

# CARMOF

New process for efficient CO<sub>2</sub> capture by innovative adsorbents based on modified carbon nanotubes and MOF materials.

**H2020-NMBP-20-2017**

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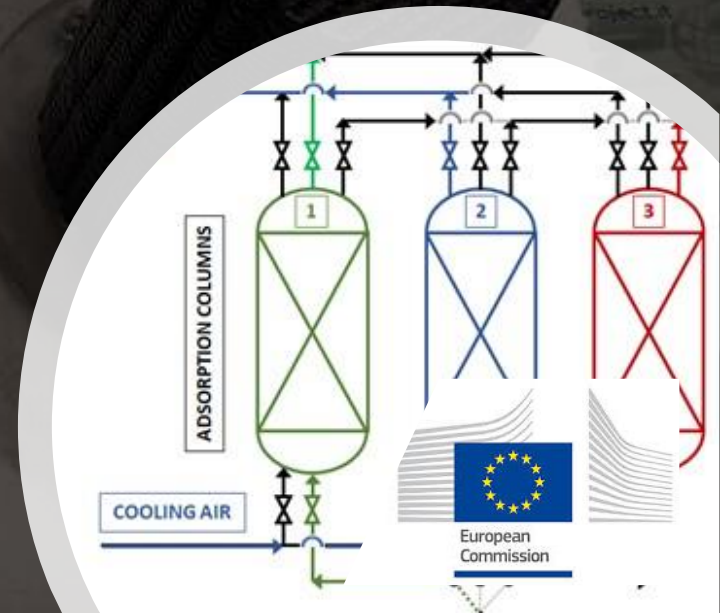
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**AIMPLAS (February 24<sup>th</sup>)**



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# CARMOF Project

**CARMOF** is developing a hybrid CO<sub>2</sub> process combining **VPsA modules** based on 3D printed monoliths with vacuum regeneration and "in cascade" **membranes system**. The goal is to achieve high purity CO<sub>2</sub> streams from synergetic effects from both technologies



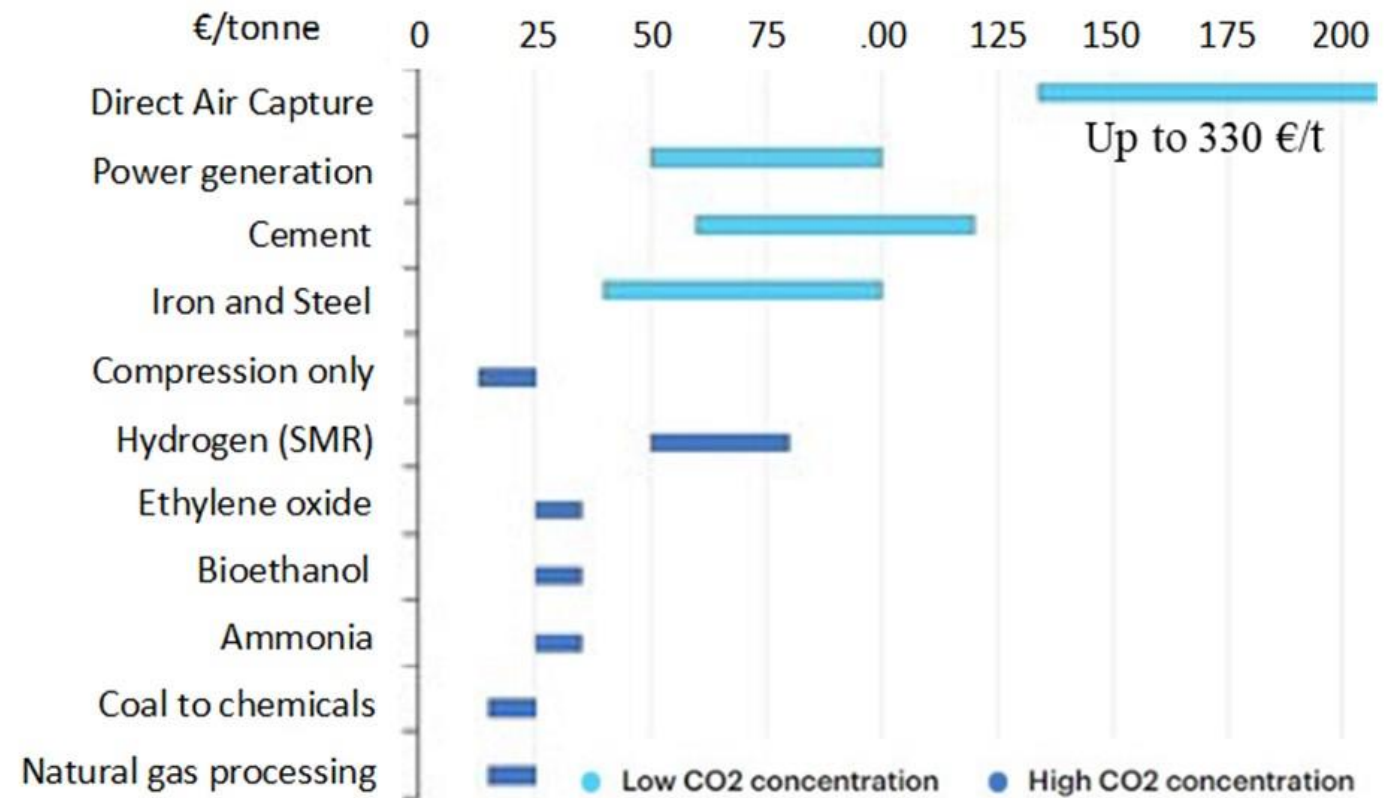


- Consortium consists of 15 partners from 9 countries
- €7.4 M overall budget

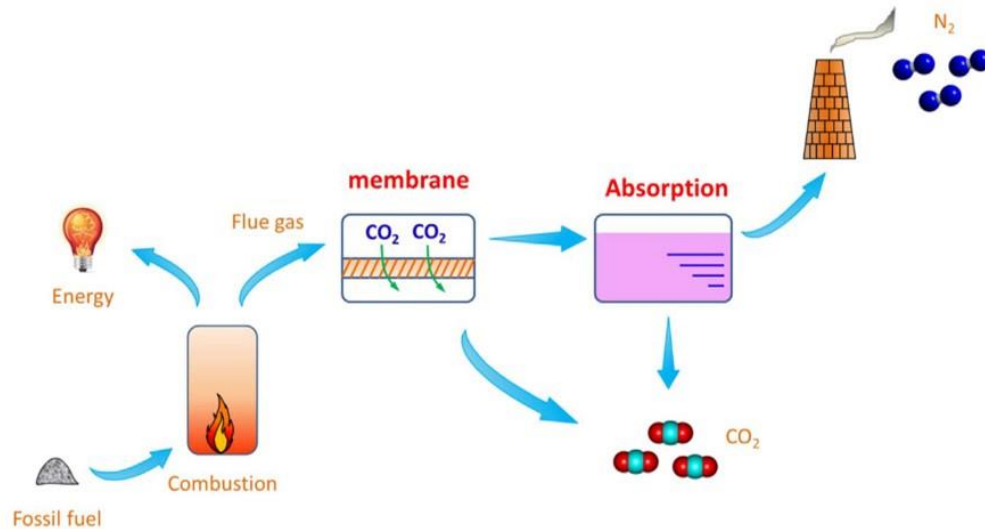




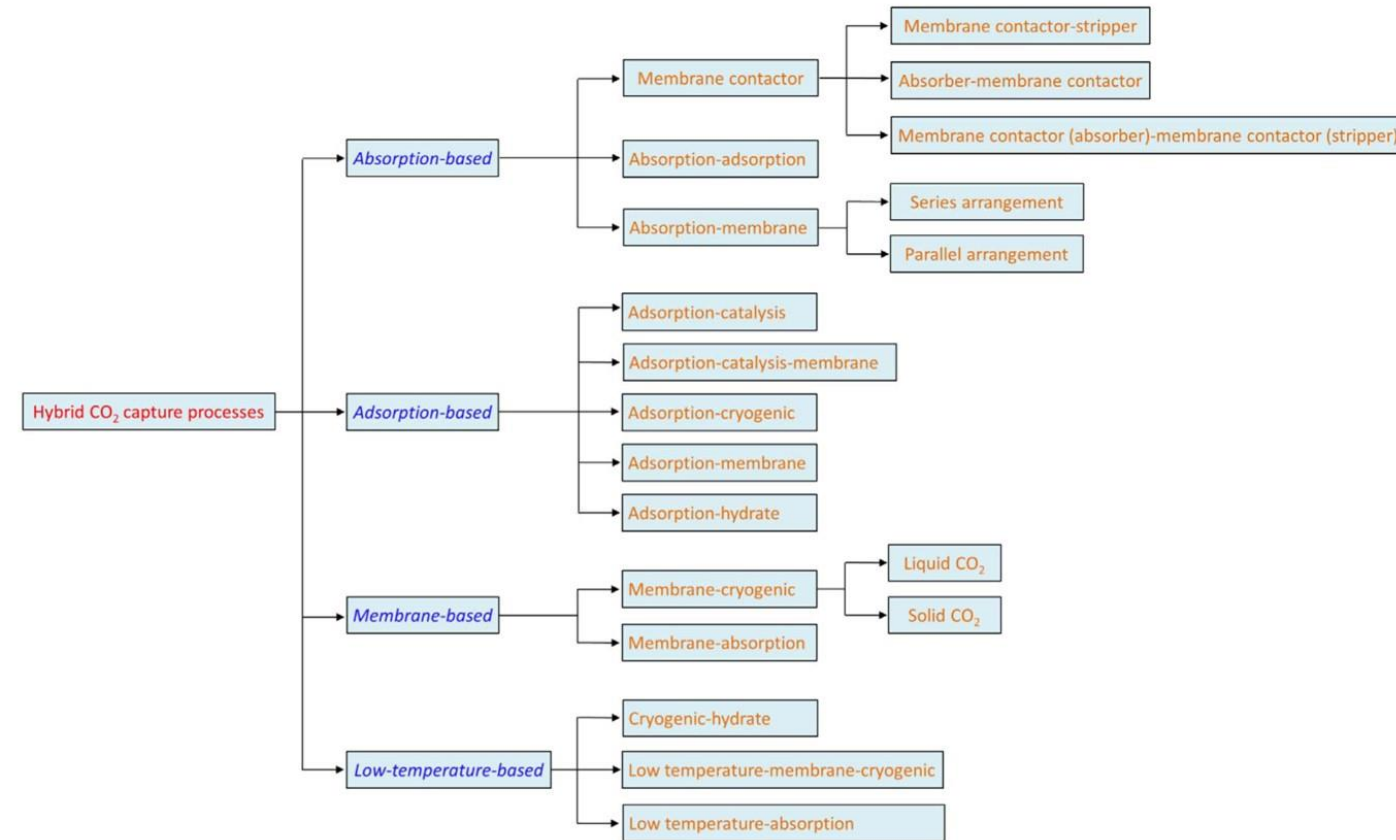
- Increasing levels of atmospheric CO<sub>2</sub> are a major contributor to anthropogenic climate change
- CCS aims to capture CO<sub>2</sub> from power plants and industry and sequester it underground
- Current capture and separation technologies use organic amines
- The margins of improvement are ever smaller and exploited.
- No single CO<sub>2</sub> capture technologies are suitable across the entire range of CO<sub>2</sub> compositions or streams.



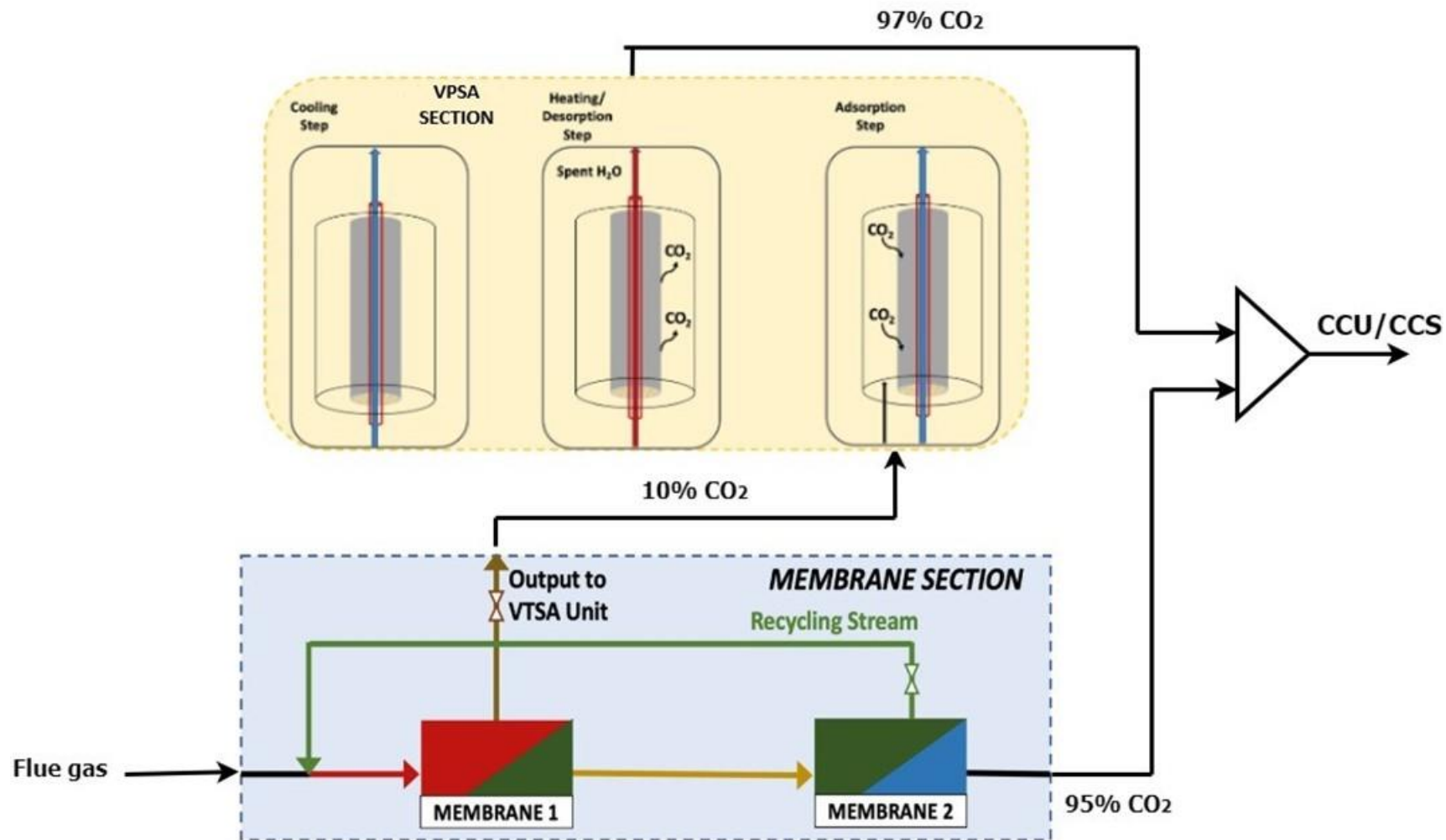
Combining different technologies into a hybrid system is more flexible and more cost efficient than conventional approaches.



Membrane/Adsorption  
hybrid technology



Hybrid Technologies

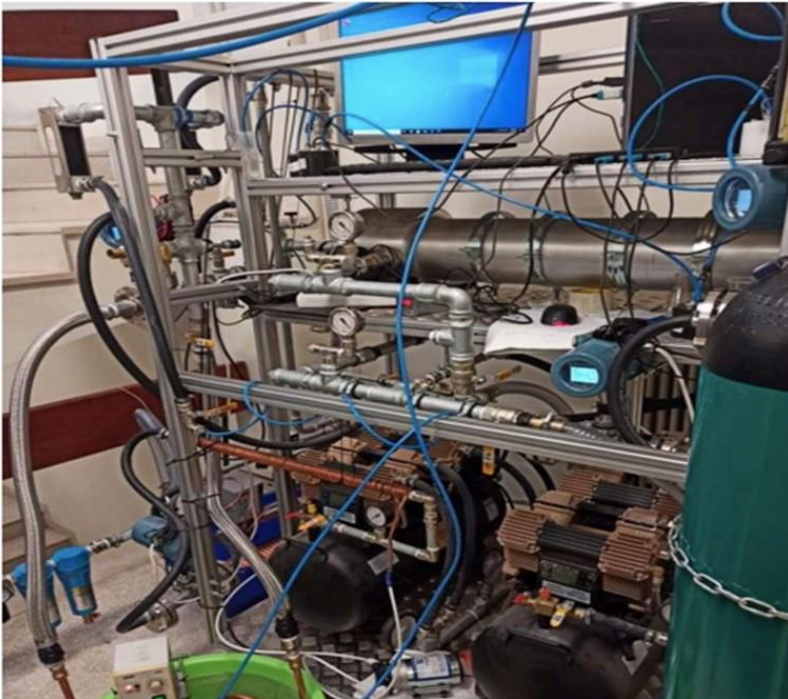


CARMOF is a hybrid system based on:

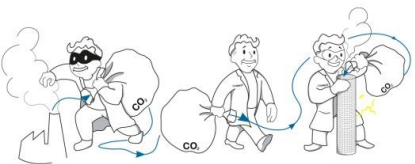
1. Membrane Separation Unit.
2. VPSA Unit.

A full ***demo pilot plant*** are planned for middle 2022 with a capacity of up to 100 tonnes CO<sub>2</sub>/year.

## 1. Membrane Unit:



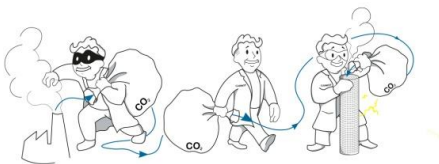
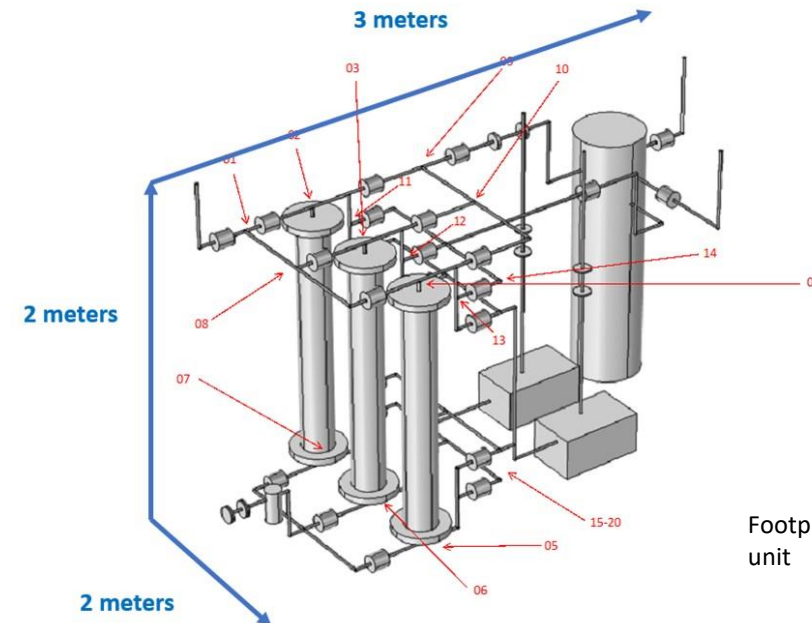
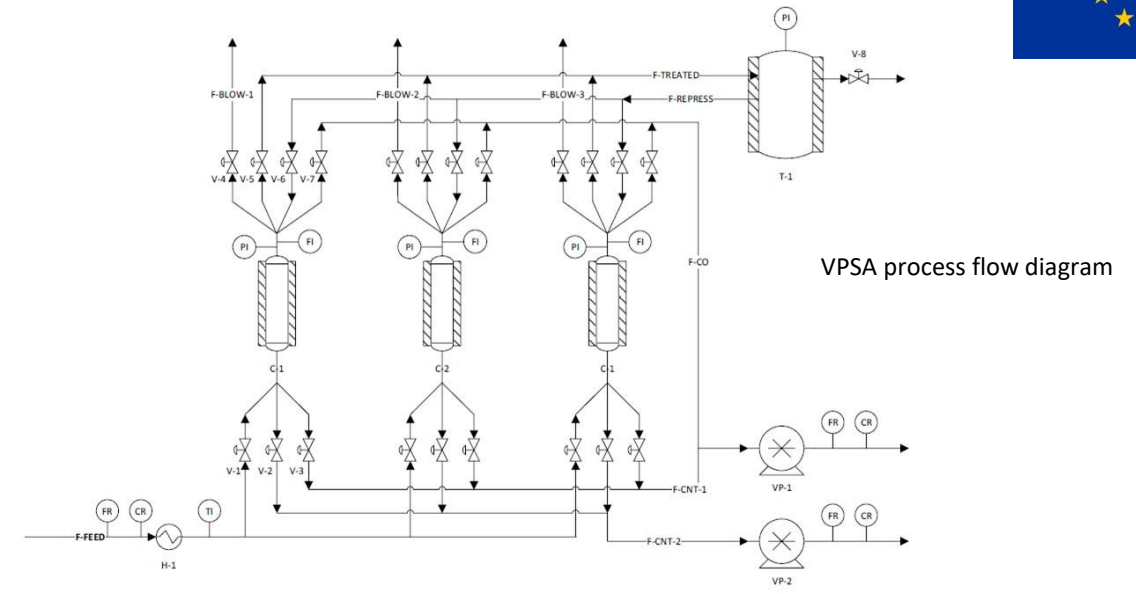
- The **membrane section of the demo unit** has been *designed, constructed, operated and optimized* using simulated dry flue gas to treat dry simulated flue gas with **flow rate 30Nm<sup>3</sup>/hr**.
- **Two-stage membrane** to produce 95 mol% of CO<sub>2</sub> to be mixed with the VPSA output.
- Gas input will be 30 Nm<sub>3</sub>/h, CO<sub>2</sub> concentration around 15% and 2 bar of pressure.





## 2. VPSA Unit:

- According to simulations to achieve the required CO<sub>2</sub> production dimensions of VPSA unit 3 columns are being manufactured with a size of 1.5 meters.
- Specific power consumption for the full stack with vacuum pumps is around **150 kWh/ton CO<sub>2</sub>**.



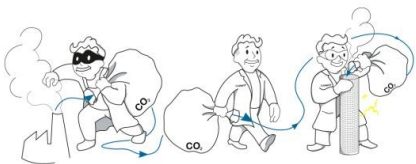
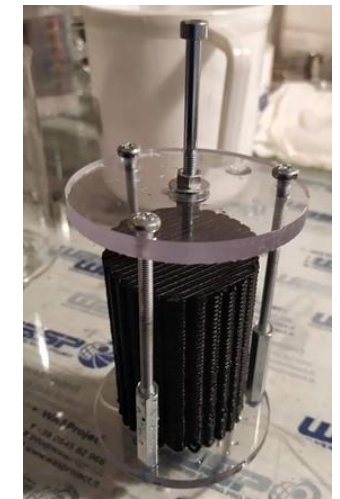


## 2. VPSA Unit:

- **Three columns** with sorbent material will be the basis of VPSA unit.
- **Sorbent pastes based on PEI/MWCNT** with high CO<sub>2</sub> adsorption performance.
- Pastes will be 3D printed with complex geometries (**monoliths**) to reduce pressure lost and to increase surface contact of the gas stream with the sorbent material.
- Scale-up of the pastes are done with a **twin-screw extruder**. Easy upscaling process.

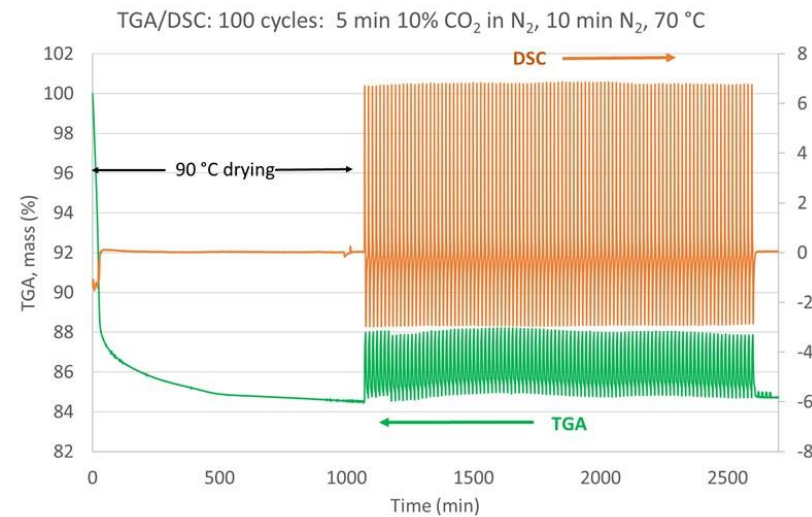
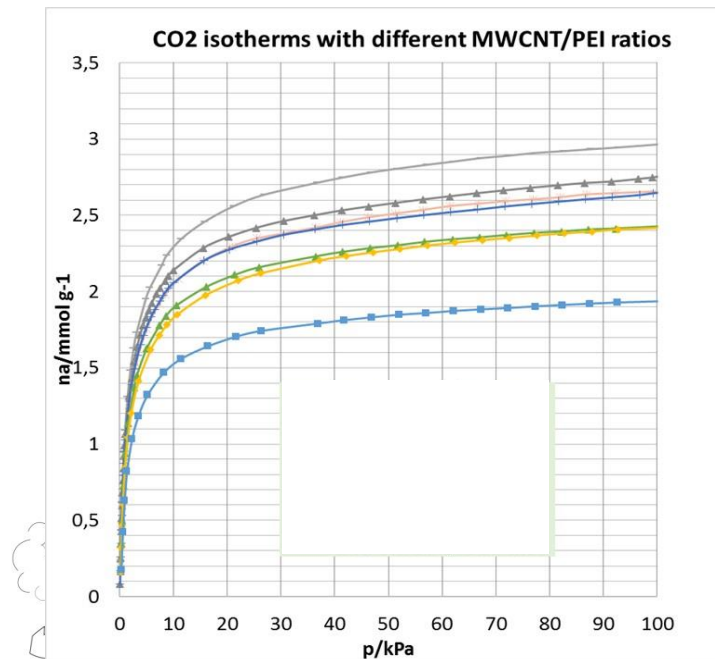


More than 900 Kg are being extruded



## Pastes Preparation (Mixing Process)

Until now best samples are MWCNT/PEI pastes, instead of 3 component. Combinations with rGO are giving promising results.

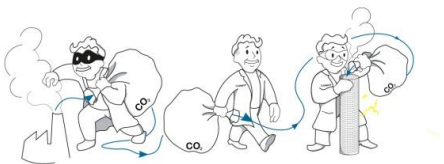


High selectivity to CO<sub>2</sub> over other gases as well as stable performance over high number of sorption/desorption cycles.

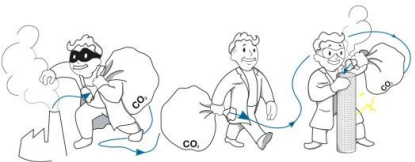
- For the MWCNT/PEI composite, MWCNT may act in two ways:
- facilitating the diffusion of CO<sub>2</sub> into the sorbent structure by diffusion through or along its surface, and
  - As spacer, avoiding thick aggregates of PEI leading to long diffusion paths through polymeric medium to reach sorption sites.

## Some of the expected impacts are the following:

- Increased competitiveness of CCS, by reducing the cost of CO<sub>2</sub> capture and the sustainability of the final products. Expected range of costs between 40-50€ by tonne of CO<sub>2</sub>.
- Increase the durability of CO<sub>2</sub> sorbent materials to reduce shutdown frequency.
- Producing new generation demonstrators based on hybrid concepts.
- Hybrid technologies will offer an impressive number of different combination of traditional technologies. This would allow to treat an extensive casuistry of gas streams compositions and sources.



- **Demonstrator will be built and validated at Kamari TITAN facilities.**
- **Equipment and services required for the adaptation of the plant facilities to the installation and operation of the demonstration unit, with emphasis on the connection of the flue gas stream to the CARMOF demonstration unit.**
- **The objectives are the following:**
  - To minimize energy consumption and CO<sub>2</sub> captured by day with purity > 97%.
  - To evaluate demonstrator performance under gas stream composition fluctuations (10-15%).
  - To prepare an instruction manual or guide based on the information collected by the end-user partners.





# Thank you

