CO2FOKUS
ADVANCING CO_2 CONVERSION

Life Cycle Assessment

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2nd CINEA LCA to CCUS & alternative fuels workshop. March 7th, 2024

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n. 838061

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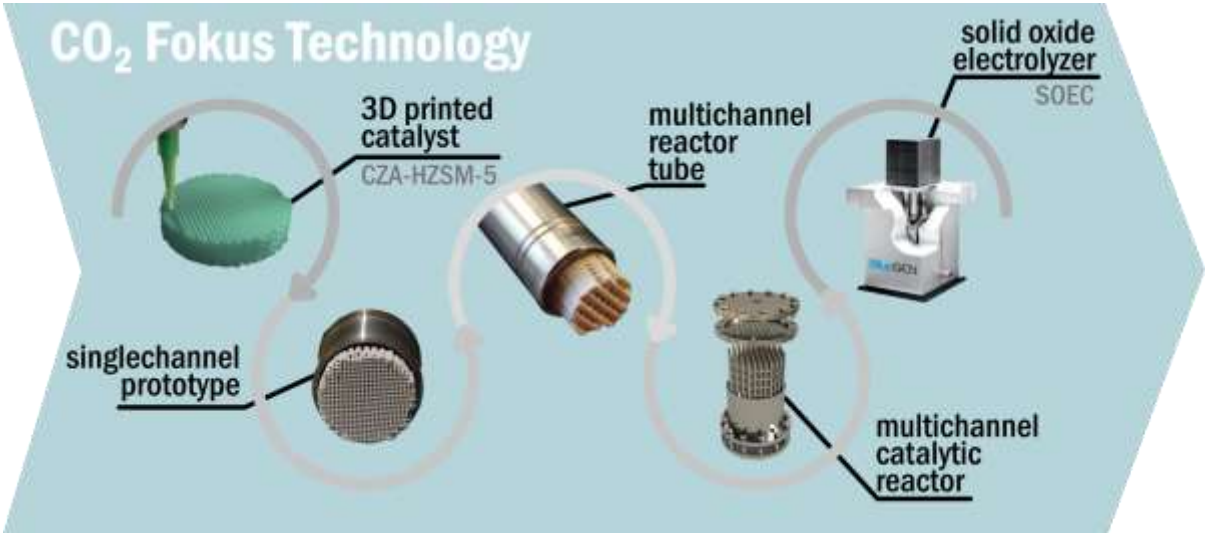
CO2Fokus project (May 2019 – Dec. 2023)

CCU: Direct catalytic conversion of CO_2 from point sources to produce Dimethyl Ether (DME).



Demostration pilot TRL5 at petrochemical plant in Turkey.

DME is an added-value gas for the chemical industry and the energy sector as fuel for heavy duty vehicles.

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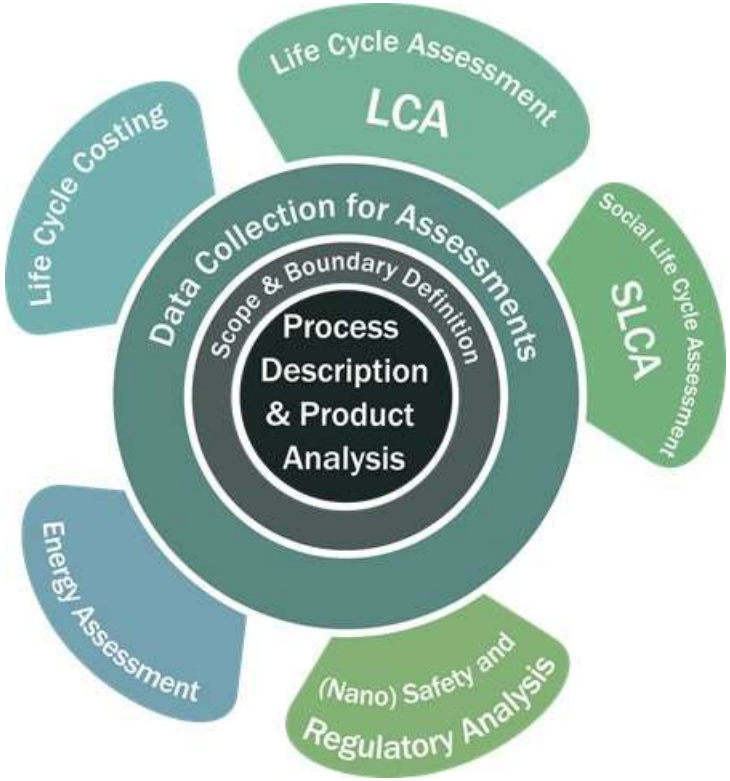
Environmental/life cycle assessment (LCA), socio-economic assessment (LCC/S-LCA) and feasibility studies.

To evaluate the costs, social and environmental impacts at pilot scale.

Five tasks <u>completed</u> in the project:

- Energy assessment
- Economic Assessment (LCCA)
- **Life Cycle Assessment (LCA)**
- Socio-Economic Assessment and social readiness/acceptance
- Analysis of (nano) safety and regulatory requirements



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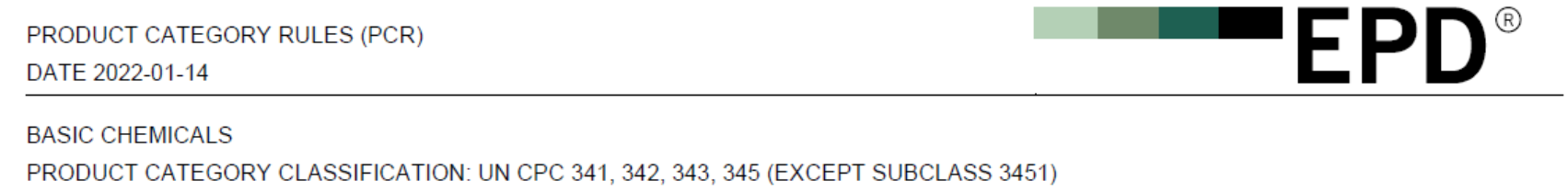
Life Cycle Assessment Methodology

LCA followed the 2022 Product Category Rules (PCR) for Basic Chemicals from EPD International:


PRODUCT CATEGORY RULES (PCR)
DATE 2022-01-14

EPD®

BASIC CHEMICALS
PRODUCT CATEGORY CLASSIFICATION: UN CPC 341, 342, 343, 345 (EXCEPT SUBCLASS 3451)

- Systems Approach: Attributional; with Cut-off Classification.
- Software: SimaPro v9.1; Database Ecoinvent v3.8 (2021).
- 22 Impact, resource use, waste output indicators (mid-point, EPD and CED methods).
- No aggregation, no normalization, no weighting.

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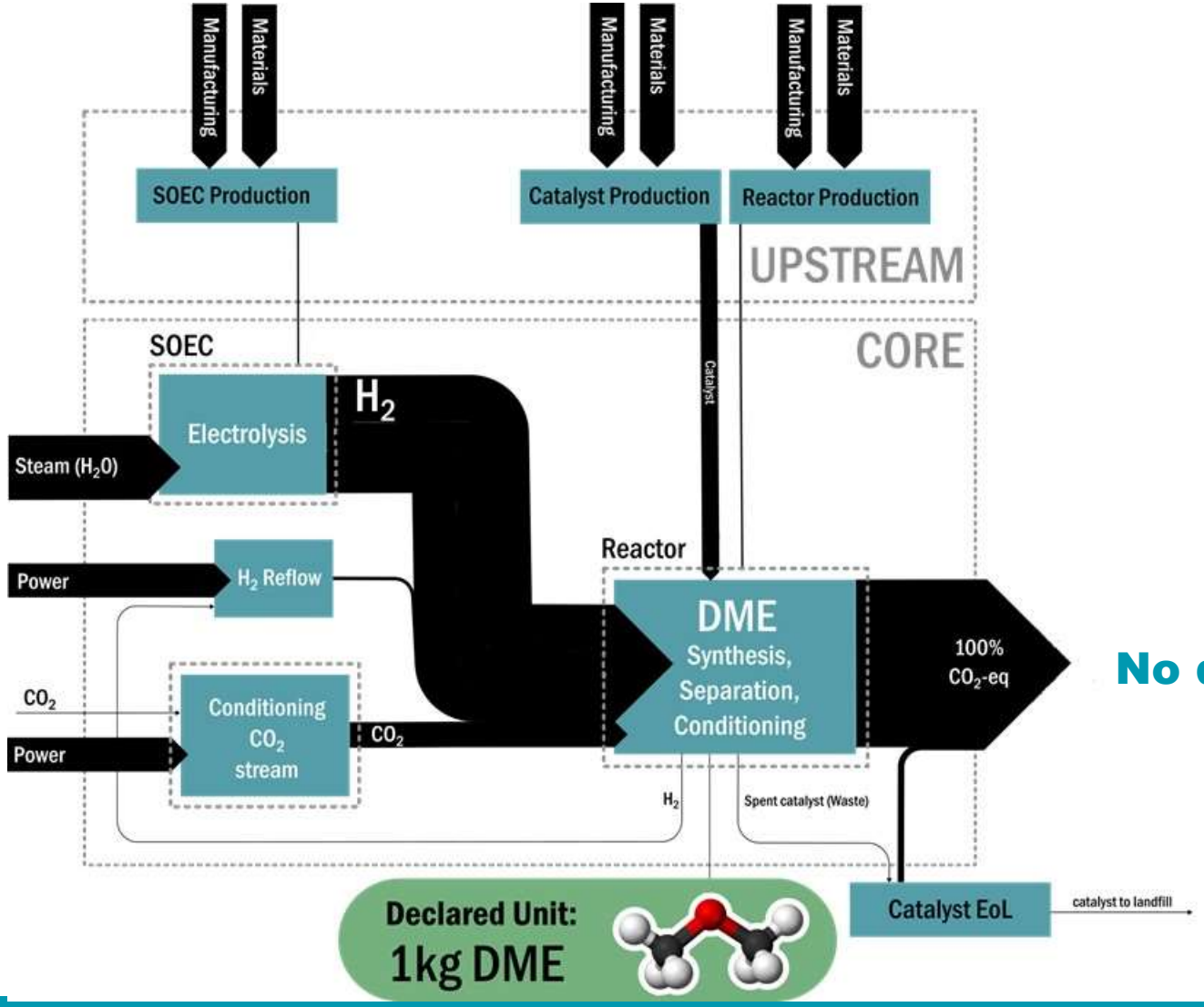
System Boundaries and Declared Unit



No downstream

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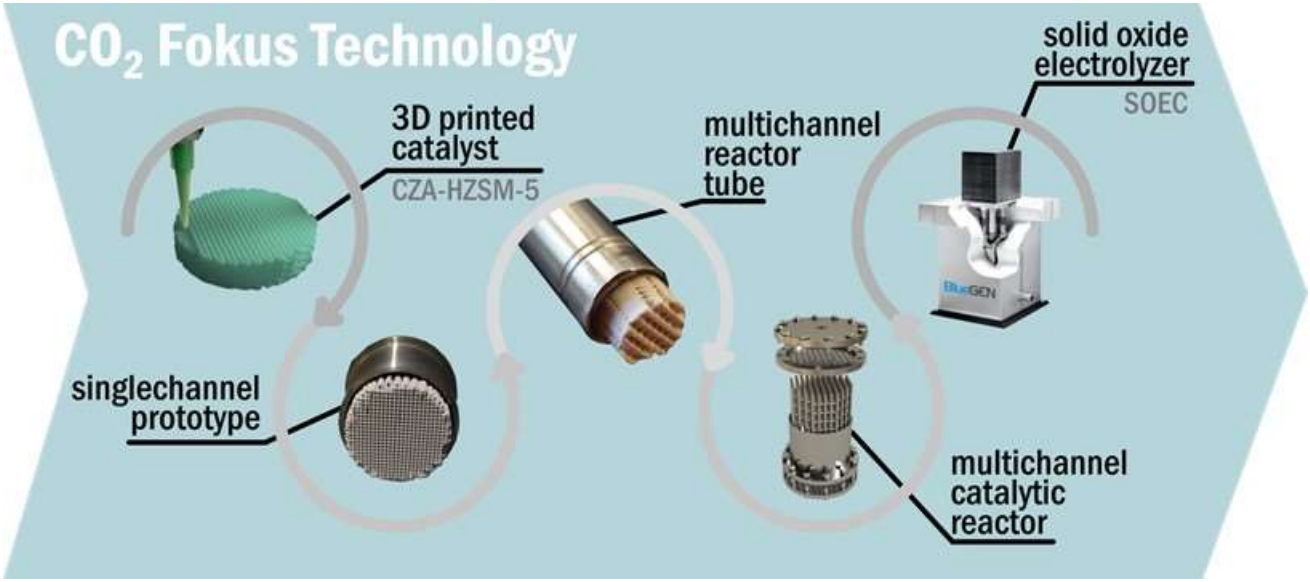
Inventory: Upstream



- Data from real components → catalyst, reactor, SOEC
- Waste CO_2 stream → from real Ethylene Oxide process.

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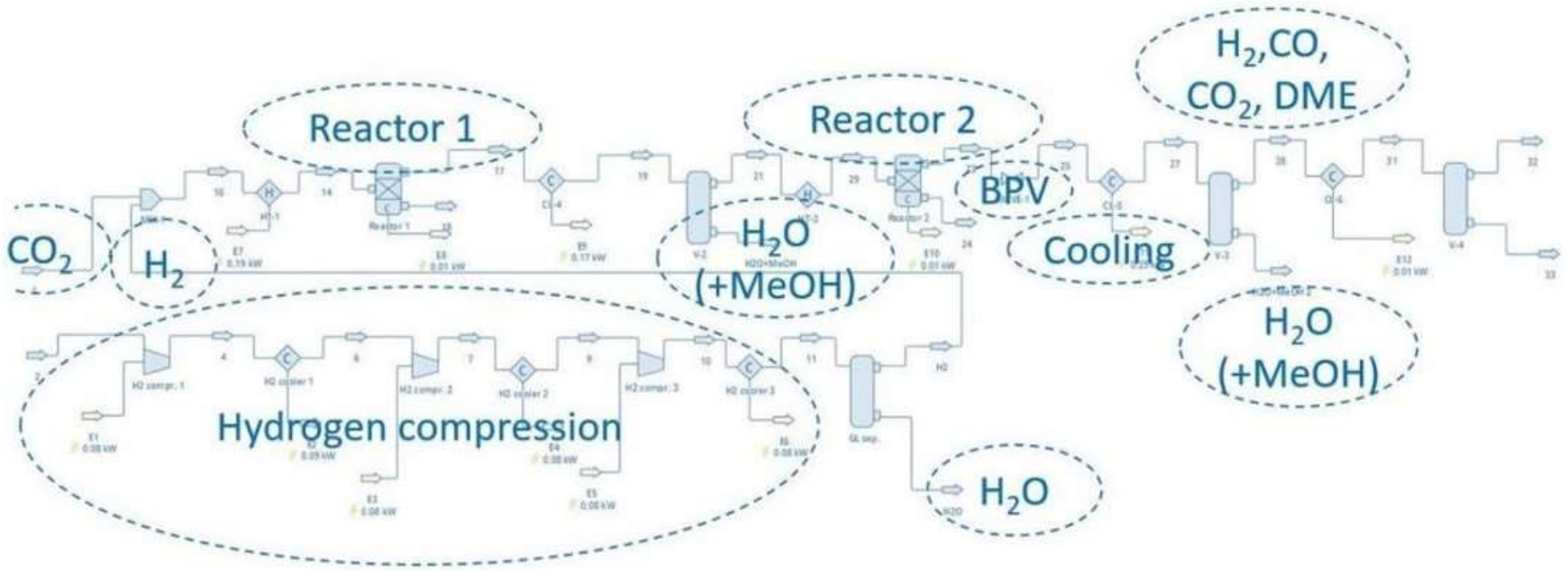
Inventory: Core module



- Modeled data for the integrated process → P&ID, mass & energy balances for H_2 production, compression trains (H_2, CO_2), conversion reaction and DME purification.
- Electricity mix of Turkey → Location of the Pilot.

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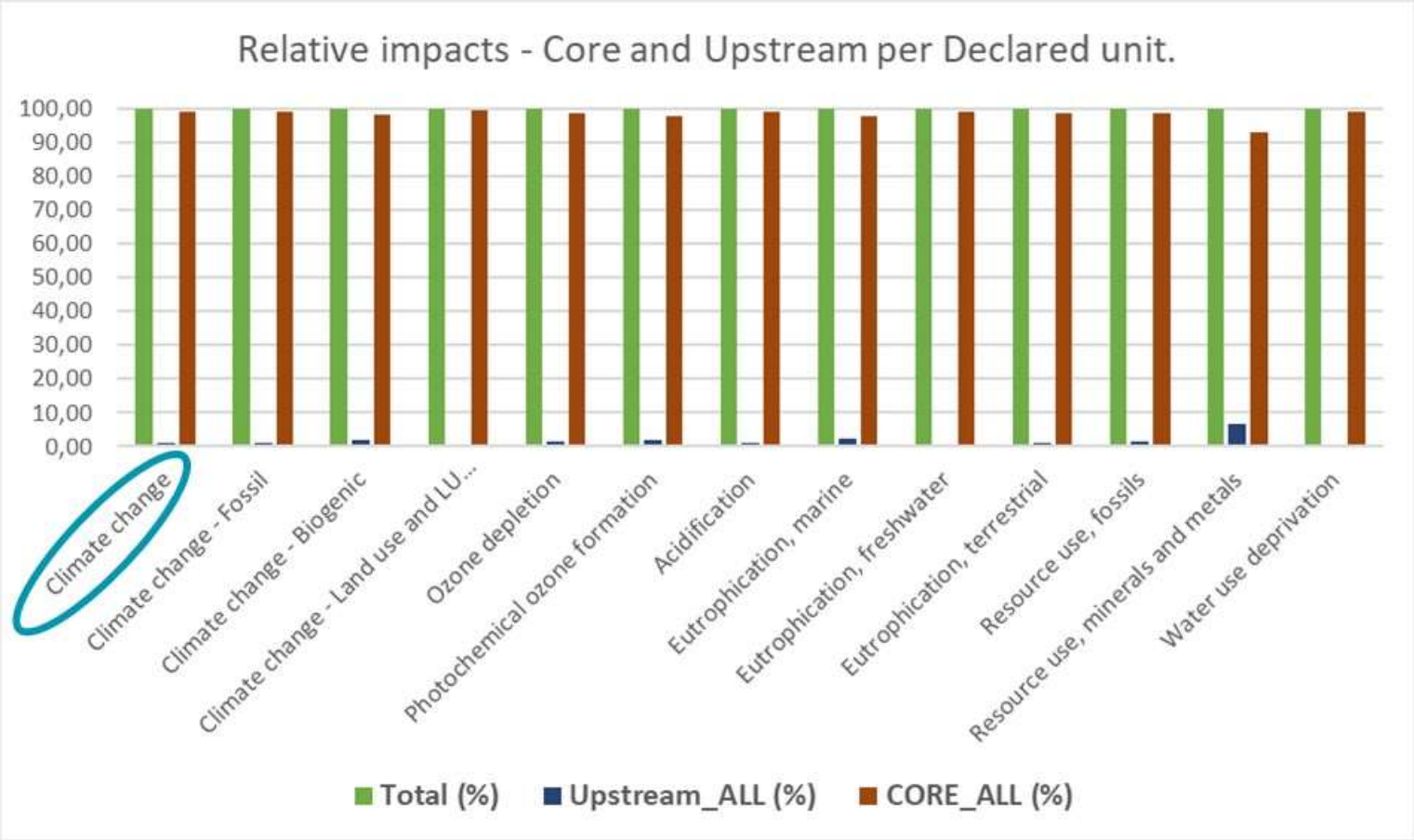
Selected results for 1kg DME



Total GWP: 120,11 kg CO_2 Eq → 100% impacts allocation to DME.

Upstream: 1,11 kg CO_2 Eq + Core: 119,00 kg CO_2 Eq

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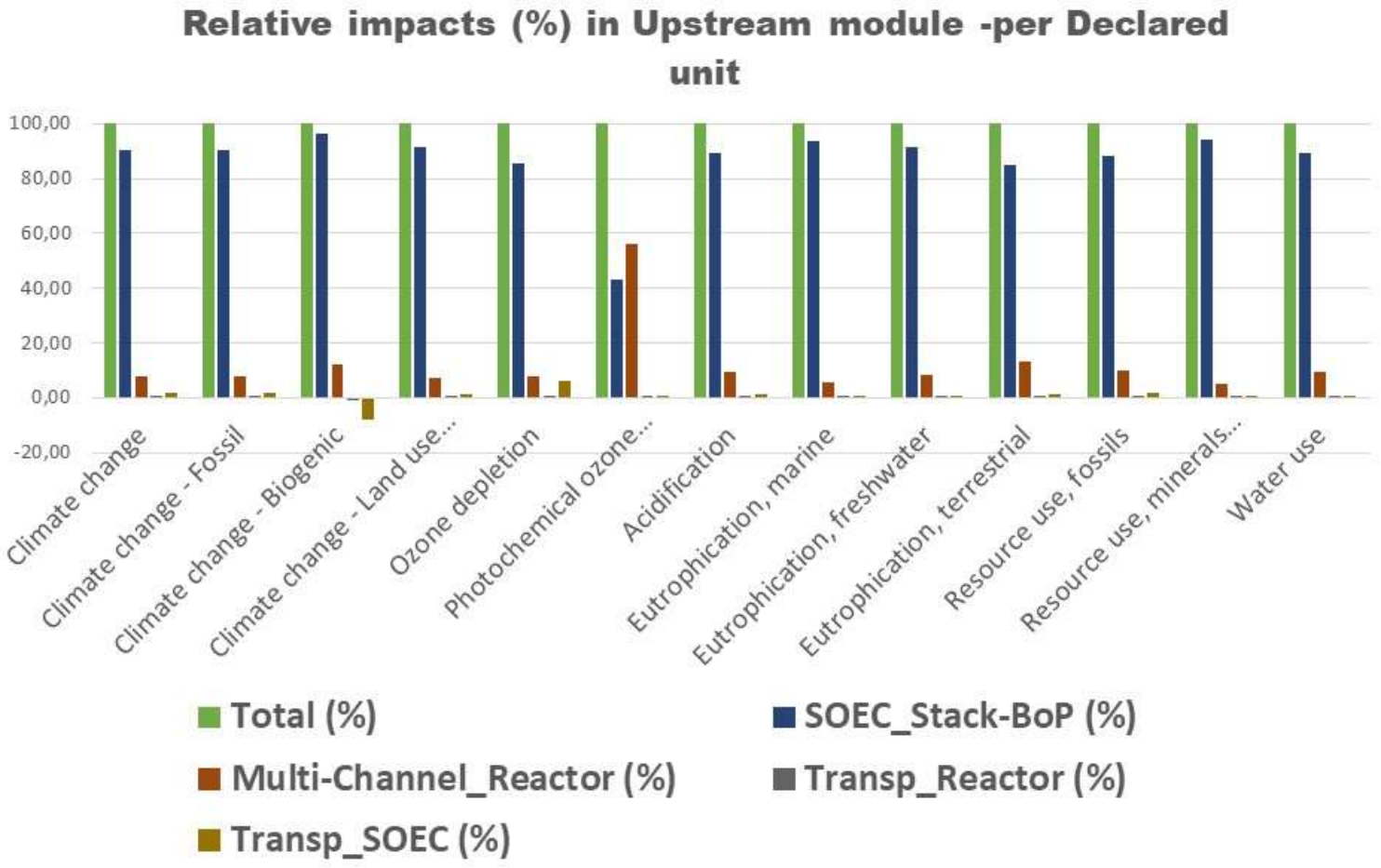
Upstream Module



SOEC relevant for the impacts in the Upstream module

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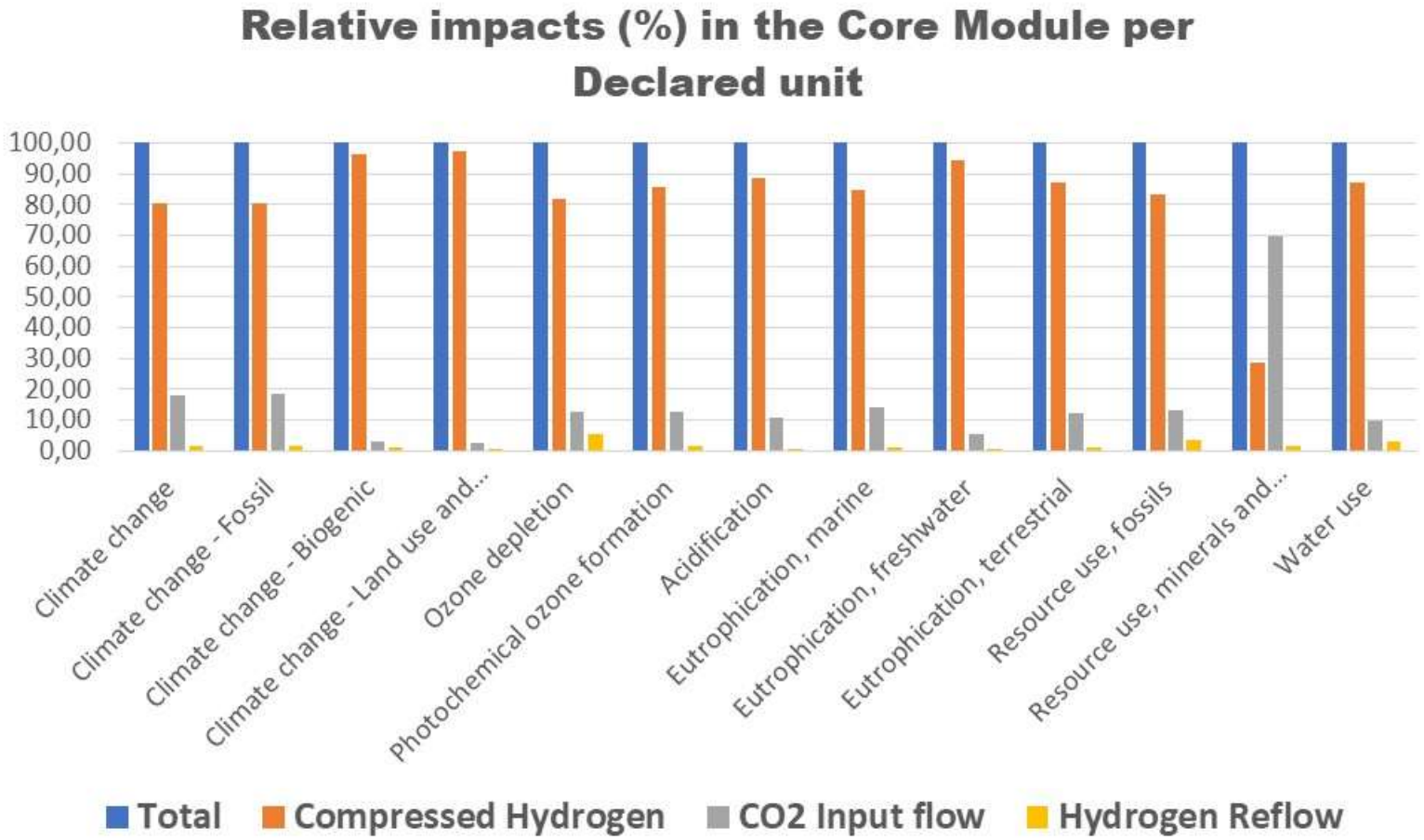
Core Module



Compressed Hydrogen is most relevant in the Core Module and overall.

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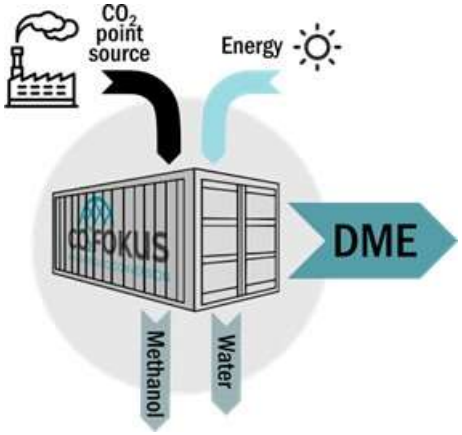
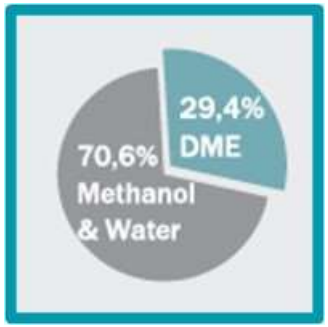
Three sensitivity scenarios:



1) **Photovoltaic electricity for Hydrogen production:**
   From 120,11 kg CO_2-Eq → **49,10 kg CO_2-Eq** per Dec. unit

2) **Wind electricity for Hydrogen production:**
   From 120,11 kg CO_2-Eq → **43,20 kg CO_2-Eq** per Dec. unit

3) **Mass allocation according to (all 3) outputs:**
   From 120,11 kg CO_2-Eq → **35,32 kg CO_2-Eq** per Dec. unit



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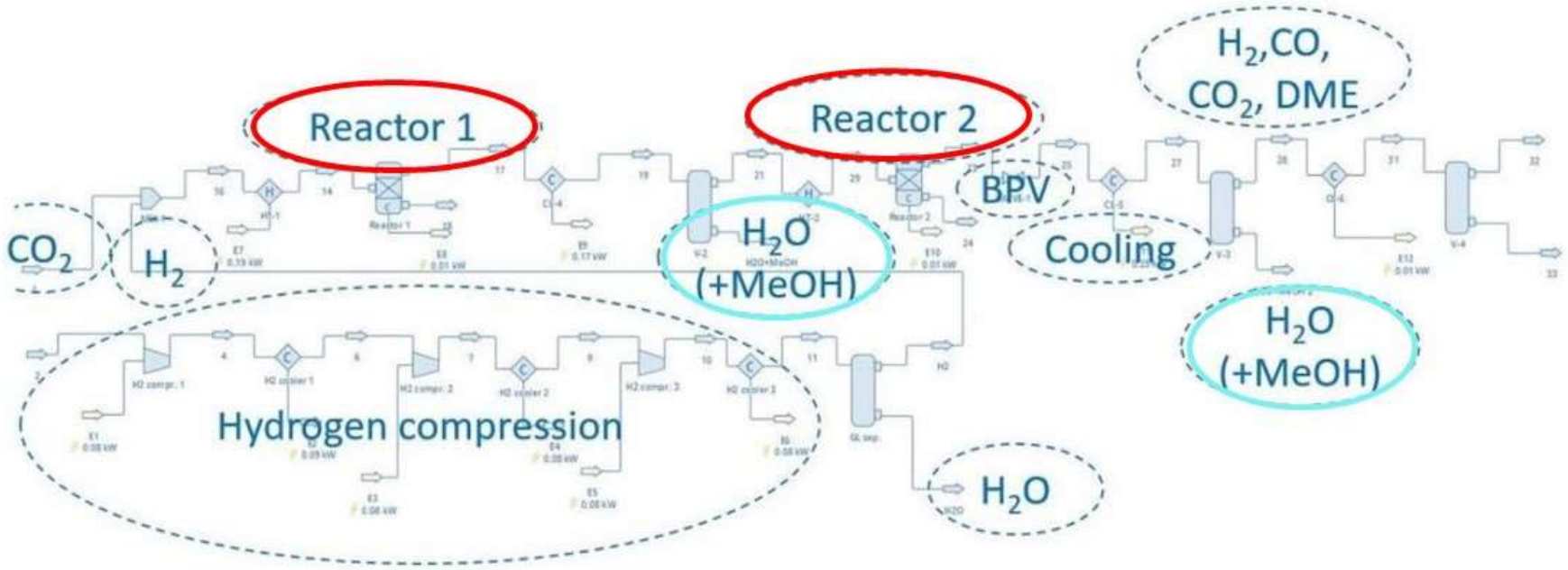
Improvements to increase DME yield



Configurations for water removal (proposed):

1) Two reactors, water removal after each reactor.
2) Zeolitic water sorbents.
3) Selective water membranes on the internal surface of nano-porous tubes in the reactor.

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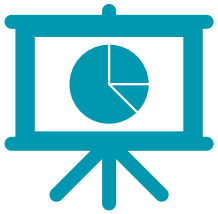
Summary of LCA of CO2Fokus



- LCA to evaluate and identify improvements in the processes, and for internal decision-making.
- System boundaries: Upstream and Core modules.
- LCI: data partly real and party modeled, pilot was not yet running.
- LCIA: 22 category indicators→ env. impacts, resources and wastes.
- 100% allocation of impacts to DME.
- Most impacts in the Core module, due to the energy demand of H_2 production. Low DME yield, water removal and low TRL pose challenges.
- Sensitivity scenarios with renewable electricity for H_2 production, and with mass allocation for 3 products.

- No real data from pilot was available to refine the LCA (Core module).
- Results with uncertainty, but improvements were identified. Project & LCA approach were presented internally and externally.

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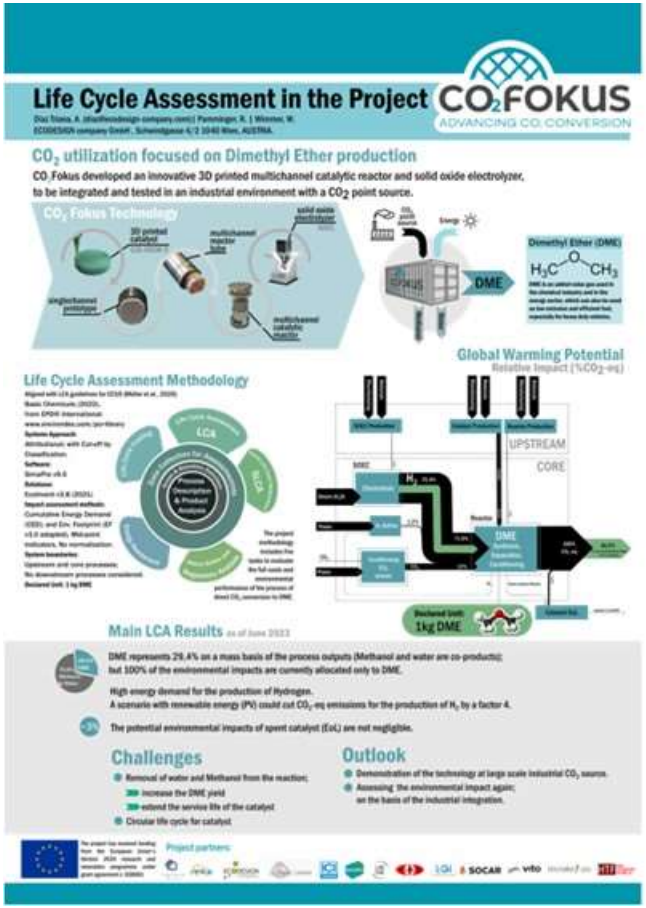
Results of the LCA of CO2Fokus presented externally

11th Life Cycle Mng. Conference & Final Project events (2023)



Thank you for your attention

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