MOF4AIR

The MOF4AIR Project

<u>M</u>etal <u>O</u>rganic <u>F</u>rameworks for carbon dioxide <u>A</u>dsorption processes in power production and energy <u>I</u>ntensive indust<u>R</u>ies

Toward 2030: New pathways to CO_2 capture – Webinar 24th February 2022

HORIZON RESULTS BOOSTER

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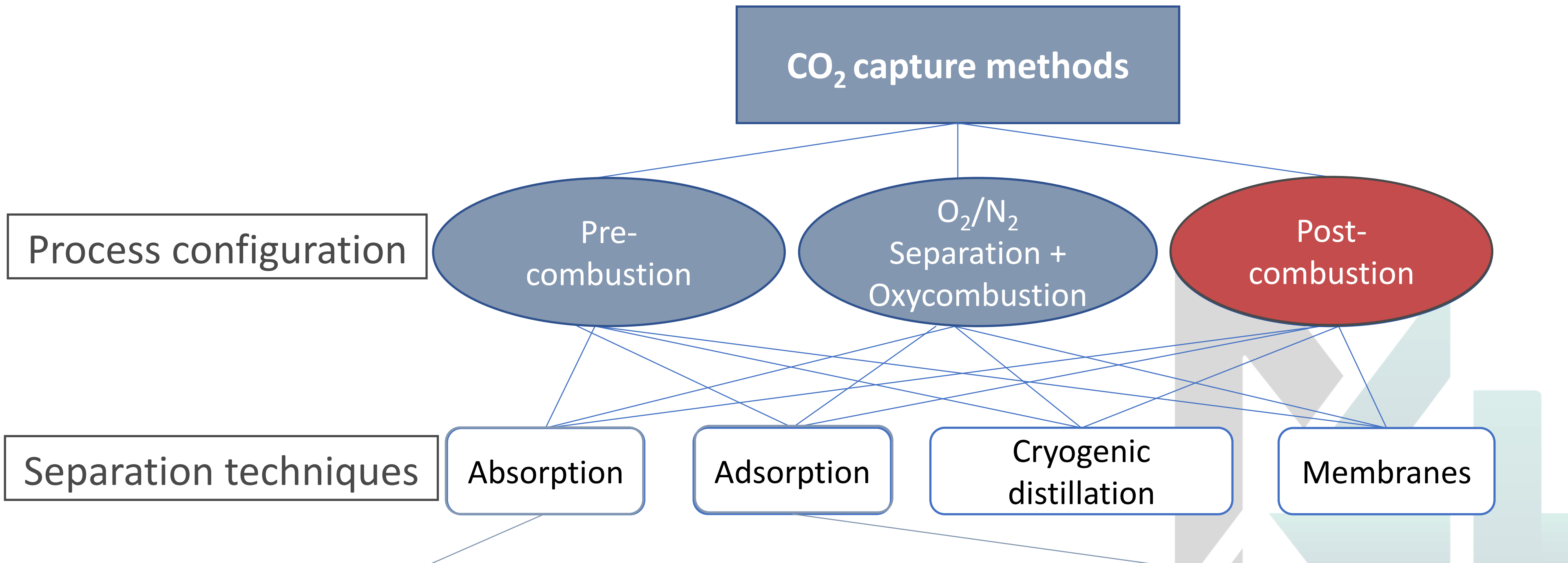
https://www.mof4air.eu/

CO_2 capture



Absorption in amine solutions is currently the most advanced separation techniques (TRL 9), but suffers from several drawbacks:

- Corrosive
- Sensitive to contaminants (SO_x, NO_x, O_2)
- Solvent loss by aerosols and degradation
- Toxic
- High energy consumption (3.5 GJ/tCO_2 (MEA) → 2.5 – 2 GJ/tCO_2 (mixing solvant /alternative configurations))

Adsorption is a promising techniques presenting many advantages:

- Already use in gas separation process
- Non-toxic
- Potentially lower enegy requiered
- Suitable for various operating conditions

→ research is required both to find the best materials and the most suitable process for CO_2 capture

H2020 - MOF4AIR

8 countries

11M €

14 partners

48 months
(07/2019 – 06/2023)

Objectives

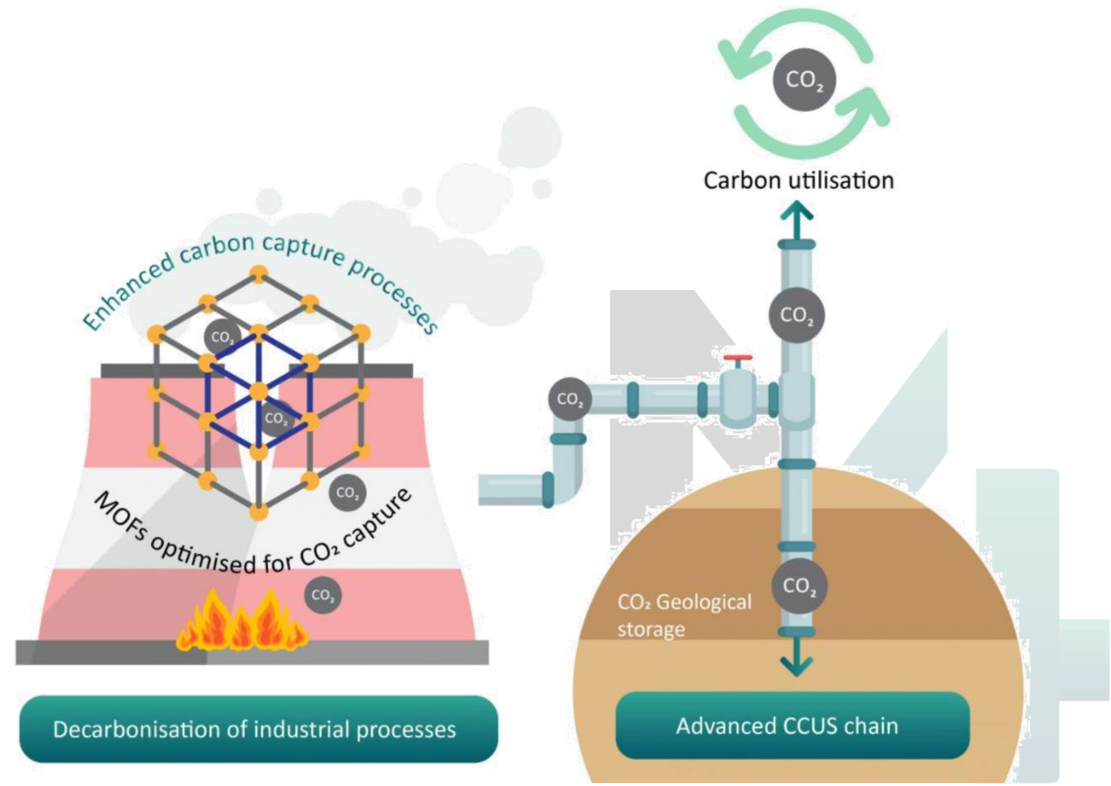
- Increase the cost effectiveness of CCS and decrease its energy penalty
- Qualify and validate the most promising MOF materials for adsorption-based carbon capture
- Fine-tune adsorption processes for high performance MOFs
- Demonstrate the performance of MOF based carbon adsorption in real operation
- Ensure the technology replication in different CO_2 and energy intensive industries and its sustainability
- Increase stakeholder and public awareness of the challenges, benefits and issues related to carbon capture, transport, use and storage

H2020 - MOF4AIR Overall concept of the project

Combine:

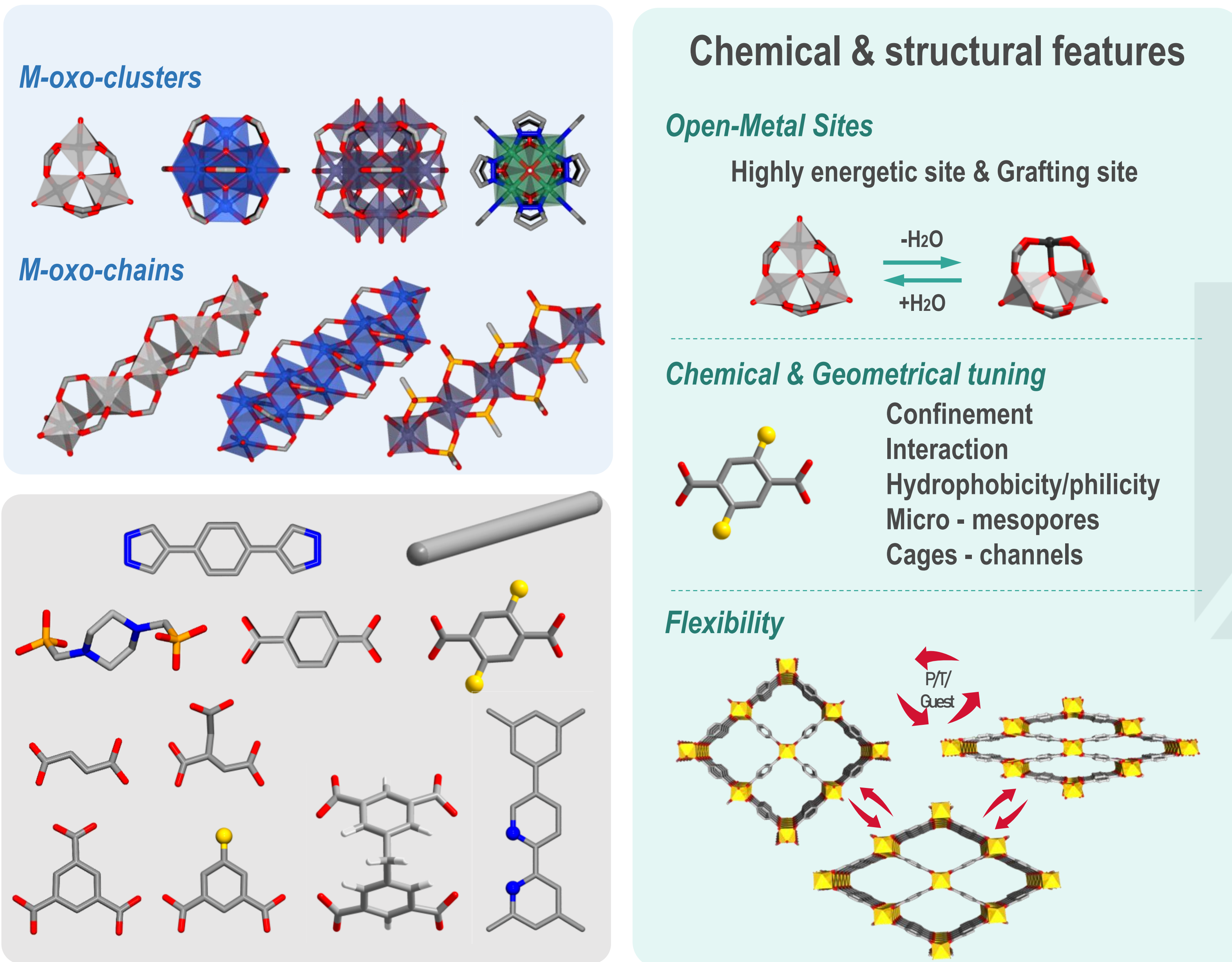
1. Carbon capture processes: VPSA and MBSTA, and
2. Innovative & highly efficient MOFs

in a tailored carbon capture solution for energy intensive industries and their varying composition of off-gases including contaminants

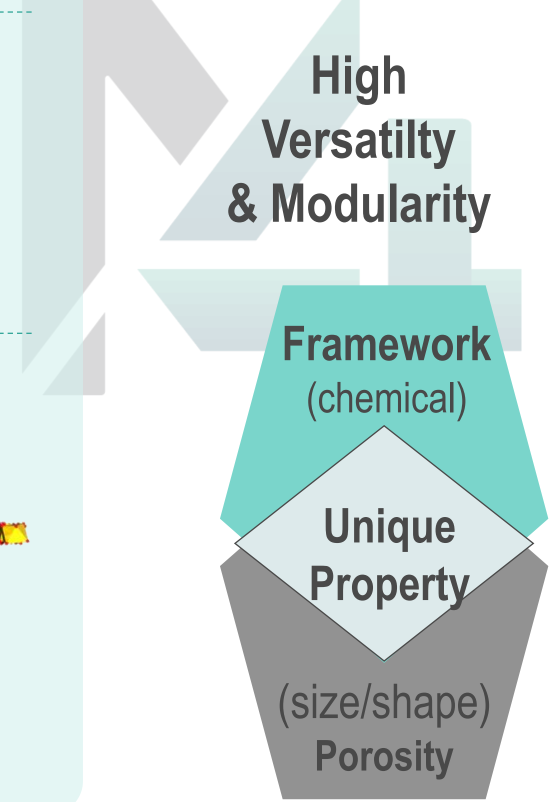


MOF4AIR will demonstrate optimized MOF-based adsorbents with fine tuned CO_2 adsorption processes through a multidisciplinary approach

MOFs



MOFs are hybrid porous solids representing a new class of crystallized porous materials. MOF4AIR takes advantage of their high tuneability to create specific adsorption sites associated for trapping CO_2.

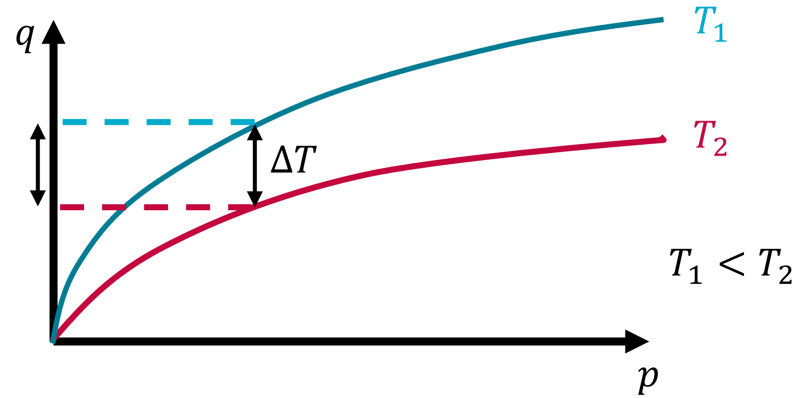


MOFs

- The MOF(s) selected for demonstration will have the following characteristics:
  - Maximum working capacity above 1 mol/kg at 10 kPa and 298-323 K
  - CO_2/N_2 Selectivity > 30 at 0.15 bar
  - Stable with water, SO_2, NO_X, H_2S (even in presence of water)
  - Heat of adsorption below 50 kJ/mol

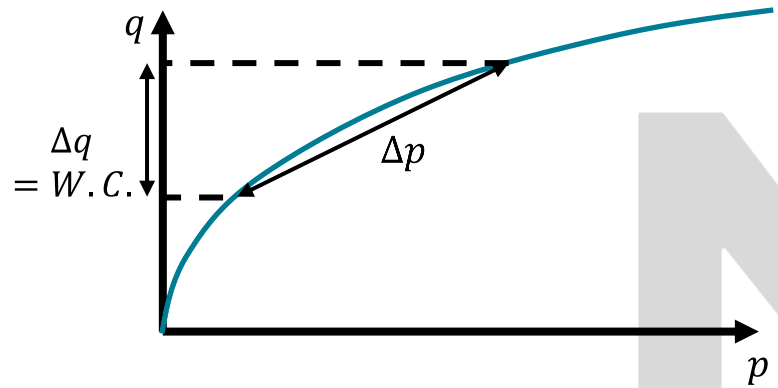
Adsorption processes

Temperature Swing adsorption



+ Allows the use of waste heat
+ High purity of the less adsorbed compound
- Long time for heating or cooling
- Higher amount of adsorbent
- Thermal aging phenomenon

(Vacuum) Pressure Swing adsorption

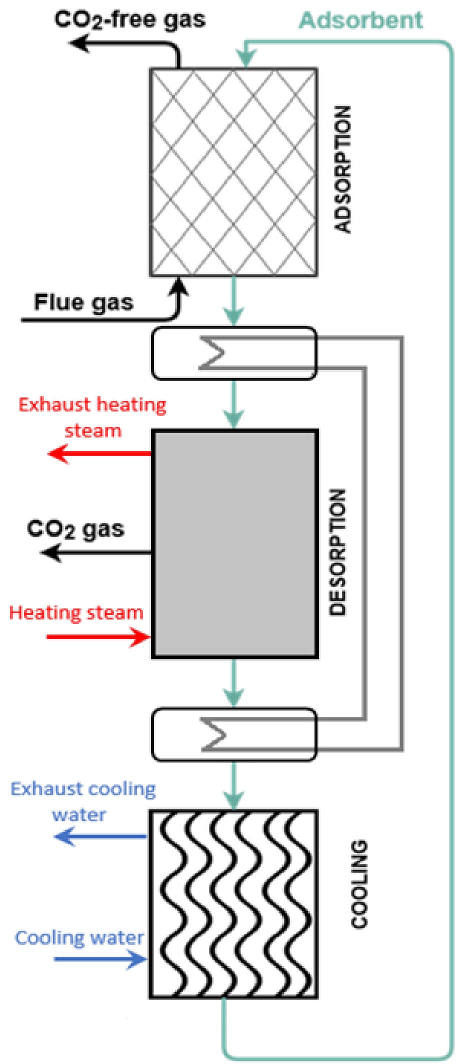


+ Rapid cycling
+ Less investment costs
- Mechanical energy required
- Purity of the most adsorbed amount may be low

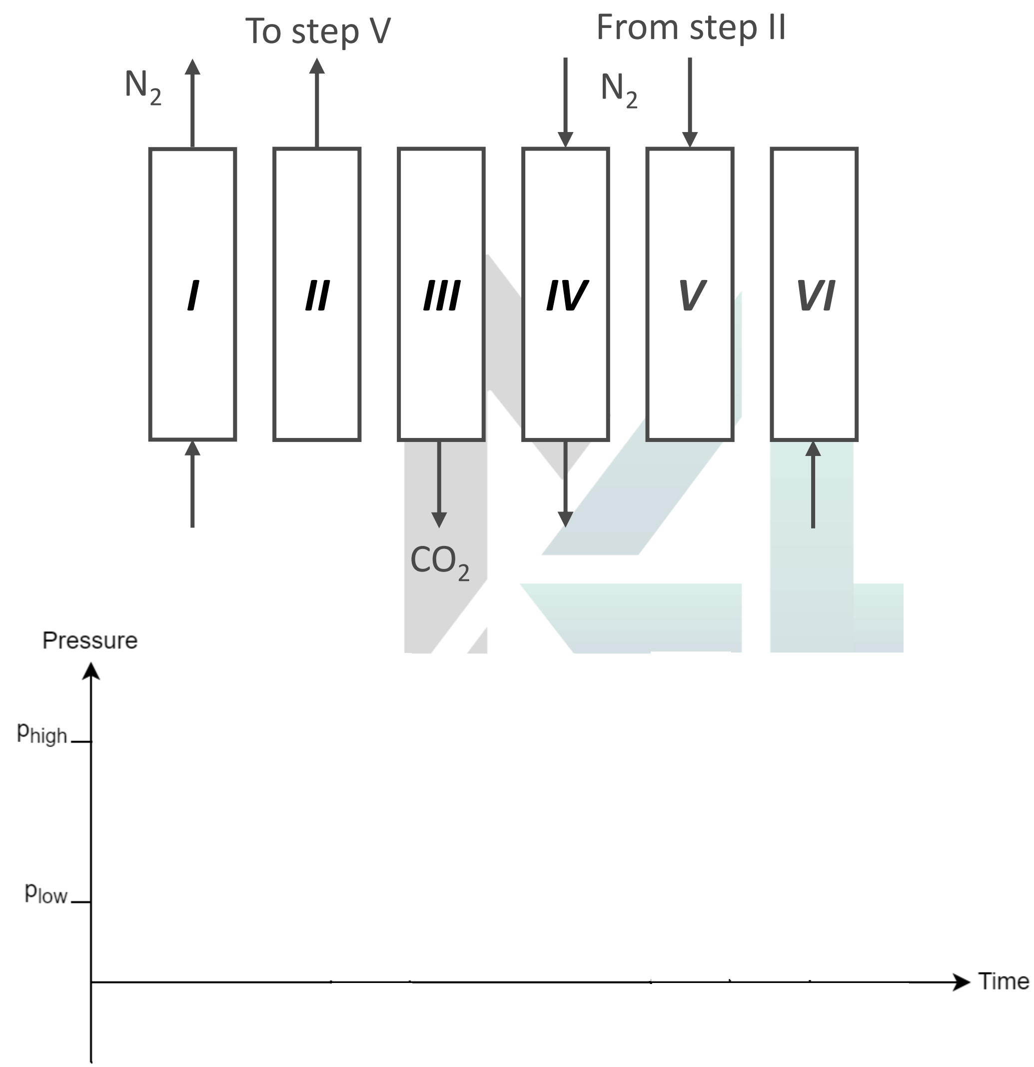
(V)PSA is suitable when concentration of CO_2 is between 5% and 33%

Adsorption processes

MBTSA principe



VPSA principe



Demonstration: TRL 6 on 3 sites

TCM (Mongstad)

- RFCC (Residue Fluid Catalytic Cracker – refinery)
- CHP (Combined Heat and Power – power plant)
- 4 major oil companies: GASSNOVA, EQUINOR, SHELL, TOTAL
- One of the most advanced and the largest post-combustion CO_2 capture pilots

TUPRAS (Izmit)

- Turkey's largest oil enterprise with 32.5 million m^3 crude processing capacity
- 7^{th} largest refinery enterprise in Europe
- Post-combustion flue gases: furnaces, boilers, steam generators, incinerators, FCC regenerators …

SOLAMAT (Marseille)

- Part of Marseille-Fos cluster
- Waste incinerator
- Pipeline collecting CO_2 from different sources and feeding different applications will be soon set up

Impacts

- Significant, step-change advances in reductions in energy penalty of CO_2 capture: (i) Producing high performant MOFs; (ii) Proving the performances of the selected capture processes; (iii) Increasing the performances of these CC technologies

- Safe and economic integration of CC into industrial clusters: (i) Final SPECCA for VPSA and MBTSA on all carbon emitting processes studied below 2.5 GJ_{LHV}/t_{CO2}; (ii) Cost of capture for all sectors and sub sectors below 25 €/t_{CO2}; (iii) Energy penalty below 18%; (iv) Incremental cost below 10%

- Prevent CO_2 emissions: (i) Include 4 clusters in its Industrial Cluster Board (ICB); (ii) Consider 10+ industrial sectors in the ICB

- European leadership: Fostering Europe as leader in MOF-based CO_2 adsorption

- SDGUN 7 and 13 by: (i) Diminishing CO_2 emissions from power plants and carbon intensive industries by 95%; (ii) Diminishing cost increase from power plants with CCS compared to power plants without CCS by 20%

Process optimization and advanced CCU/CCS chains

- The MOF4AIR consortium considers their performant capture solution as one brick of the global carbon chain.
- As compressing CO_2 at high CO_2 purity is needed for transport and use or storage and require the use of energy, MOF4AIR will study the best integration of adsorption process with conventionally used CPU.
- In addition to the conventional process optimization of stand-alone VPSA/TSA processes, integrated sorption-CPU process configurations will be compared and systematically optimized from the techno-economic point of view using *ad hoc* numerical methods for the optimization of flowsheets and adsorption cycles.

Thank you

More information

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