ICO2CHEM Project: From industrial CO_2 streams to added value Fischer-Tropsch chemicals and fuels

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steps | Synergies of Thermo-chemical and Electro-chemical Power Systems

Outline

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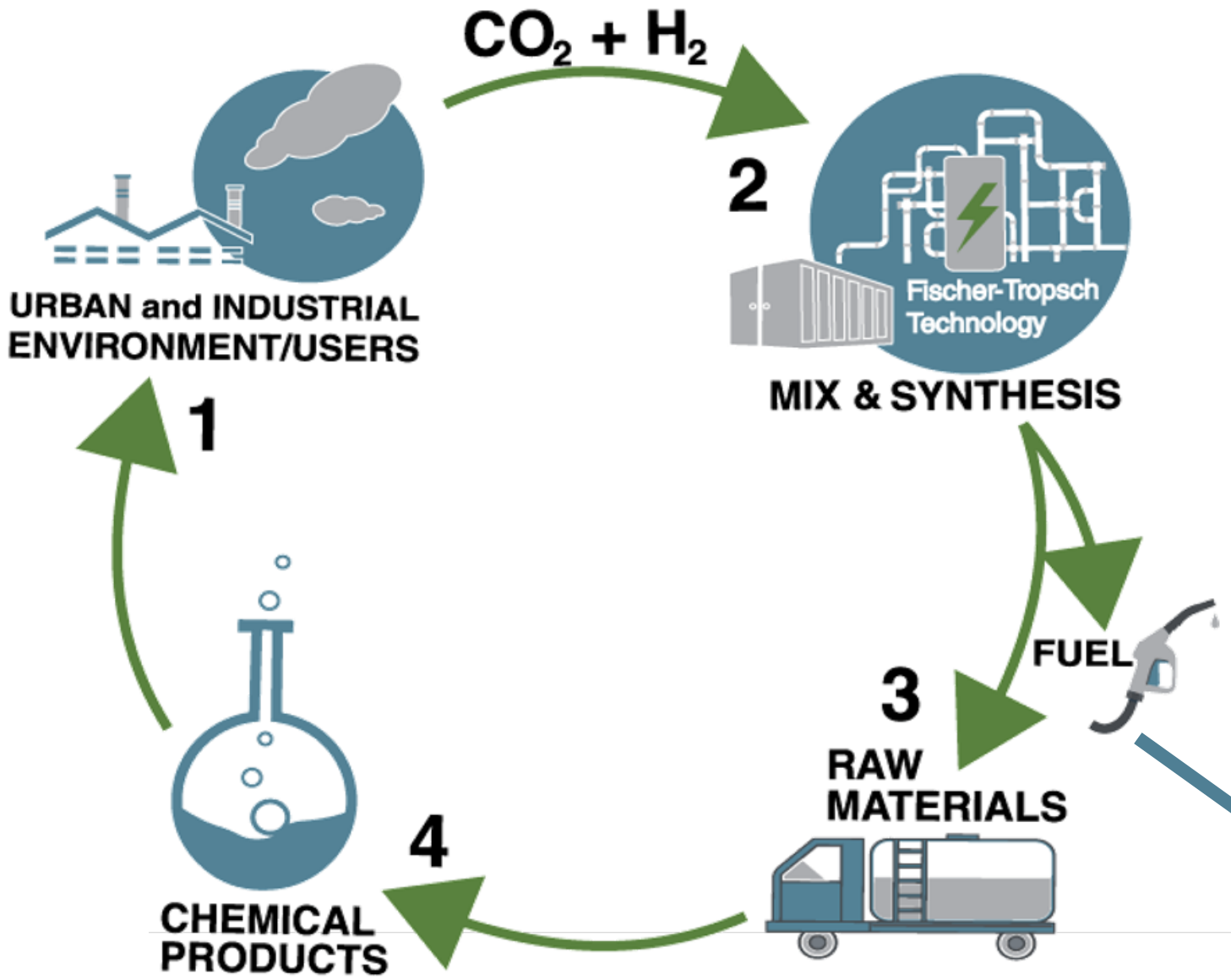
- **Activity and results**
- **Economic assessment methodology**
- **An alternative pathway: SOEC-based Fischer-Tropsch process**
- **Future activity**

Introduction and description of the project



Global framework

Circular pathway involving:

- **CO_2 production/separation**
- **H_2 production**
- **CO_2 reaction with H_2 (synthesis)**
- **Final products utilization**

Synthesis products may be used directly as fuels or as precursors for added-value chemical products

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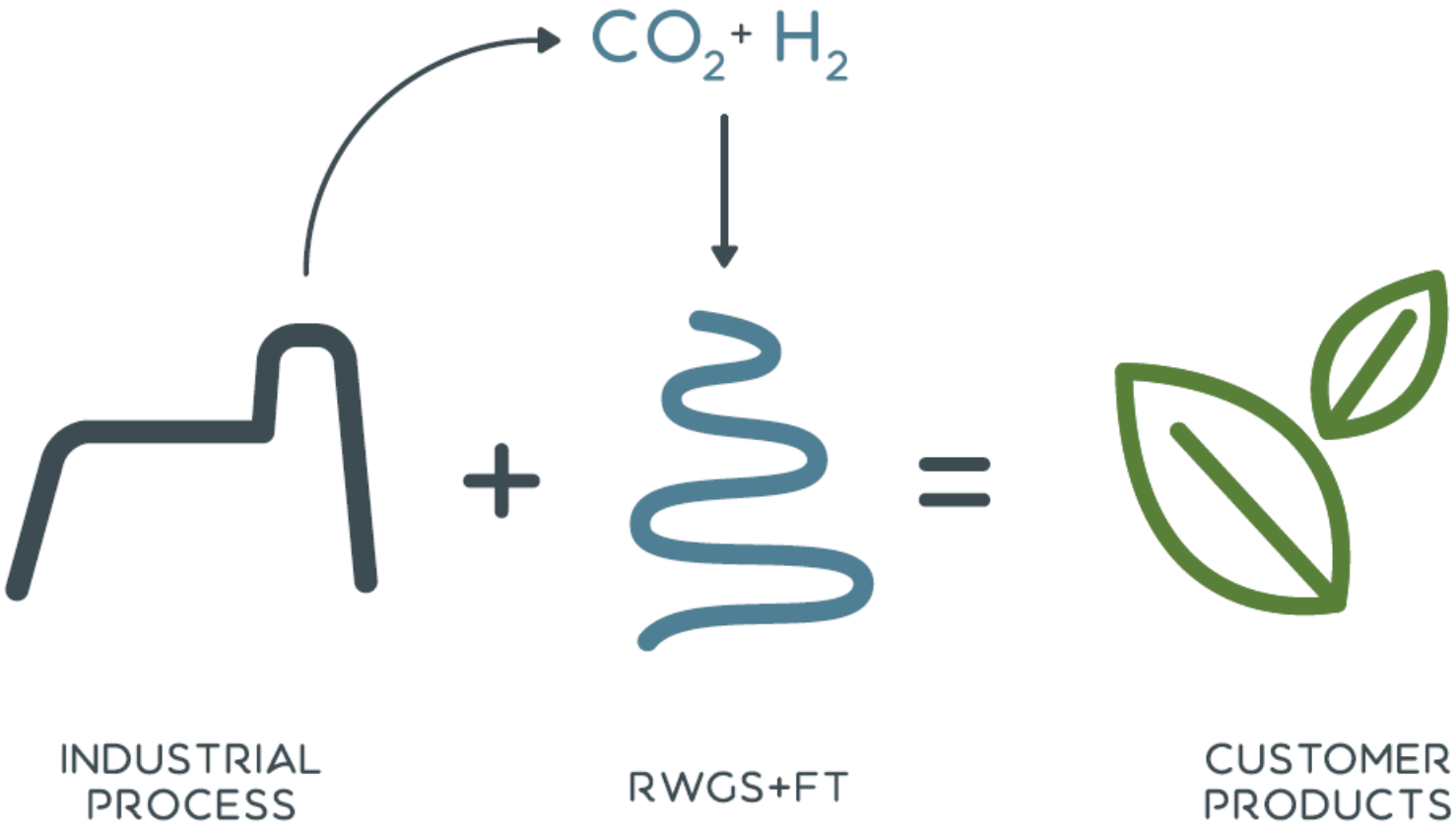


https://www.spire2030.eu/ico2chem

What is?

ICO2CHEM is an EU Horizon 2020 project. It is funded through SPIRE, the European Public-Private Partnership dedicated to innovation in resource and energy efficiency enabled by the process industries.

What is the ICO2CHEM purpose?

ICO2CHEM, being part of the call SPIRE08-2017 'Utilization of CO_2', aims at developing a new production concept for converting waste CO_2 to value-added chemicals. The focus is on the production of white oils and high molecular weight aliphatic waxes.

Introduction and description of the project

InfraServ Höchst
Industrial infrastructure integration and waste gases supply

CO_2: from MEA-based Biogas upgrading plant

H_2: from Chlor-alkali electrolysis

$CO_2 + H_2$

Ineratec, VTT
Mobile synthesis unit RWGS+FT

VTT
Catalyst manufacturing

Ineratec, Polito, VTT
Catalyst testing, Process modelling and Energy integration

FT product

Altana
Product testing

PHS, Polito, VTT
TEA and LCA analysis

A containerized chemical pilot plant (MOBSU – Mobile Synthesis Unit) will be installed and operated at the Industrial Park Höchst in Frankfurt, Germany.

The technological core of the project consists in the combination of a Reverse Water Gas Shift (RWGS) reactor coupled with an innovative modular Fischer-Tropsch (FT) reactor.

RWGS

$CO_2 + H_2 \leftrightarrow CO + H_2O$

Part of the hydrogen is consumed for CO production (required for Fischer-Tropsch synthesis)

FT

$CO + H_2 \leftrightarrow -CH_2 - + H_2O$

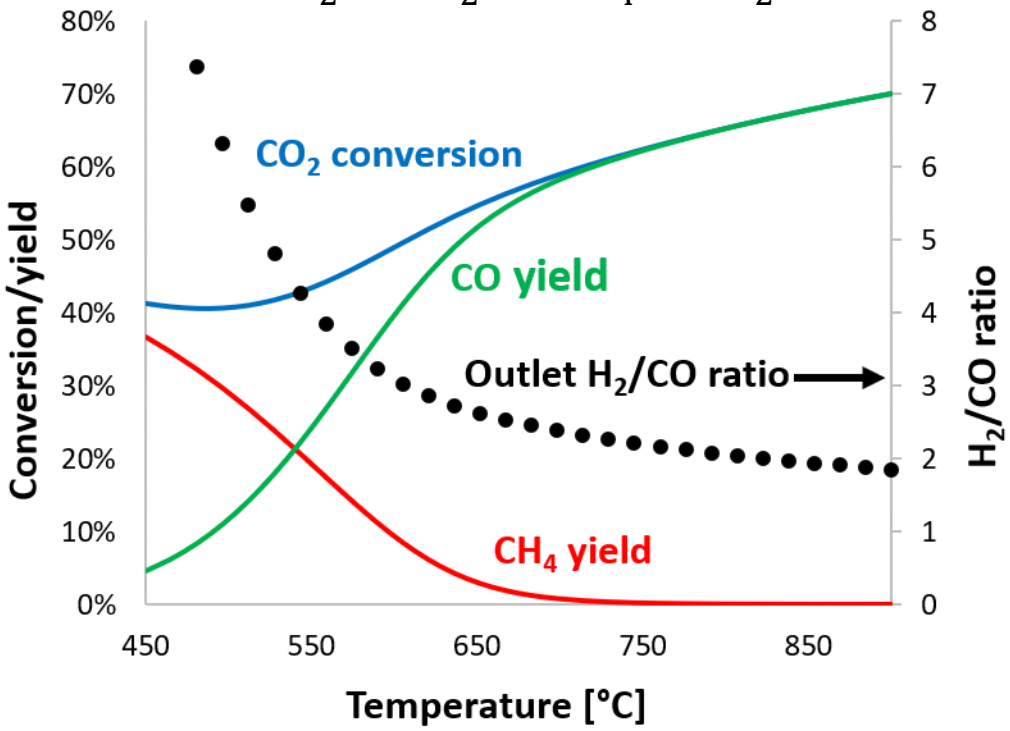
The synthesis gas is converted into highly valuable white oils and high molecular weight aliphatic waxes. These final products could be used as a raw material for chemical products, such as coatings and sealant materials.

Introduction and description of the project

REVERSE WATER GAS SHIFT

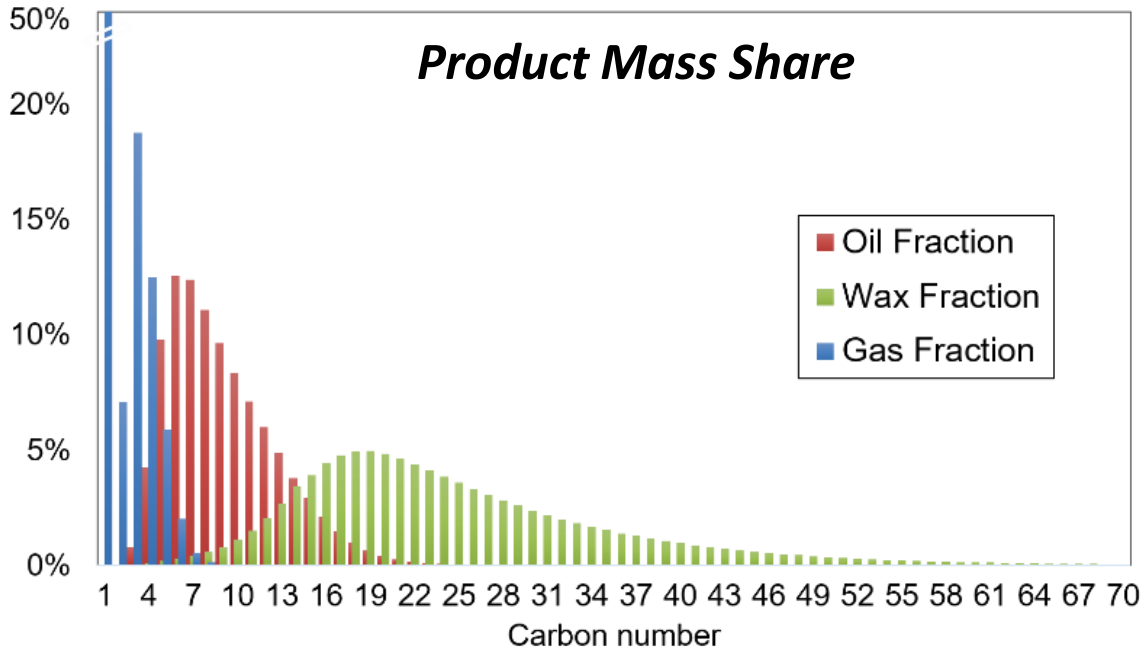
$$H_2 + CO_2 \leftrightarrow H_2O + CO$$

$$4H_2 + CO_2 \leftrightarrow CH_4 + 2H_2O$$



FISCHER-TROPSCH SYNTHESIS

$$CO + 2H_2 \longrightarrow -CH_2 - + H_2O$$

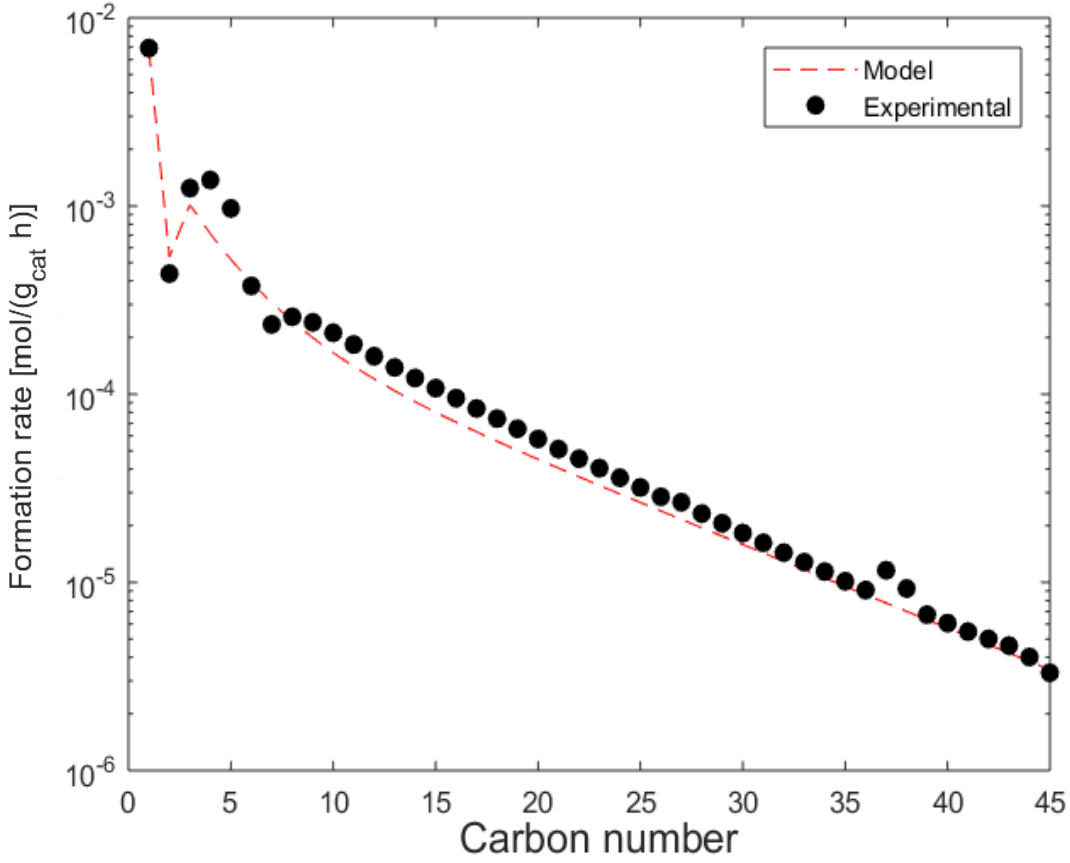


Activity and results: kinetic modeling

Aim: identification of a kinetic law and estimation of kinetic parameters ensuring the best possible fitting of experimental data

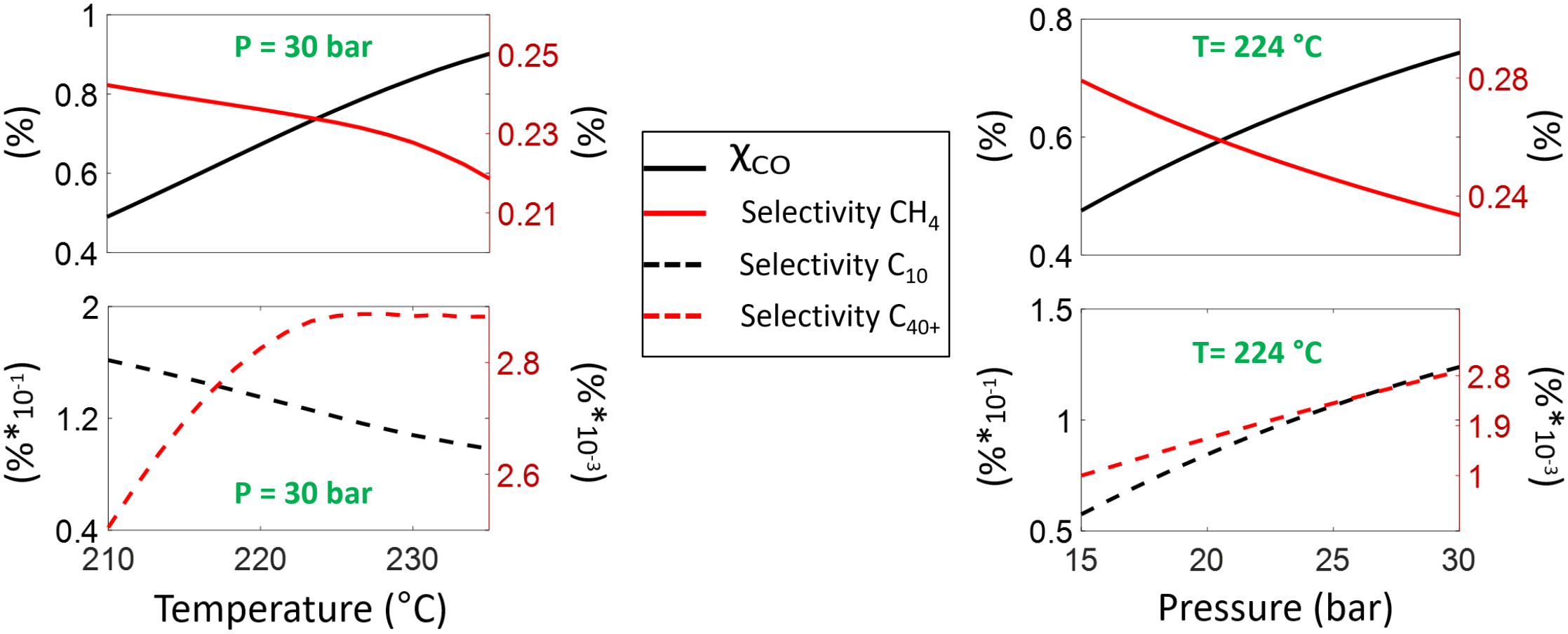
Kinetic law depends on the corresponding reaction mechanism, i.e., the set of elementary steps describing the process at catalyst scale. Several reaction mechanisms have been proposed in the open literature

Genetic and interior-point algorithm for global and local optimization, respectively



Activity and results: reactor modeling

The obtained kinetics has been used in a PFR model reactor to investigate the effect of pressure and temperature on the outlet composition



Economic assessment methodology

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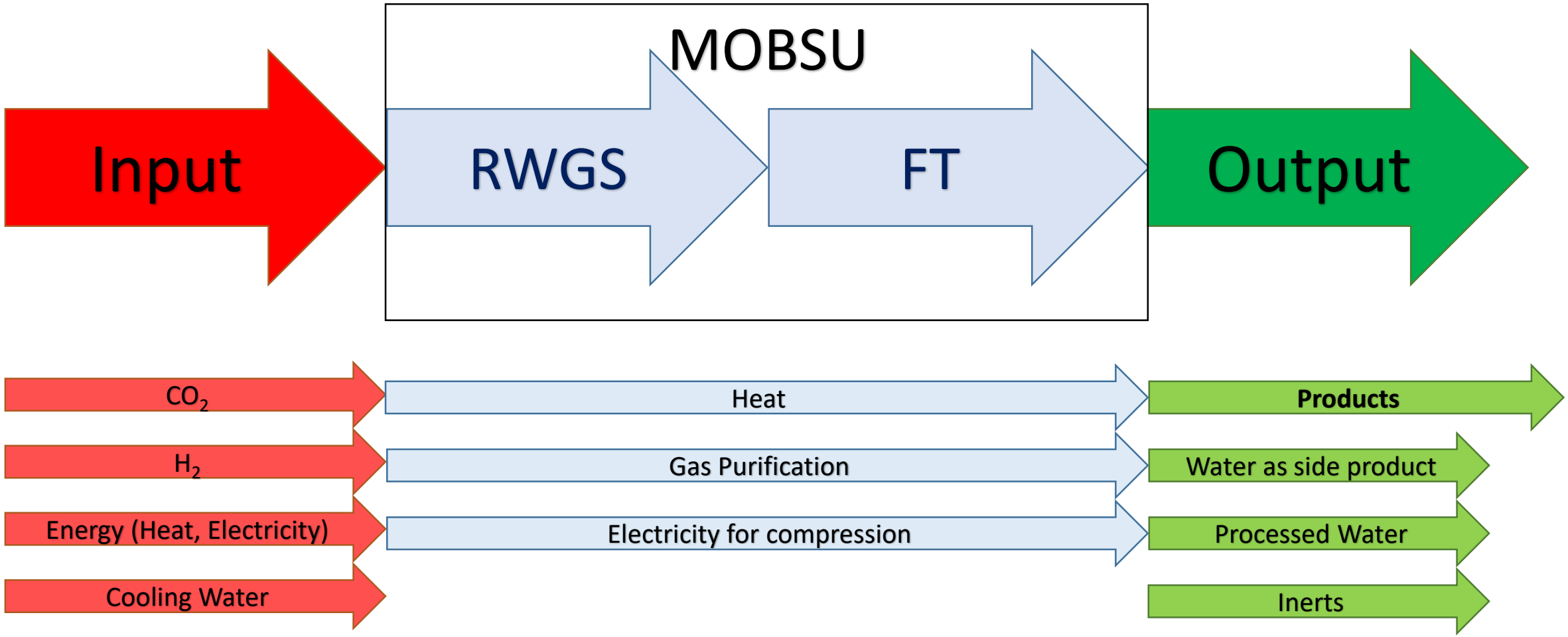


Economic assessment methodology

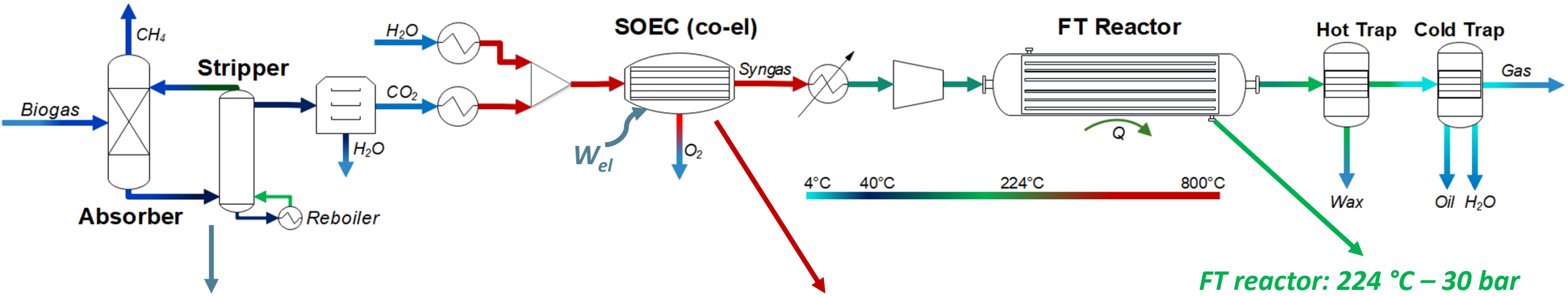
Methodology

Discounted cash flow analysis for Net Present Value (NPV) calculation

- Time horizon: 20 years
- Discount rate: 6%
- Operating hours: ≈ 8000 h per year
- Investment cost: it could include or not an electrolysis unit purchasing for alternative H_2 production
- Operating and maintenance (O&M) cost, including CO_2 cost, H_2 cost, input energy, personnel, maintenance, insurance
- Products selling price: 1.533 €/kg (averaged value from previous analysis)

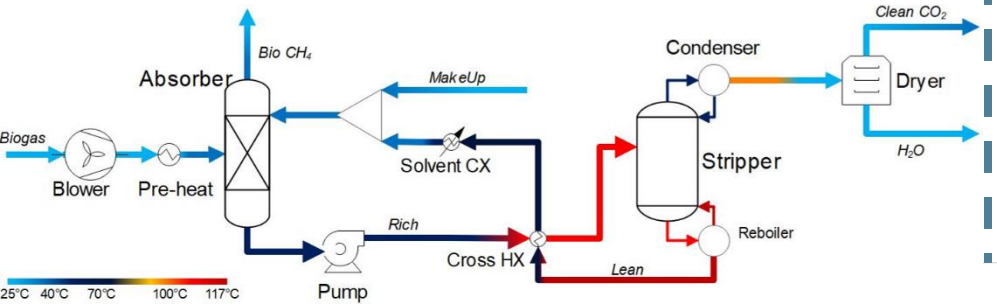
An alternative pathway: SOEC-based FT

Idea: The RWGS step could be replaced by a solid oxide electrolyzer (SOEC)
SOEC may electrochemically split both H_2O and CO_2 (co-electrolysis) to produce a syngas that can be directly fed to the Fischer-Tropsch (FT) reactor



FT reactor: 224 °C – 30 bar

MEA-based CO_2 separation for biogas upgrading



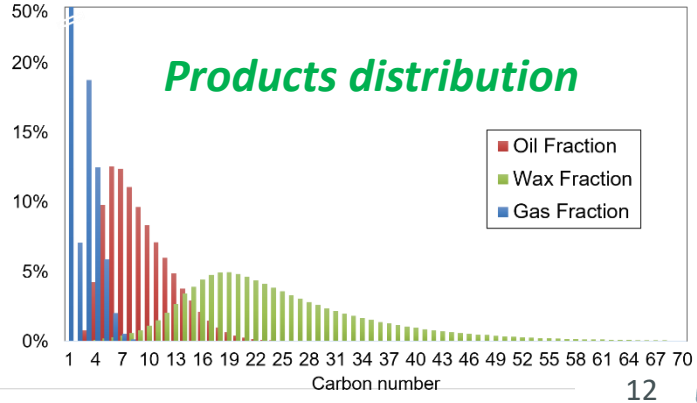
Co-electrolysis reaction scheme

$$H_2O \longrightarrow H_2 + \frac{1}{2}O_2$$

$$CO_2 \longrightarrow CO + \frac{1}{2}O_2$$

$$H_2O + CO \leftrightarrow H_2 + CO_2$$

Products distribution



Future activity

- **Further data collection for economic analysis (estimated average product price: 1.53 €/kg)**
- **Market analysis**
- **Detailed reactor modeling**
- **Complete process integration**
- **MOBSU production and installation**
- **Experimental activities for SOEC testing and model validation**
- **Techno-economic and Life Cycle assessment of different CCU systems**

For additional info:

- **Project website: https://www.spire2030.eu/ico2chem**
- **Contact: andrea.lanzini@polito.it**
- **STEPS group website: http://www.steps.polito.it/**

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Thank you for your attention!