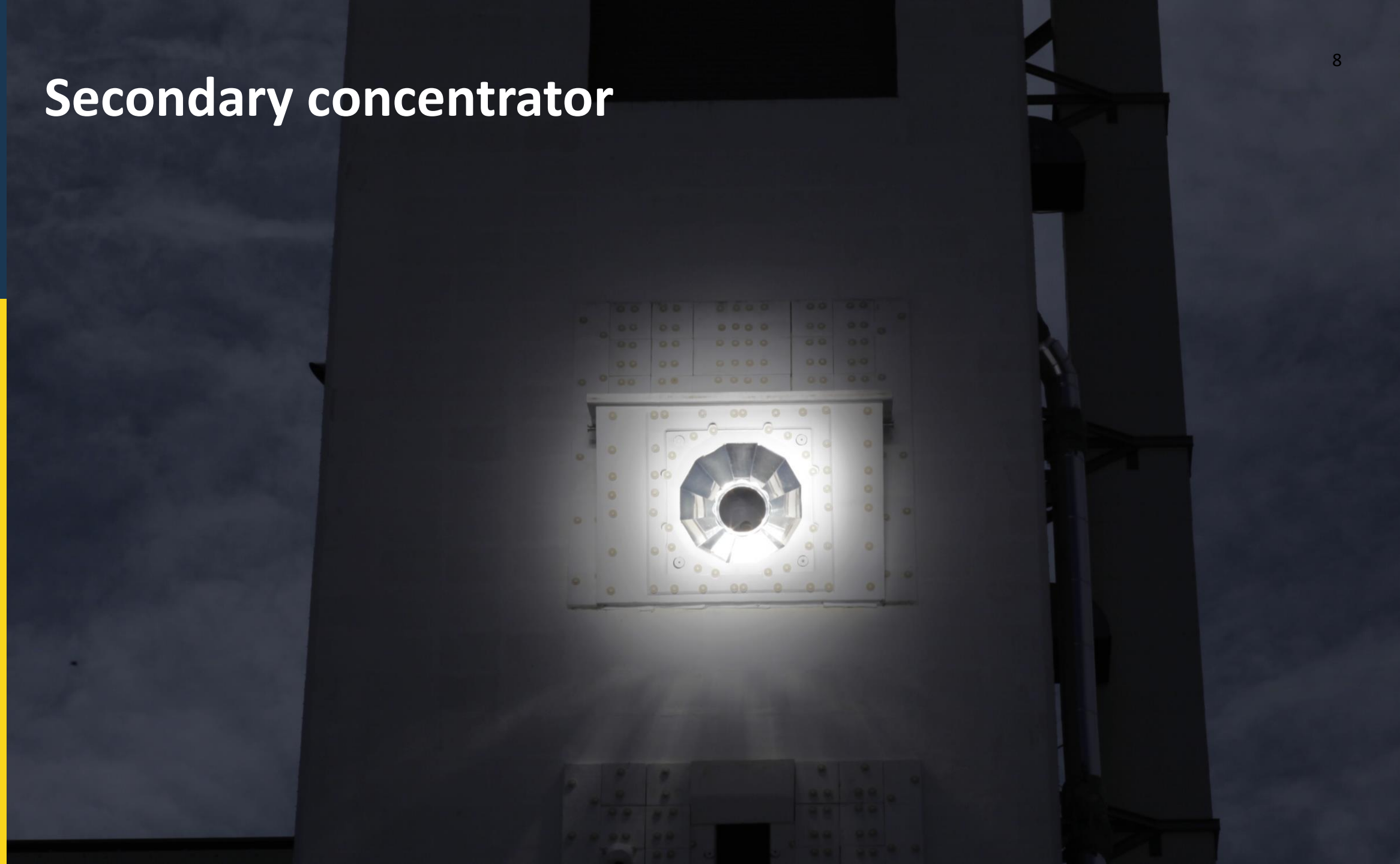
WASEL
www.wasel-kraene.de

Synhelion

Synhelion

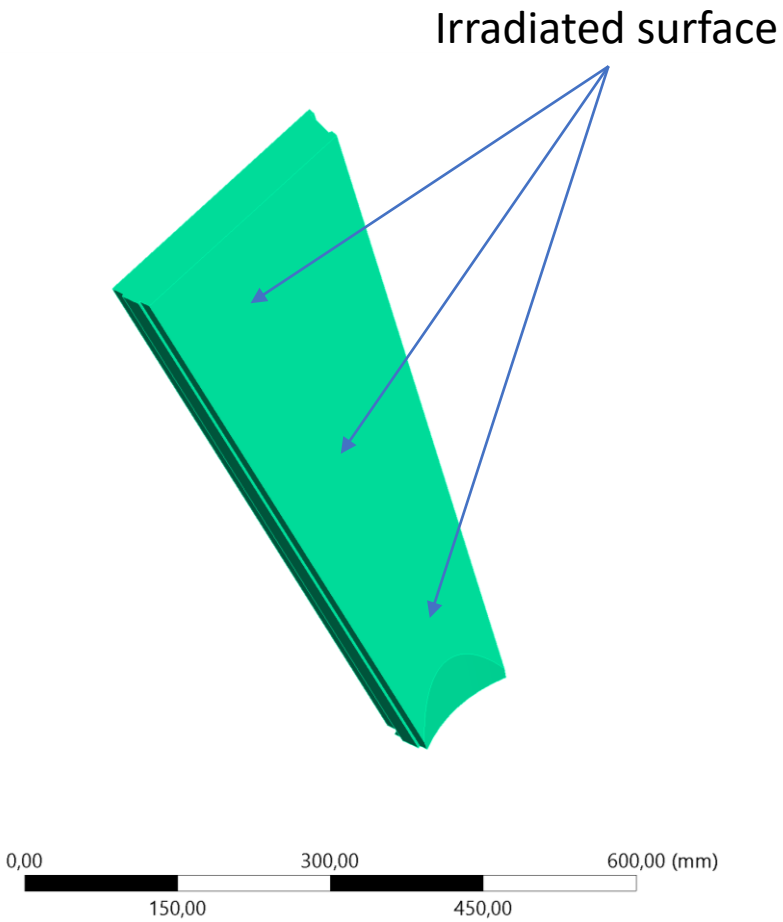
Secondary concentrator



TURNING SUNLIGHT INTO FUEL.

Simulation

Boundary conditions

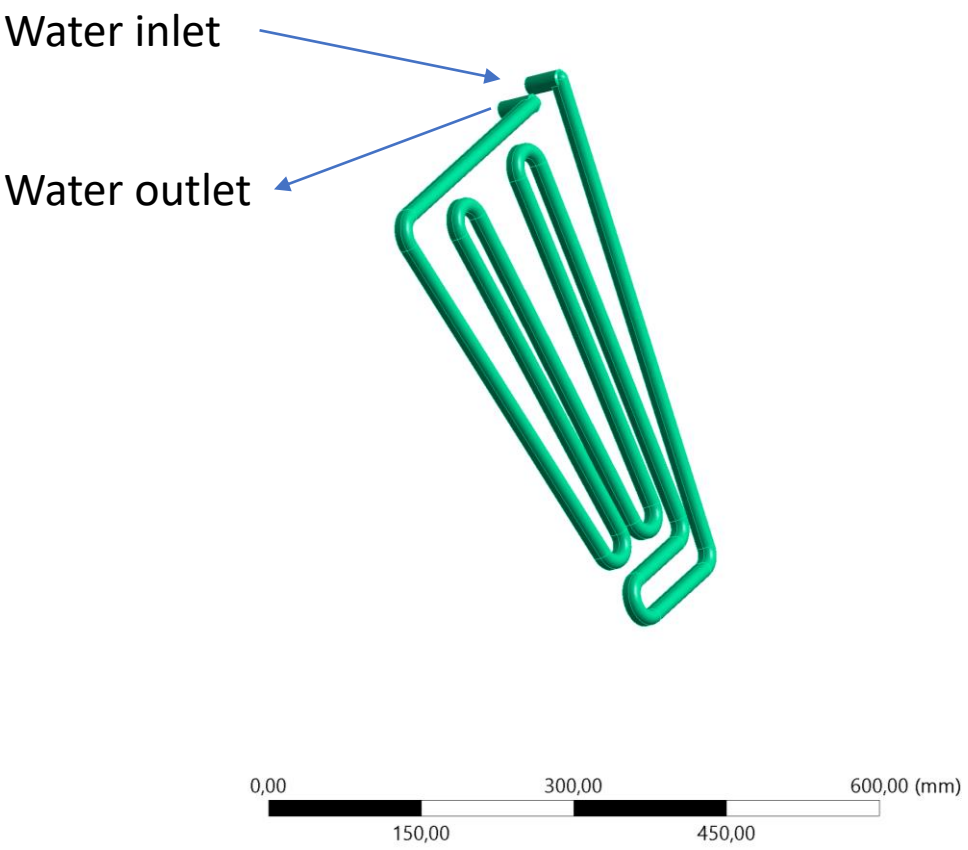


- Solid: Aluminum
- Incoming heat flux on surface: 1’500 kW/m^2
- Reflectivity: 0.8
- Absorbed heat flux on surface: 300 kW/m^2
- Conductivity: 160 W/(m*K)
- Convection: 5 W/(m^2*K) with T_a= 300K

TURNING SUNLIGHT INTO FUEL.

Simulation

Boundary conditions

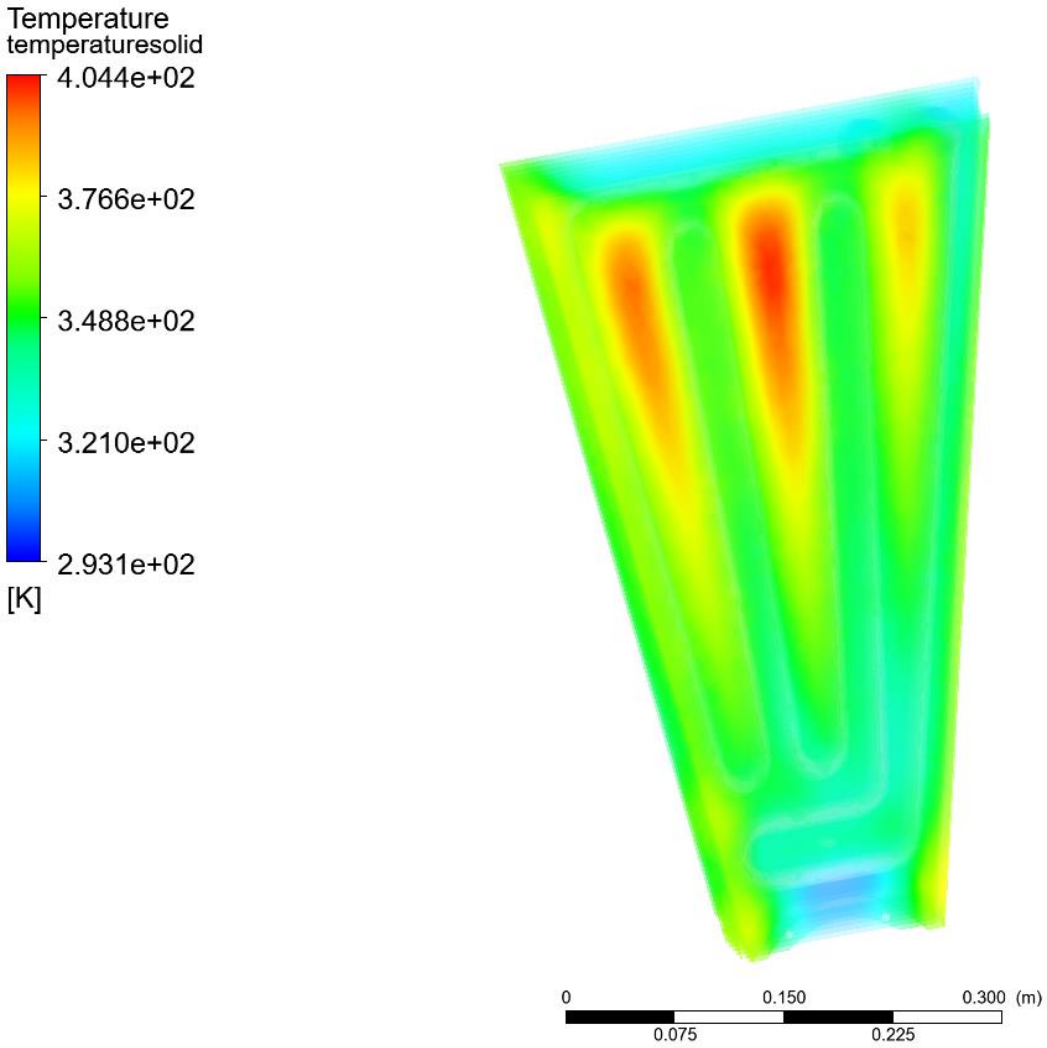


- Fluid: Water
- Mass flow rate: 30 l/min
- Inlet temperature: 20°C (293.15K)
- Pressure: atmospheric

TURNING SUNLIGHT INTO FUEL.

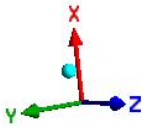
Simulation

Results with cooling water mass flow rate of 30 liters per minute



Ansys
2022 R2

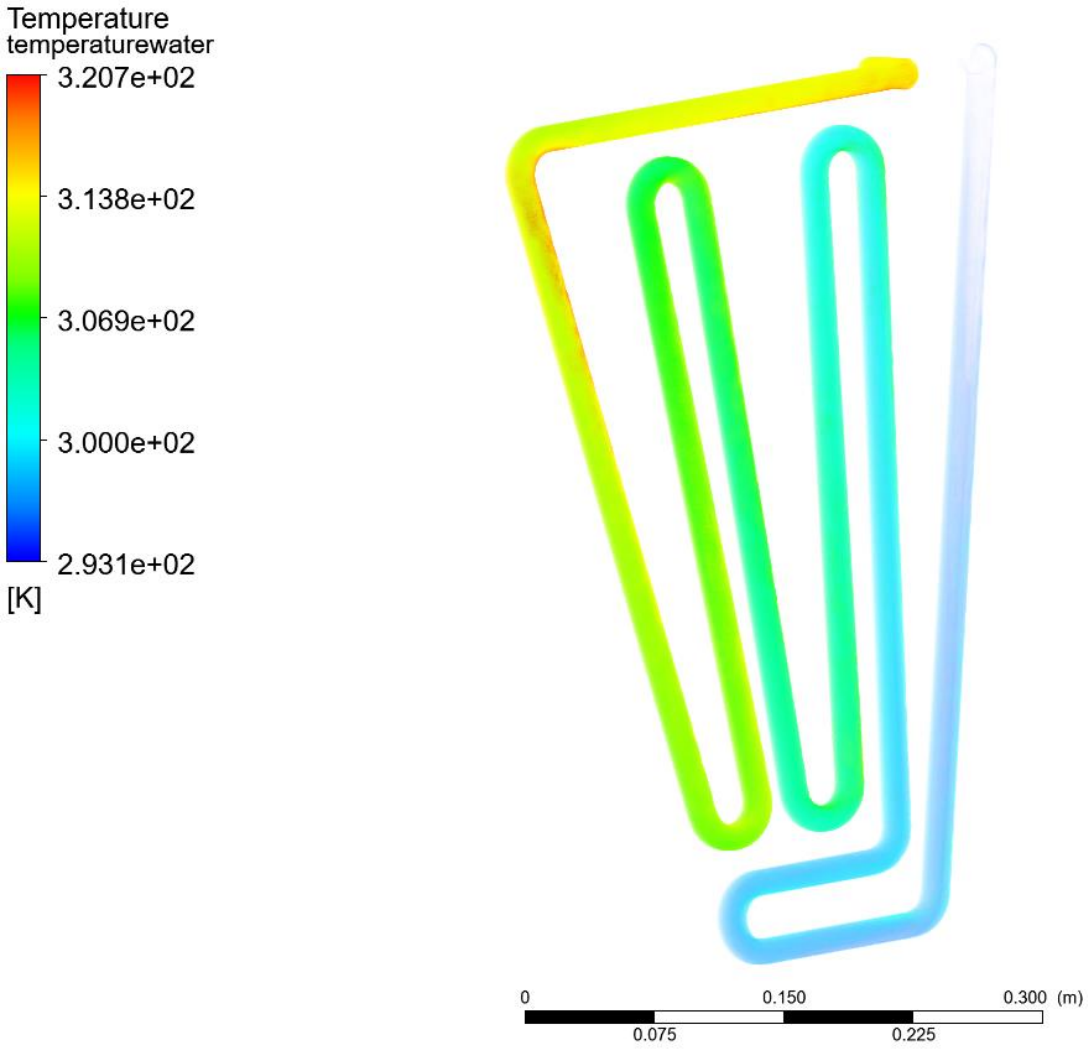
Maximum solid temperature: 404 K (131.85°C)



TURNING SUNLIGHT INTO FUEL.

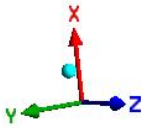
Simulation

Results with cooling water mass flow rate of 30 liters per minute



Ansys
2022 R2

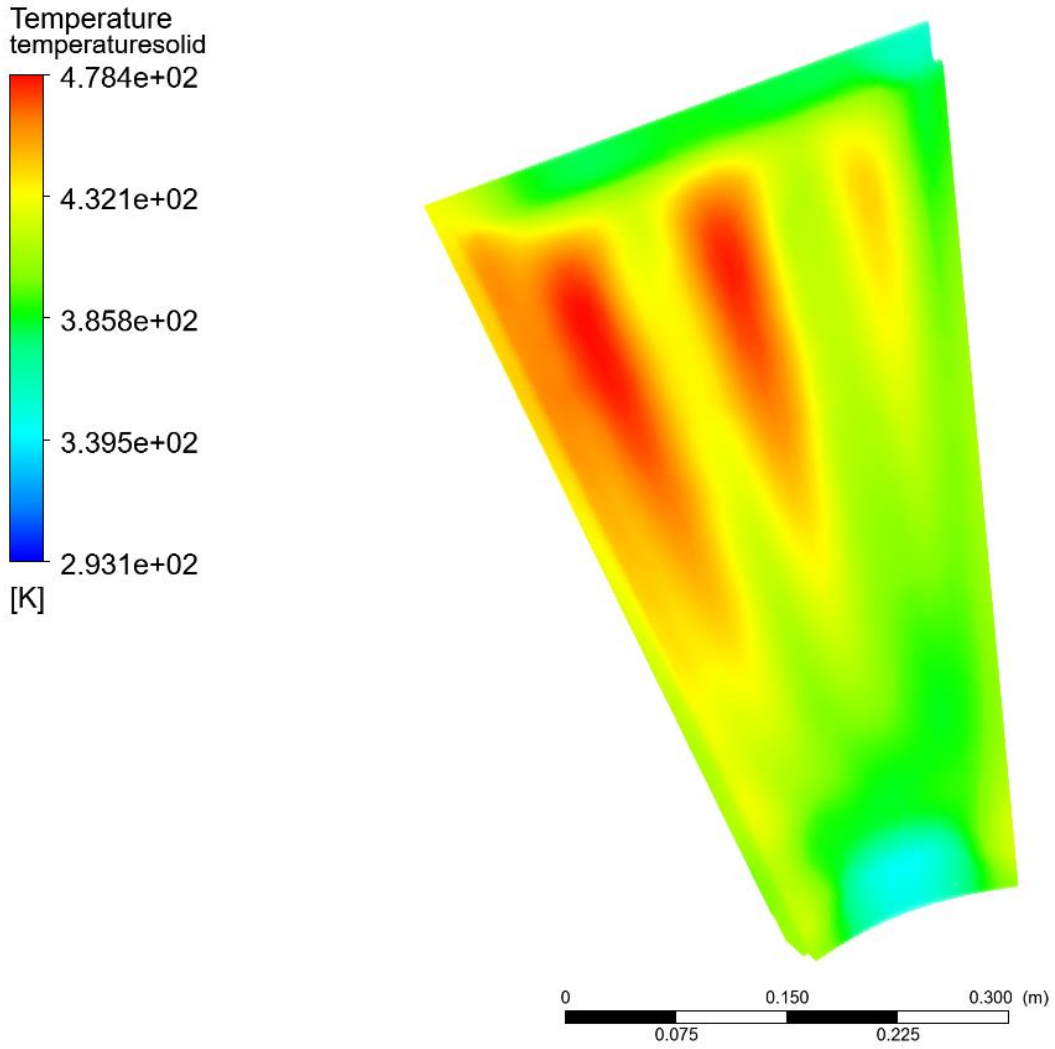
Average outlet temperature: 313 K (45.85°C)
Maximum water temperature: 319 K (51.85°C)



TURNING SUNLIGHT INTO FUEL.

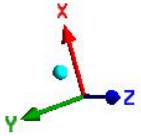
Simulation

Results with cooling water mass flow rate of 10 liters per minute



Ansys
2022 R2

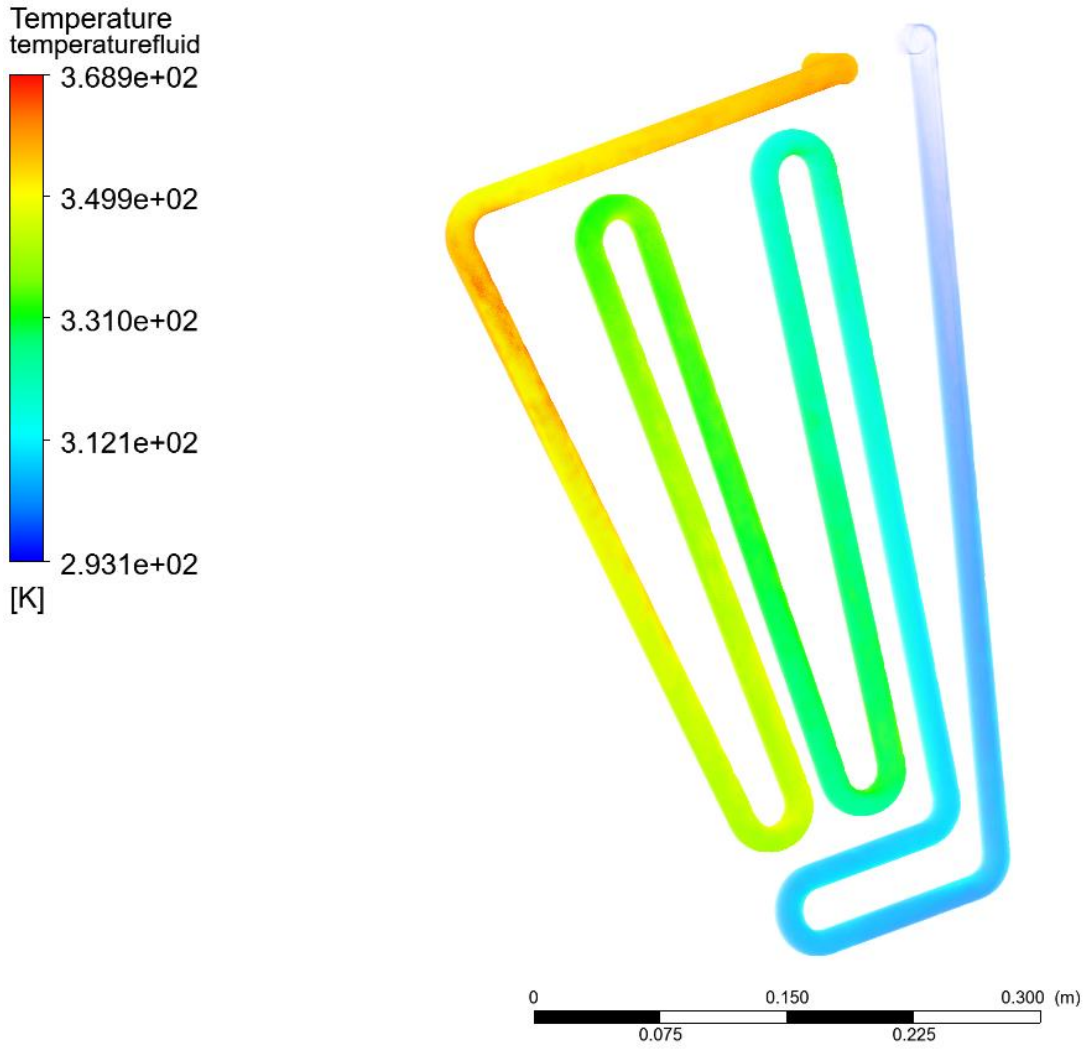
Maximum solid temperature: 478 K (204.85°C)



TURNING SUNLIGHT INTO FUEL.

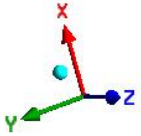
Simulation

Results with cooling water mass flow rate of 10 liters per minute



Ansys
2022 R2

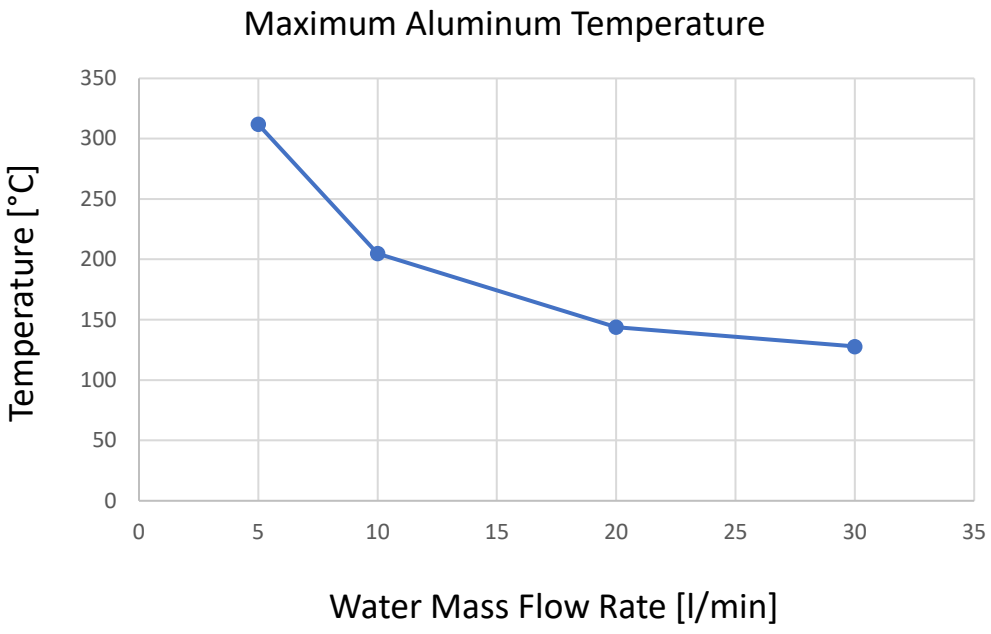
Average outlet temperature: 355 K (81.85°C)
Maximum water temperature: 369 K (95.85°C)

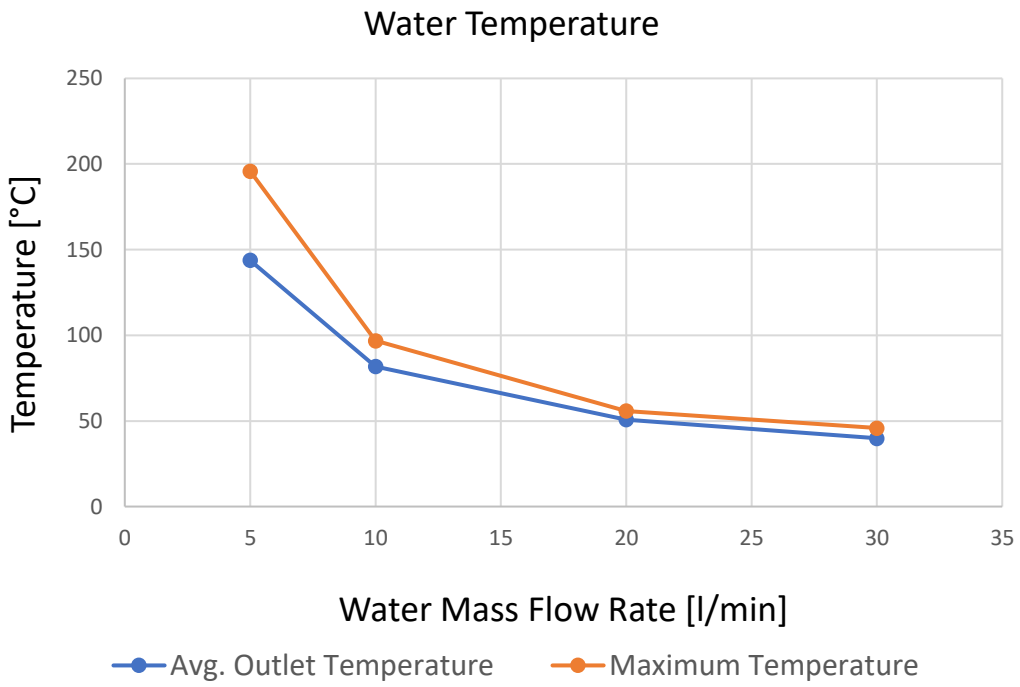


TURNING SUNLIGHT INTO FUEL.

Simulation

Results – parametric study

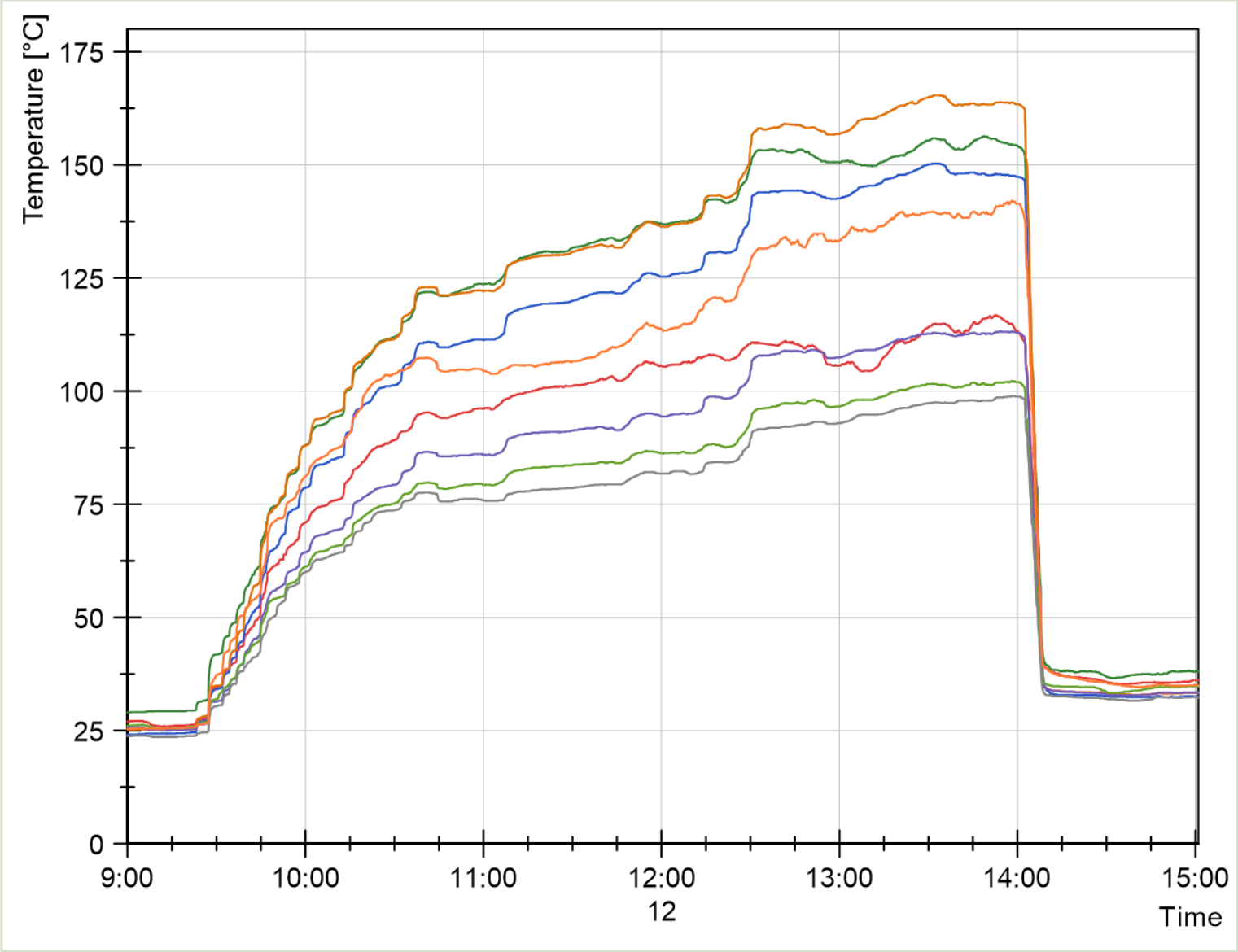




TURNING SUNLIGHT INTO FUEL.

Receiver on-sun tests

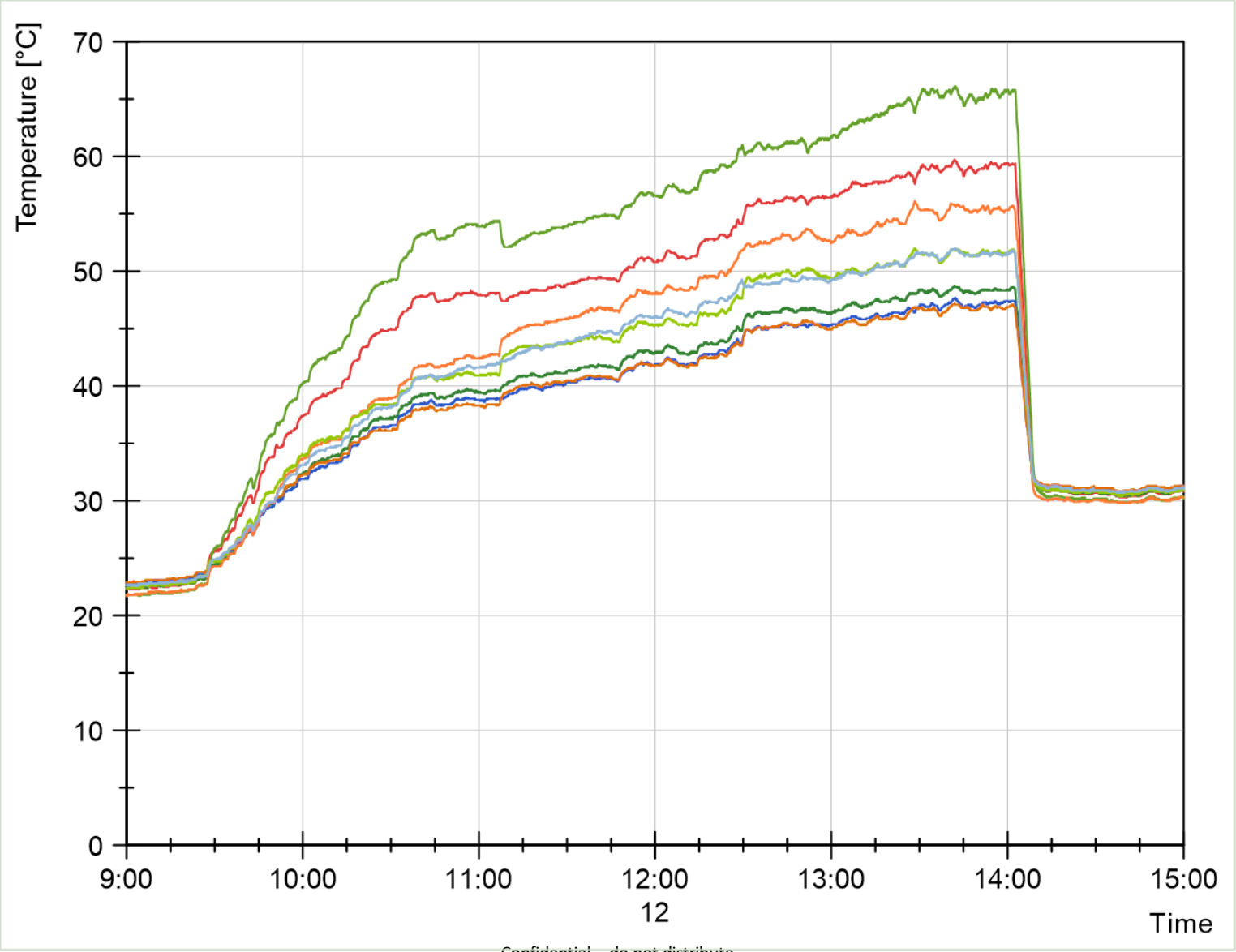
Secondary concentrator surface temperature



TURNING SUNLIGHT INTO FUEL.

Receiver on-sun tests

Secondary concentrator water outlet temperature

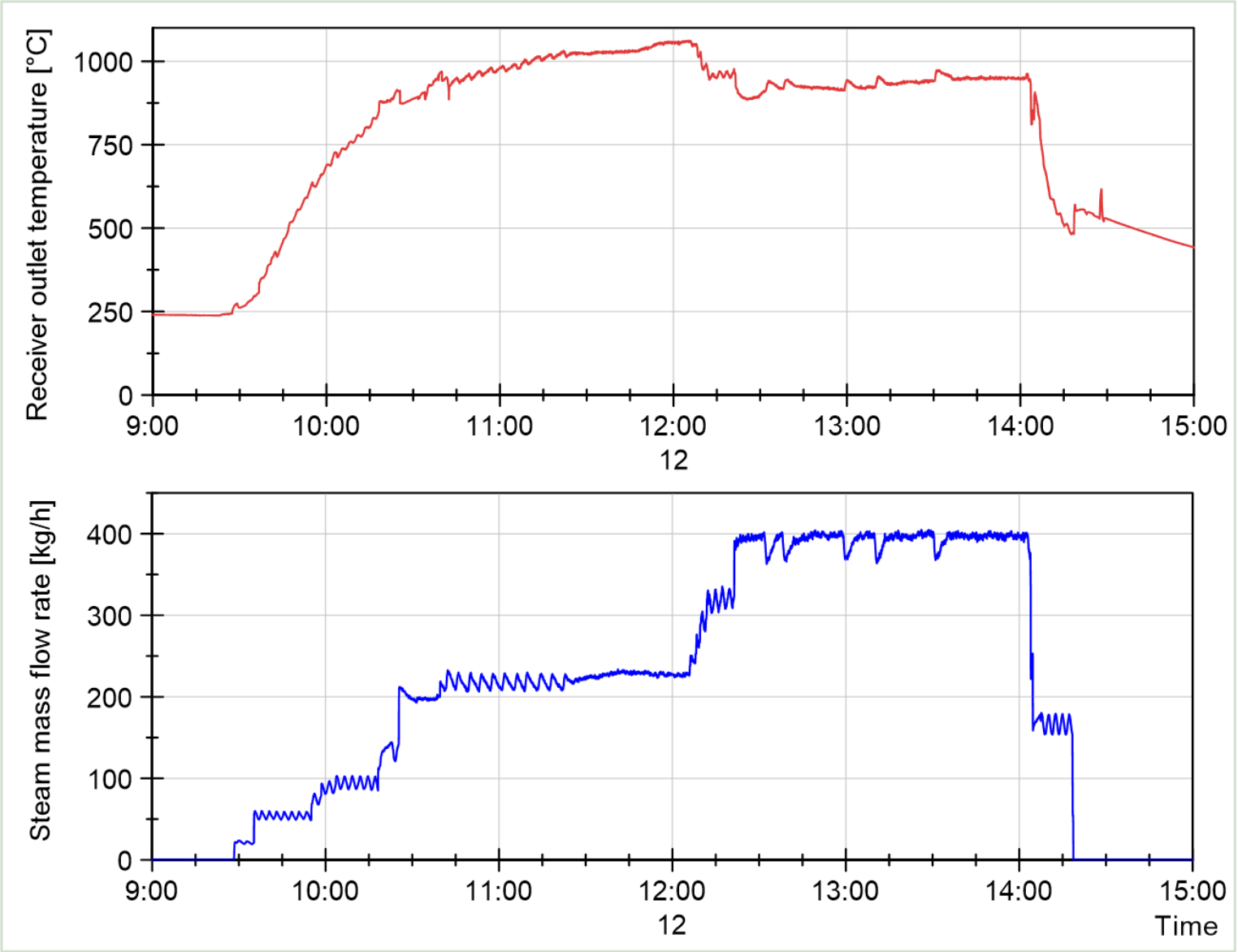


Avg. cooling water flow mass rate per concentrator: 10 l/min

TURNING SUNLIGHT INTO FUEL.

Receiver on-sun tests

Receiver process outlet temperature and steam mass flow rate to chemical reactor



TURNING SUNLIGHT INTO FUEL.

Receiver on-sun tests
Loss of cooling water

TURNING SUNLIGHT INTO FUEL.

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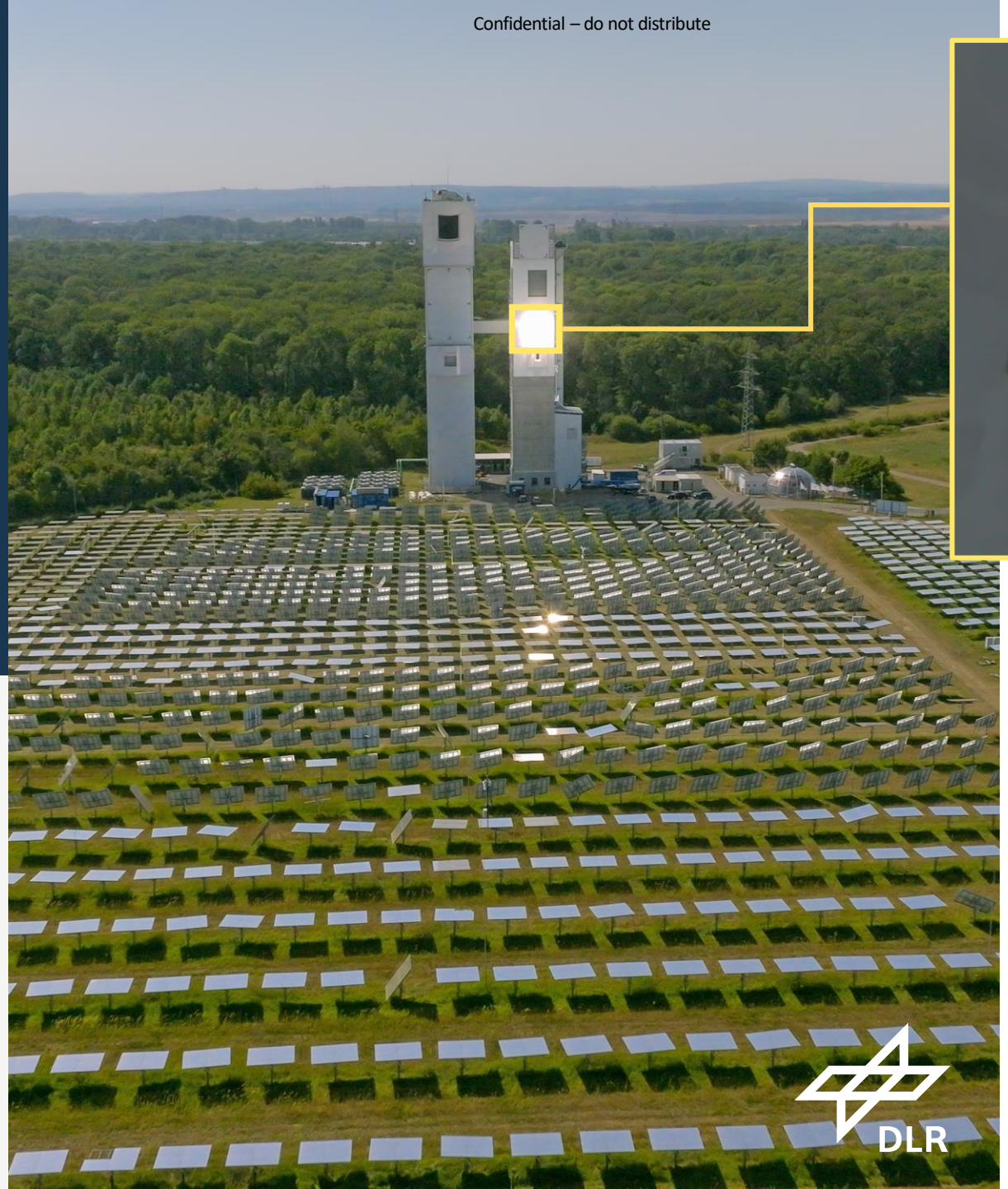
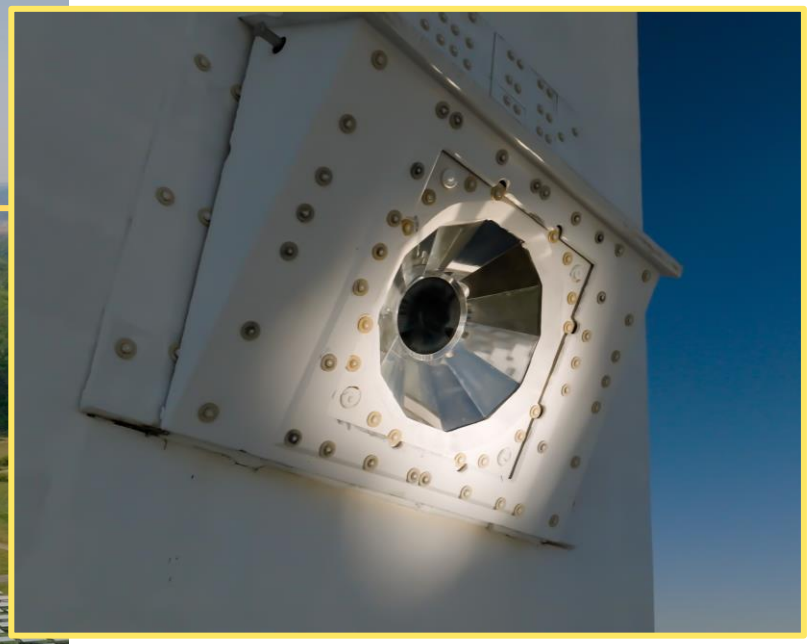
2022: Industrial solar syngas production

TURNING SUNLIGHT INTO FUEL.

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.





Synhelion SA
Dufourstrasse 101
8032 Zurich
Switzerland
www.synhelion.com

The challenge

Global CO_2 emissions are rising

Transportation: 3 billion tons of fuel

Liquid fuels are here to stay

Liquid fuels:

Unbeatable gravimetric and volumetric energy density

Long-term stability (long-term / seasonal storage)

The solution: renewable fuels

SUSTAINABLE
alternative to fossil fuels

SCALABLE
to cover global demand

COMPATIBLE
with existing infrastructure

A record-breaking path to market

TURNING SUNLIGHT INTO FUEL.

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

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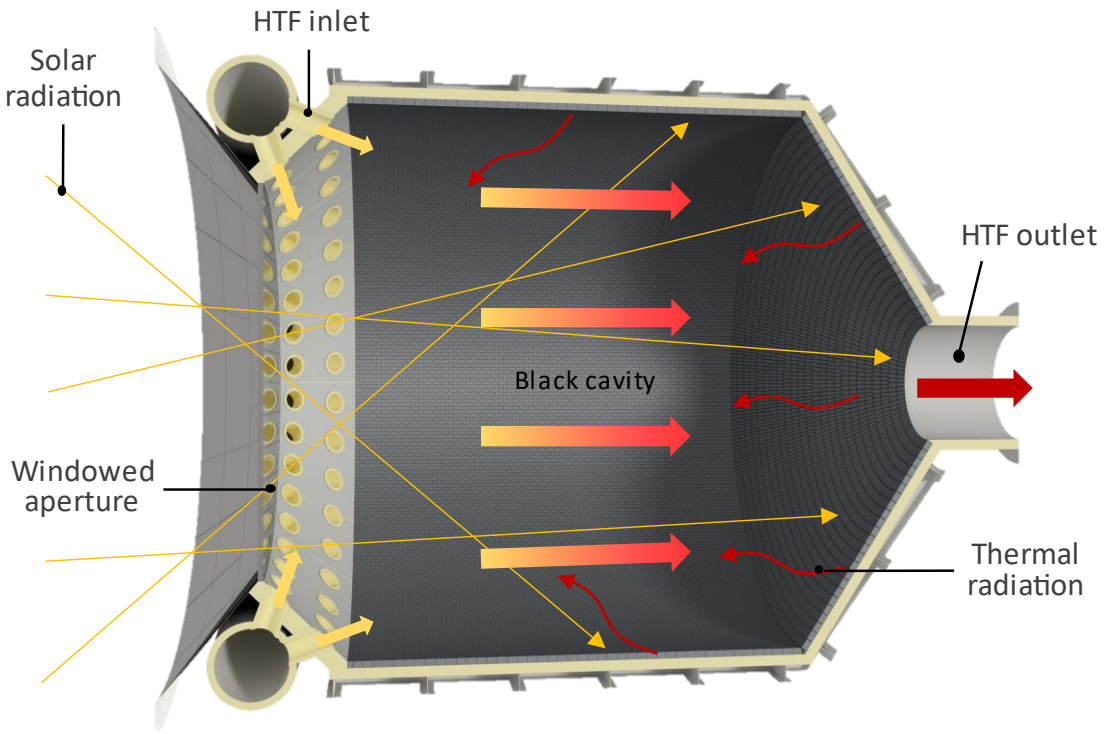
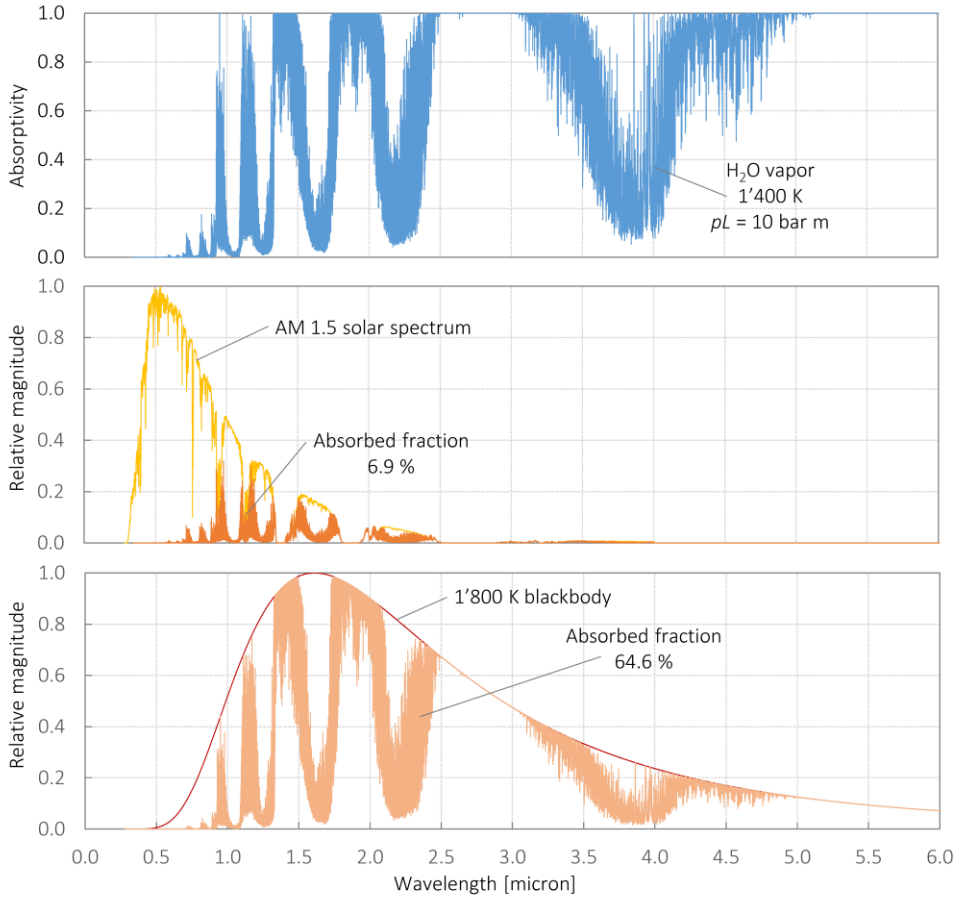
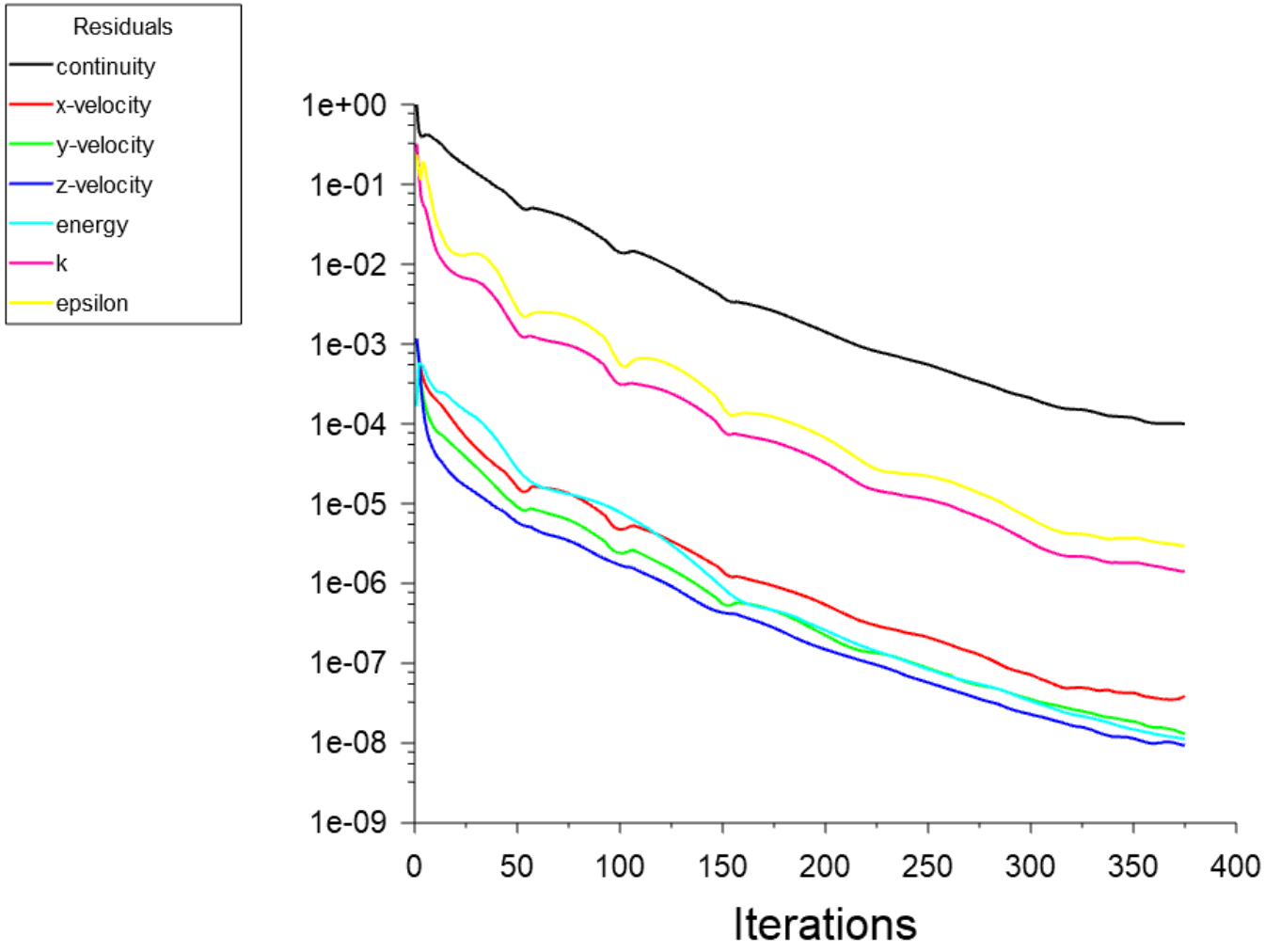
Synhelion solar receiver





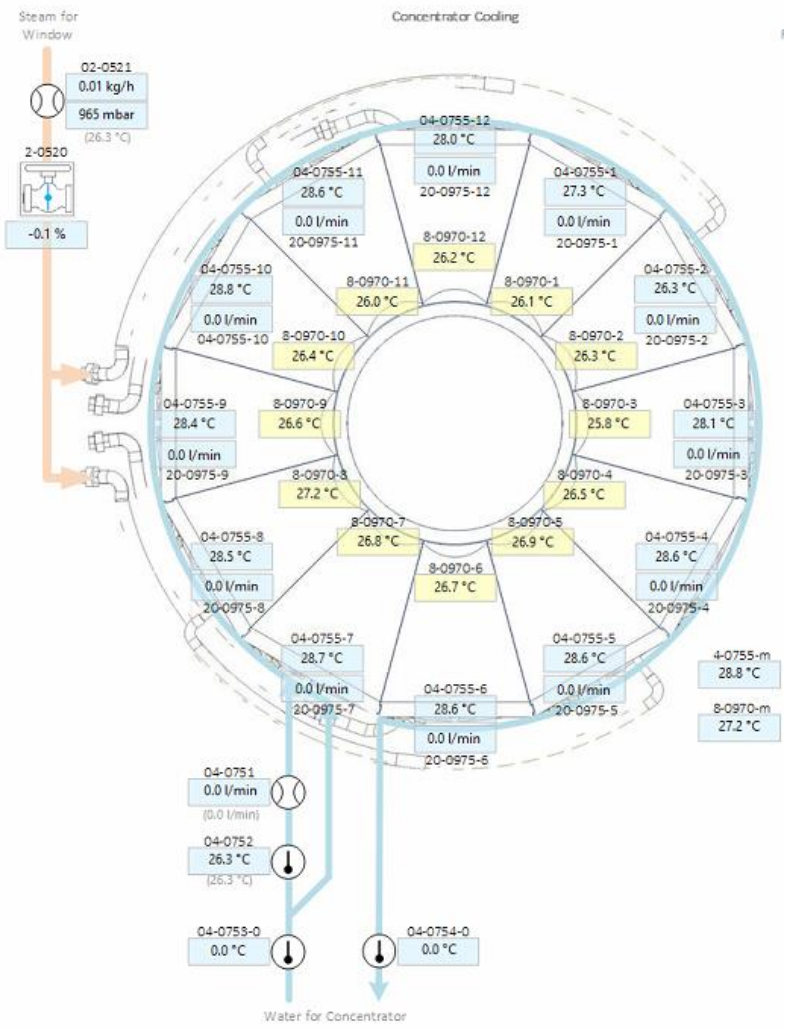
The absorbing (greenhouse) gas is heated by the thermal radiation of the receiver walls and acts as heat transfer fluid (HTF).
Temperatures in excess of 1'500°C can be reached.

Simulation
Residuals



TURNING SUNLIGHT INTO FUEL.

Control System
Installation of additional Flow Meters



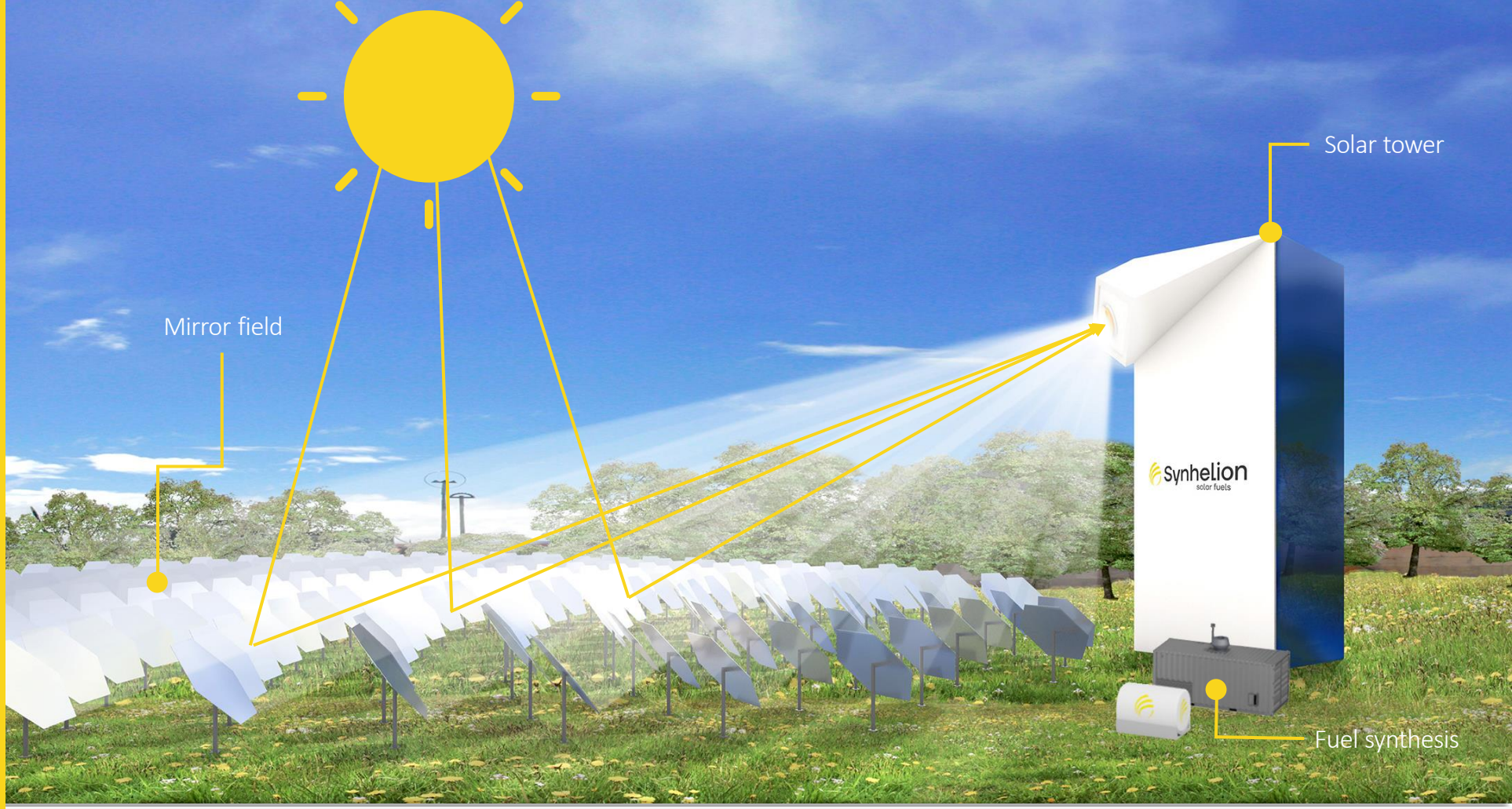
TURNING SUNLIGHT INTO FUEL.

Heliostats

TURNING SUNLIGHT INTO FUEL.

2023: Industrial plant DAWN

TURNING SUNLIGHT INTO FUEL.



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

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Synhelion roadmap

TURNING SUNLIGHT INTO FUEL.

= 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

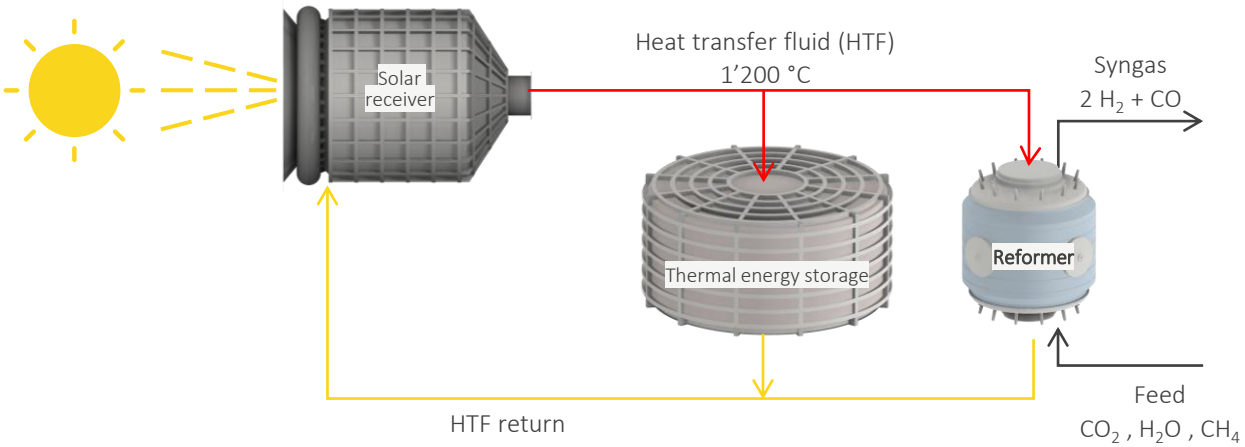
2040

TOWARD NET ZERO

Target total capacity: 50 BL/y

Solar "upgrading"

Processes upgrading hydrocarbon precursors such as natural gas (methane) via industrial catalytic **reforming**.



Gas-heated catalytic reformer

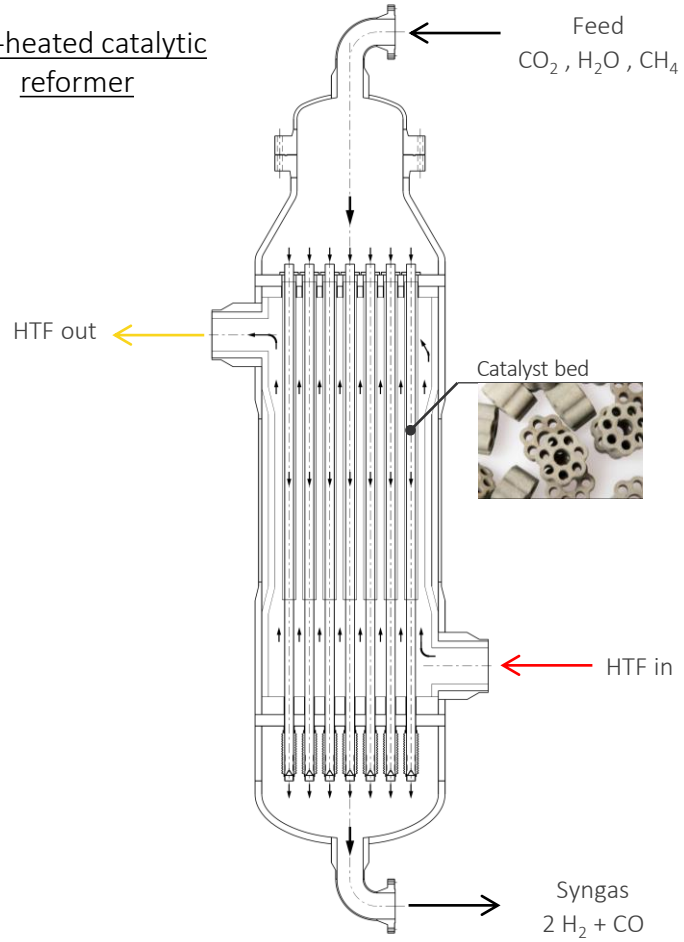


Image: John Wood Group PLC

The *mixed reforming* reaction:

$$3/4\ CH_4 + 1/2\ H_2O + 1/4\ CO_2 \longrightarrow \underbrace{2\ H_2 + CO}$$

25% of the C-content of the product comes form **CO_2 uptake**

2:1 syngas, ideal for fuel synthesis

High-temperature (solar) heat, 800 – 1'200 °C, provides **22 % of the energy content** of the product

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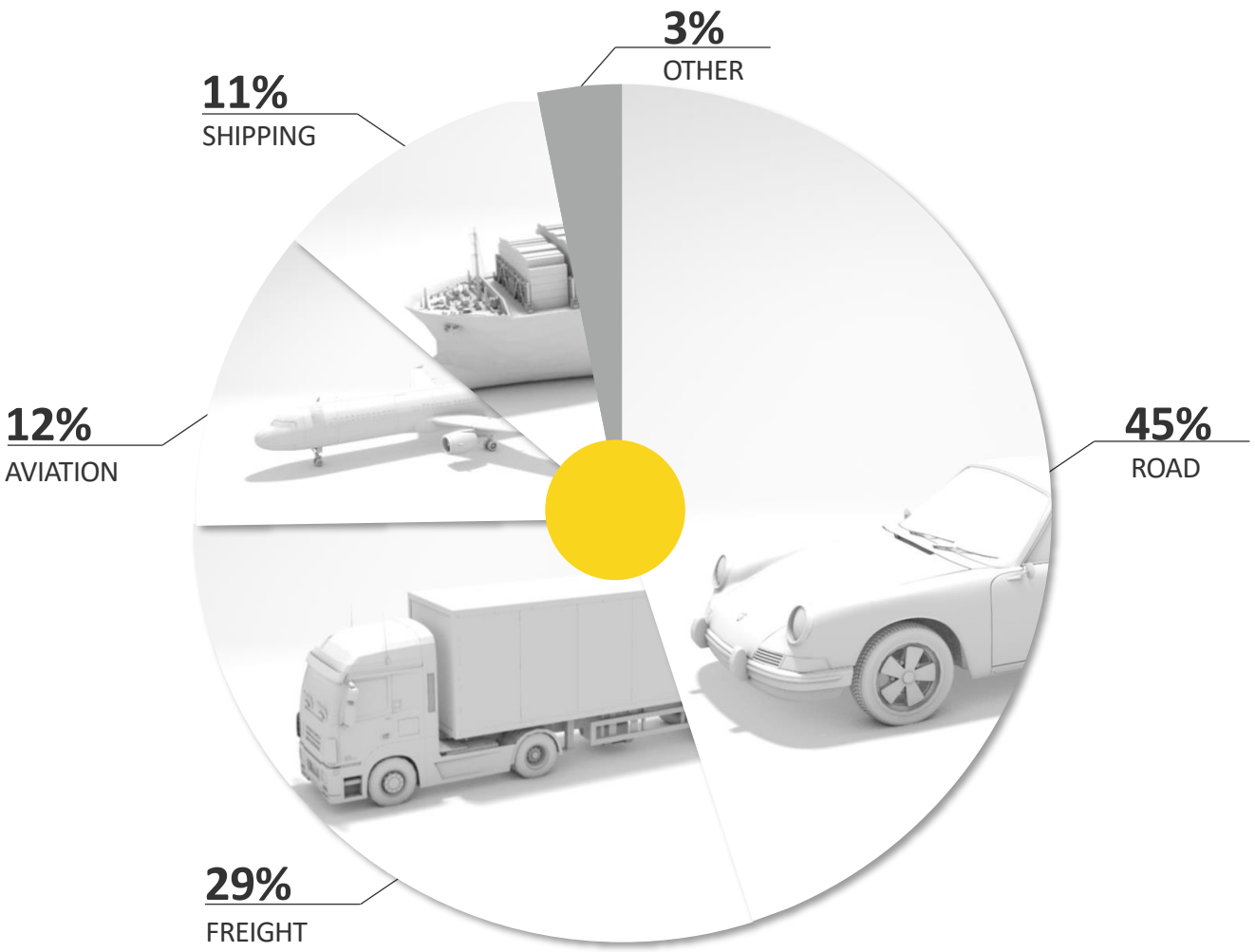
TURNING SUNLIGHT INTO FUEL.

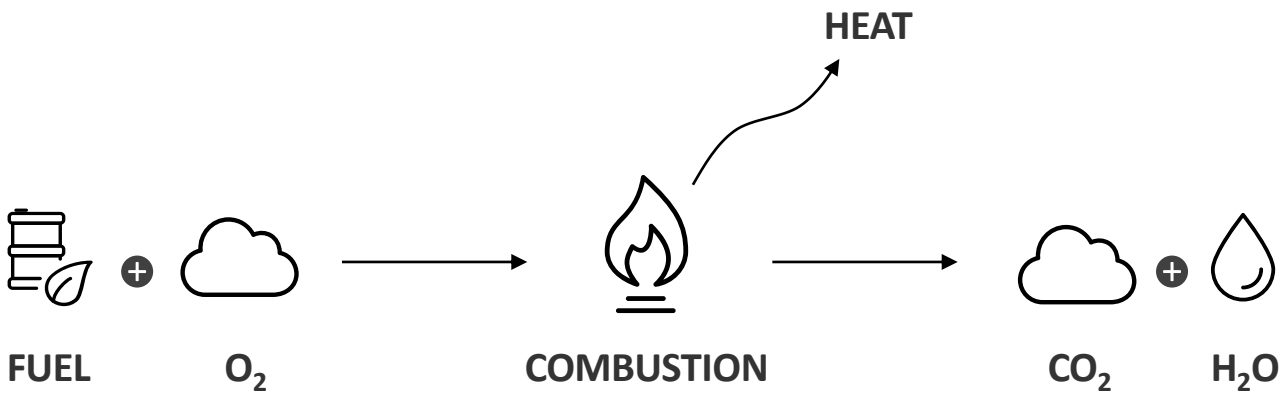
WE TURN CO_2 INTO FUEL.

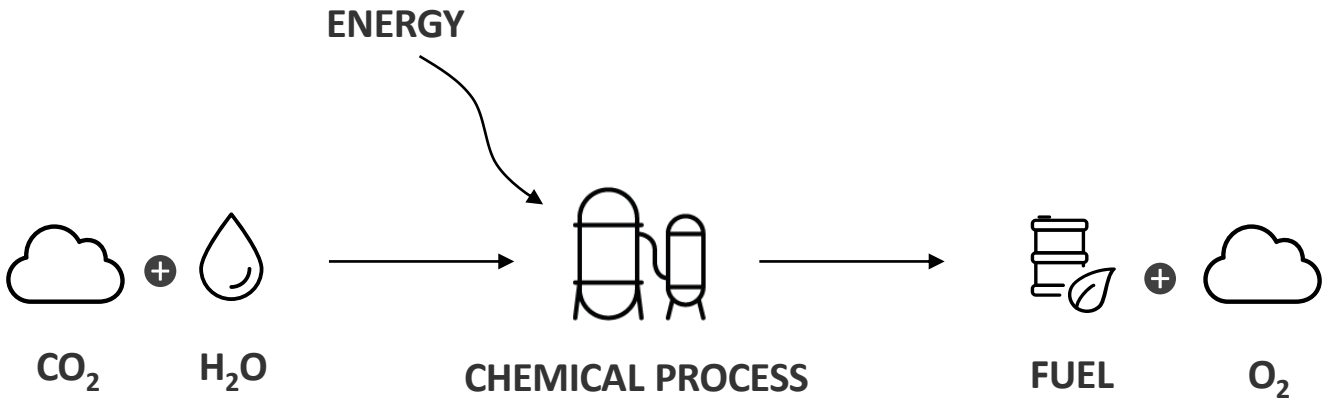


CO_2 emissions by sector

The vision

TURNING SUNLIGHT INTO FUEL.





Reversing combustion

Our vision

TURNING SUNLIGHT INTO FUEL.

Let’s close the carbon cycle.