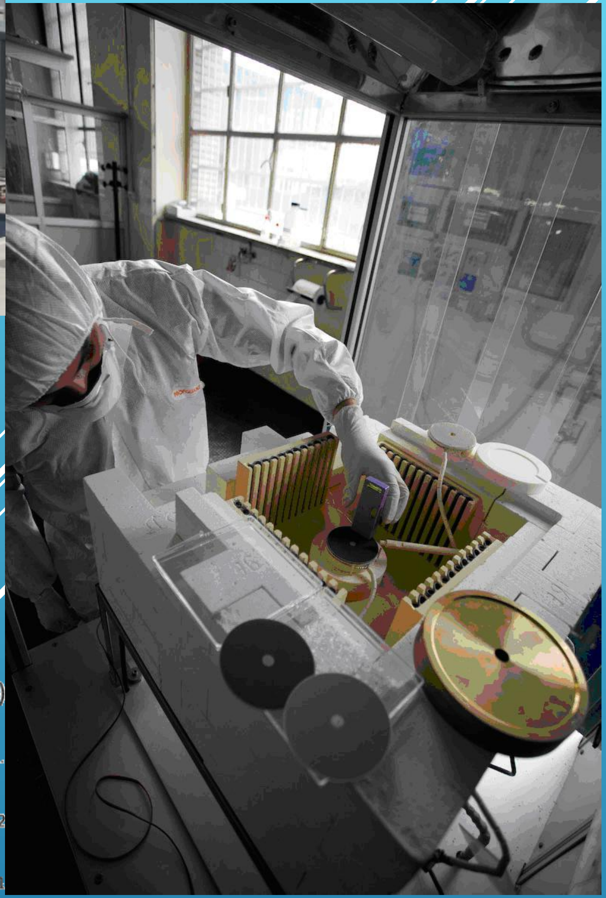
POLITECNICO
DI TORINO

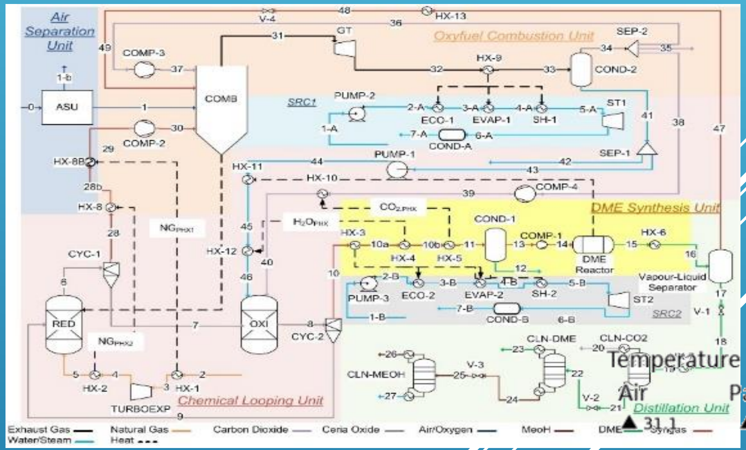
ENERGY CENTER

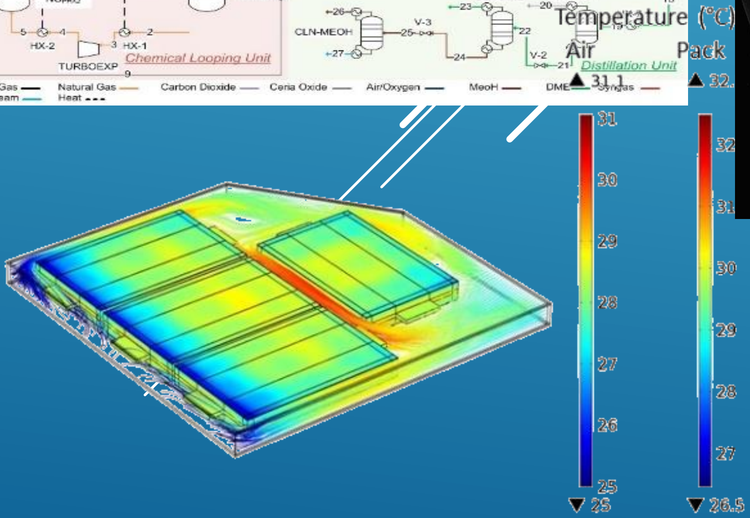
ENVIRONMENT PARK Parco Scientifico Tecnologico per l'Ambiente

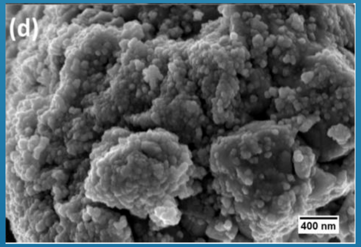
CO_2 Circle Lab

H2@POLITO









H2 @ POLITO

5
Involved Departments

100+
Research Projects

100+
Researchers

1500 mq
Labs

Focused collaborations:

ISTITUTO ITALIANO DI TECNOLOGIA

ENVIRONMENT PARK Parco Scientifico Tecnologico per l'Ambiente

LABS

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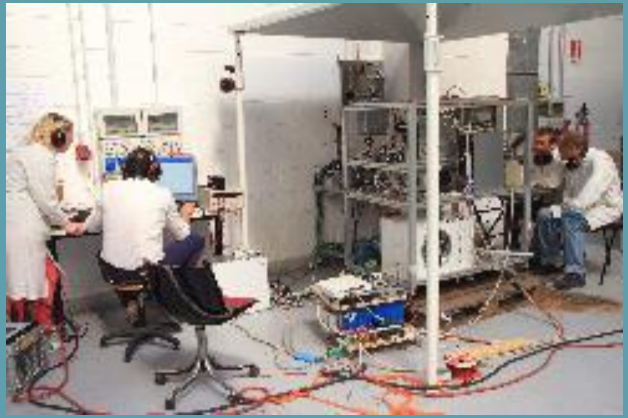
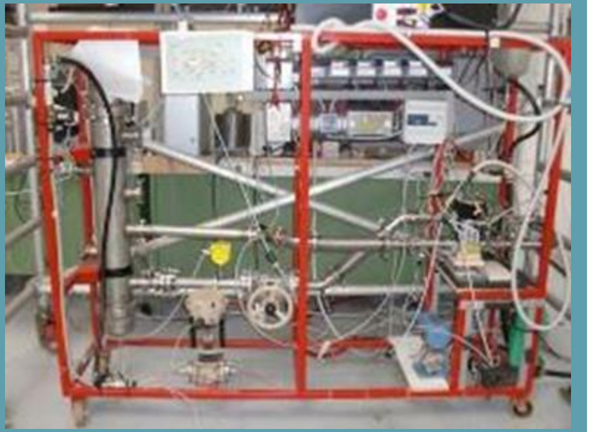




Test area at Environment Park

Test area at departments labs

Test area at Energy Center Lab

- ✓ Test benches for several H2/FC activities
  - Fuel cells single cell and stacks (LT and HT)
  - Electrolyzers (LT and HT)
  - Alternative H2 production processes (chemical looping, photocatalysis, biochemical processes)
  - Balance Of Plant components
- ✓ Test benches for processes CO2/H2
  - CO2 capture
  - CO2 reduction
  - CO2 and H2 storage (HT e HP)

RICERCA

The **Polytechnic of Turin [POLITO]** has been active for 30 years in research on hydrogen processes and technologies.

Founding member of Hydrogen Research Europe (2007) and member of H2IT, it is the coordinator of around 10 projects in the European FCH-JU Platform and partner of about 30 projects in the same Platform.

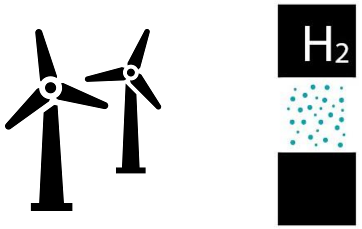
The research activities are focused on:

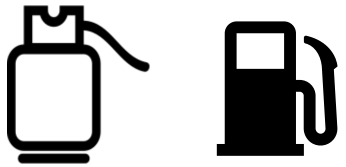
- **electrolysis from renewable sources**
- **new pathways for Green hydrogen production (chemical looping, photo-catalysis, biochemical routes)**
- **hydrogen mobility (storage and HRS)**
- **fuel cells LT and HT**
- **generation of synthetic chemicals in association with the capture of CO2.**
- **system integration (e.g. with batteries)**

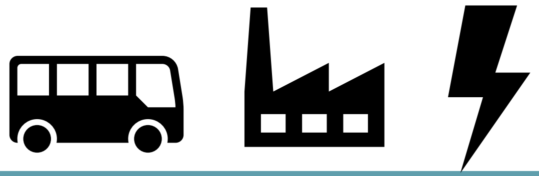
In these areas the activities develop from test and modeling to the creation of prototypes and technological demonstrators.

In the hydrogen field, POLITO collaborates with major national companies in the development of innovative solutions, including SNAM, ITALGAS, ENEL, ENI, IREN, CVA, SMAT, ASJA, ACEA, STELLANTIS, PUNCH.

AN EFFORT ALONG THE VALUE CHAIN…







PRODUCTION

- Electrolysis (low T, high T)
- Blue hydrogen - CCS technologies
- Bio-based processes (thermal, biological)
- Fotocatalisi
- Solar-assisted chemical looping

STORAGE AND DISTRIBUTION

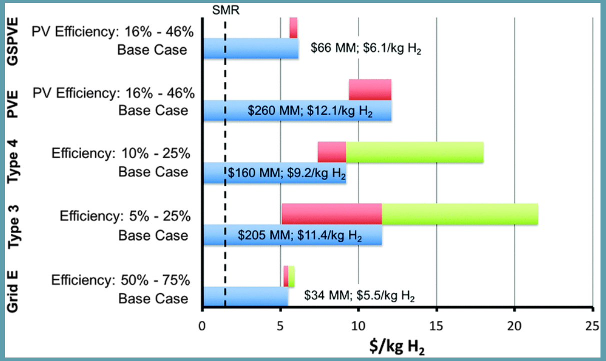
- Compression
- Ad/Absorption on solid matrix
- Underground storage
- Injection in NG networks
- LOHC / NH3

FINAL USES

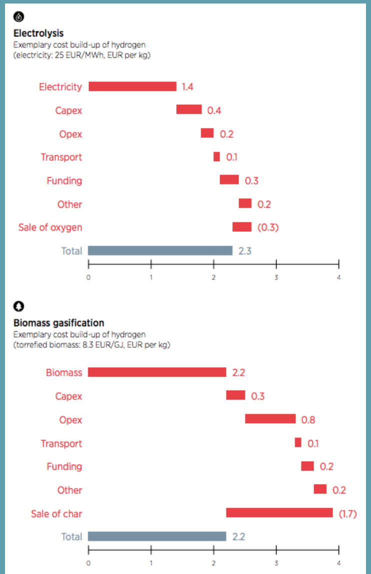
- Industrial feedstock
- Mobility/transportation
- Hydrogen/FC to power
- Syntetic chemicals
- Solar fuels
- Residential energy uses
- Grid services

SERVICES

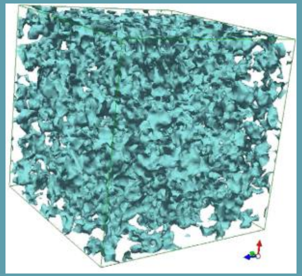
Test and experimental services

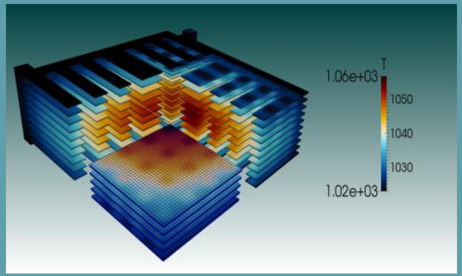


Feasibility studies, strategic consultancy, scenario analysis



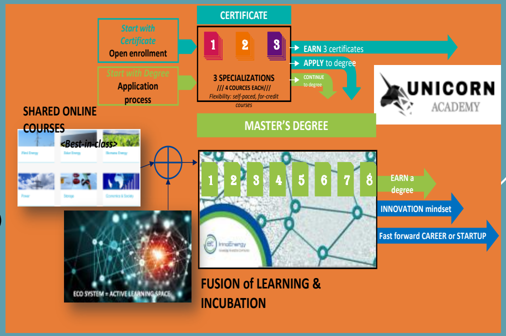
Modeling



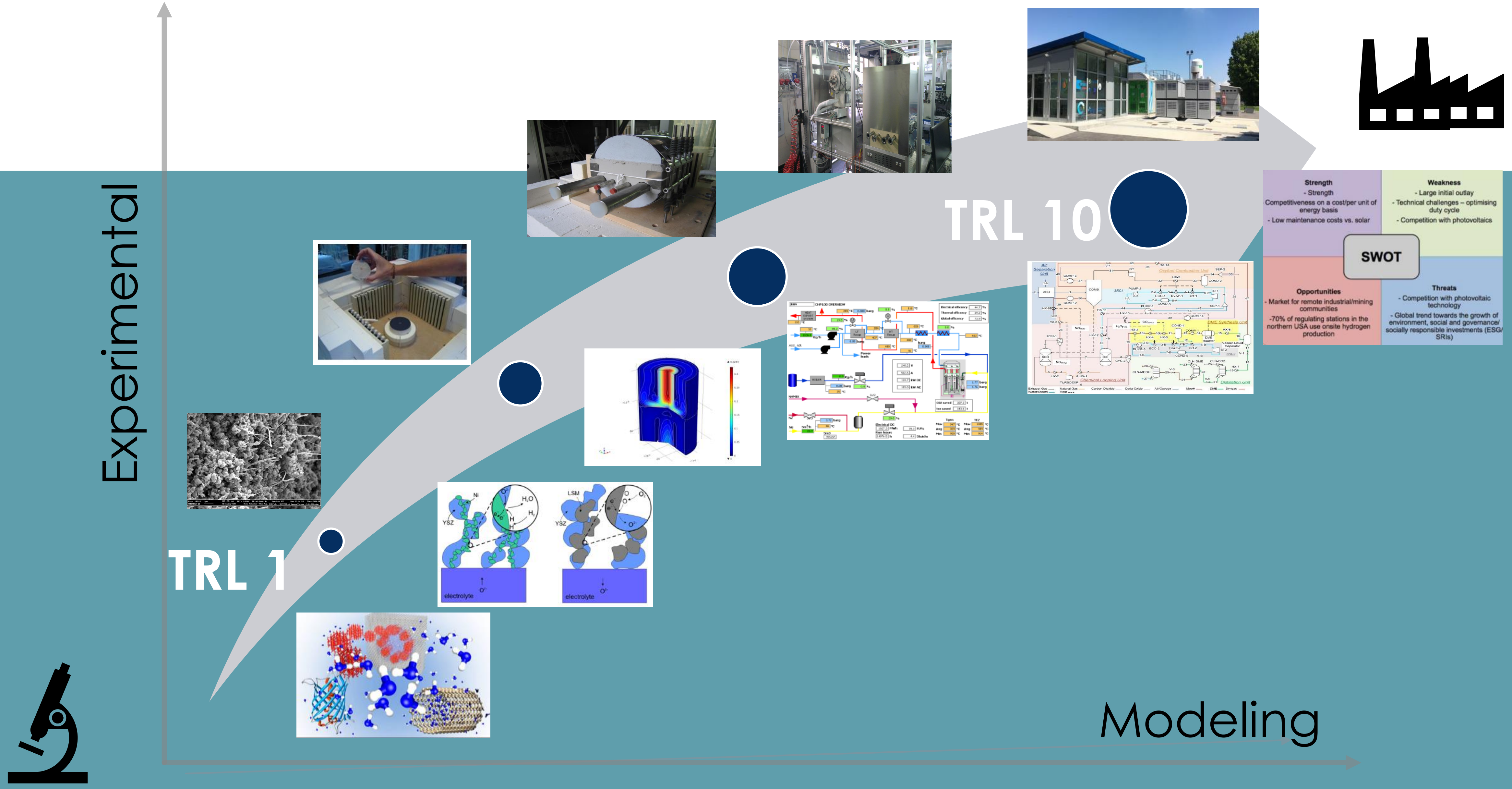


Prototyping

Training



… AND ON SEVERAL TRLS: FROM CONCEPT TO THE MARKET



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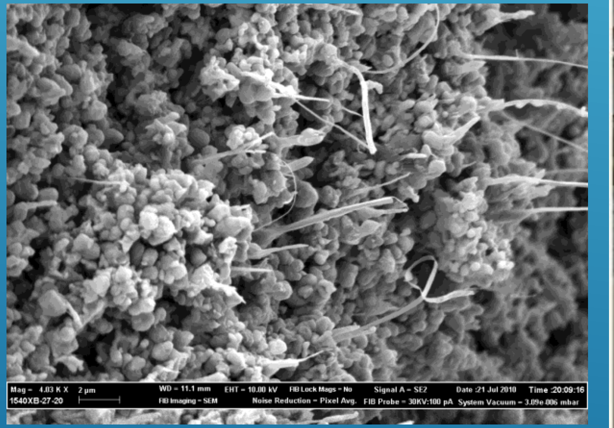
H2 @ POLITO

FROM LAB (LOW TRL) …

… to industrial plants (high TRL)



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ELECTROLYSIS

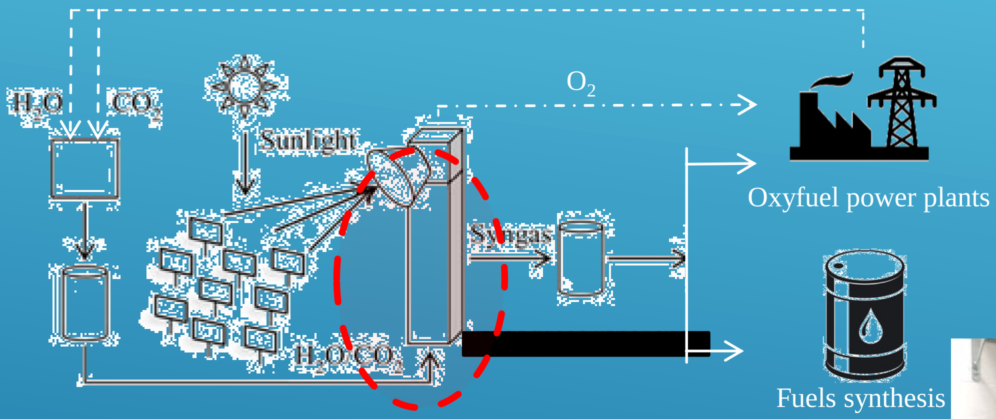
Alkaline and PEM single cells and stacks

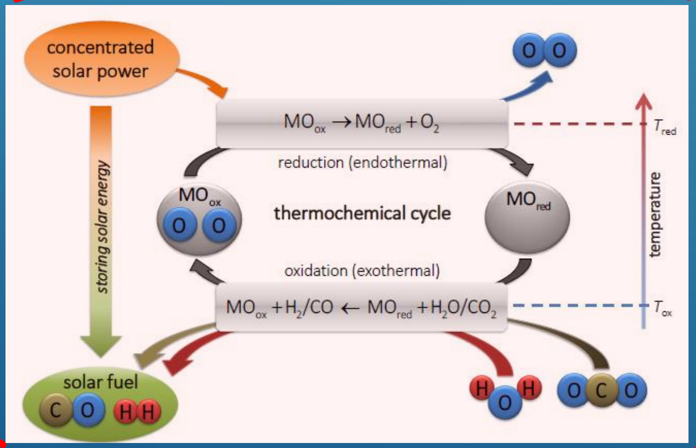
High pressure PEM stacks

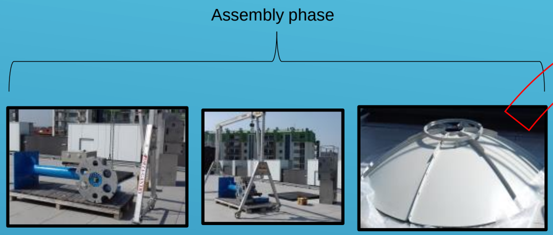
SOEC (ceramic) single cells and stacks

CSP-fed chemical looping for H2O/CO2 splitting

Converting emissions (CO_2/H_2O) into fuels through solar energy. Solar thermo-chemical looping (STC) cycles of redox materials (metal oxides: ceria, perovskites) that can act as oxygen carriers for the thermochemical cycle. The process can be enhanced by biomethane injection







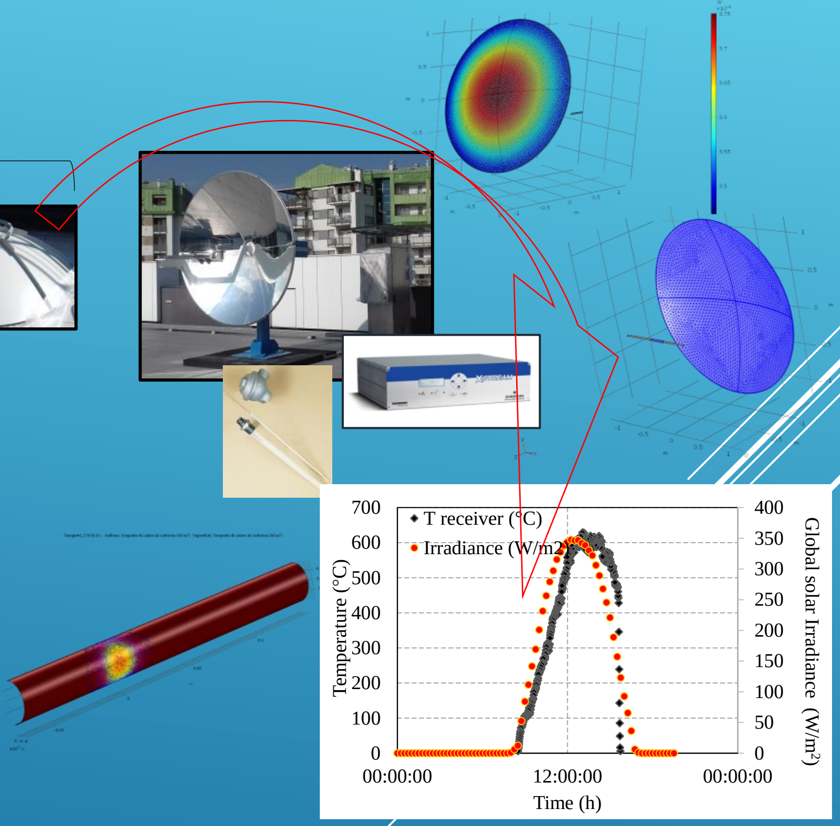


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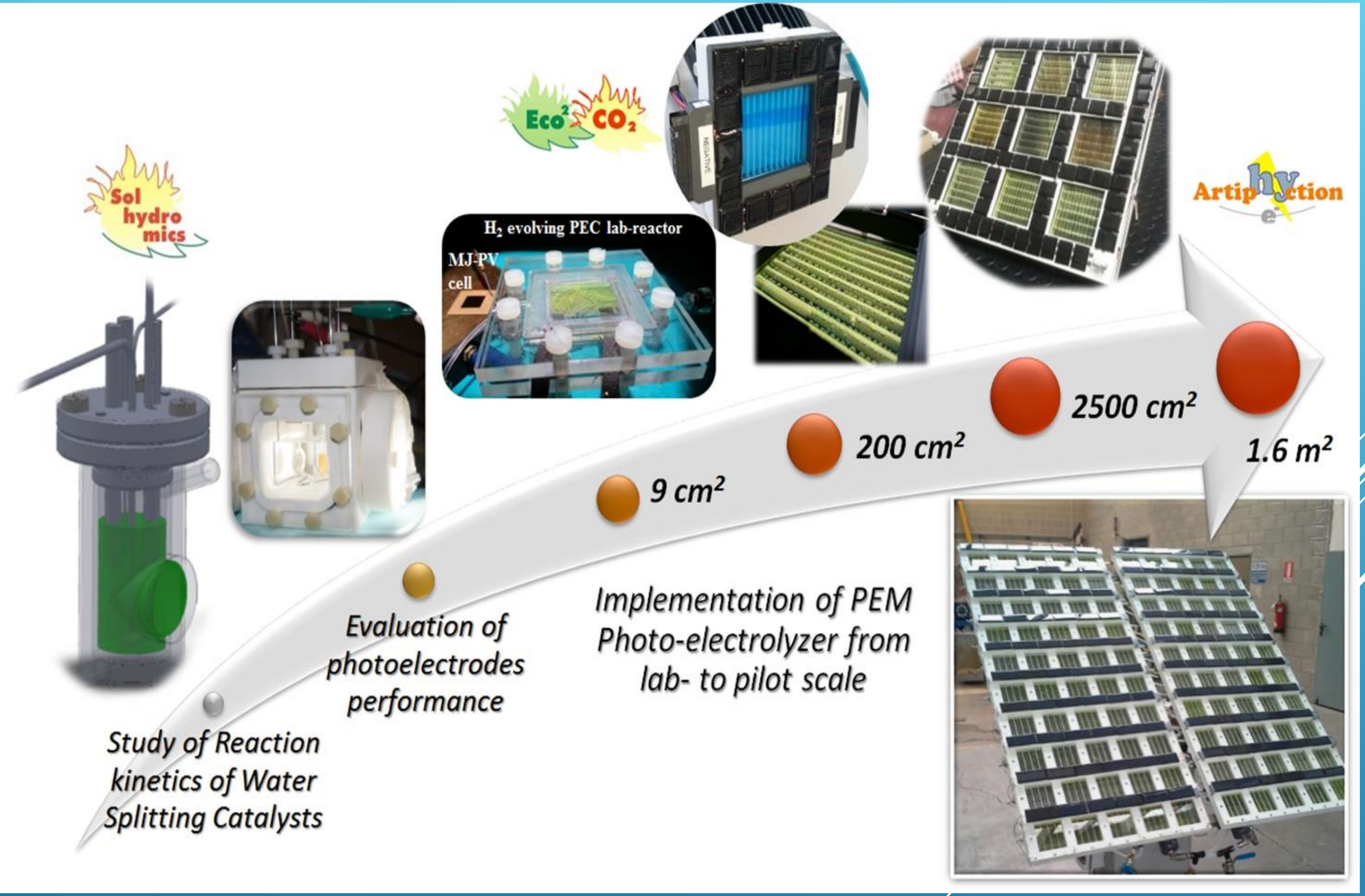
PHOTO-CATALYSIS

Test-bench for photo-electrochemical tests



BIO-CHEMICAL

Organic matrices pre-treatment pilot plants

Membranes filtration plant

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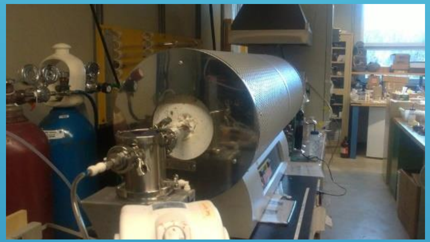
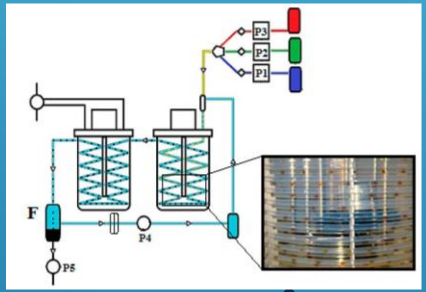
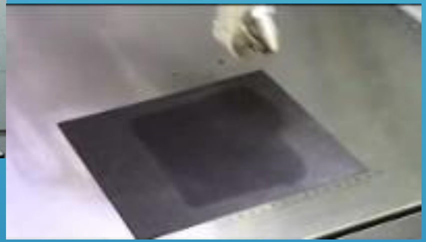
FUEL CELL: FROM CATALYST TO SINGLE CELL TESTING

Material synthesis (scalable processes)





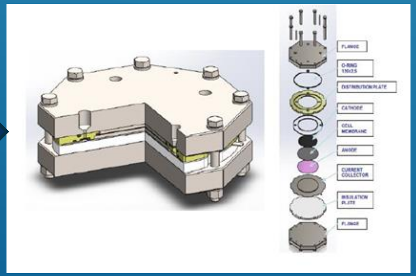
Electrode optimization with automatic deposition

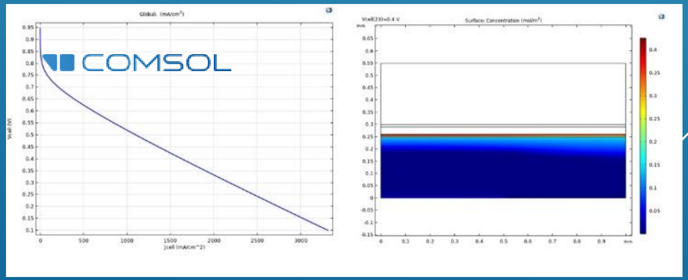


Electrochemical test-bench

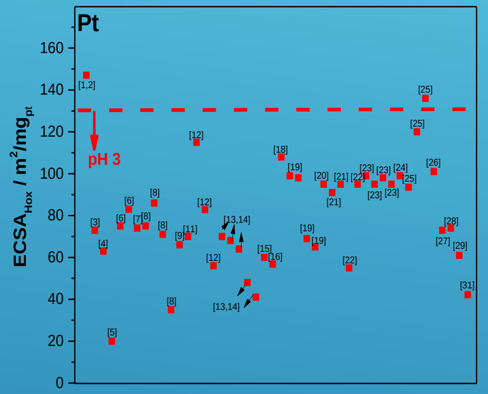
Material screening

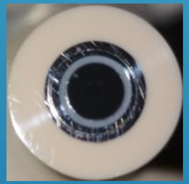
Cell design, simulation and optimization

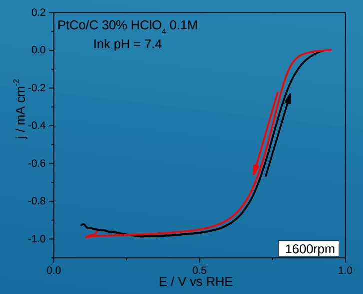




MEA fabrication (from ink formation to MEA assembly) each step is crucial!!





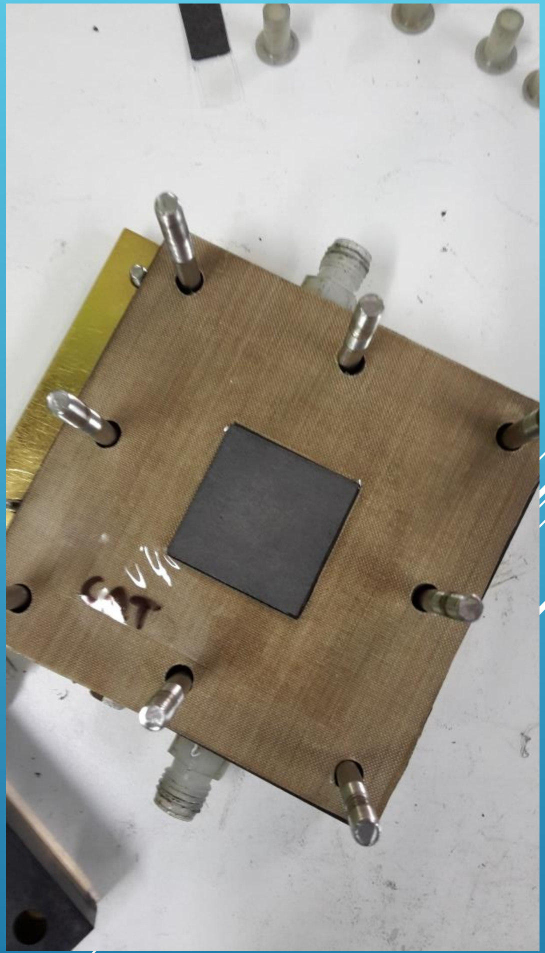


Ionomer to catalyst optimization

Ink dispersion

Spray Deposition

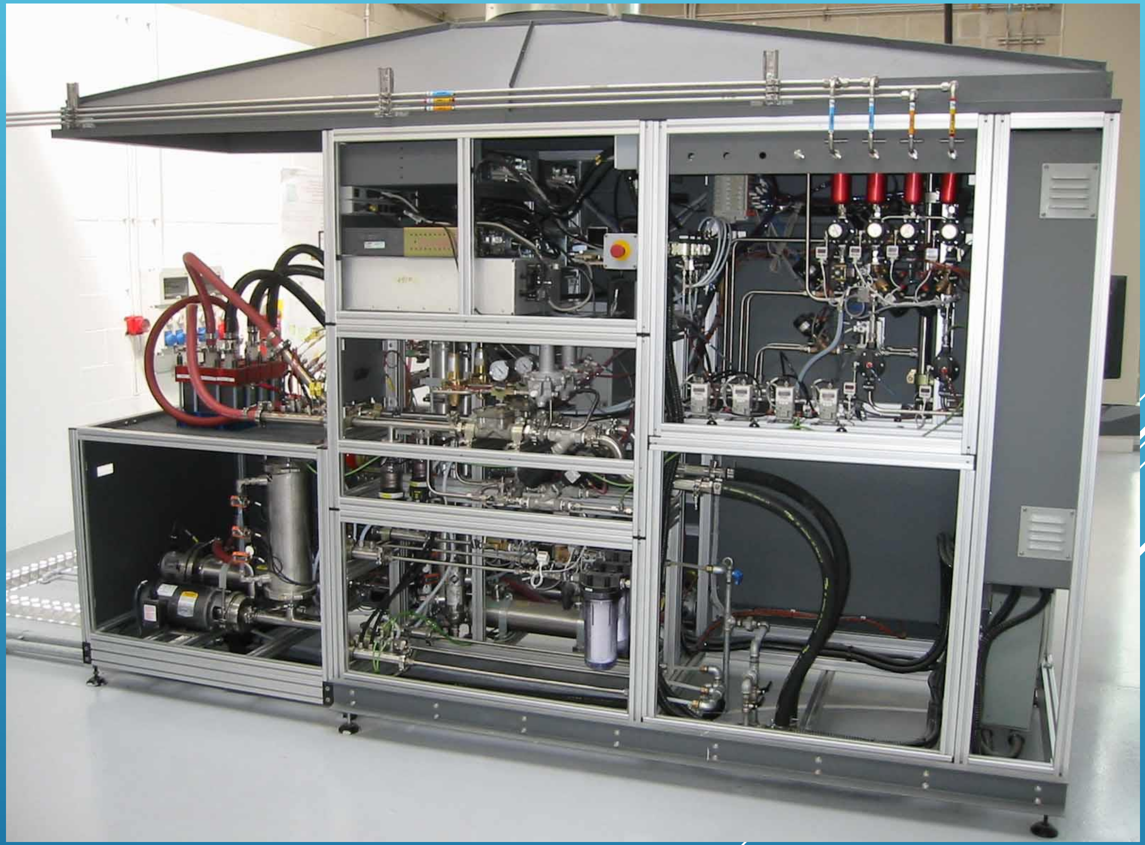
Hot Pressing



Assembling and Compressing

FUEL CELL TESTING: LOW TEMPERATURE

PEMFC stack testing



PEMFC test bench

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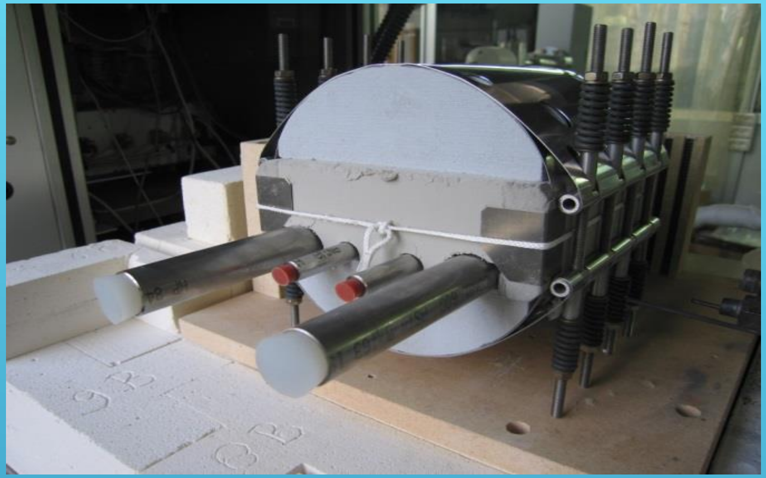
FUEL CELL TESTING: HIGH TEMPERATURE

SOC single cell testing



SOFC stack test bench

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THERMO-CATALYTIC PROCESSES

Reactor system for thermo-catalytic tests

Production of synthetic chemicals through CO2 hydrogenation tests

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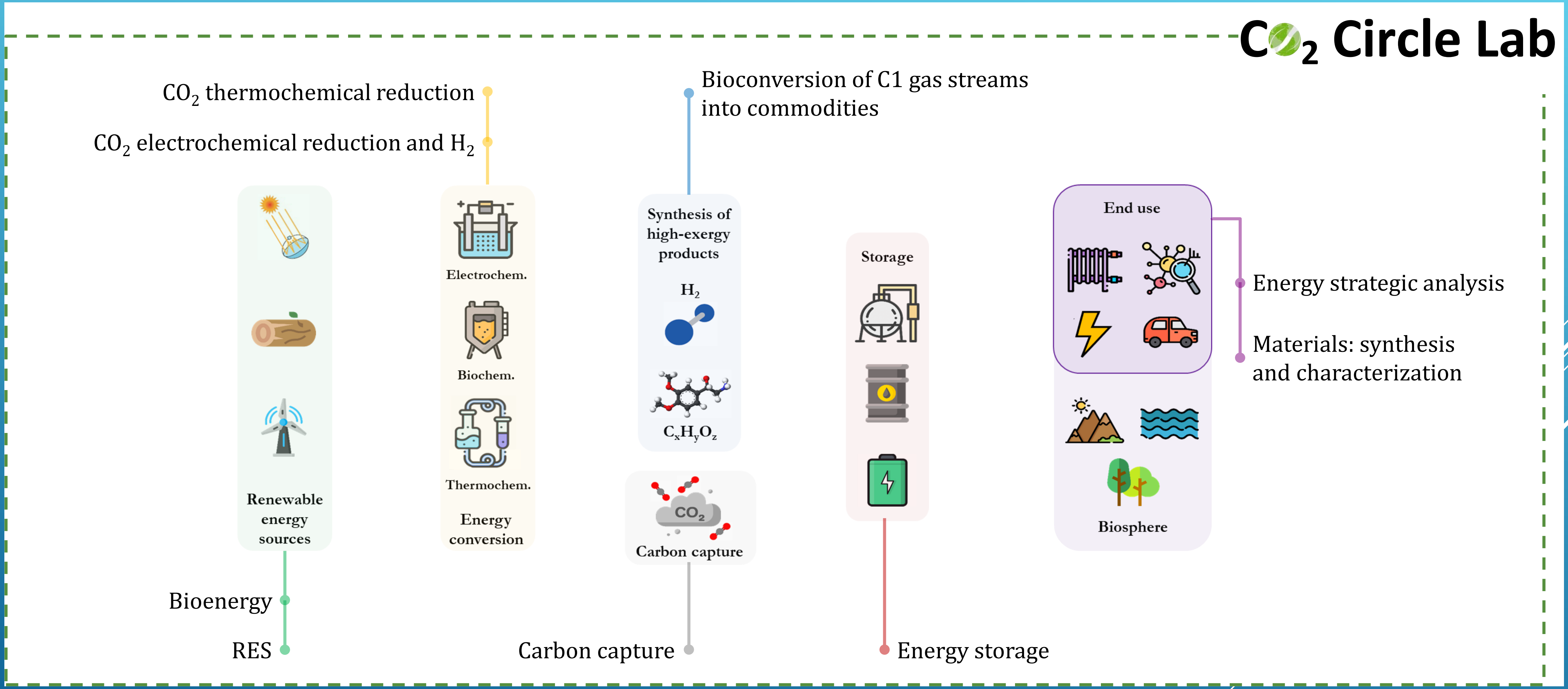
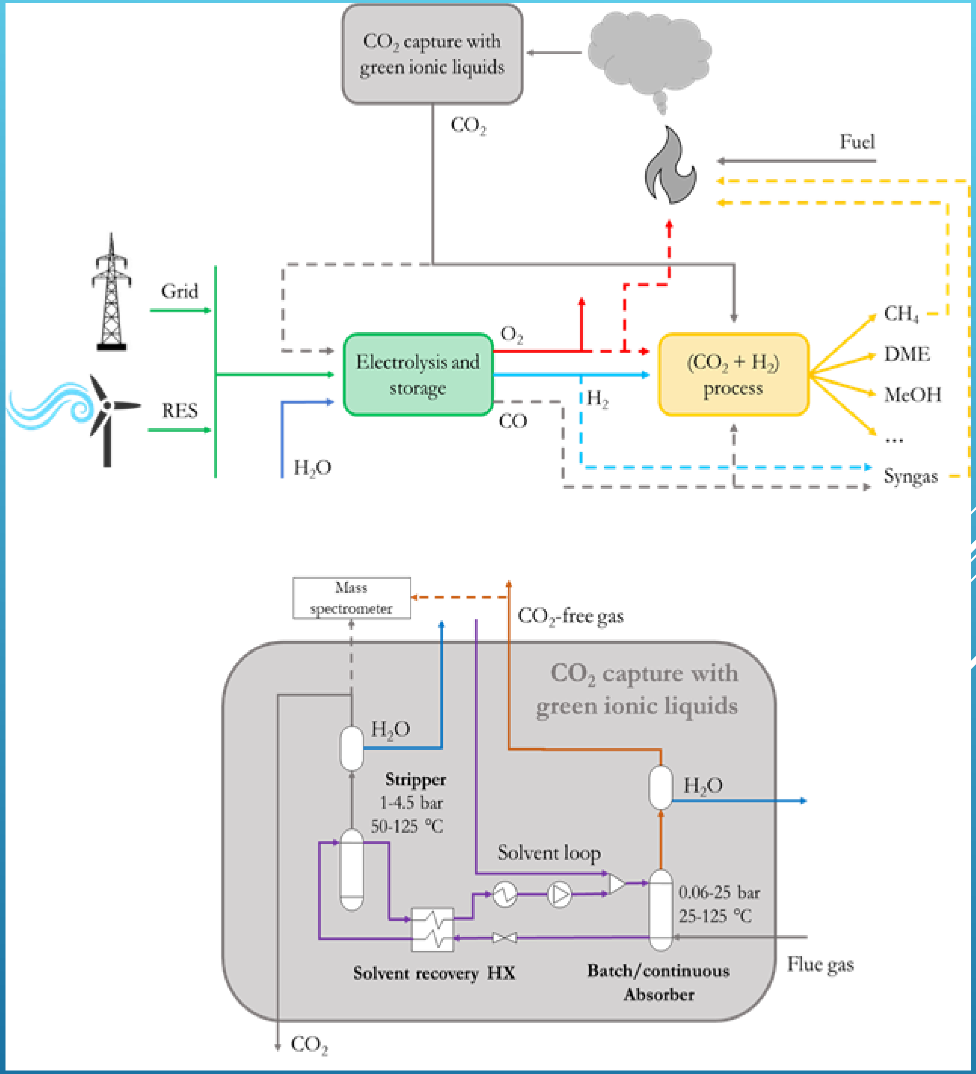
CO2 Circle Lab



CO2 recovery

CO_2 Capture

- Bench for the study of CO2 absorption and release in liquid systems (HEL)
- Measurement bench for gas permeation (in particular CO2) in membranes
- CO2 recovery test bench for absorption in ionic liquids (synthesis and characterization)
- CO2 recovery test bench for absorption in ionic liquids (test)
- Benches for ultrafiltration and centrifugation of materials deriving from biomass treatment processes, for recovery of useful materials and CO2 recovery



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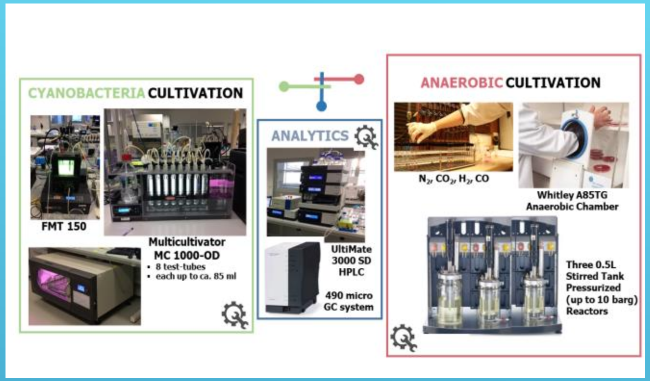
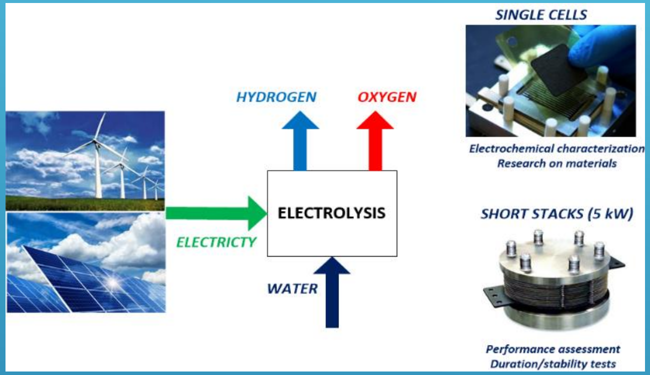
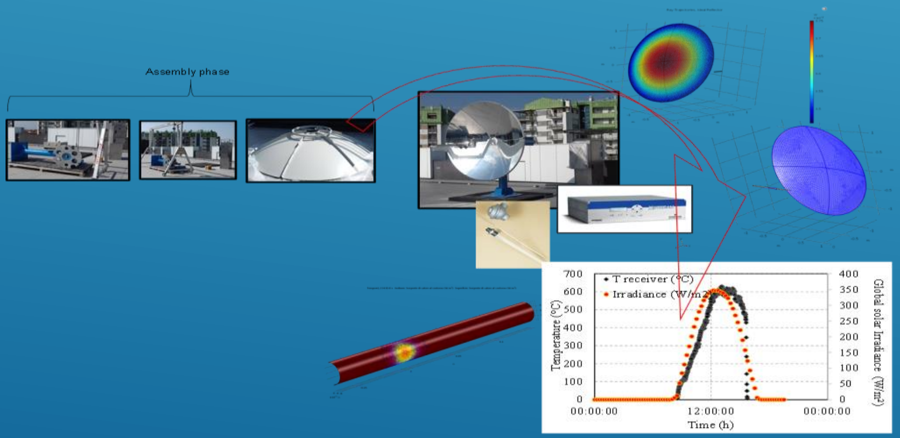
H2 for CO2 re-utilization

Hydrogen for CO2 re-utilization

- Test benches for photo / electro, thermo-activated CO2 reduction and chemical composition analysis
- CO2 and H2O reduction benches for thermo-catalytic hydrogenation
- Benches for H2 production by electrochemical way (high and low temperature) for CO2 hydrogenation
- Benches for thermo-catalytic processes for power-to-fuels processes and power-to-chemicals processes from CO2
- Benches for direct H2O / CO2 reduction in syngas by chemical looping
- Modular and high precision anaerobic cultivation of bacteria







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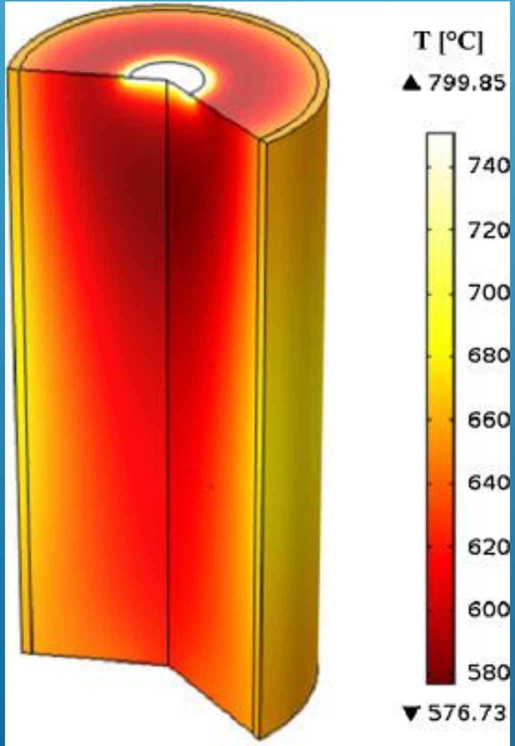
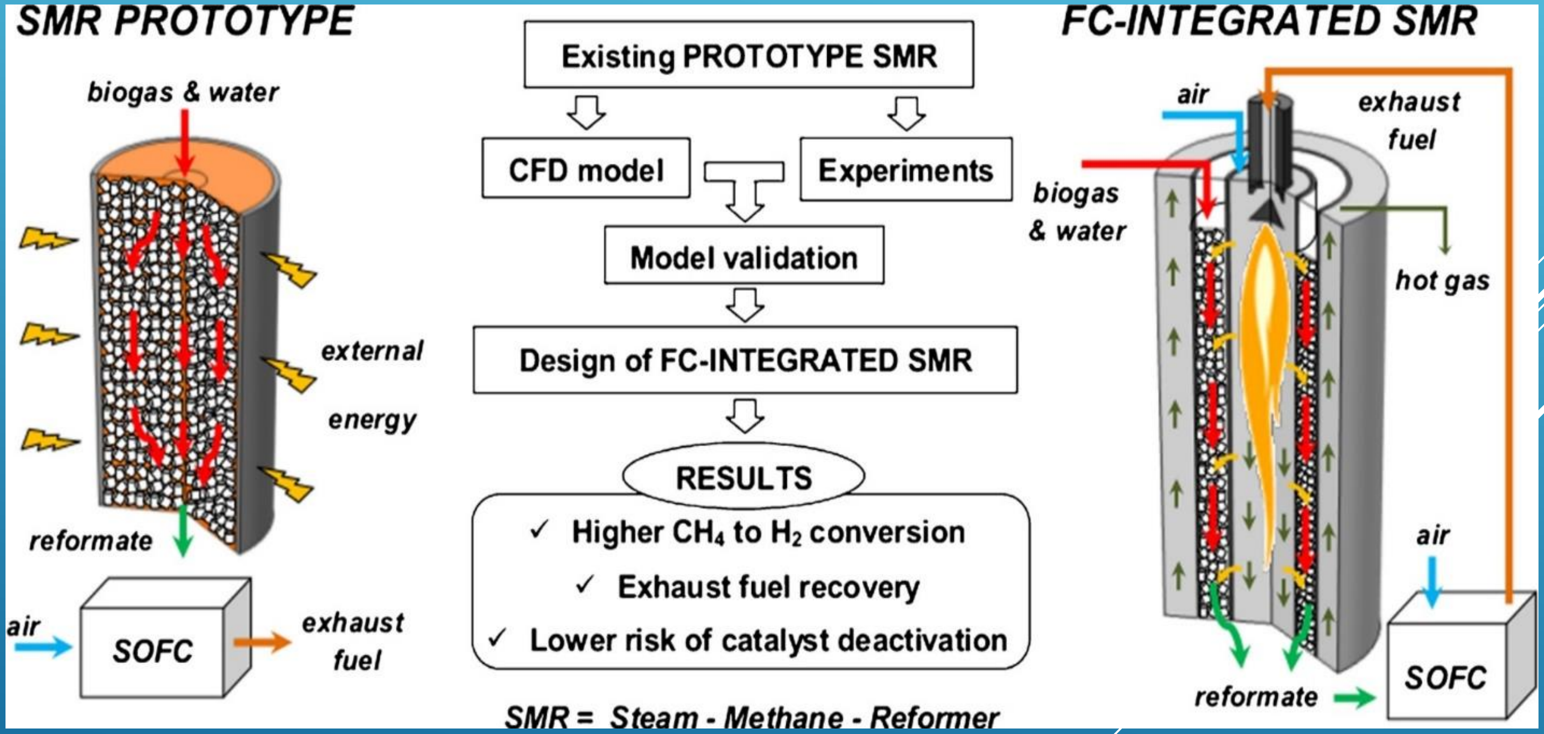
Modelling

From kinetic to CFD to dynamic modelling





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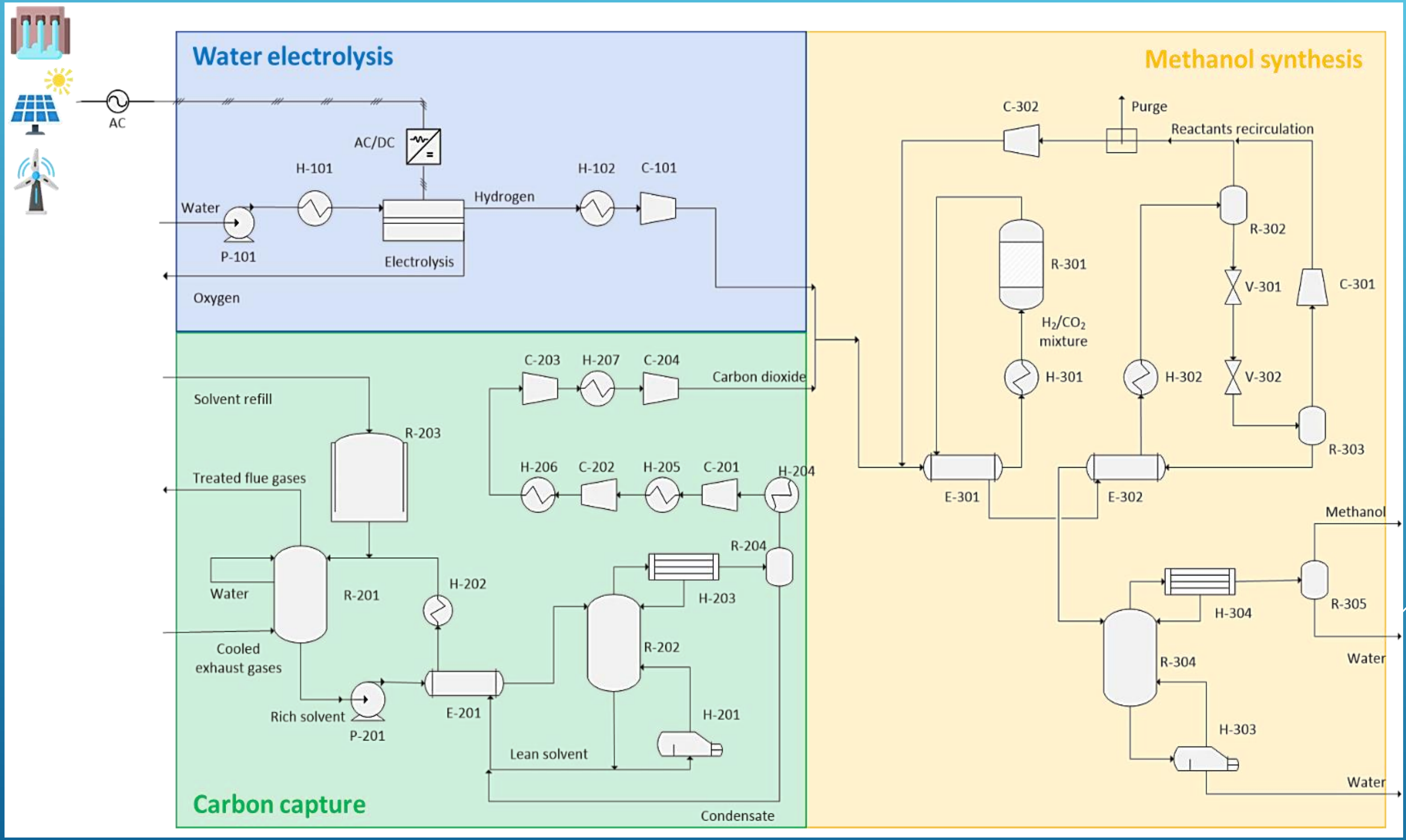
System analysis

Modelling, system analysis and optimization of complete processes, and economic assessment of the complete value chain



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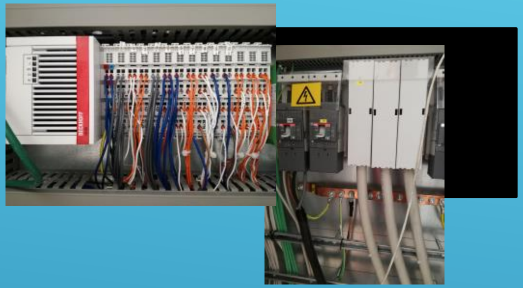
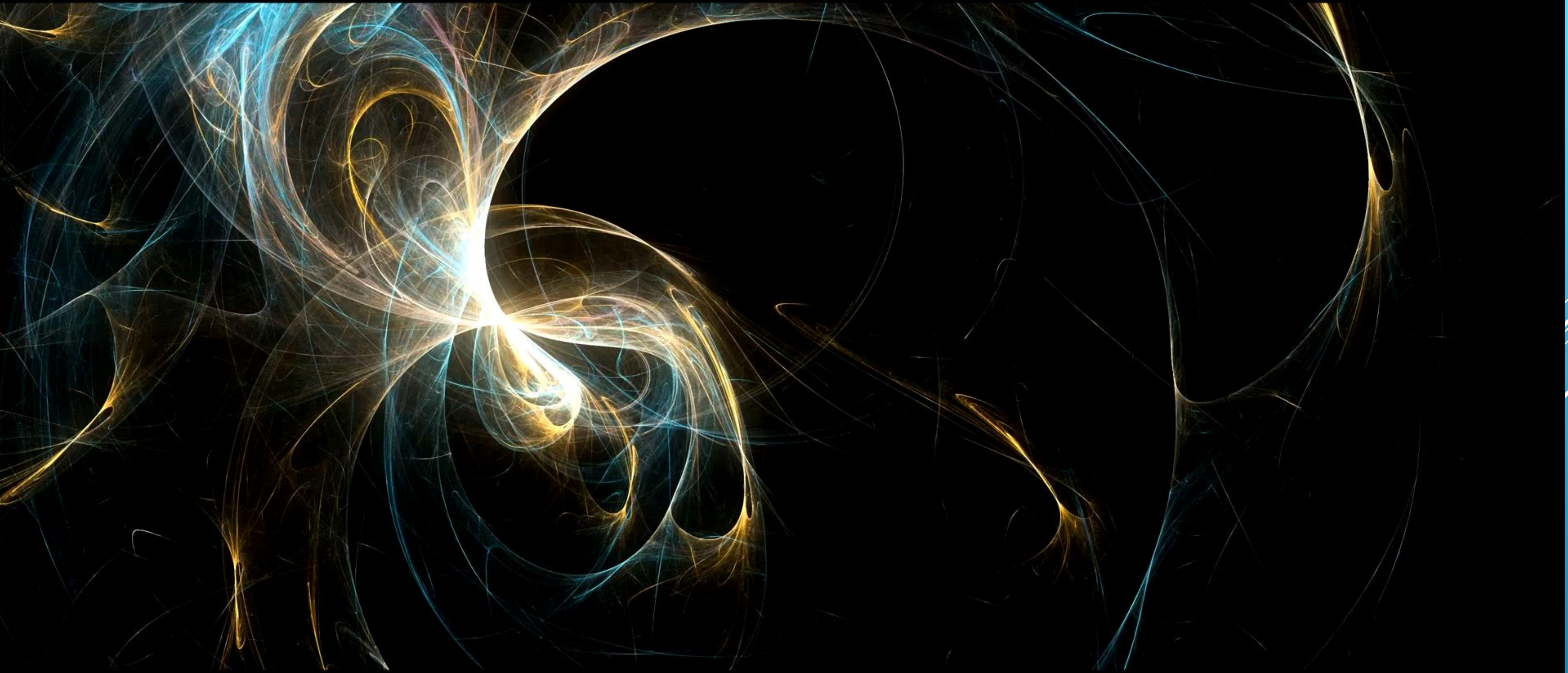
Industrial size FC plants

- High electrical efficiency (> 55 %)
- Thermal recovery at 220:C
- Zero pollutants emissions
- Fuel flexibility
- Black box for the end-user, easy to install&operate



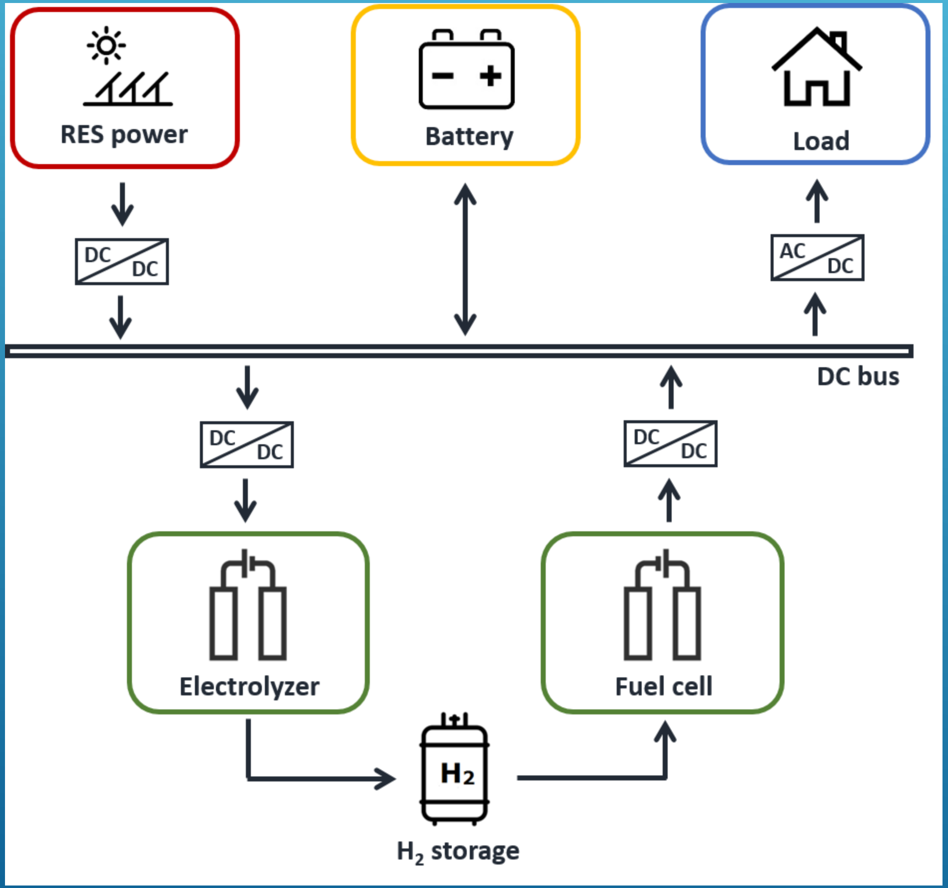
Inlet flows:
- Biogas
- Ambient air
- Compressed air (only for start-up)
- NH mix purge gas (for standby)

Outlet flows:
- Electrical power
- Thermal power
- Exhaust gas (CO2 and H2O only)



H2-based power-to-power systems

General configuration of a hybrid stand-alone P2P system



- **Electrolyzer**: converting the excess of RES power into H_2
- **Fuel cell**: re-converting the stored H_2 into electricity when a RES power deficit occurs
- **Battery**: support for the system operation and daily energy buffer
- **Converters**: to make the different sub-systems to exchange the correct amount of energy

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STEPS: EU PROJECT COMSOS

comsos

OBJECTIVE

VALIDATE AND DEMONSTRATE FUEL CELL BASED COMBINED HEAT AND POWER SOLUTIONS (MINI FC-CHP SYSTEMS) IN THE MID-SIZED POWER

RANGES OF

10-12KW
20-25KW AND
50-60KW

CONSORTIUM

THE 42 MONTHS PROJECT (2018-2021)

HAS A BUDGET OF EUR 10.2 MILLION AND HAS BEEN GRANTED EUR 7.4 MILLION UNDER THE EU'S HORIZON 2020 PROGRAMME.

THE CONSORTIUM CONSISTS OF

- **VTT** (FINLAND)
- **CONVION OY** (FINLAND)
- **SUNFIRE GMBH** (GERMANY)
- **SOLIDPOWER SPA** (ITALY)
- **POLITECNICO DI TORINO** (ITALY)
- **BLUETERRA** (THE NETHERLANDS)
- **HTCERAMICS SA** (SWITZERLAND)

INNOVATION

MINI FC-CHP SYSTEMS
FOR COMMERCIAL APPLICATIONS

23 UNITS WITH A TOTAL POWER OUTPUT OF AT LEAST **450KW**

COMSOS **TARGET FOR ELECTRICAL EFFICIENCY IS MORE THAN 50%** AND OVERALL EFFICIENCY OVER 90%.

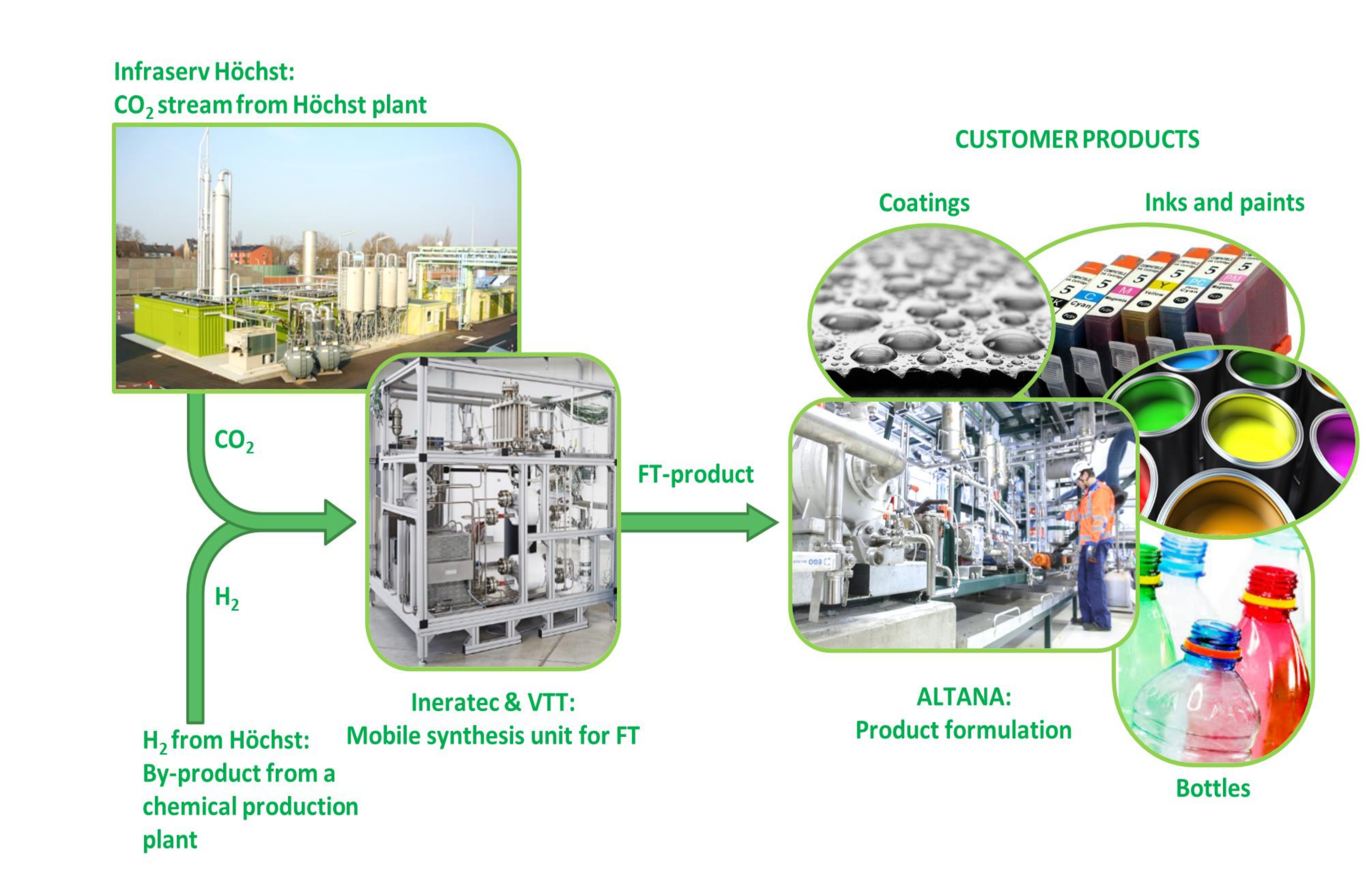
LIFETIME MORE THAN **10** YEARS, DURABILITY MORE THAN **90%** ACHIEVED DURING COMSOS PROJECT.

THE AVERAGE CONSUMPTION OF A 350 M2 FAST FOOD IS 305 MWH/Y ELECTRICITY AND 205 MWH/Y HEAT.

A 50 KWE SOFC SYSTEM CAN COVER **94%** OF THE ELECTRICAL LOAD AND **70%** OF THE THERMAL LOAD WITH A PRIMARY ENERGY SAVING OF **200 MWH/Y (-28%)** AND A CO2 SAVING OF **11.6 TONS CO2** PER YEAR.

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 779481. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research.

STEPS: EU PROJECT ICO2CHEM



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