PLAN.
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ETIP SNET
EUROPEAN TECHNOLOGY AND INNOVATION PLATFORM
SMART NETWORKS FOR ENERGY TRANSITION

Storage technologies and sector interfaces

Energy Lab 2.0 & Kopernikus Project "P2X"

The Energy Lab 2.0

The Energy Lab 2.0 large scale research infrastructure

Consortium

Helmholtz Research Centers

- Karlsruhe Institute of Technology (KIT)
- German Aerospace Center (DLR)
- Forschungszentrum Jülich

Budget for building the infrastructure

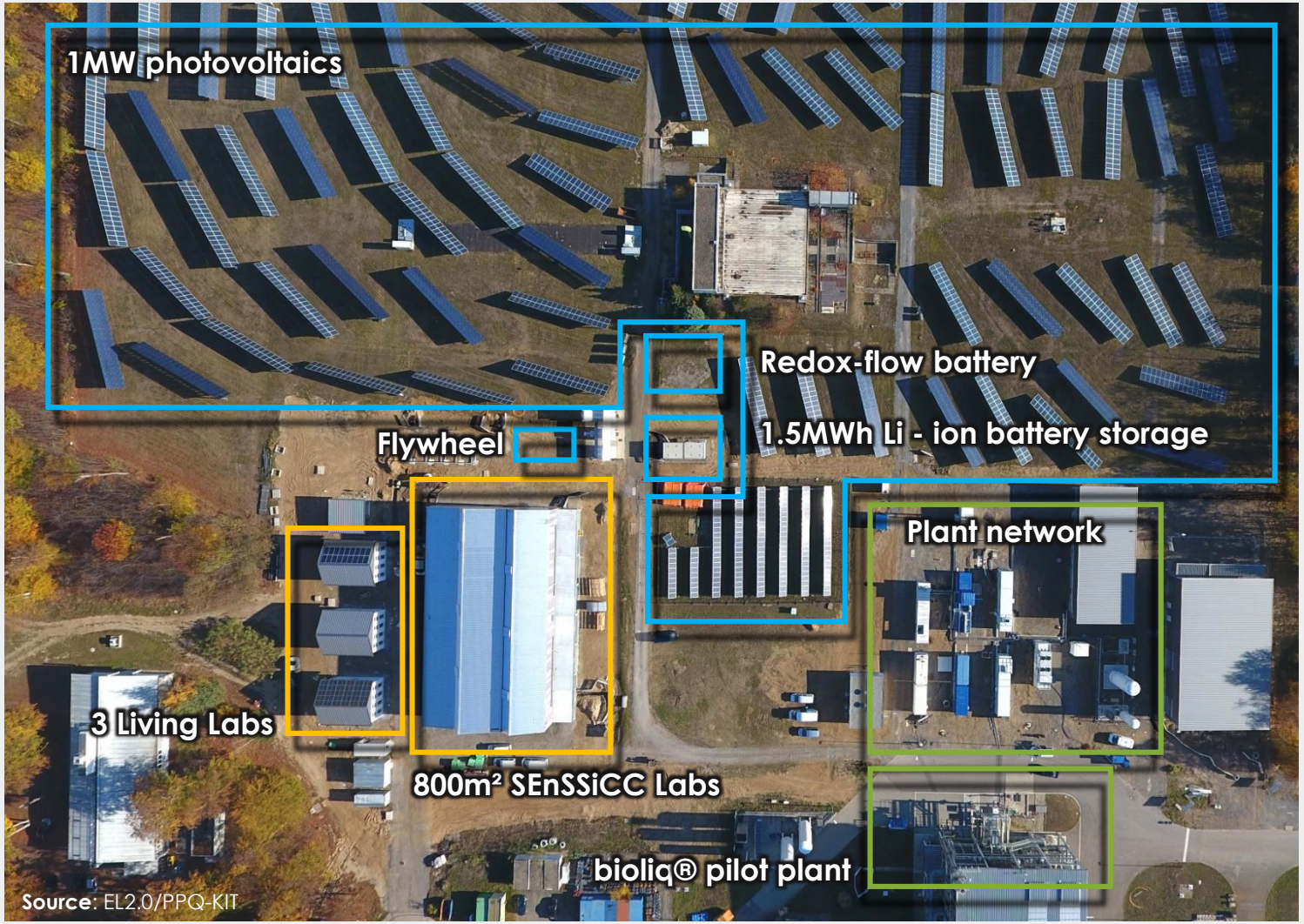
25 Mio. €, funded by

- Ministry of Education and Research (BMBF)
- Ministry of Economic Affairs and Energy (BMWi)
- Ministry of Science, Research and Art (MWK)

Overarching Objective

Development of technological solutions for the overall energy system in 2050 & technology-oriented research on a demonstrator scale to successfully integrate the **renewable energies** into the **power grid**, especially by conducting (**PtG**, **PtL**, **PtH**) and complementing it with comprehensive **energy systems analysis**.

The Energy Lab 2.0 @ KIT



Plant network of the EL2.0

- 1 MW peak Photovoltaics
- 1.5 MWh Li-Ion battery storage
- Power-to-Gas (output 10 m³ NTP per hour)
- Power-to-Fuel (output 1-2 bbl/day)

Smart Energy System Simulation & Control Center (SEnSSiCC) of the EL2.0

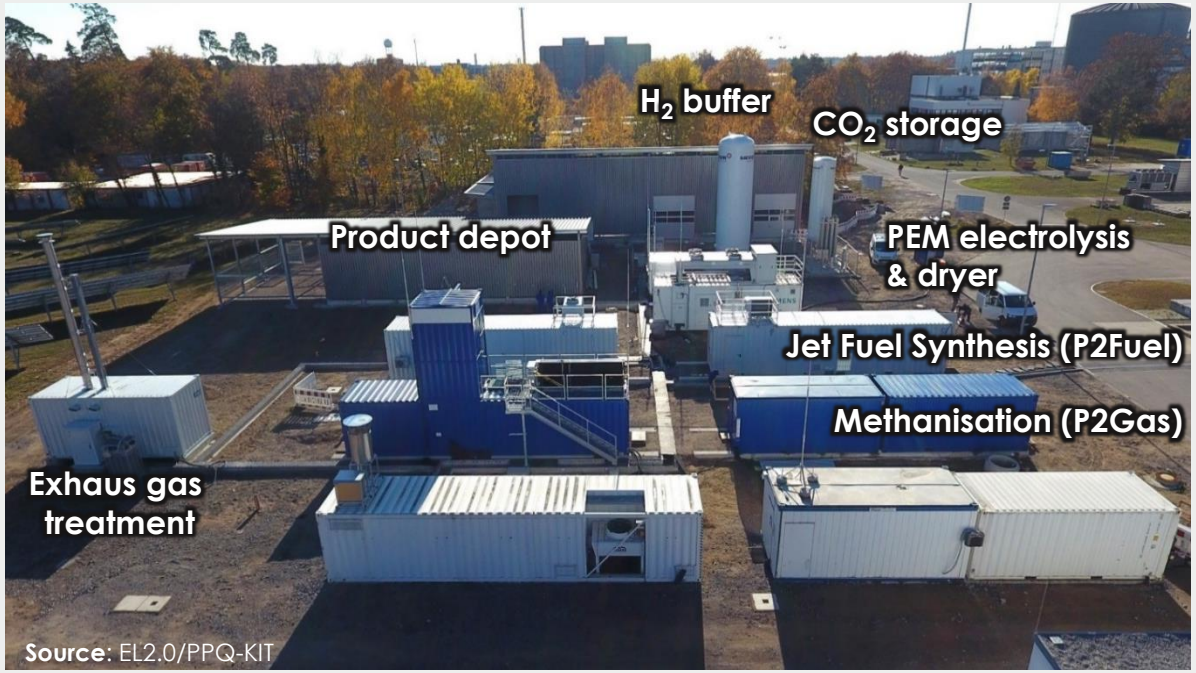
- Power Hardware in the Loop Lab (1MVA)
- Smart Energy System Control Lab
- Control, Monitoring & Visualization Lab
- Energy Grids Simulation and Analysis Lab

+ funded within other projects

- Geothermal power generation
- Flywheel & Redox-flow battery
- 3 Living Labs (model consumer: residential houses)
- bioliq® pilot plant (biomass residues to fuel)

Status EL2.0: Comissioning of of the individual parts ongoing. Operation will start by the end of the year

The Plant Network of EL 2.0



Example: P2Fuel via Fischer-Tropsch synthesis in microstructured reactors

Modular, container-based approach and microstructured reactor technology (P2Fuel) allows for

- tailored scaling → low barrier for market entry
- dynamic operation → more direct utilization of volatile RE, stabilization of the electricity grid

Kopernikus Project „P2X“

Kopernikus Project „P2X“ (Phase I)

Consortium & Budget „P2X“

- ~50 Partners from industry and research incl. environmental and social NGOs.
- 30 Mio. € (BMBF) + 8.3 Mio € (industry)

Federal Ministry of Education and Research

Overarching Objective

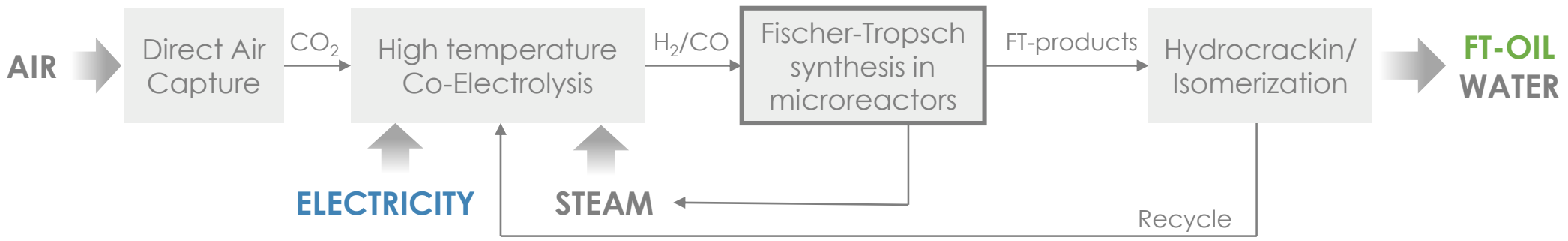
Exploration, validation and implementation of “Power-to-X” concepts.

- 3 Upstream-Clusters (Electrolysis → H_2 or H_2/CO)
- 3 Downstream-Clusters (amongst others: → **hydrocarbon fuels**)

Research Cluster B2, WP1: Carbon-neutral Fuels from Air and Green Power

Overarching Objective (WP1)

Development & demonstration of a modular and scalable, fully integrated **P2Fuel** process chain



CLIMEWORKS

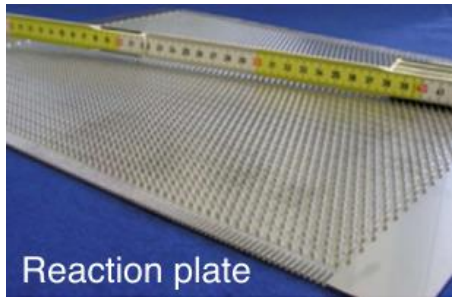
sunfire

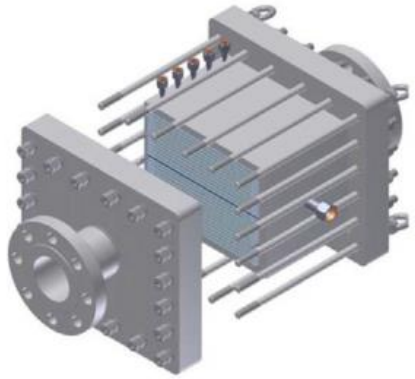
INERATEC

KIT

P2Fuel in Microstructured Reactors

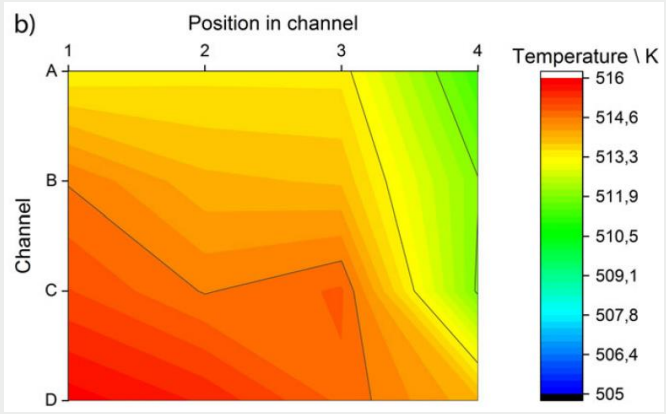
Microstructured Reactor



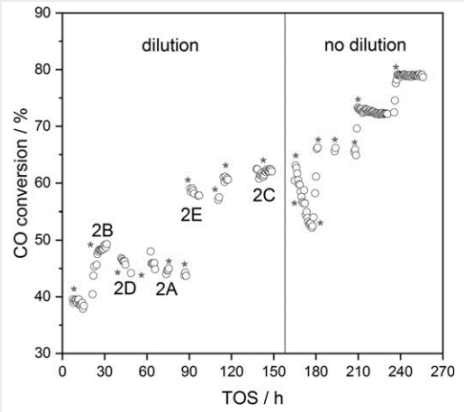


Dittmeyer et al. Curr. Opin. Chem. Eng. 17 (2017) 108

Homogeneous temperature distribution



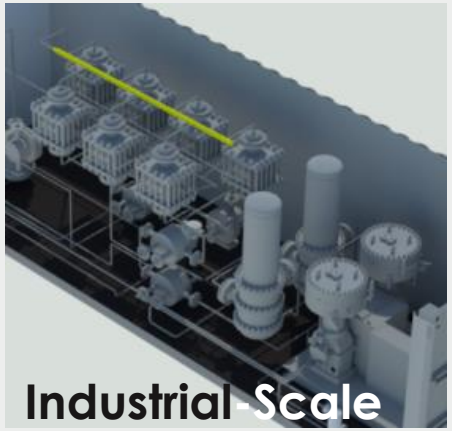
High performance, e.g.: CO-conversion vs. time



Loewert et al. Chem. Eng. Techn. (2019) DOI: 10.1002/ceat.201900136 (*in press*)

From lab to industrial scale

grams/day *capacity* **tons/day**



Source: INERATEC GmbH

KIT Spin off

INERATEC

www.ineratec.de

Key exploitable results addressing energy system integration

Source: P2X FC-B2 WP1 Project Team, P. Langer (KIT)

First of its kind process chain in operation since 08/2019

> 50 L **fuel synthesized** starting from CO_2 capture from the air and electricity

Potential for sector coupling and CO_2 mitigation

Modelling reveals for plants in 100kW – 10MW range:

→ **Efficiency up to 60%**
(electricity in vs. heating value product out)
→ **Carbon conversion >>90%**
(„C“ from CO_2 converted into hydrocarbons)

Lessons learned and barriers to innovation deployment

Process integration allows for increased efficiency of P2F process chains

But: in order to achieve a CO_2- neutral fuel, it is mandatory to

- Utilize **renewable, green electricity** (grey in the transition period)
- Capture CO_2 from ambient air in order to **guarantee a closed carbon cycle**

→ 400 ppm CO_2 in the air demands for large volume of air being processed*
→ even with 60% efficiency, a large amount of renewable electricity is required**

Scaling effects will lead to a decrease in CAPEX. However, OPEX costs having a large influence on the economics of P2X-fuels are much depending on **electricity costs** and potential **carbon pricing.**

* 1 metric ton of P2X-hydrocarbons require 3.1 metric tons of CO_2, thus, the CO_2 in approx. 4 Mio. m³ air
** for 1 Liter diesel fuel (approx. 10kWh heating value) with 60% efficiency ~17 kWh renewable electrical energy is needed.

Deployment prospects & future R&I activities

From proof-of-concept to industrial scale…

Proof-of-concept plant

Implemented ✓
Kopernikus Phase I

2019

10 L/day

Demonstration plant

Realization @ EL 2.0 platform
Kopernikus Phase II

2022

~ 200 L/day

Pre-industrial demonstration plan

In cooperation with industrial partner(s)
e.g. Kopernikus Phase III

≥ 2025

~ 1500 – 2000 L/day

Future R&I activities

Investigation (R&D + LCA) of building integrated PV + DAC coupled with HV/AC system

→ OPEX/CAPEX of DAC might be lower; 10% of the global power consumption for HV/AC systems!
→ Crowd Oil not Crude Oil: New stakeholders/democratization of the energy
→ Reduces additional demand of land by utilization of existing infrastructure


nature COMMUNICATIONS

PERSPECTIVE
https://doi.org/10.1038/s41467-019-09685-x OPEN
Crowd oil not crude oil
Roland Dittmeyer[1], Michael Klumpp[1], Paul Kant[1,2] & Geoffrey Ozin[2]

Nature Comm. (2019) 10:1818

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Thank you for your kind attention.

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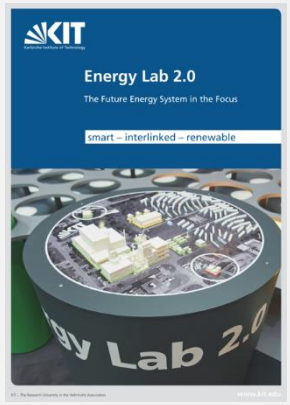
Read more:



Broschure on Energy Lab 2.0
www.elab2.kit.edu → Downloads

KIT Press release on Carbon-neutral Fuels (PI No. 107)
https://www.kit.edu/kit/english/pi_2019.php

Webpage Kopernikus Projects
https://www.kopernikus-projekte.de/en/home

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