

# Progetto per la sicurezza e la transizione energetica

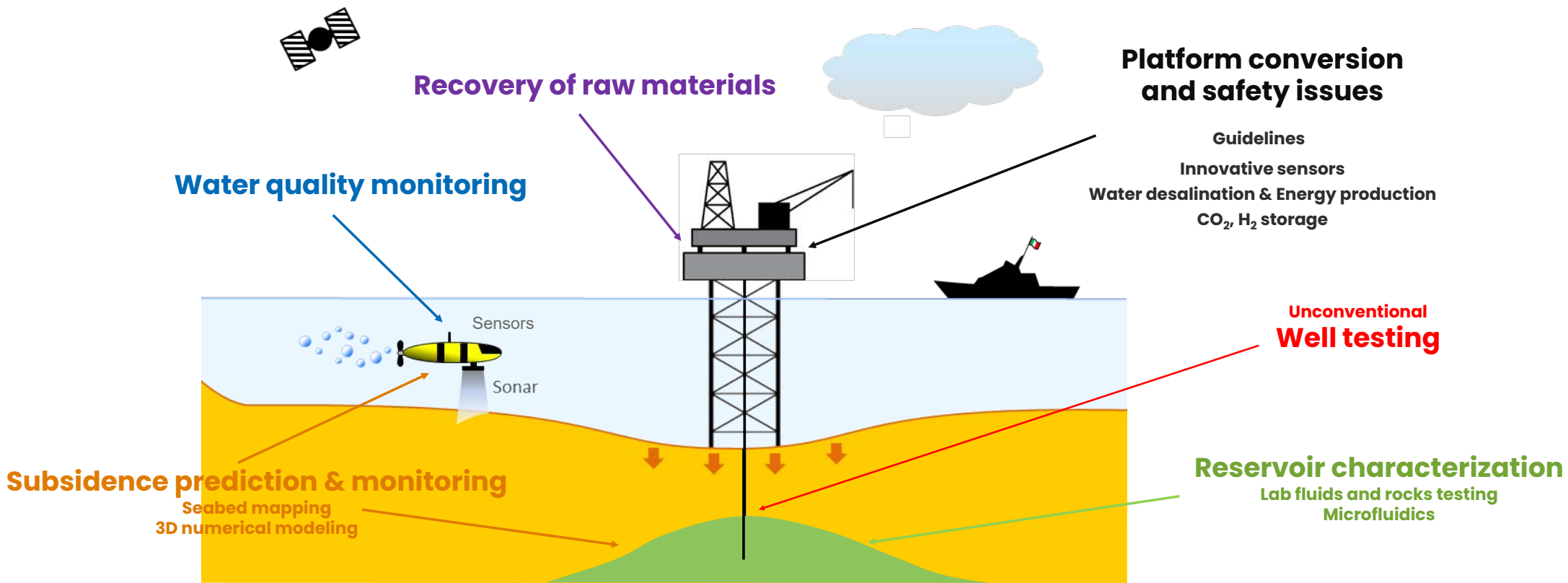
Accordo Direzione Generale Infrastrutture e Sicurezza e Politecnico di Torino

A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

# ACTIVITIES WITHIN MISE/MITE PROJECTS (2015-2022)



A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

SEASTAR



SEASTAR  
COMPETENCE CENTER

## Sustainable Energy Applied Sciences, Technology & Advanced Research

Established in 2018, the center aims at developing research activities, innovation and technology transfer in the framework of energy transition, decarbonization, sustainability and circular economy

[www.seastar.center](http://www.seastar.center)

A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

--- LOCATION



Environment Park

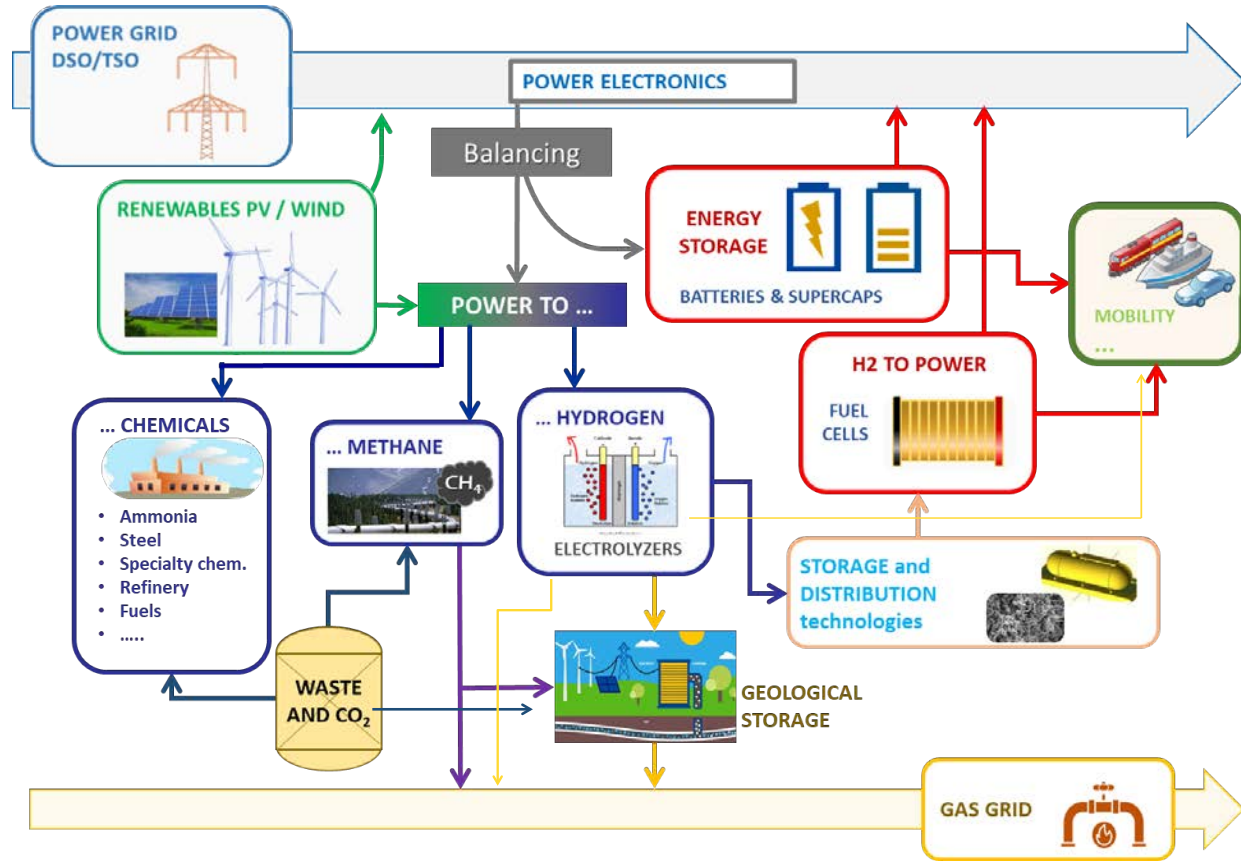


A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

# THE NEW ENERGY SYSTEM: A HOLISTIC APPROACH

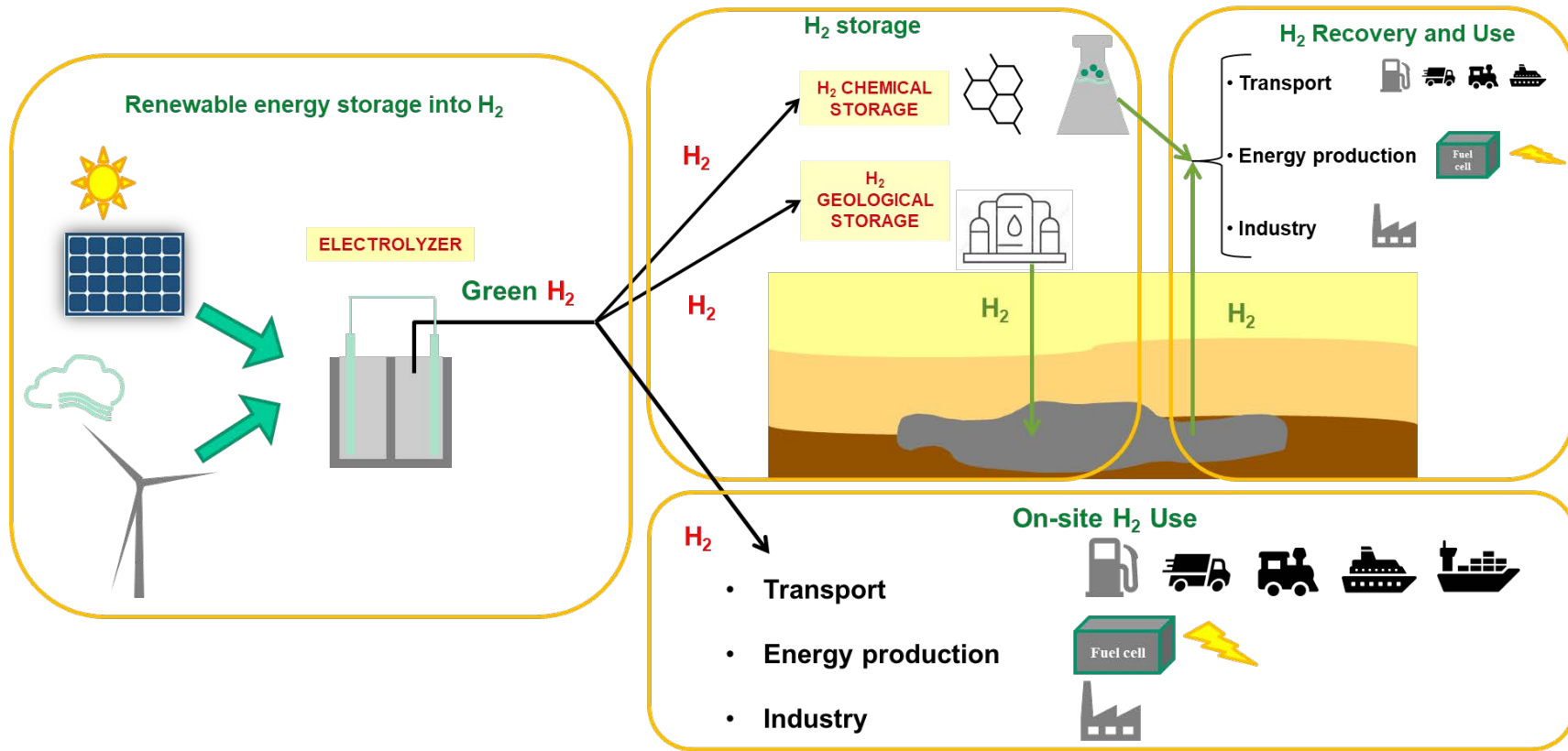


A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

# THE H<sub>2</sub> VALUE CHAIN

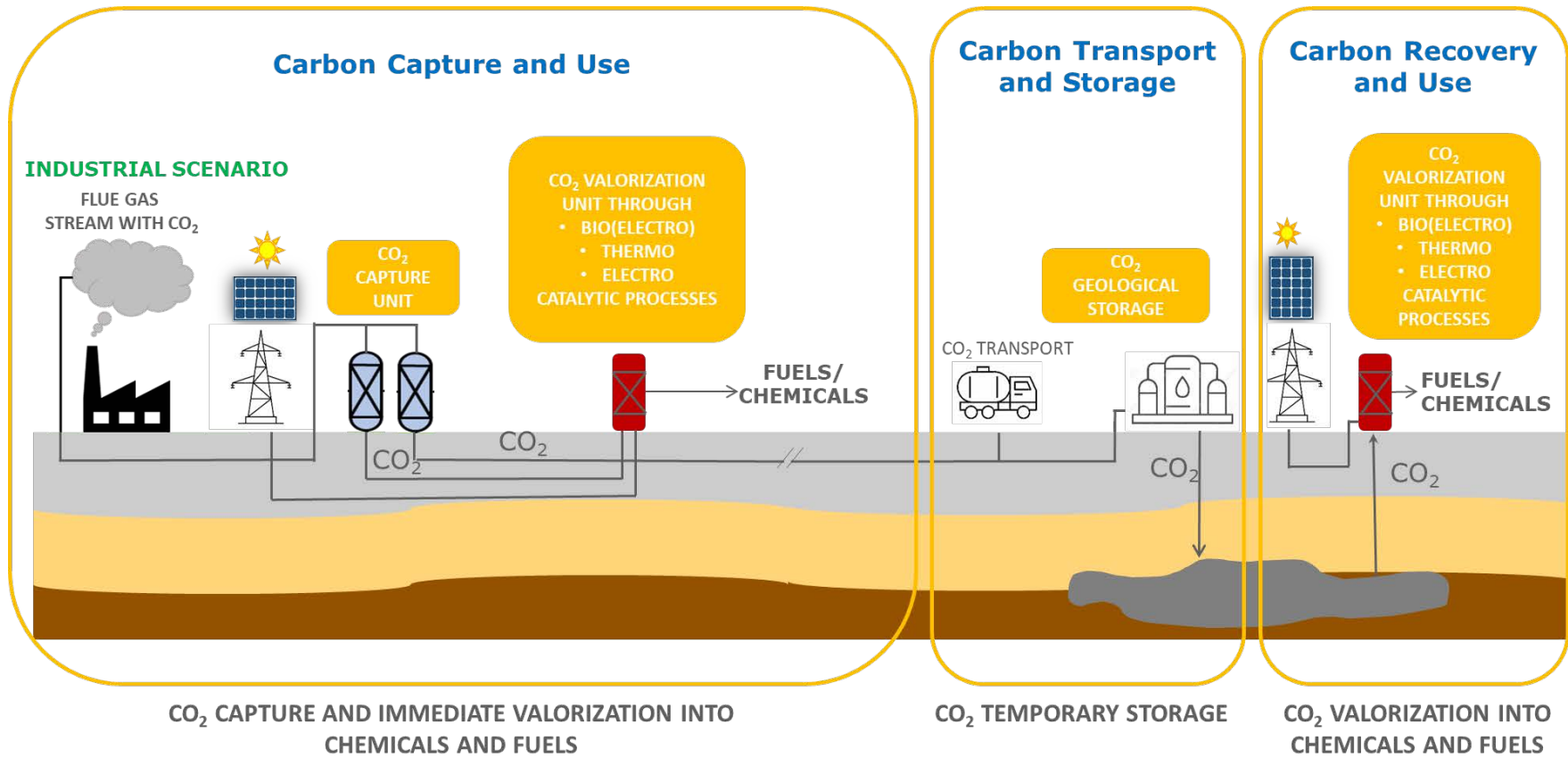


A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

# THE CO<sub>2</sub> VALUE CHAIN



A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

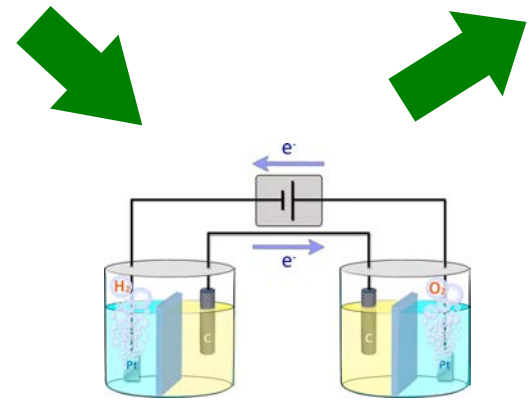


# POWER TO GAS

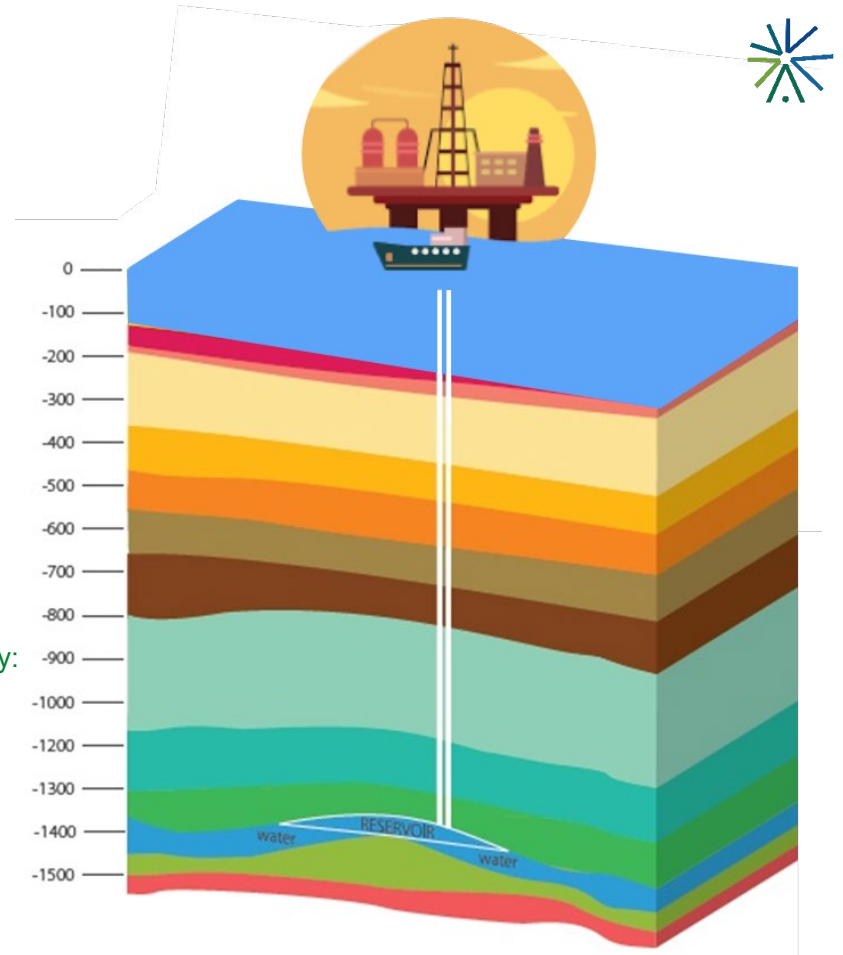
Wind and solar energy are intermittent by nature



H<sub>2</sub> and CO<sub>2</sub> are combined to produce green CH<sub>4</sub>



Solutions for the storage of excess electricity:  
water electrolysis to produce H<sub>2</sub>



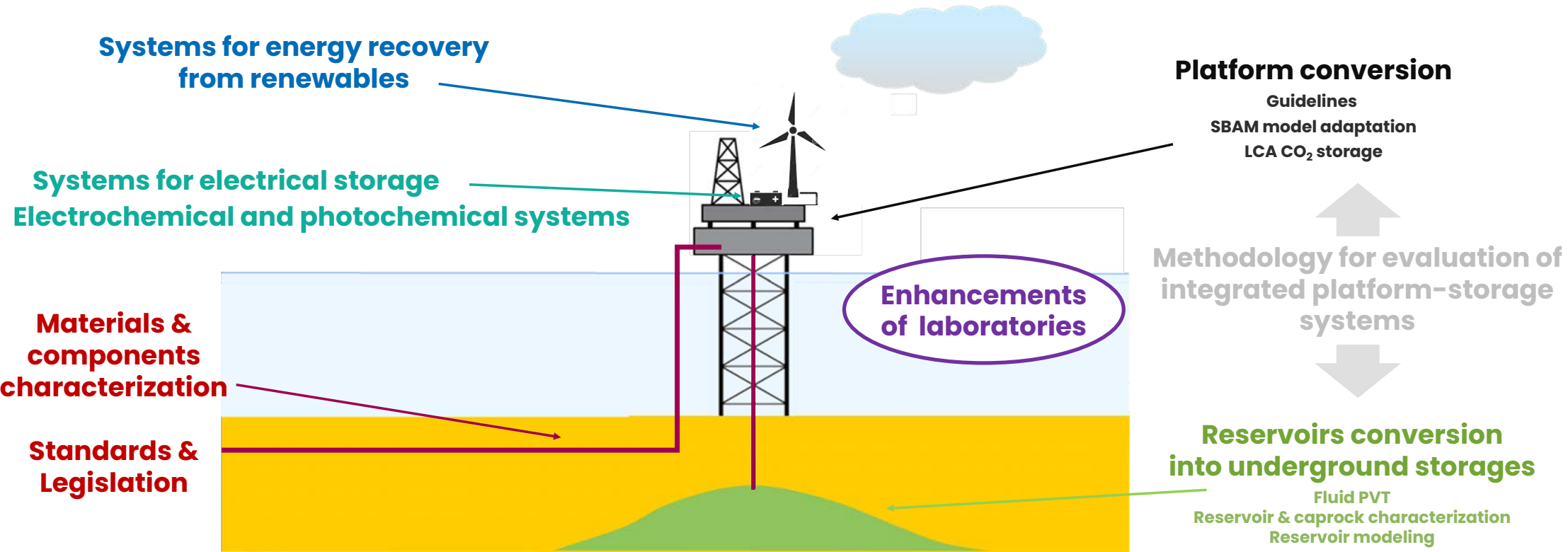
A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma



# ACTIVITIES WITHIN MASE PROJECT (2023-24)

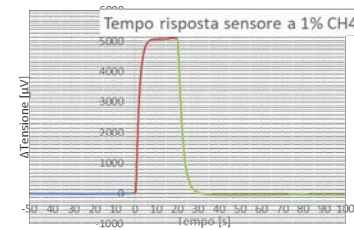
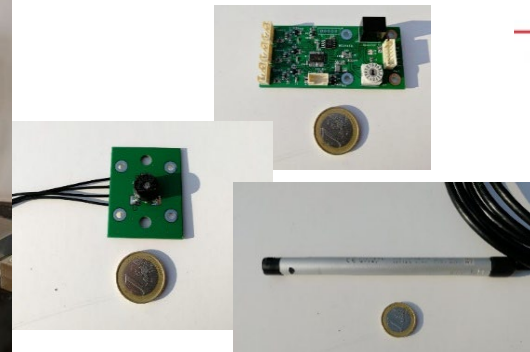
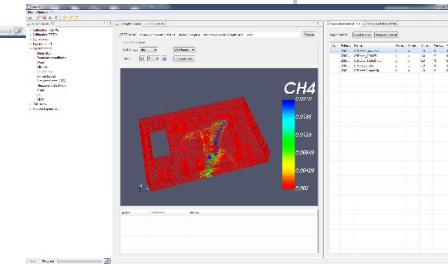
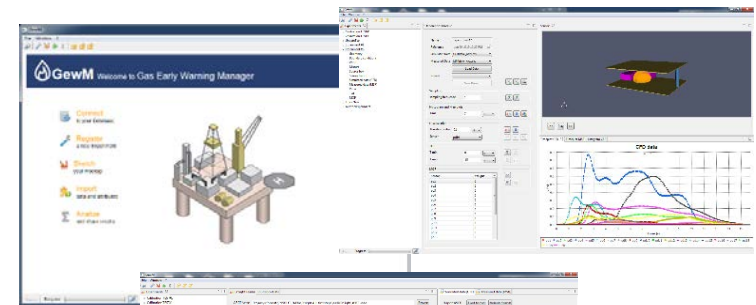
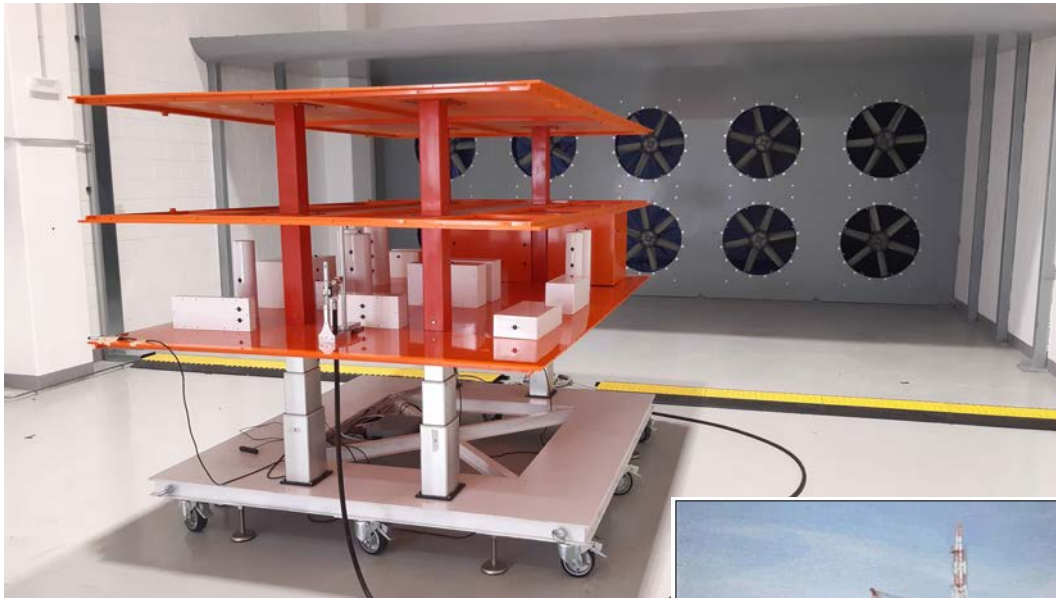


A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

# --- PLATFORM MOCK-UP



A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

## High Pressure - High Temperature H<sub>2</sub> LABORATORY



### PID Microactivity Reactor



to test the reactivity of rock samples

### Vinyl Anaerobic Chamber



### Orbital-Shaker Incubator



for anaerobic manipulation of biological samples

### HP-HT Multi-phase reactor system



Two-vessels fully customized reactor system to assess microbial activity in reservoir condition

A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

# ROCK TESTING



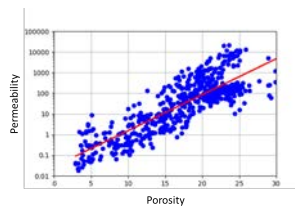
## Plugs preparation



- Coring
- Cutting
- Rectification
- Plug saturation



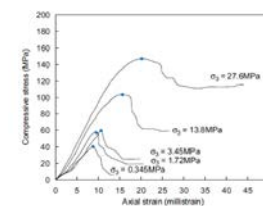
## Petrophysics



- Porosity
- Absolute permeability
- Confined absolute permeability
- Diffusivity



## Geomechanics



- Deformation parameters
- Strength parameters
- Hysteresis phenomena



A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma



# FLUID & ROCK-FLUID INTERACTION TESTING

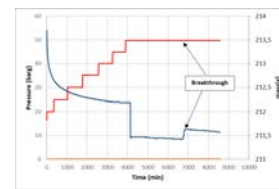
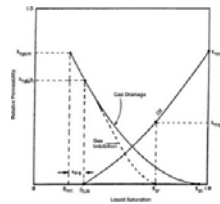


## PVT tests

- Hydrocarbons
  - CO<sub>2</sub>
  - H<sub>2</sub>



## Rocks & Fluids



- Relative permeability curves
- Critical and residual fluid saturations
  - Hysteresis phenomena
  - Threshold pressure

W.C.  
200°C/700 bars

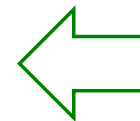
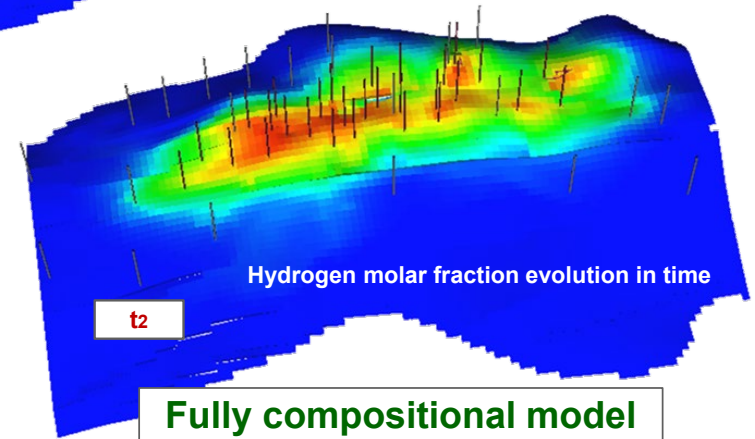
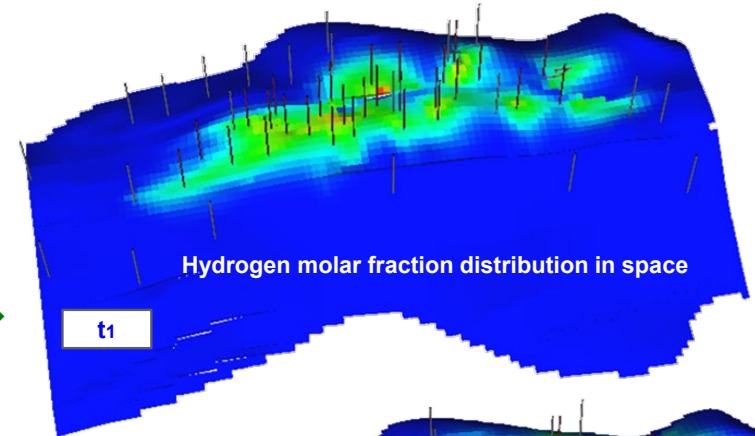
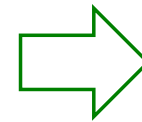
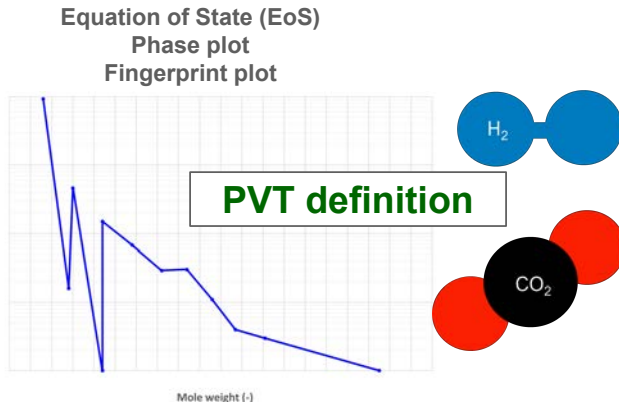
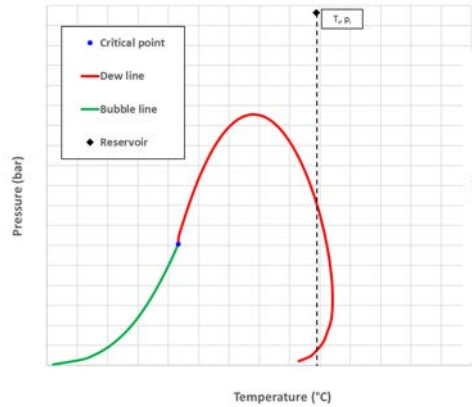


A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino

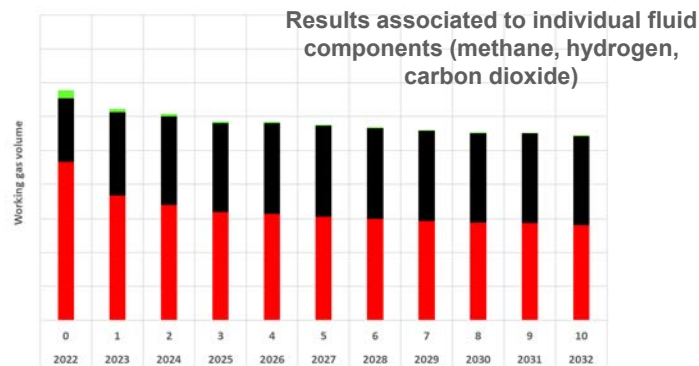


3-4 maggio 2023 Accademia delle scienze XL Roma

# DYNAMIC SIMULATION OF UNDERGROUND FLUID STORAGE



**Simulation of forecast scenarios**



A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma



# CHEMICAL SYNTHESIS LABS



A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma



# ELECTROCHEMICAL LAB CHARACTERIZATION

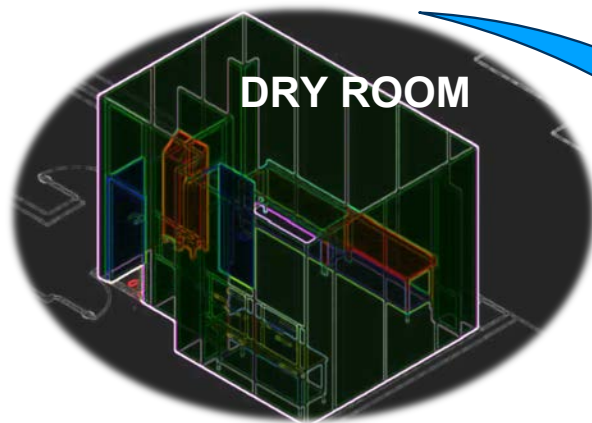


A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

# GREEN ELECTROCHEMISTRY & ELECTROCHEMICAL DEVICES PILOT LINE



Mixing



Roll to roll



Drying and assembly



Green electrochemical devices



Pressing and cutting



- Synthesis of active materials for electrochemical devices
- Device realization and packaging
- Electrochemical characterization of materials and devices

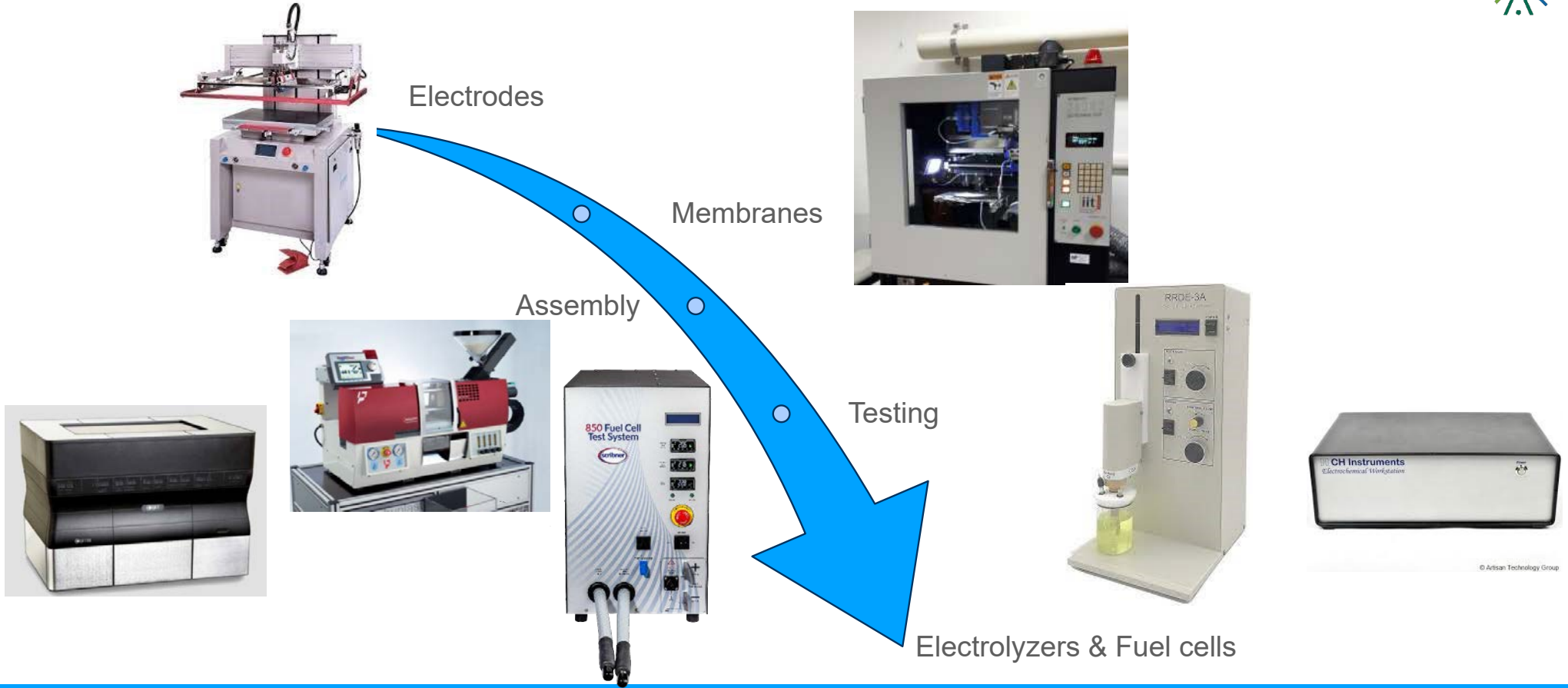
A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma



# Pilot line for Electrolyzer & Fuel cells realization & packaging

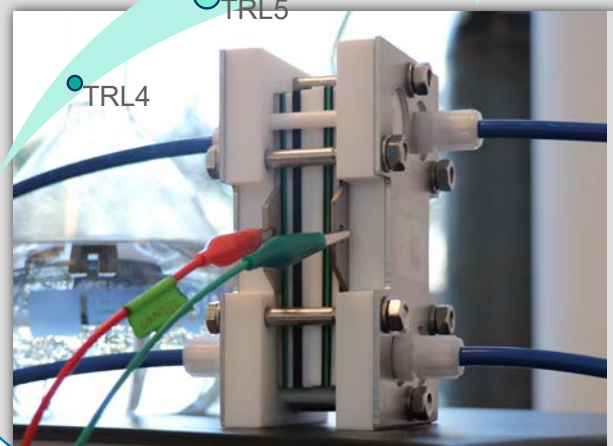
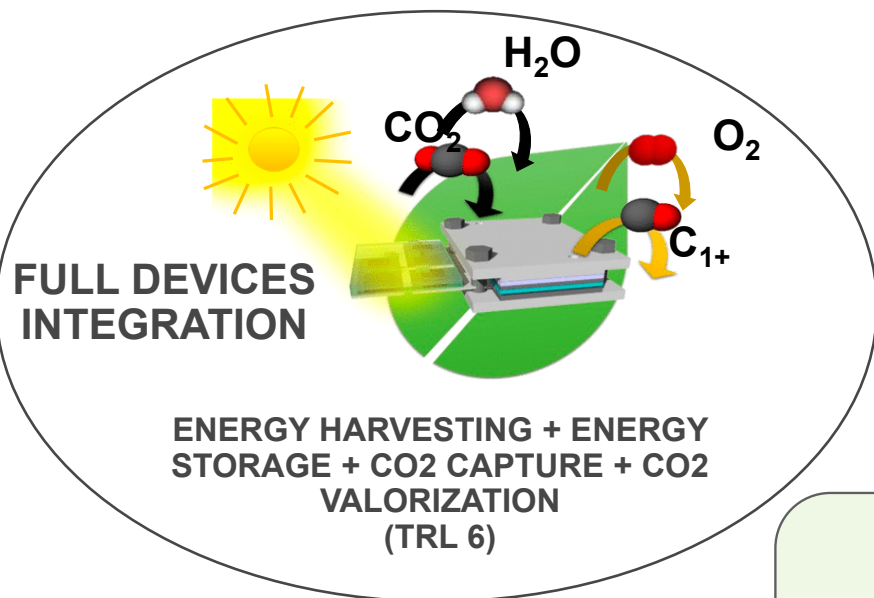


A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

# CO<sub>2</sub> VALORIZATION: ELECTRO & PHOTOCATALYSIS



ELECTRO & PHOTOCHEMICAL CHARACTERIZATION, REACTOR ENGINEERING, SCALING-UP, ELECTRO & PHOTOCHEMICAL MODELING



- CARBON MONOXIDE
  - SYNGAS
- FORMIC ACID
- ETHYLENE
- ETHANOL
- METHANE
- ...

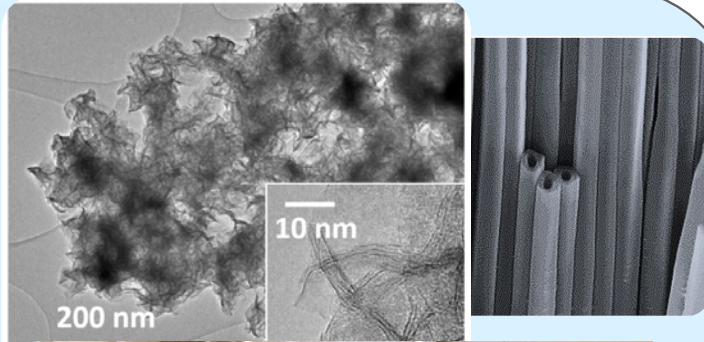
A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



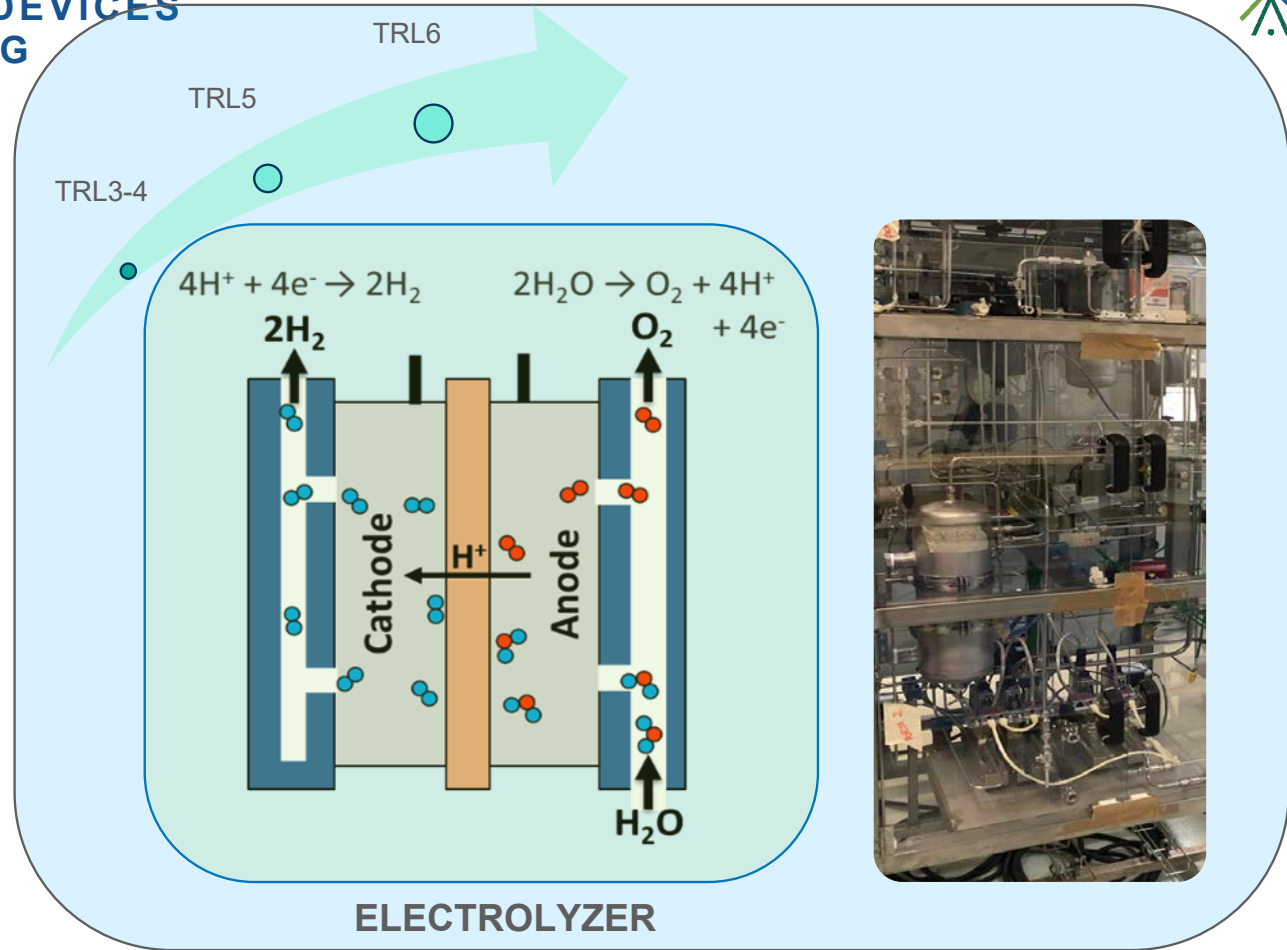
3-4 maggio 2023 Accademia delle scienze XL Roma



# H<sub>2</sub> PRODUCTION: MATERIALS AND DEVICES CHARACTERIZATION AND MODELING



DESIGN, AB-INITIO MODELING,  
SYNTHESIS AND CHARACTERIZATION  
OF CATALYSTS AND MEMBRANES



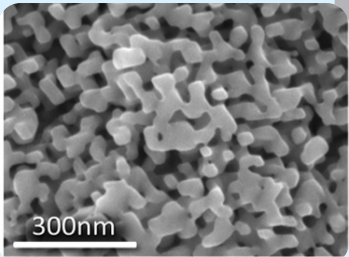
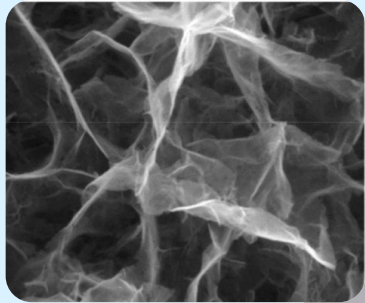
A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



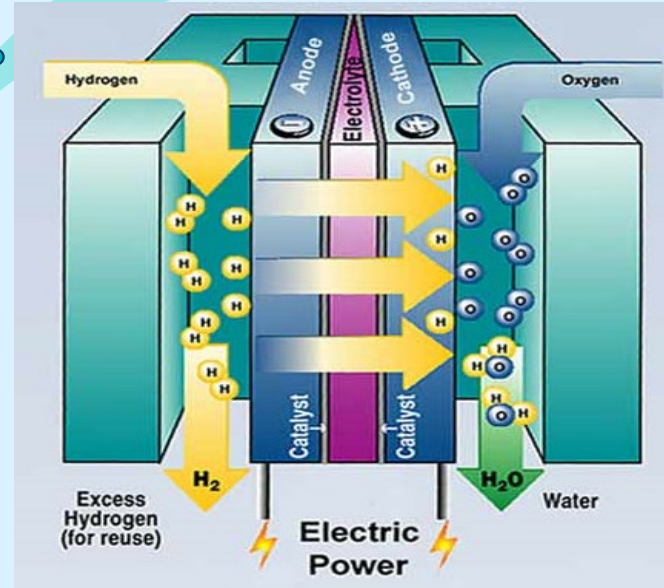
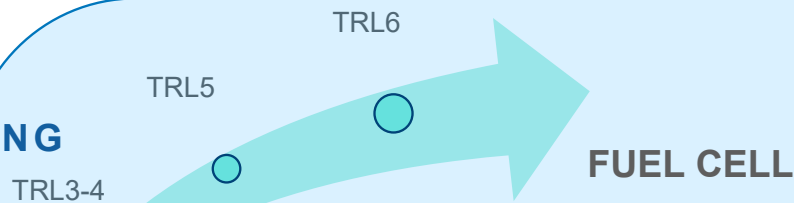
3-4 maggio 2023 Accademia delle scienze XL Roma



**H<sub>2</sub> AS FUEL:  
MATERIALS AND DEVICES  
CHARACTERIZATION AND MODELING**



DESIGN, AB-INITIO MODELING, SYNTHESIS AND CHARACTERIZATION OF CATALYSTS AND MEMBRANES



DEVICES  
INTEGRATION  
FUEL CELL + ENERGY STORAGE

A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

## LABORATORY dedicated to BIOMETHANATION



### VERTICAL LAMINAR FLOW

- To allow sterile handling of biological samples



### ORBITAL-SHAKER INCUBATOR

- For anaerobic incubation and cultivation of biological samples & liquids



### GAS MIXING PANEL

To generate gas mixtures containing  $H_2$ ,  $CO_2$ ,  $CH_4$ , AIR,  $N_2$

### PROCESS SCALE-UP AND TESTING



Bioreactor System design:

- Min. 5L - Max. 12L
- Movable
- Compact
- User friendly

A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

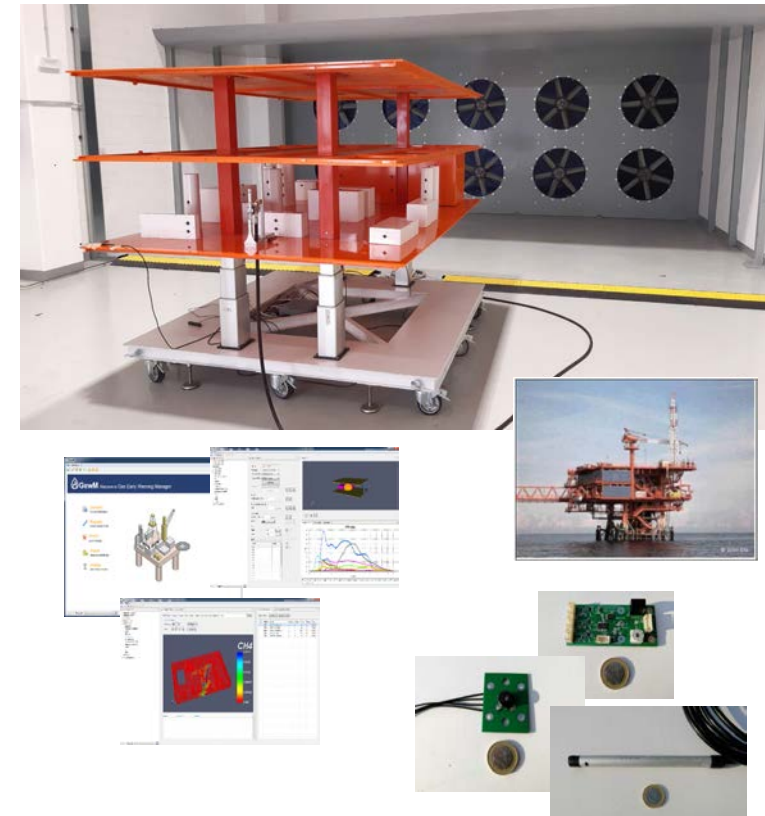
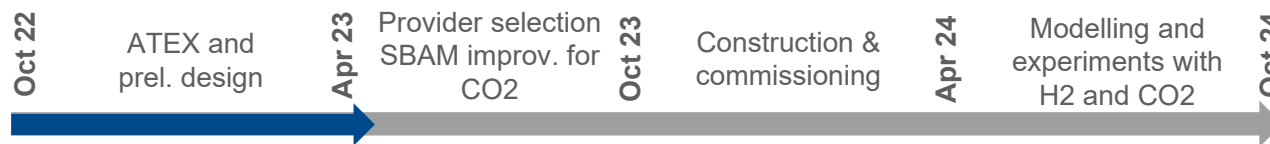
## ENHANCEMENT OF LAB FACILITIES



**Goal:** Implementation of SEASTAR Wind Tunnel and MockUp in order to manage H<sub>2</sub> and CO<sub>2</sub> experiments

### Activities:

1. **ATEX** assessment of the Wind Tunnel laboratory
2. **Enhancement of MockUp** to be compliant with ATEX Zone 1
3. Design, testing and construction of **new sensors sets for H<sub>2</sub> and CO<sub>2</sub>**. A new technology is necessary for H<sub>2</sub> due to ATEX requirements
4. Design and construction of a new **independent line for H<sub>2</sub> delivery** to MockUp
5. **Enhancement of data transmission devices** to control room and **control software** to allow the switch among different type of tests (NG, H<sub>2</sub>, CO<sub>2</sub>).
6. **SBAM development** to manage H<sub>2</sub> and CO<sub>2</sub> releases.



A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



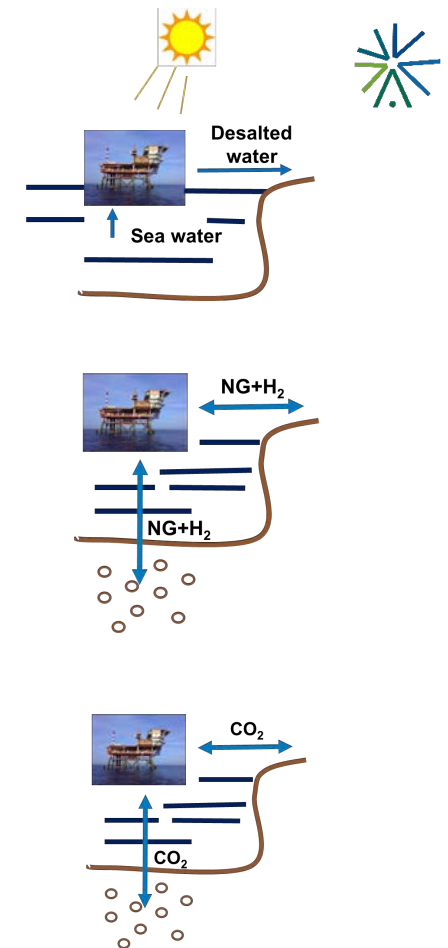
3-4 maggio 2023 Accademia delle scienze XL Roma

## --- OFF SHORE PLATFORM – CONVERSION OPTIONS

**Goal:** Based on past experiences (Basic Design for three conversion options) a **Conversion Guideline** will be set

### Activities:

- **Options harmonisation:**
  1. PV production + water desalinization + rare materials
  2. Temporary storage of NG and H<sub>2</sub> mix (**platform + reservoir**)
  3. Temporary storage of CO<sub>2</sub> (**platform + reservoir**)
- **Setting of a Guideline** to drive the conversion of a specific installation
- Guidelines will be based on two types of criteria:
  - a) **Mandatory criteria** exclude the possibility of conversion option for the specific plant under investigation (e.g. platform surface, reservoir properties, etc.)
  - b) **Non-mandatory criteria** drive to choose the best conversion option (e.g. existing equipment, distance from coastline, etc.)



A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

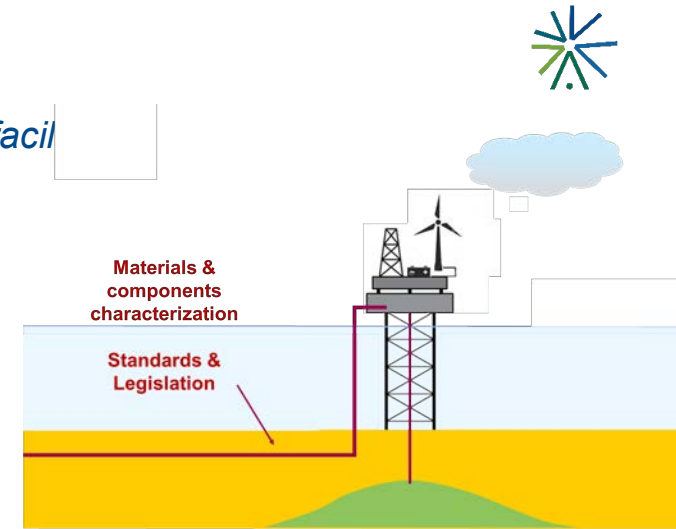
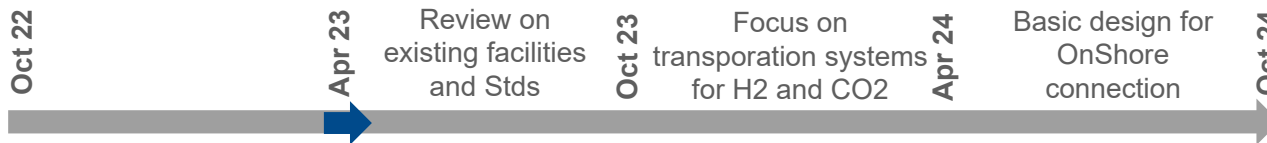


## ADD ONS FOR OFF SHORE PLATFORM CONVERSION

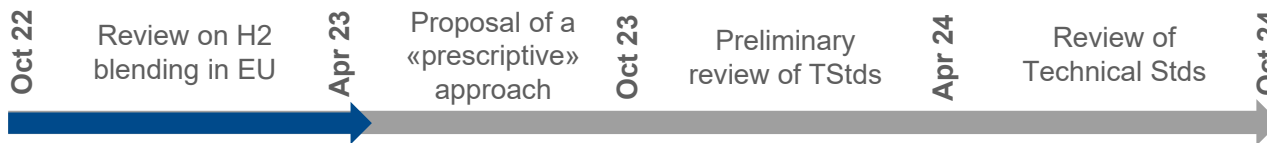
**Goal:** Study of the interface between the Off Shore converted platform and On Shore facilities

### Activities:

- **Basic design for the connecting pipeline to H<sub>2</sub> or CO<sub>2</sub> on-shore facilities:**
  - a) Connection pipelines to on-shore facilities and gas transport network
  - b) Investigation on the best available technologies for H<sub>2</sub> production and CO<sub>2</sub> capture



- **Regulation issues regarding H<sub>2</sub> blending in pipelines and readiness of technologies for H<sub>2</sub> transp. and distribution:**
  - a) Proposal for a “prescriptive” approach to NG-H<sub>2</sub> blending starting from Italian Fire Prevention Regulation and Std ASME B31.12-2019 (Hydrogen Piping and Pipelines)
  - b) Review of Technical Standards for H<sub>2</sub> equipment and technologies

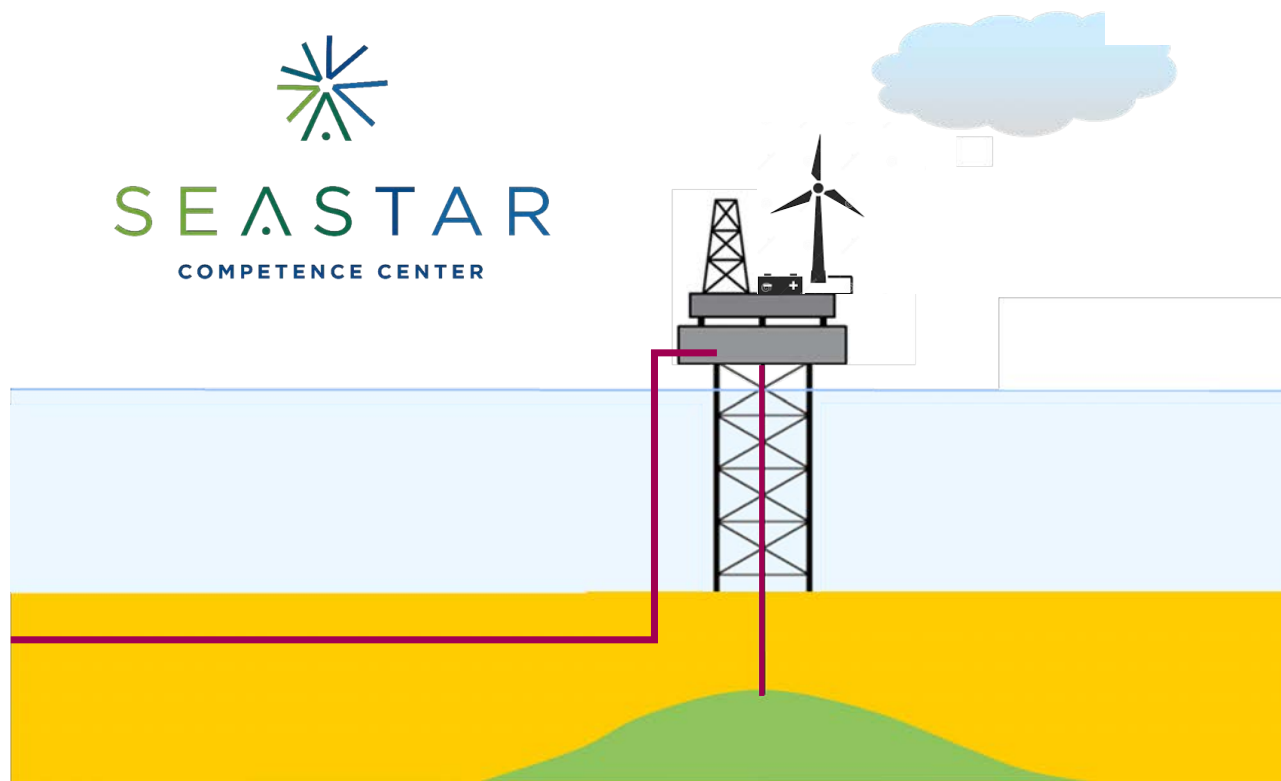


A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma

--- Grazie per l'attenzione!



A. Carpignano, F. Pirri, F. Verga – Politecnico di Torino



3-4 maggio 2023 Accademia delle scienze XL Roma