

ISTITUTO ITALIANO
DI TECNOLOGIA
CENTRE FOR SUSTAINABLE
FUTURE TECHNOLOGIES

CO₂ Circle Lab : the H₂ in carbon capture, utilization and storage chain

SMARTENERGY Torino, 24 Febbraio 2021





CO₂ circle lab

Research Infrastructure co-financed by Regione Piemonte, POR FESR Piemonte 2014-2020, ASSE I, Azione I.1.a.1.5, “INFRA-P - Sostegno alle infrastrutture di ricerca considerate critiche/cruciali per i sistemi regionali”

<http://co2circlelab.eu>

CO₂ Circle Lab Research Infrastructure



Management of Green House Gas emissions in the atmosphere is undoubtedly an actual challenge, but it also represents a potentially extraordinary innovation engine, both at the research level and at the technological and industrial one.

CSFT-IIT is engaged with Politecnico di Torino and Environment Park in boosting the **CO₂ Circle Lab (CCL)**

Research Infrastructure with the aims to:

- provide technological solutions for CO₂ capture and utilization envisioning CO₂ transformation paths towards novel products
- provide solution for H₂ production and use
- elicit or consolidate synergy of high-tech with start-ups, SMEs or companies willing to take part to the transition to a sustainable management of production



WHY DO YOU CONTACT THE INFRASTRUCTURE?



CONFIDENTIAL



FINANCIAL DERISKING



SHORTEN TIME TO MARKET

CO₂ Circle Lab Innovation Engines

The **CCL** research infrastructure aims to set up an **easily accessible** network of **multipurpose** facilities to foster **open innovation** towards **sustainable development goals**



- CO₂ & H₂ capture
- Bioconversion of C1 gas in commodities
- CO₂ reduction
- H₂ production
- Synthesis and characterization
- Bioenergy
- Multi-energy systems analysis
- Energy storage
- Renewable energy sources

Heat from RES
(concentrated solar, geothermal energy, wind)



Electricity from RES
(wind, PV)

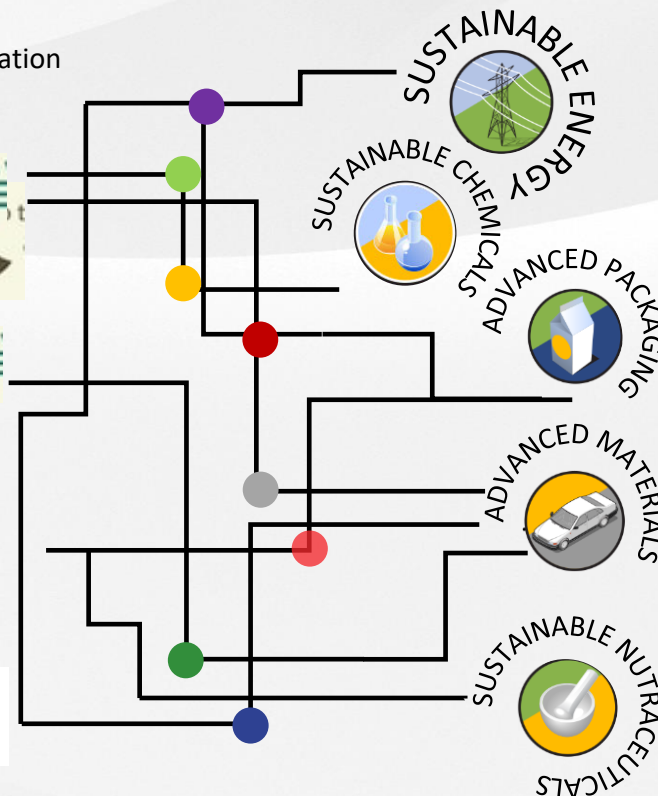


H₂ production and storage

Carbon-rich gas streams
(industrial off-gases, air, reformed biogas)



Biomass matrices (MSW, organic industrial waste, agrofood waste)



Centre for Sustainable Future Technologies

The Centre for Sustainable Future Technologies

(CSFT-IIT) is focused on technologies for sustainability, energy transition and low carbon economy .

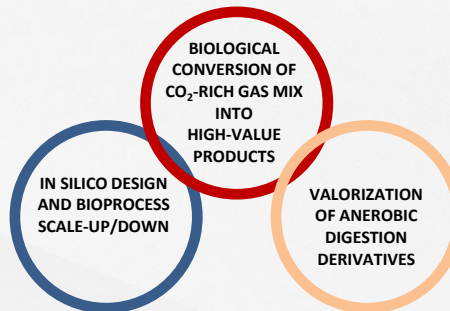
In particular CSFT-IIT develops the future generation of materials, processes and systems

- to ensure the reduction of antropic carbon dioxide through capture, storage and valorization
- to investigate H₂ production, storage and use
- to improve the efficiency in the use of renewable feedstocks within a circular economy perspective



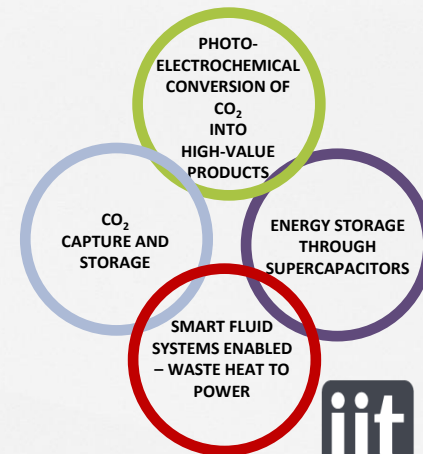
Systems and Synthetic Biology

The research program formulates bio-based processes for carbon valorization through microbes into efficient waste-recycling bio-factories to produce chemicals and fuels.



Advanced Materials for Sustainable Future Technologies

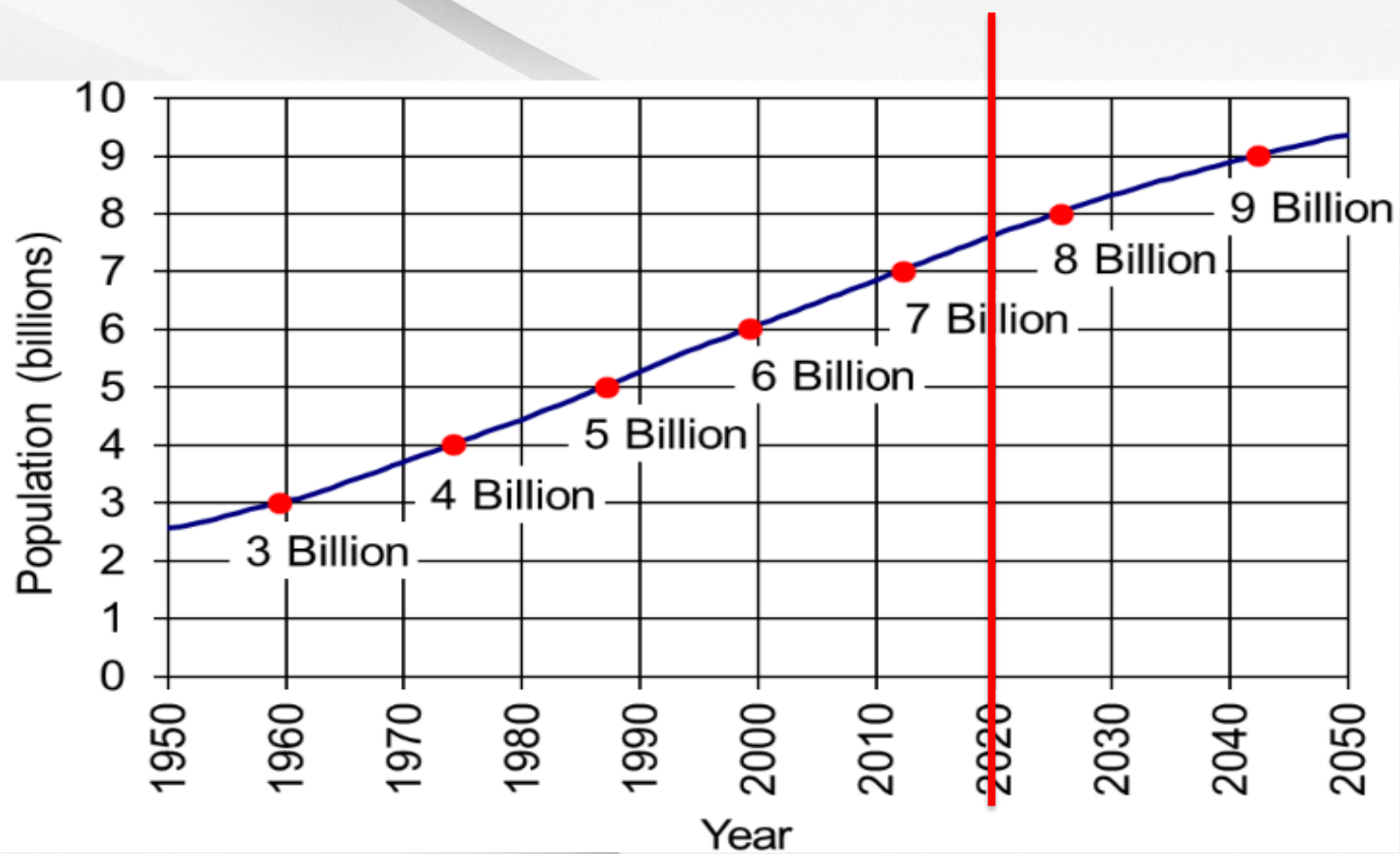
The research program develops materials with tailored properties for CO₂ capture, storage and reduction to valuable products, as well as for efficient energy storage and waste heat to power. Moreover, H₂ production, storage and use is investigated.





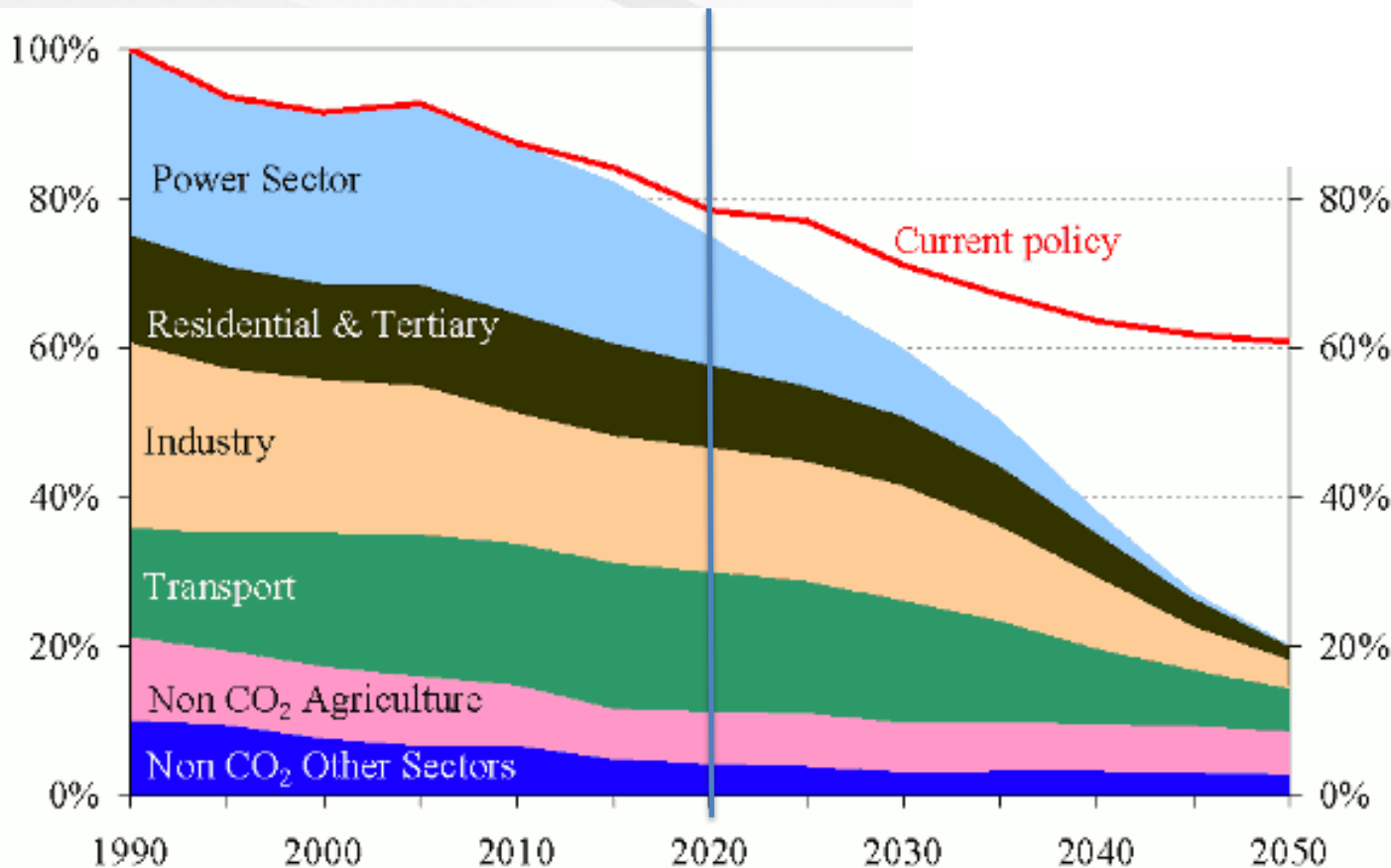
**Total world energy
consumption: 16 TW y**

World population growth

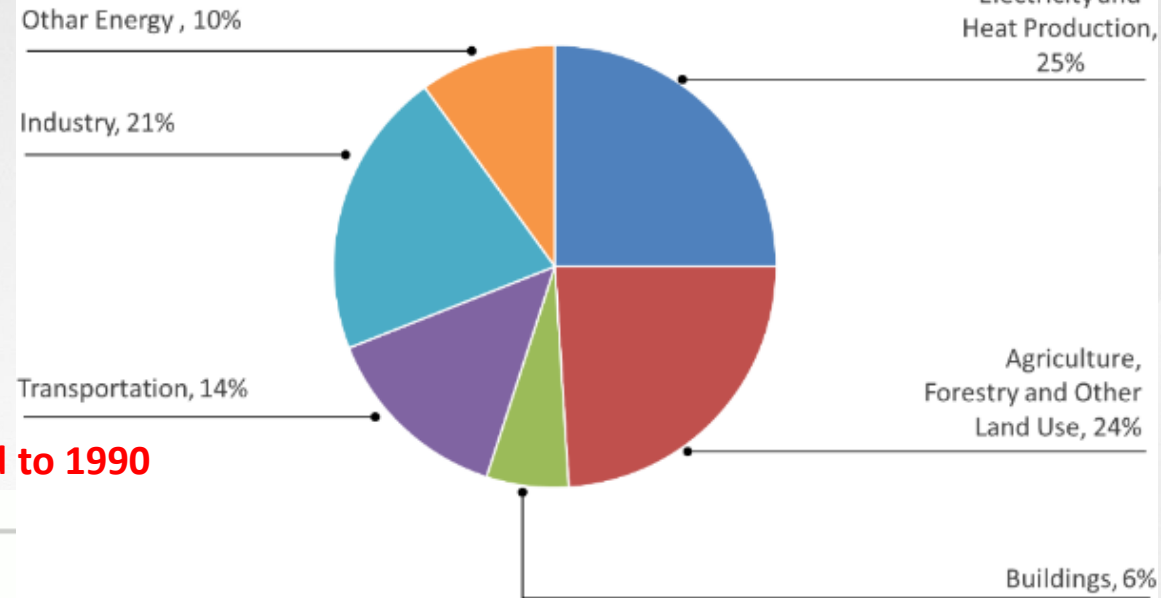


EU roadmap for a low carbon economy

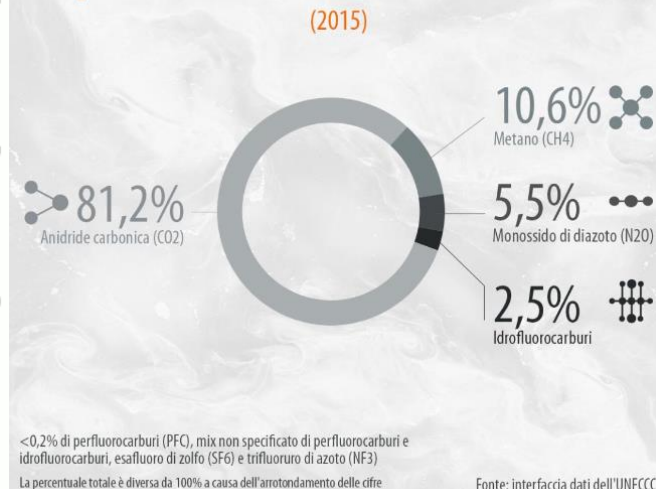
within 2050 EU 80% reduction of Co2 compared to 1990



Immissione CO₂ per settori nel mondo

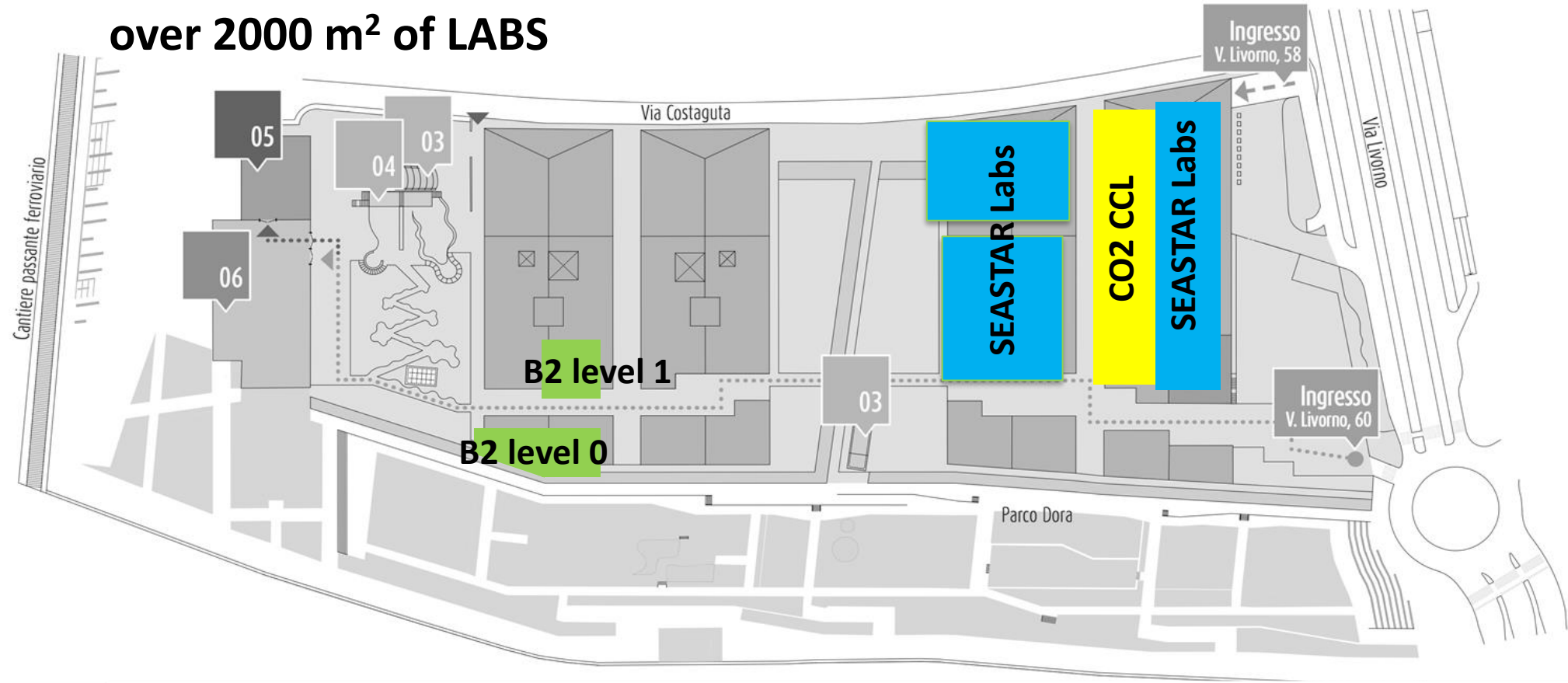


Inquinanti emessi nell'aria nel mondo (2015)

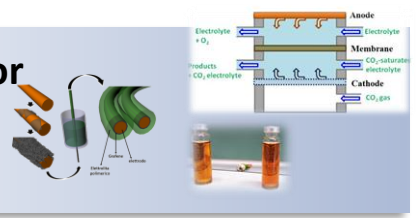




over 2000 m² of LABS



Advanced Materials for Sustainable Future Technologies



Systems and Synthetic Biology





CERES LAB Smart Fluid Lab

TF LAB Thin Films growth and characterization Lab

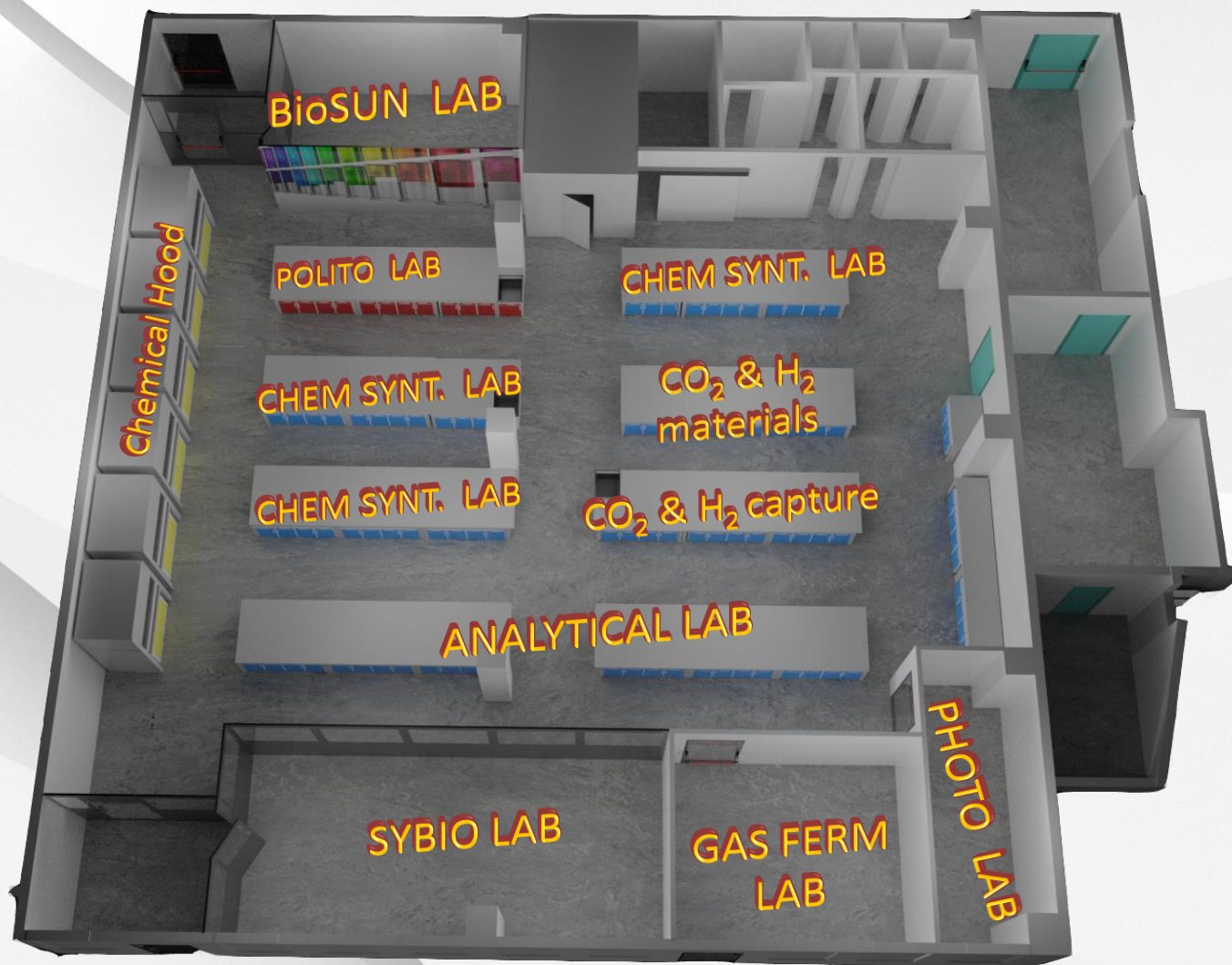
TOC LAB Spectroscopic and Thermal chacterization Lab

FLUO LAB

FIB LAB Optical and electronic microscopy Labs
TEM LAB

ELN LAB Electronic Lab

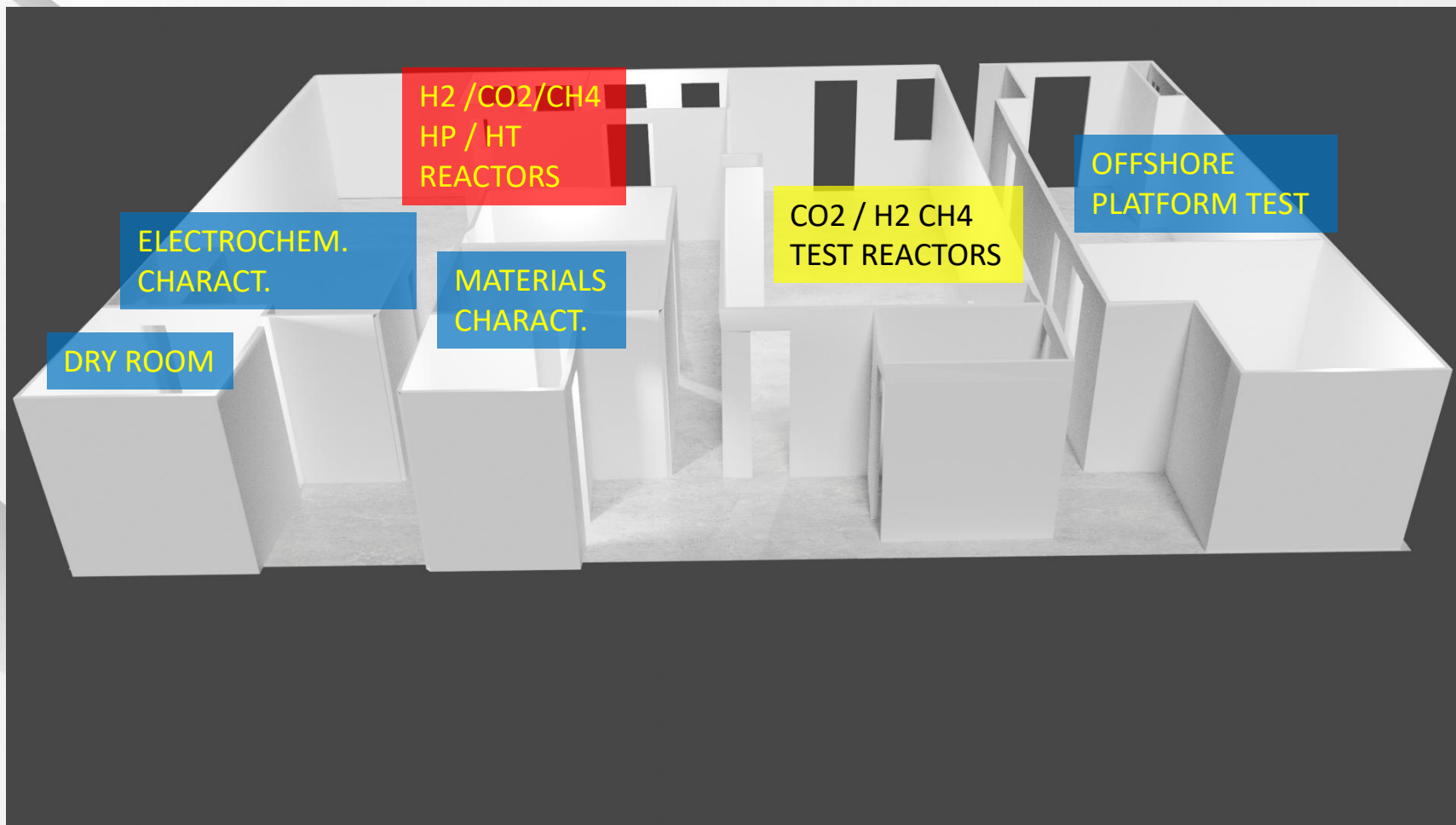
ELCHEM Electrochemical characterization Lab



Advanced Materials and Bio LABS:

Chemicals and materials synthesis and characterization

Synthetic Biology Labs: microorganism growth and manipulation / bioreactors

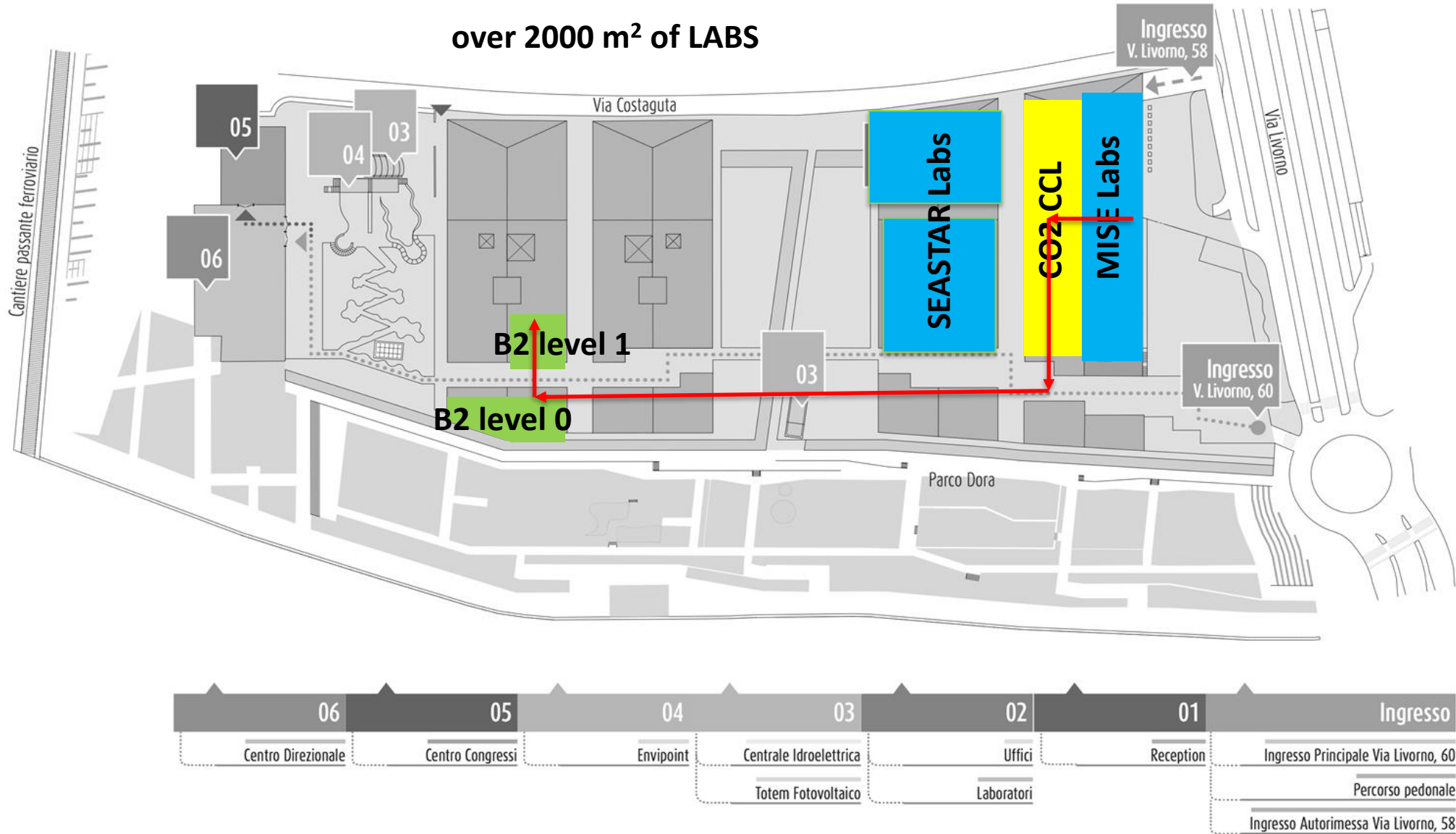


In collaboration with:



**POLITECNICO
DI TORINO**

A virtual tour following the red path





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FUTURE TECHNOLOGIES

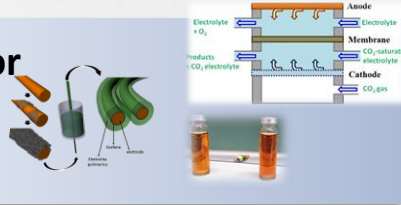
VIRTUAL TOUR OF THE LABS



ISTITUTO ITALIANO
DI TECNOLOGIA

The Center is organized in two research lines:

Advanced Materials for Sustainable Future Technologies



Systems and Synthetic Biology

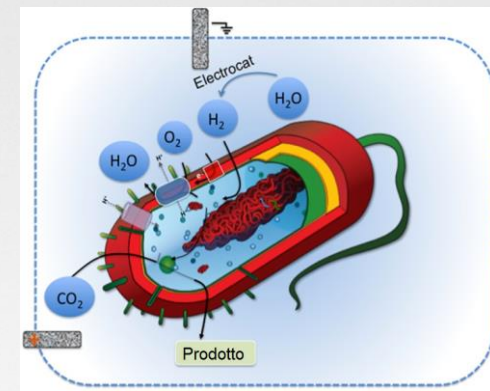


The mission is focused on materials, technologies and processes for sustainability:

- **capture/storage and valorization of antropic CO₂; H₂ production and storage ; H₂ and CO₂ geological storage**
- **technologies for production of renewable raw materials for a circular economy**
- **synthetic fuels and chemicals**
- **energy harvesting, storage and raw materials recovery through sustainable processes**
- **waste heat to power through the use of smart fluids**



Synthetic biology and Metabolic engineering



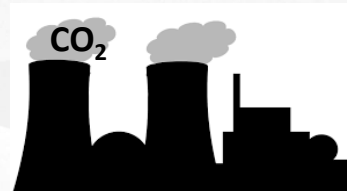
CO_2 capture/separation/storage

CO_2 valorization



Chemicals

Fuel storage



Waste
 heat to power



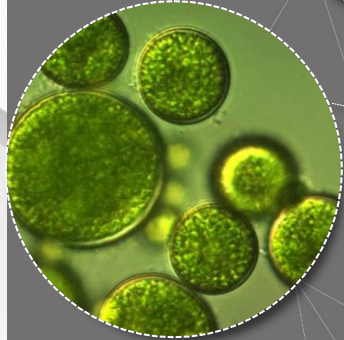
Storage in green SuperCap
Integrated energy HS systems
Blue Energy
Raw materials recovery



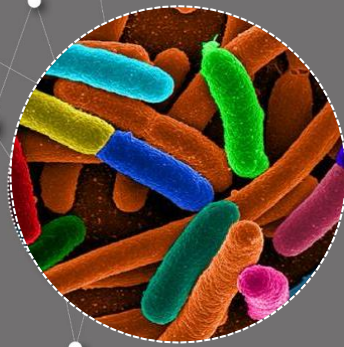
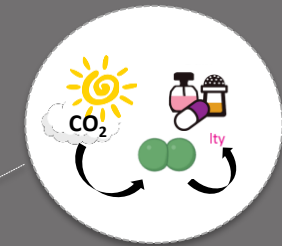
From CO_2 & H_2 to:

- new synthetic fuels
- chemicals
- pharma compounds
-

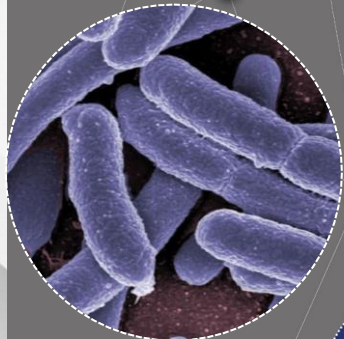
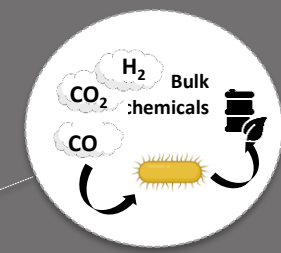
SyBio main Sublines



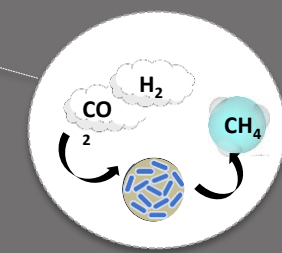
• **SB1:** Light-powered carbon capture and upcycling through **cyanobacteria**



• **SB2:** Gas fermentation for commodity chemicals through **acetogens**



• **SB3:** Gas fermentation for commodities through **archaea** and aerobic methanotrophs



• **SB4:** Multi-scale bioprocess modelling



RENEWABLE ENERGY

to produce green H₂ or to power the processes



Added value purified **raw materials from industry or ambient waste**

CO₂



Added Value Products

CO, HCOOH,
CH₃OH, CH₄, ...

for energy, mobility
and industry

Materials for CO₂ capture and separation

Ionic Liquids – Carbon based materials,
membranes

Catalysts for CO₂ valorisation

Electrocatalysis – Photocatalysis –
Thermocatalysis

Energy harvesting from salinity gradient and raw materials recovery



Raw materials recovery



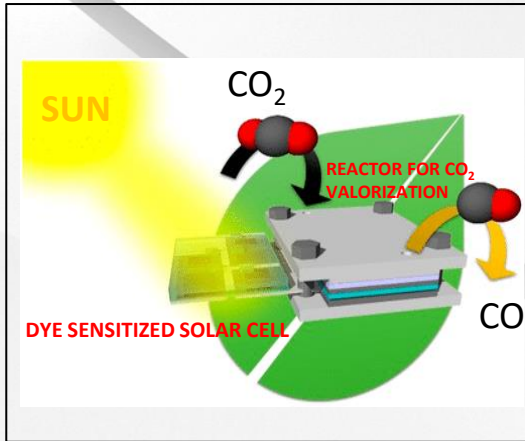
Blue energy exploiting salinity gradient power

Desalination powered by renewable source

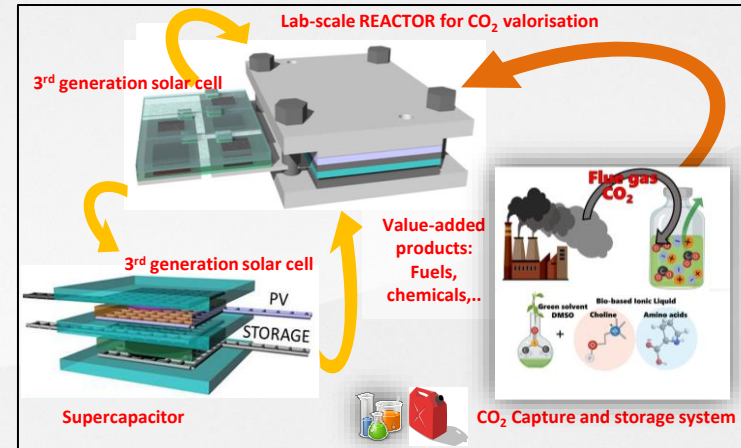


From CO₂ to **fuels and chemicals**: the artificial leaf

TODAY

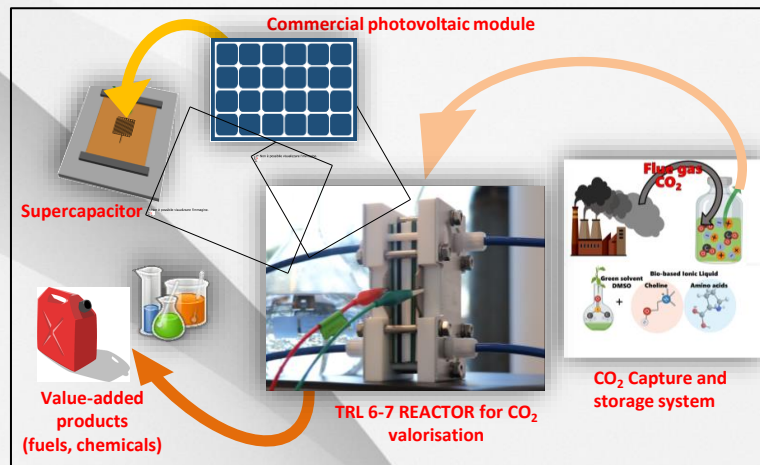


INTERMEDIATE STEP

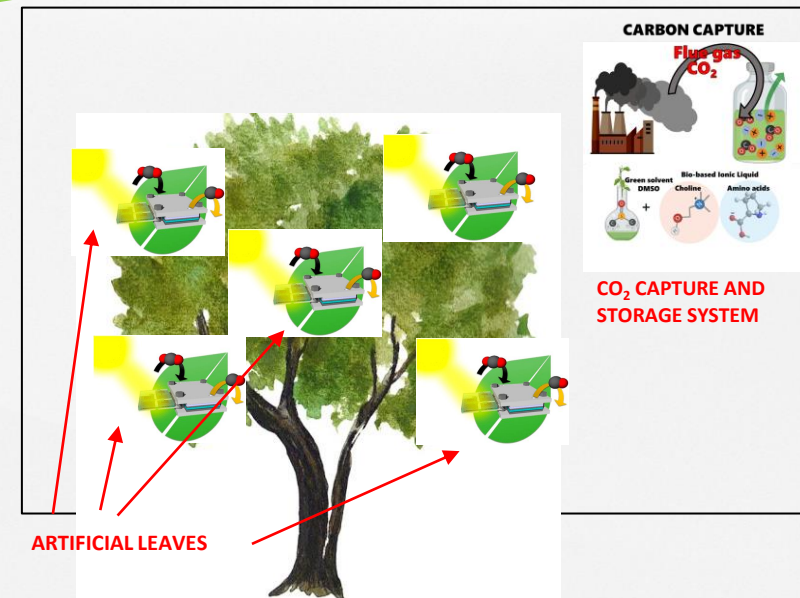


ACS Sustainable Chem. Eng. 2020, 8, 20, 7563–7568

INTERMEDIATE STEP

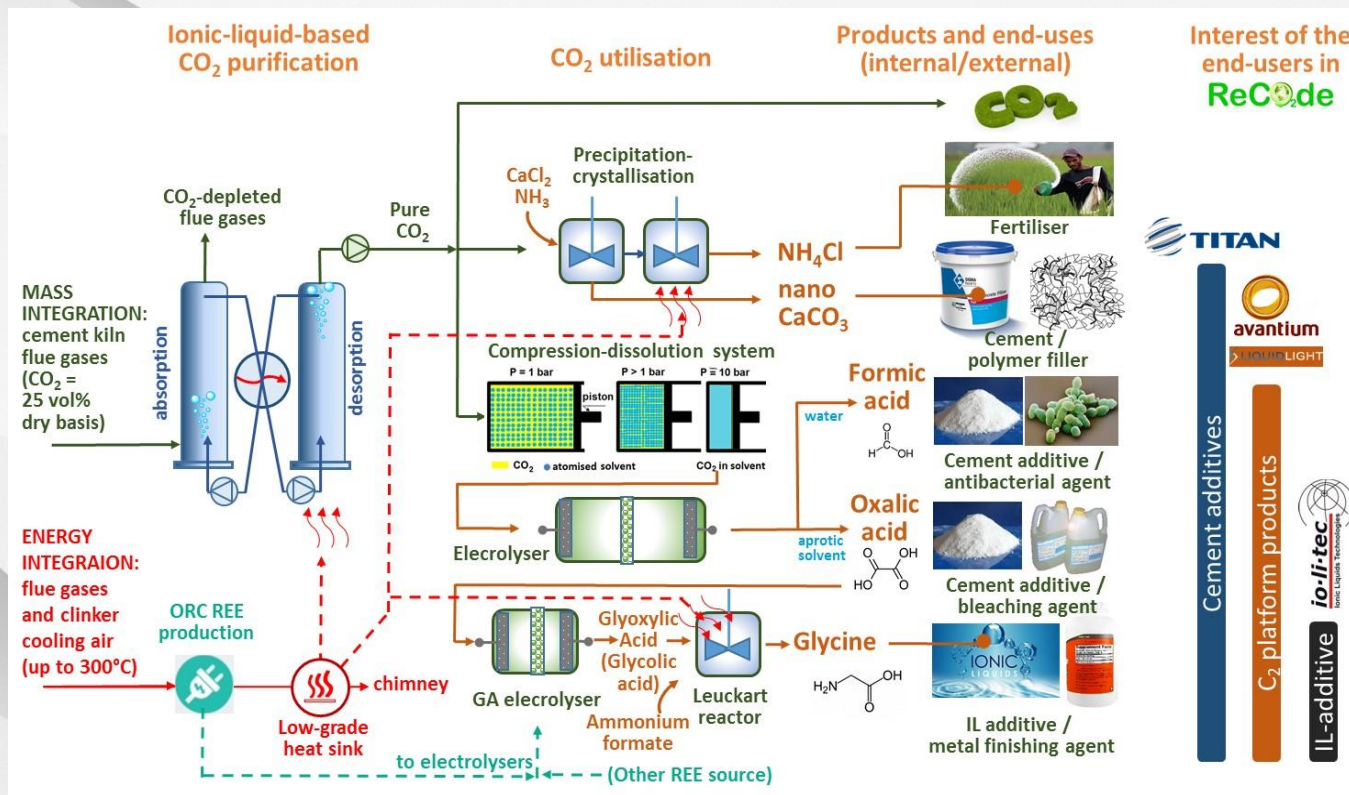


TOMORROW



Recycling carbon dioxide in the cement industry to produce added-value additives: a step towards a CO₂ circular economy

Goal: make cement industry able to contribute to at least 20% reduction of CO₂ emissions in the medium to long term

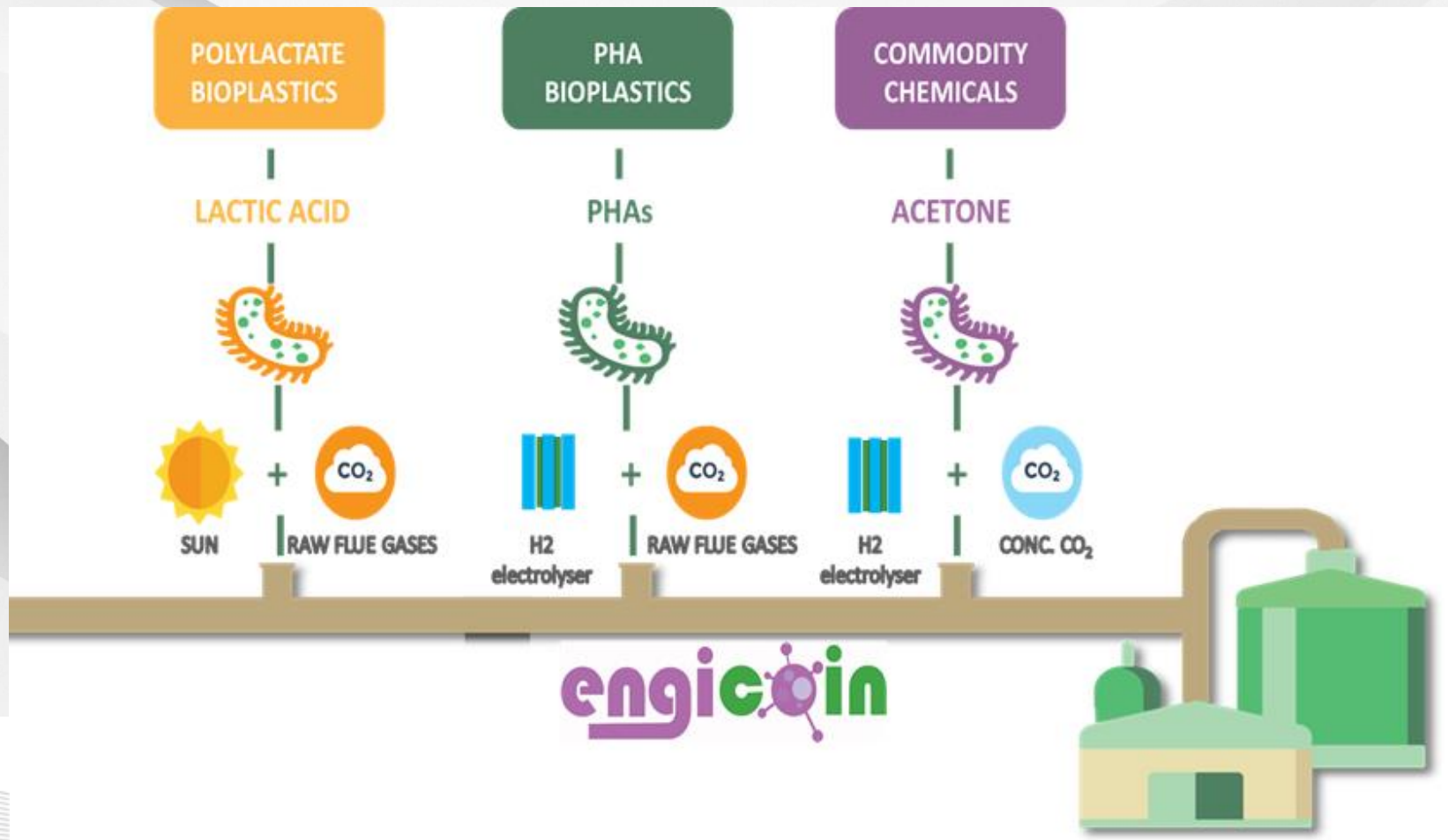


Engicoin Project: Microbial Factories

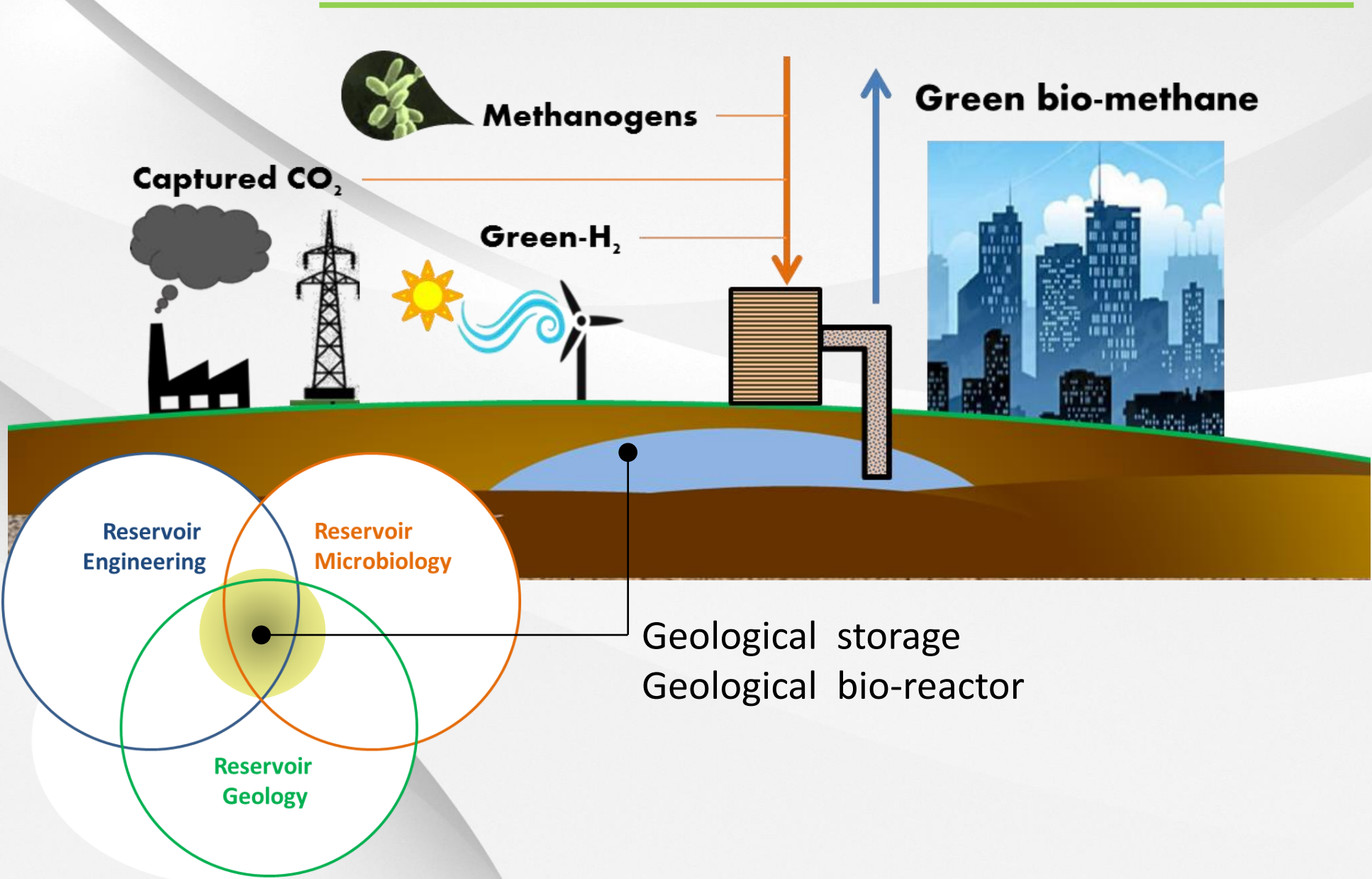
MF1
CO₂ conversion
to lactic acid with
Synechocystis

MF2
Synthesis of PHA
from CO₂ + H₂ with
Cupriavidus necator

MF3
Synthesis of acetone
from CO₂ + H₂ with
Acetobacterium woodii.

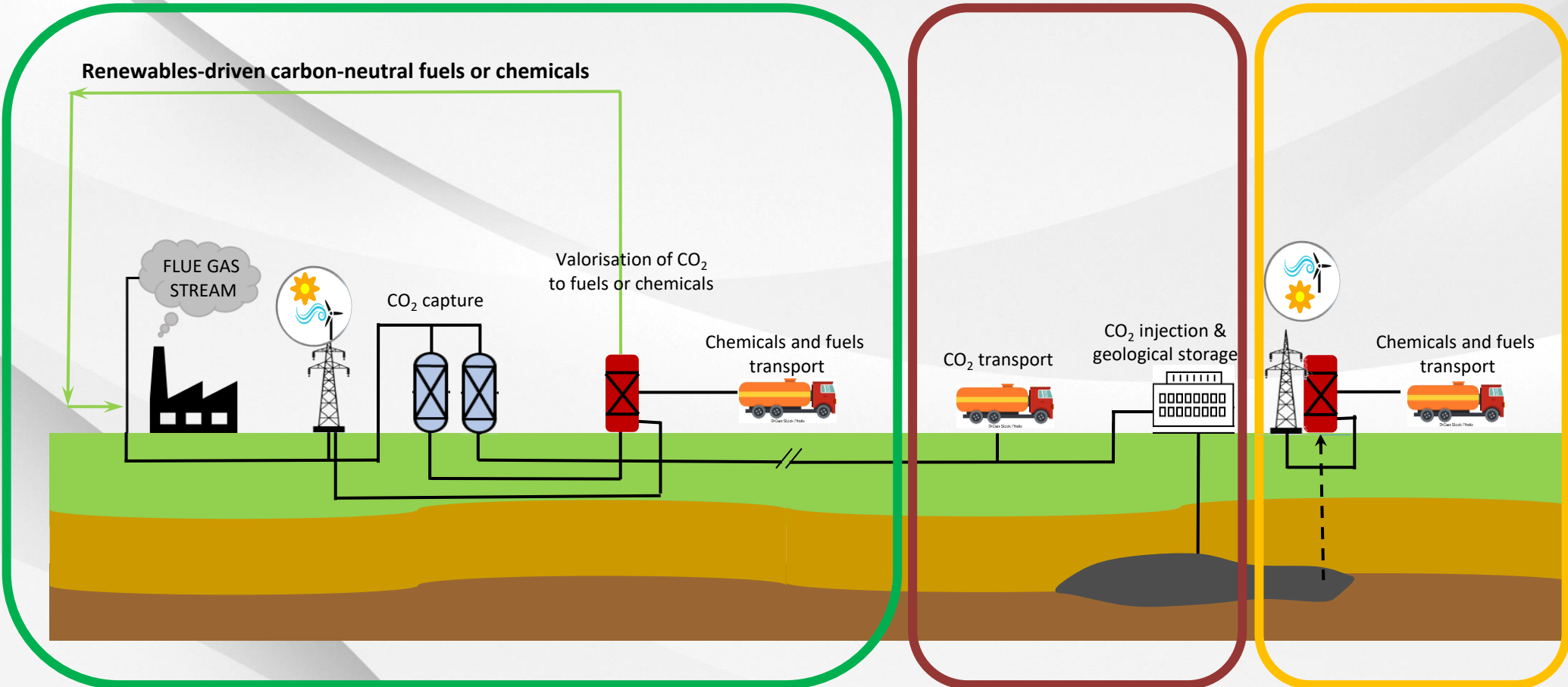


Sustainable underground H₂ and CO₂ storage





Carbon Capture Usage and Storage (CCUS)



Renewables-driven carbon-neutral fuels or chemicals

FLUE GAS STREAM

CO₂ capture

Valorisation of CO₂ to fuels or chemicals

Chemicals and fuels transport

CO₂ transport

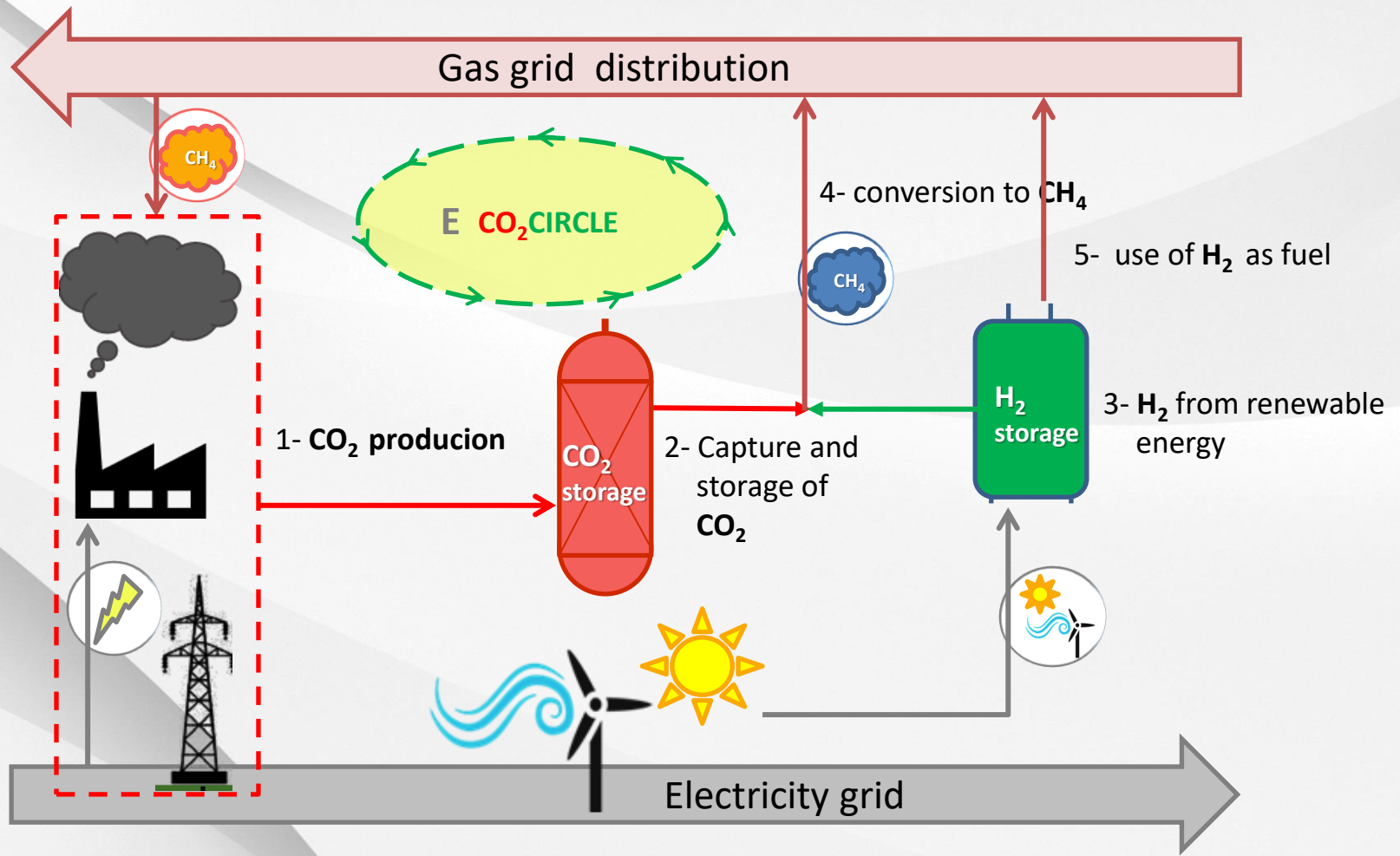
CO₂ injection & geological storage

Chemicals and fuels transport

CO₂ CAPTURE, SEPARATION AND VALORISATION INTO CHEMICALS AND FUELS

CO₂ GEOLOGICAL STORAGE

ON DEMAND CO₂ VALORISATION INTO CHEMICALS AND FUELS





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