



Development of a Circular CO₂ Capture and Reuse System for Small and Medium-Sized Industrial Applications

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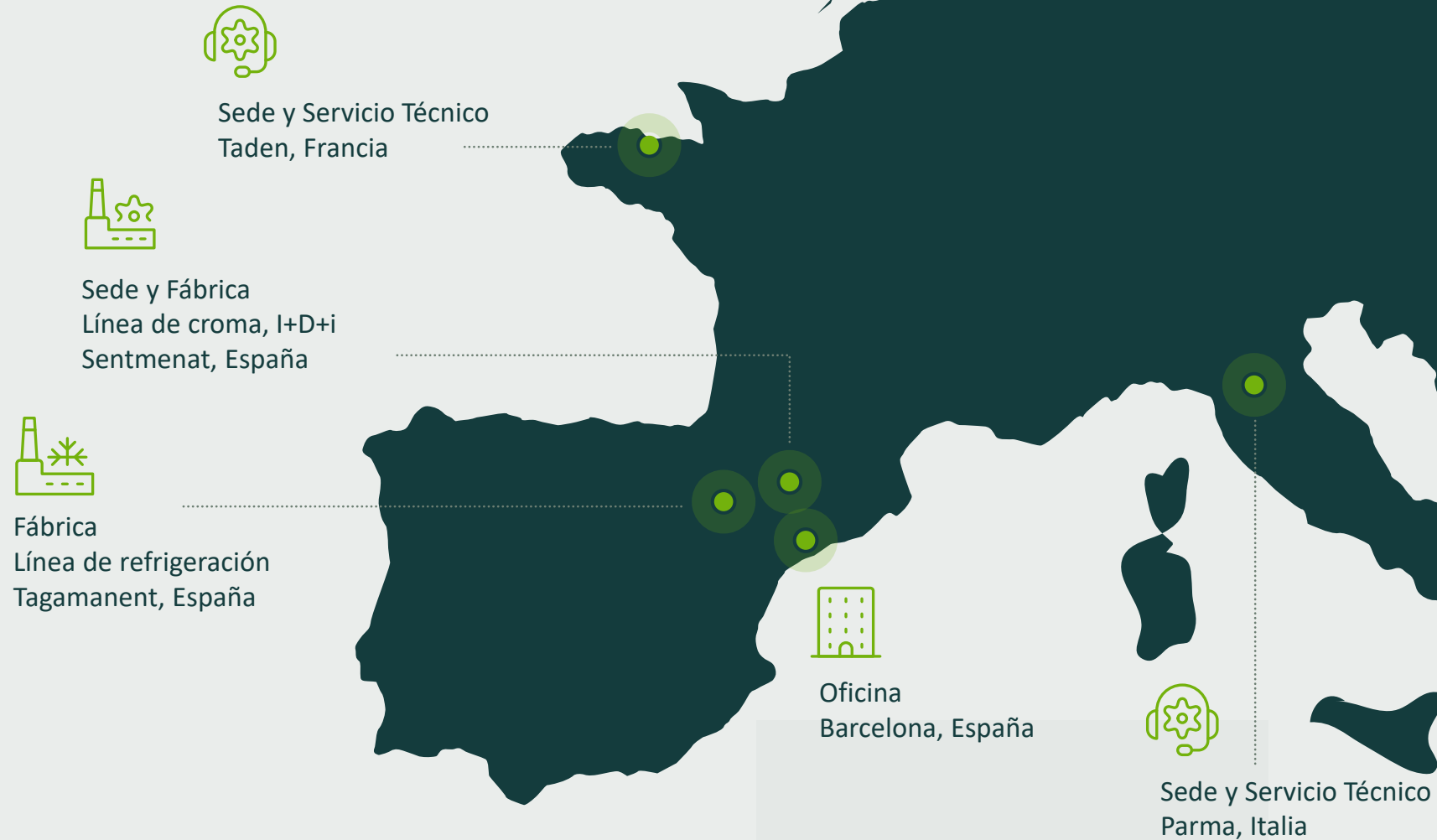
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Puntos estratégicos para una **servicio** **eficiente y confiable**



Nitrógeno

Oxígeno

Refrigeración

Secado

I+D



Capture and CO₂ use



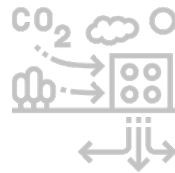
CO₂ Liquefaction from flue gas



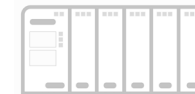
High temperature heat pump



Synthetic fuels



DAC CO₂ for holticulture



Own controllers and sensors and data processing

1. CO₂ market – Small to Medium Enterprises (SMEs)

Potential Market

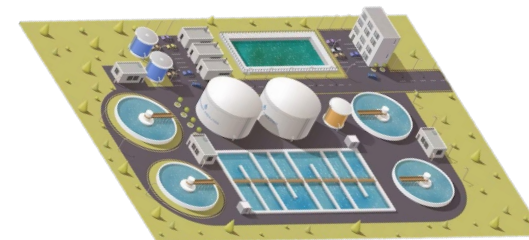
SPAIN: 310 ktCO₂/yr
EU: 1.650 ktCO₂/yr



Tonics, sparkling water, carbonated drinks

SPAIN: 24.000 tCO₂/y

EU: 180.000 tCO₂/y



Wastewater neutralization

SPAIN: 135.000 tCO₂/yr

EU: 750.000 tCO₂/yr



Meat processing

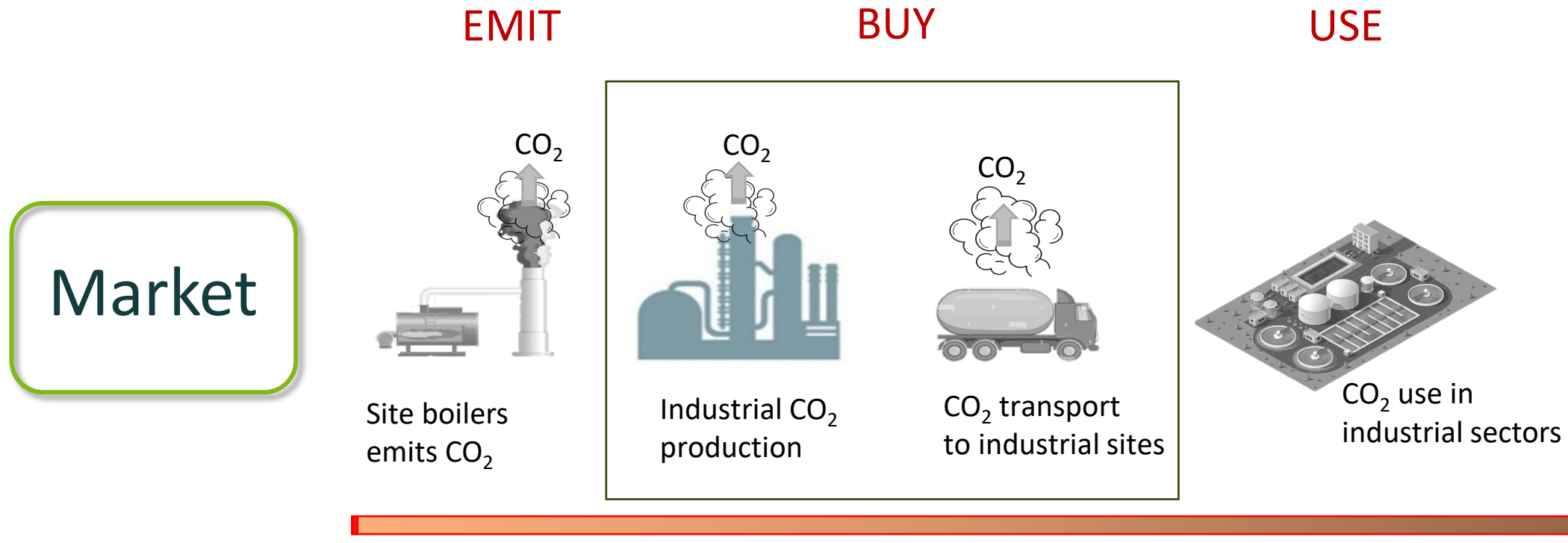
SPAIN: 125.000 tCO₂/yr

EU: 625.000 tCO₂/yr

And many others:

- Food packaging 12.000/ 25.000tCO₂/yr
- Waste incineration
- Synthetic fuels (methanol)
- Horticulture 14.000/70.000tCO₂/yr
- Surgical applications
- Algae production
- ...

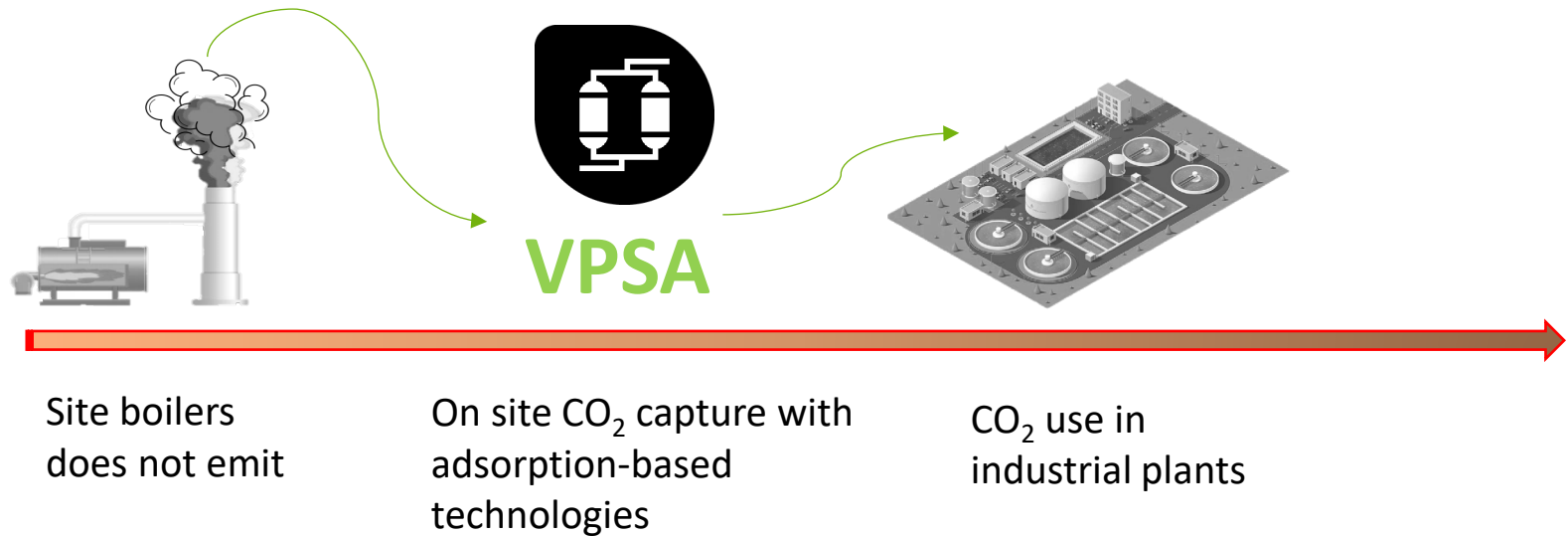
2. CO₂ market operation vs Our solution



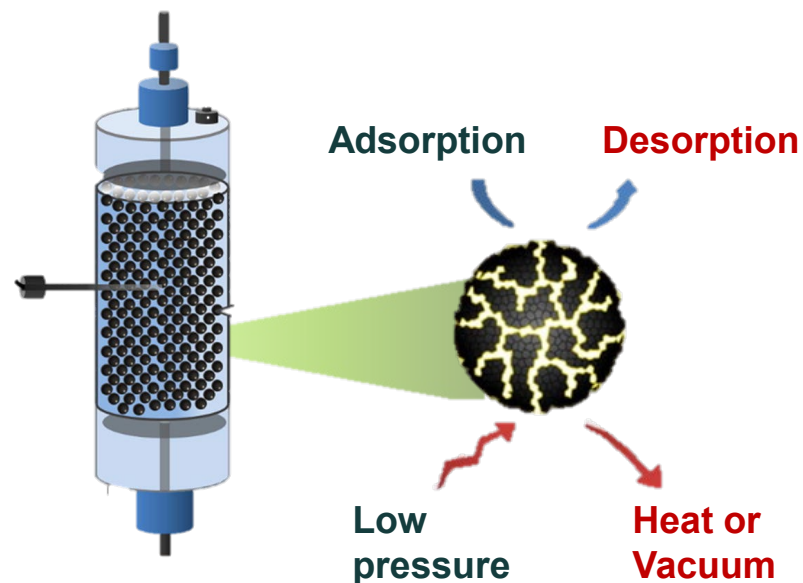
2. CO₂ market operation vs Our solution

Our
solution

CAPTURE AND REUSE



3. VSA technology and materials



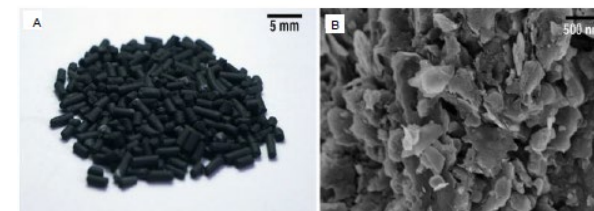
Zeolites – Binder or binderless.

Three dimensional microporous crystalline silicate structure composed of interconnecting channels with uniform pore sizes.



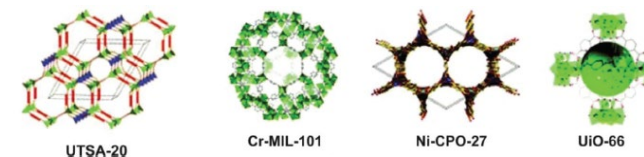
Carbon Molecular Sieves (CMS).

Amorphous microporous structure made out of inexpensive carbonaceous material with low inorganic compounds.



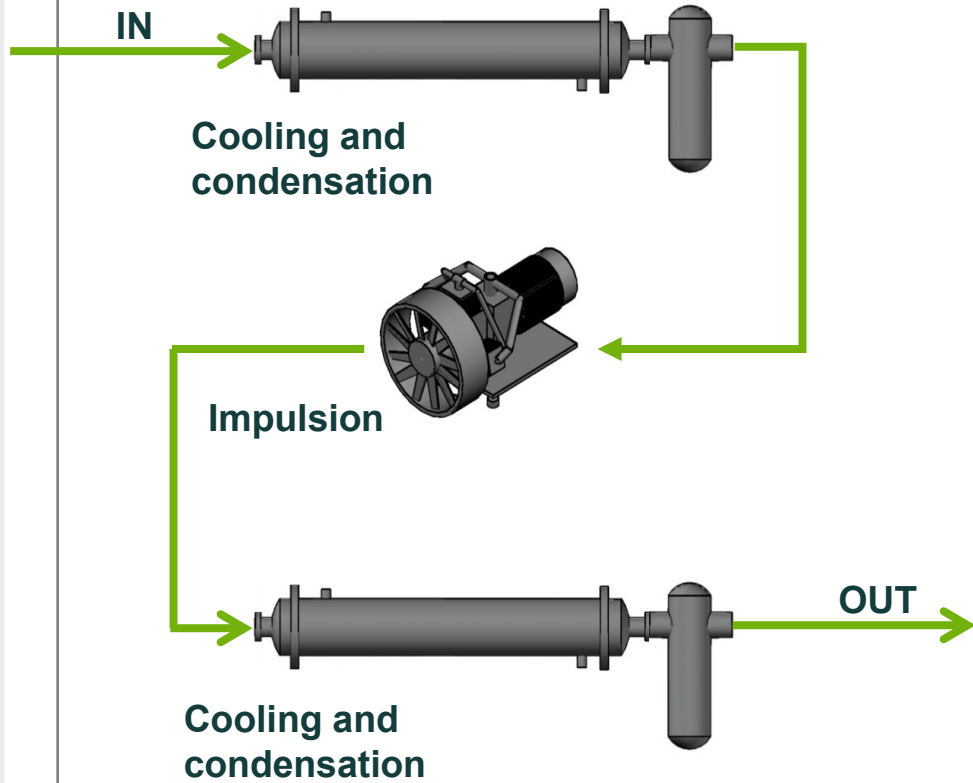
Metal Organic Framework (MOF).

Novel hybrid materials composed of metal ions, metal clusters, and organic ligands with extraordinary chemical tunable pore geometry.

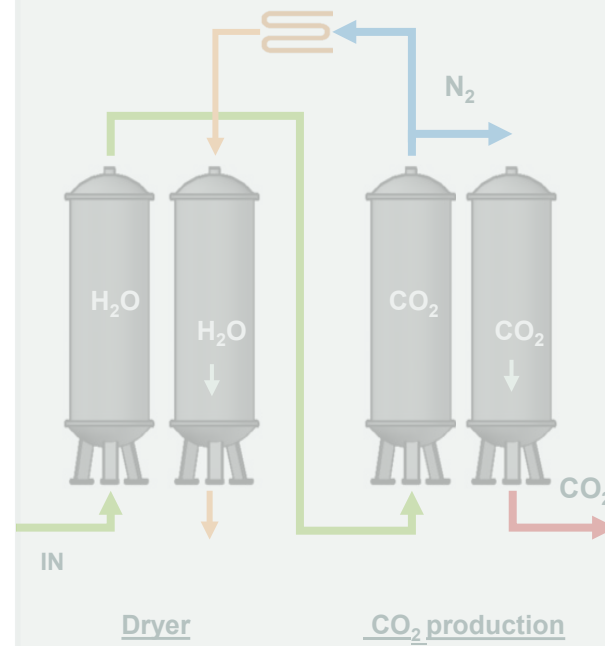


4. VSA process

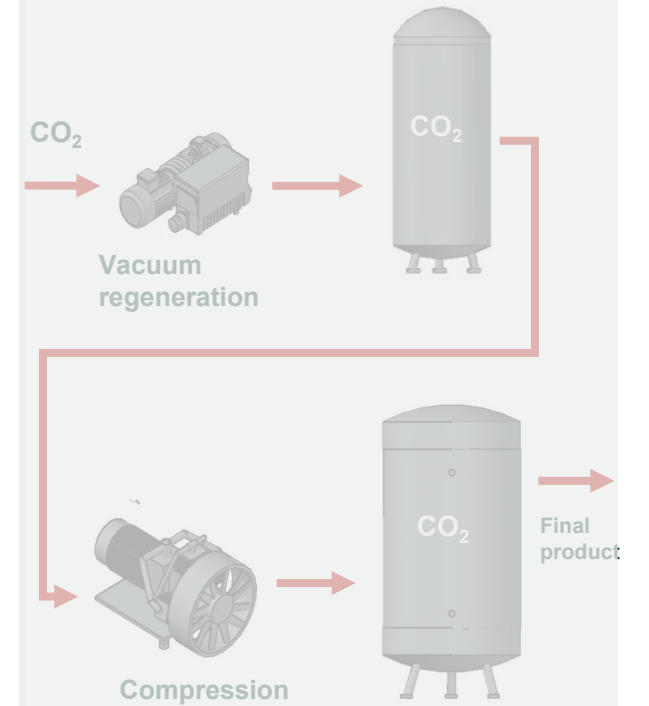
Pre-Treatment



Treatment

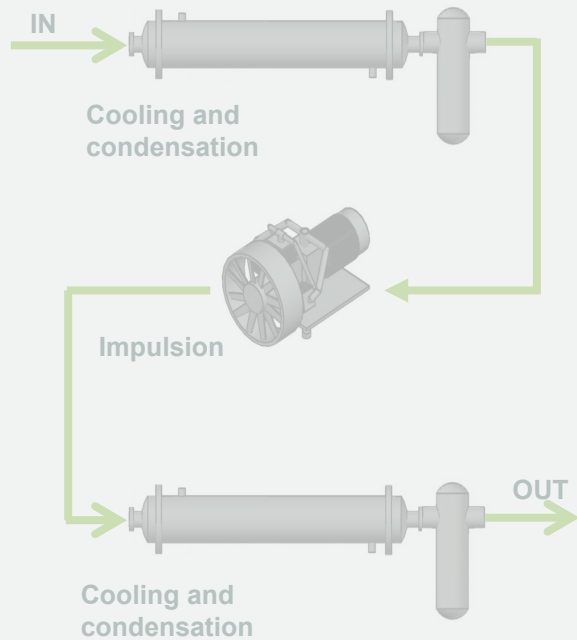


Post-Treatment

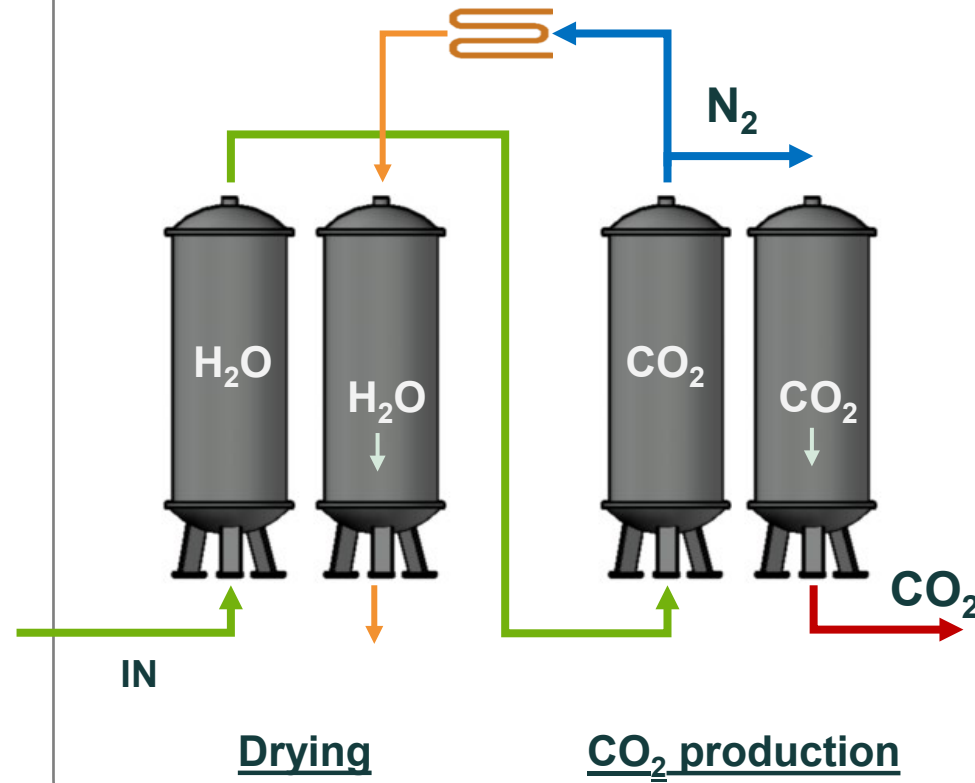


4. VSA process

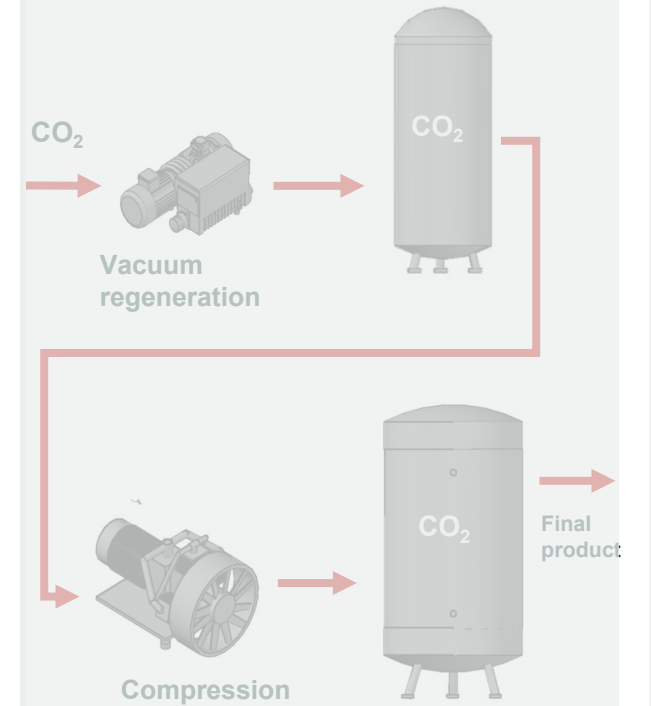
Pre-Treatment



Treatment

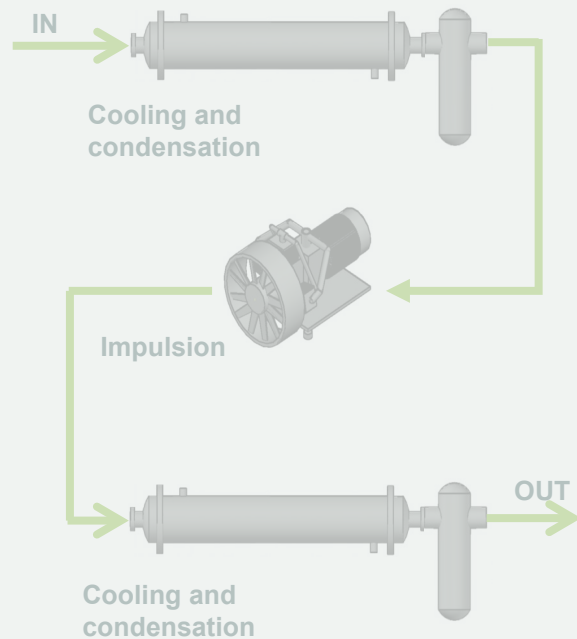


Post-Treatment

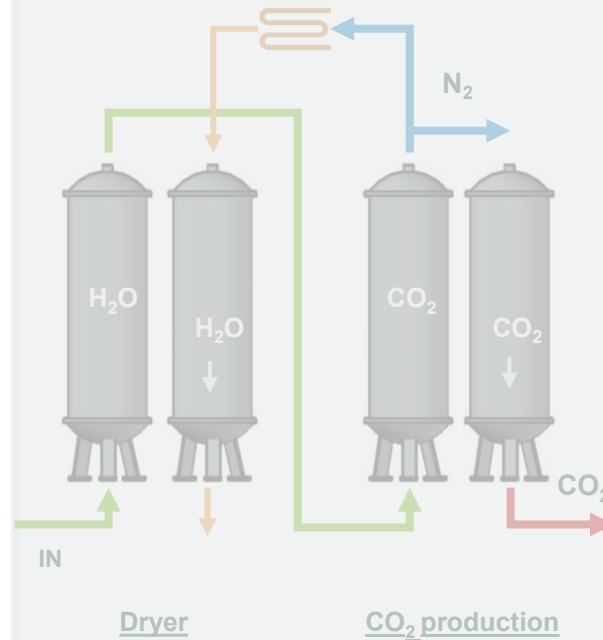


4. VSA process

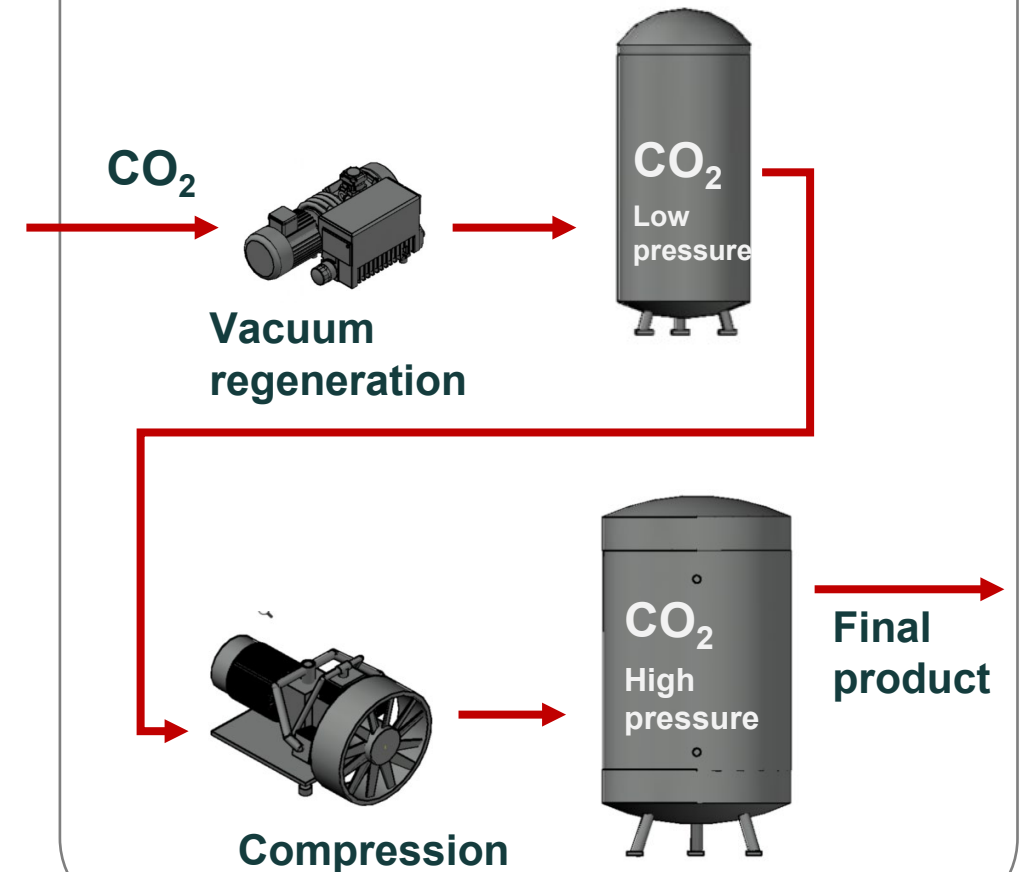
Pre-Treatment



Treatment



Post-Treatment



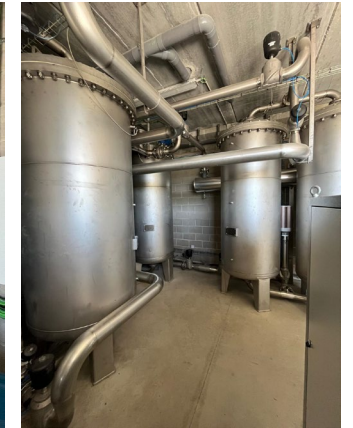
5. The journey from TRL5 to TRL9



DOCTORATS
INDUSTRIALS
Aliança de talent!



Generalitat
de Catalunya



2015-2019
TRL4

>

2020-2022
TRL5

>

2022-2023
TRL6-7

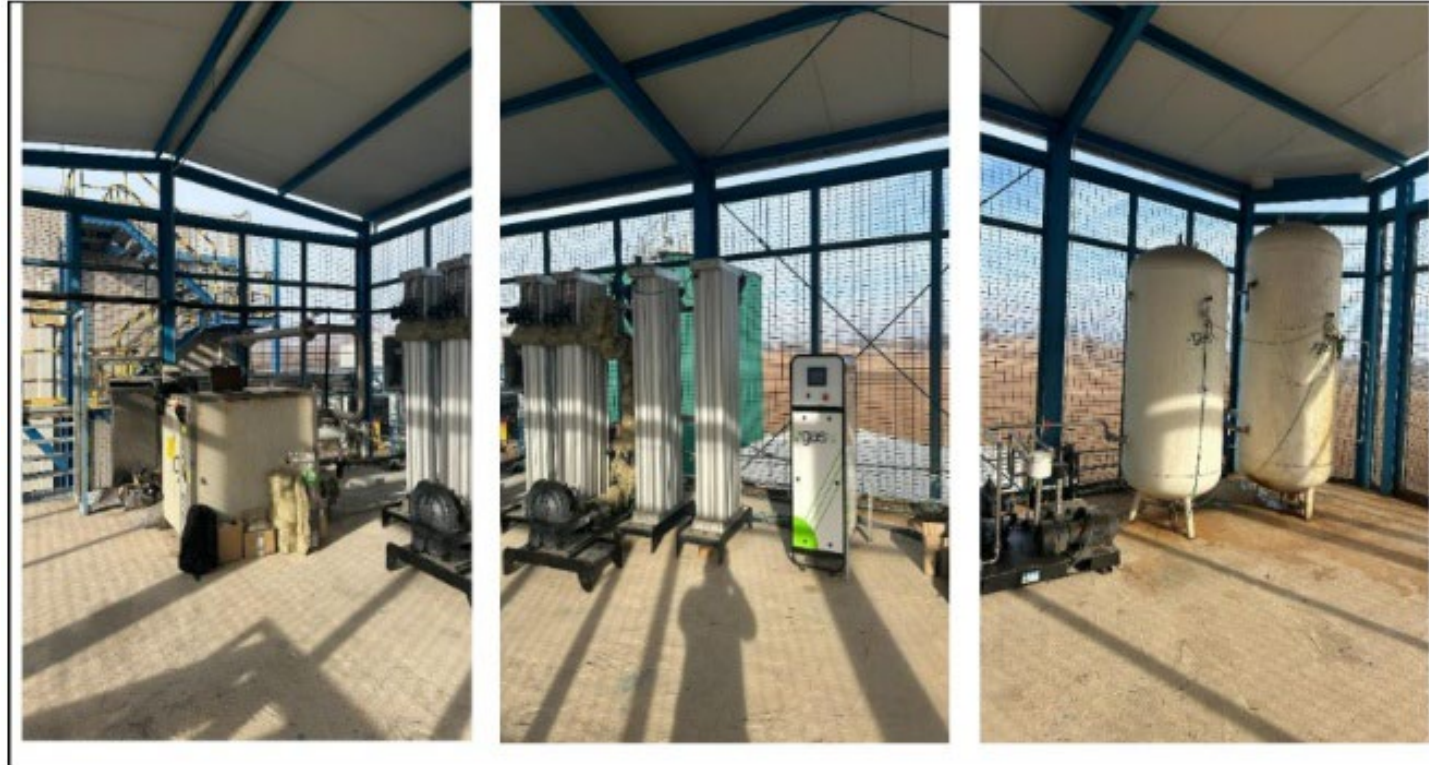
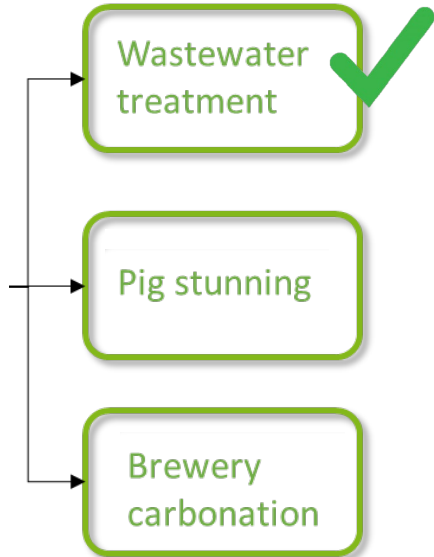
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2023
TRL8

>

2024-2025
TRL9

5. Pilot plant TRL 6-7. Spain (Girona).

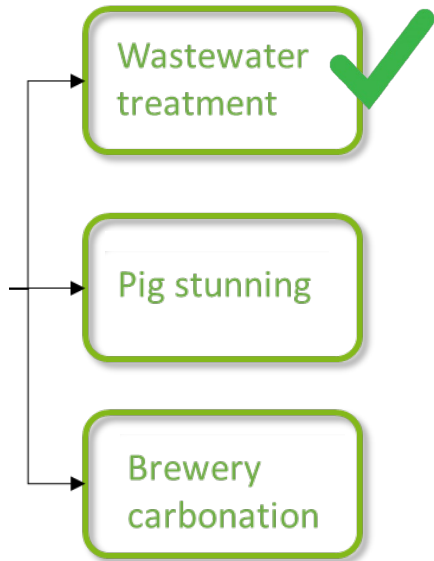


**Neutralization
Achieved**

Up to 70% purity / 1,1 kwh/kgCO₂ / 100 tnCO₂/yr

See LCA in Rafael González presentation on Session 7C, tomorrow

5. Pilot plant TRL 6-7. Spain (Girona).



**Neutralization
achieved**

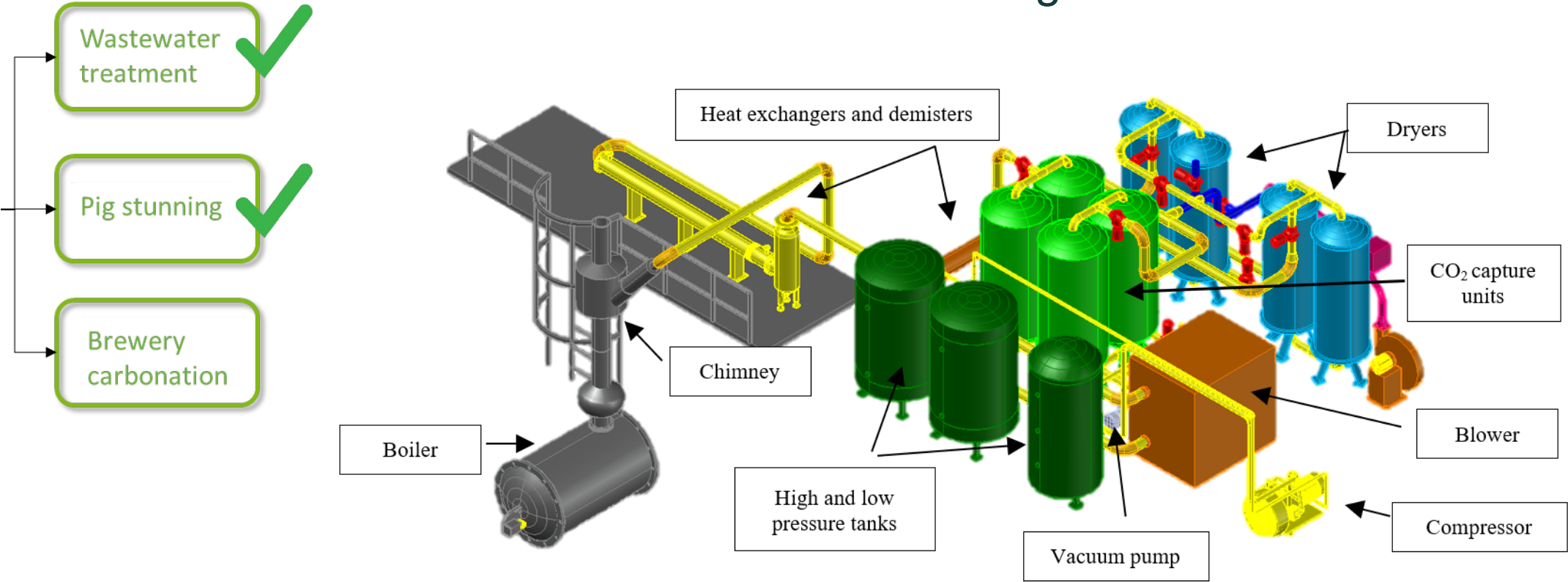
- 1 – Better column design
- 2 – More selective adsorbent for drying
- 3 – Better drying scale up
- 4 – Better condensation treatment
- 5 – Etc...

Learning curve

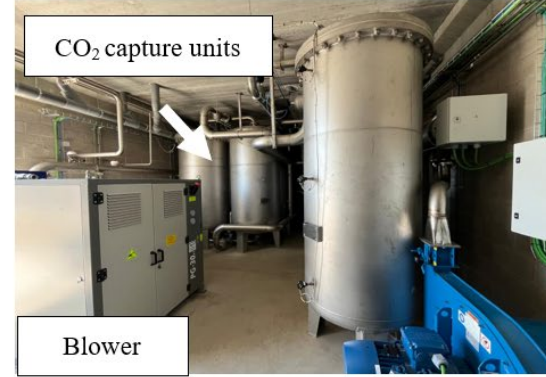
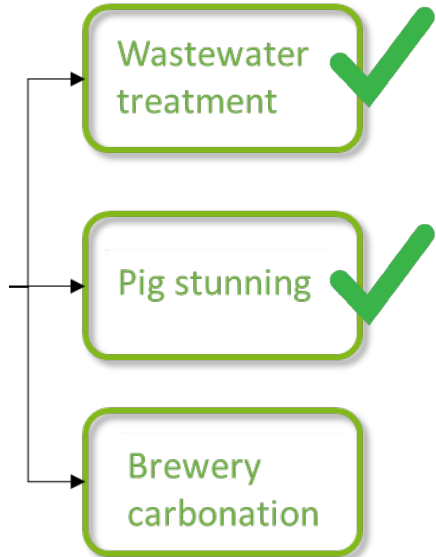
Up to 70% purity / 1,1 kwh/kgCO₂ / 100 kgCO₂/yr

5. Scale up plant TRL 8-9. Spain (Barcelona).

Re-design



5. Scale up plant TRL 8-9. Spain (Barcelona).



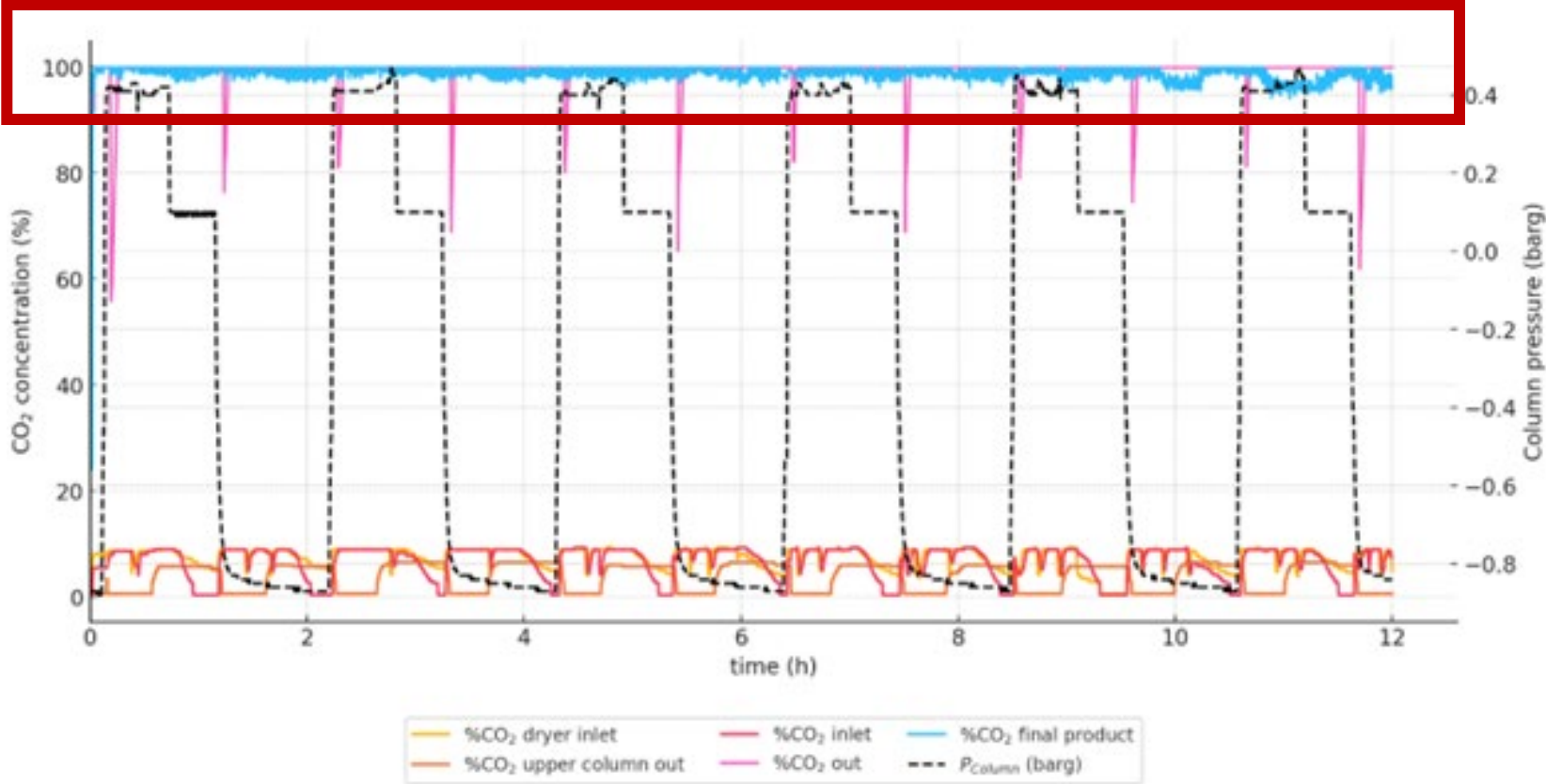
**Stunning
achieved**

Up to 99,5% purity / 0,65 kwh/kgCO₂ / up to 1.000 tCO₂/yr

1 year 2 months of continuos production

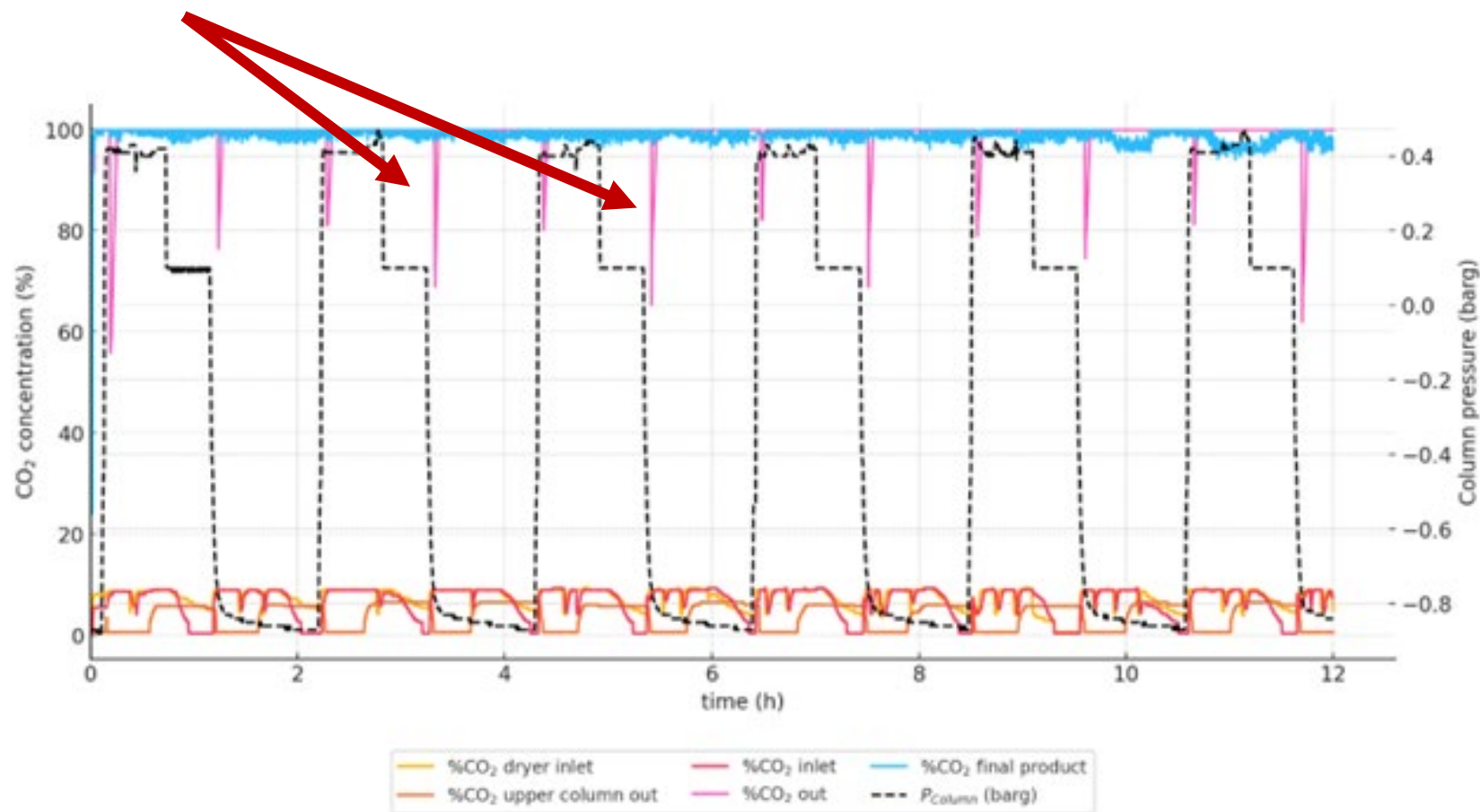
5. Scale up plant TRL 8-9. Spain (Barcelona).

Stable purity between 98-99,5%

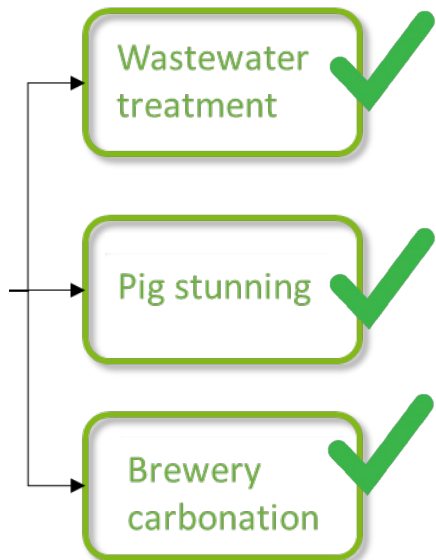


5. Scale up plant TRL 8-9. Spain (Barcelona).

Peaks of lower purity at the beginning of the regeneration



5. Pilot plant TRL 6-7. Spain (Lleida).



**Brew carbonation
achieved**

In commissioning

6. How future looks

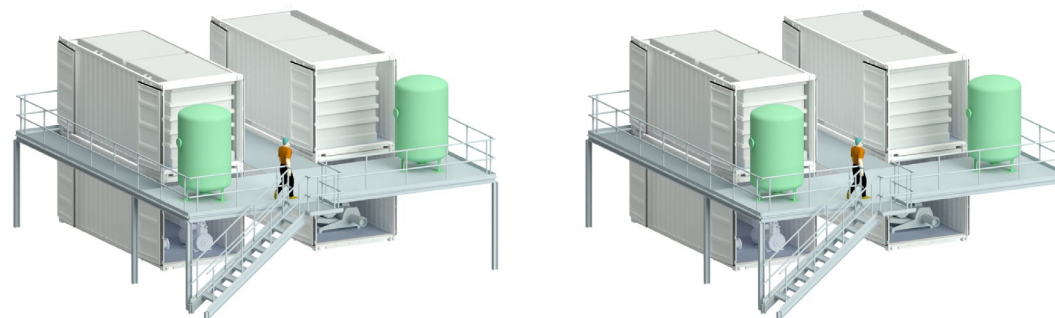
Next targets

Optimization of a carbon capture plant to achieve:

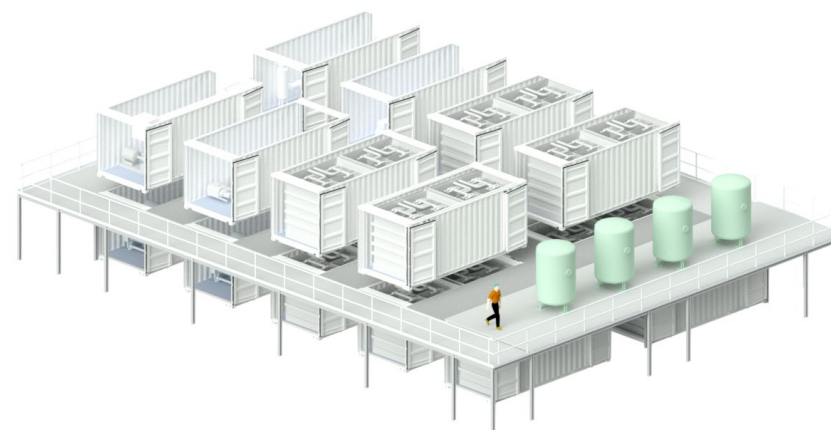
- OPEX cost: <0,5 kWh/kgCO₂
- CAPEX cost: <100 EUR/tnCO₂
- Production: scale up to 10.000 tnCO₂/yr

Challenge: cost effective adsorbent with higher working capacity.

2.000 tn CO₂ /yr



10.000 tn CO₂ /yr



7. Facilities available for testing adsorbents



Several columns

VSA/VPSA

TSA – Direct hot gas

Recirculation

Double stages



8. Conclusions



Demonstrated feasibility of a circular CO₂ capture and reuse system for SMEs.



Continuous operation >1 year with VSA technology using zeolite 13X.



Achieved up to **99.5%** CO₂ purity with **competitive energy** consumption ($\sim 0.65 \text{ kWh} \cdot \text{kg}^{-1} \text{CO}_2$).



Successful applications in wastewater neutralization and stunning.



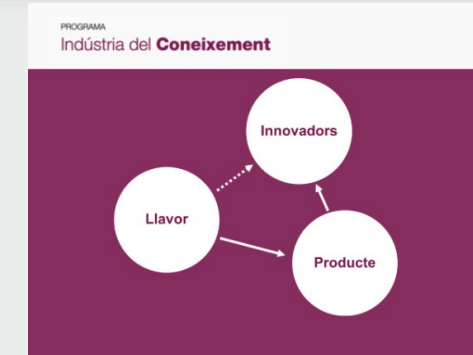
Next Step

Further **scale-up requires** improved adsorbents with **higher working capacity** at affordable cost.

Promising pathway towards decentralized and circular CO₂ management for industry.



Acknowledgements



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www.gasn2.com

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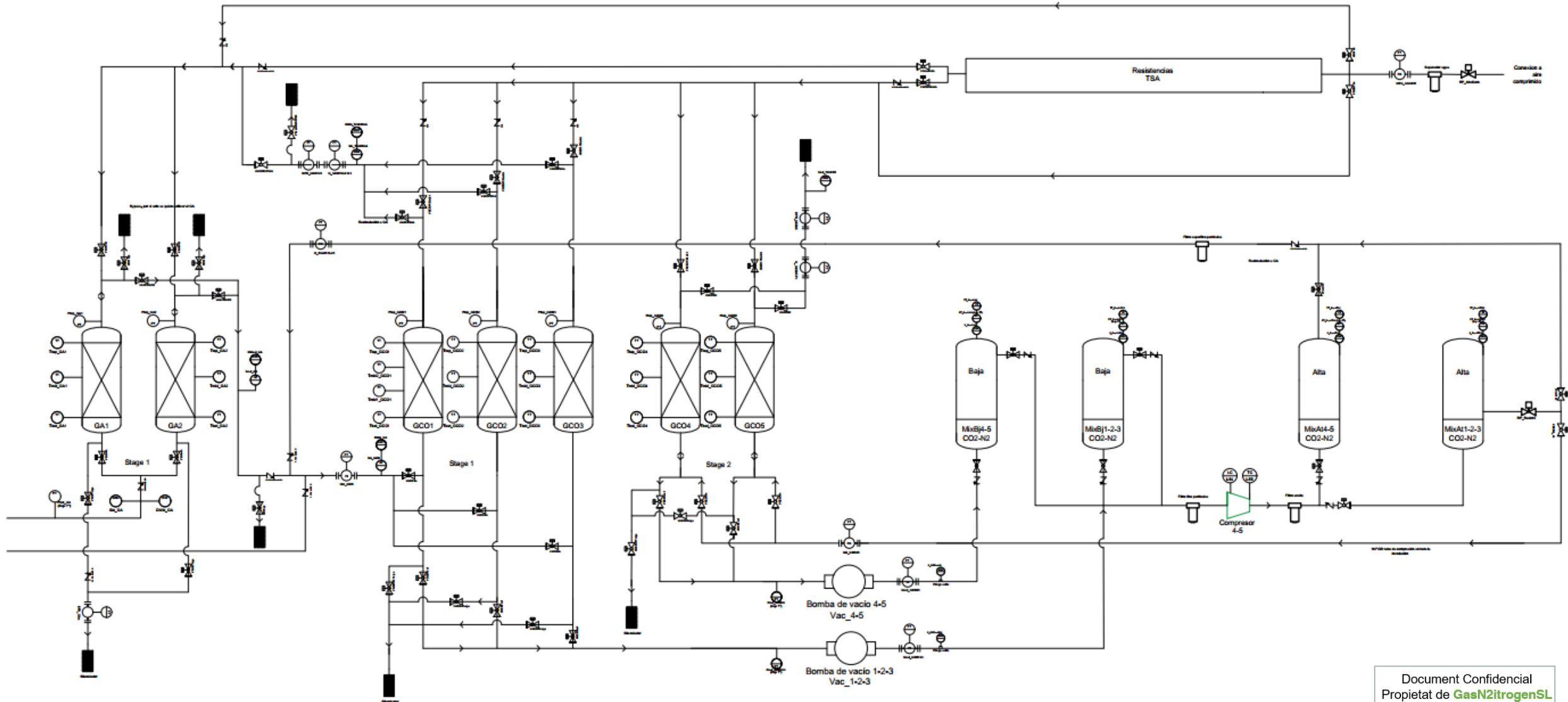
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10. Back up slides



10. Back up slides

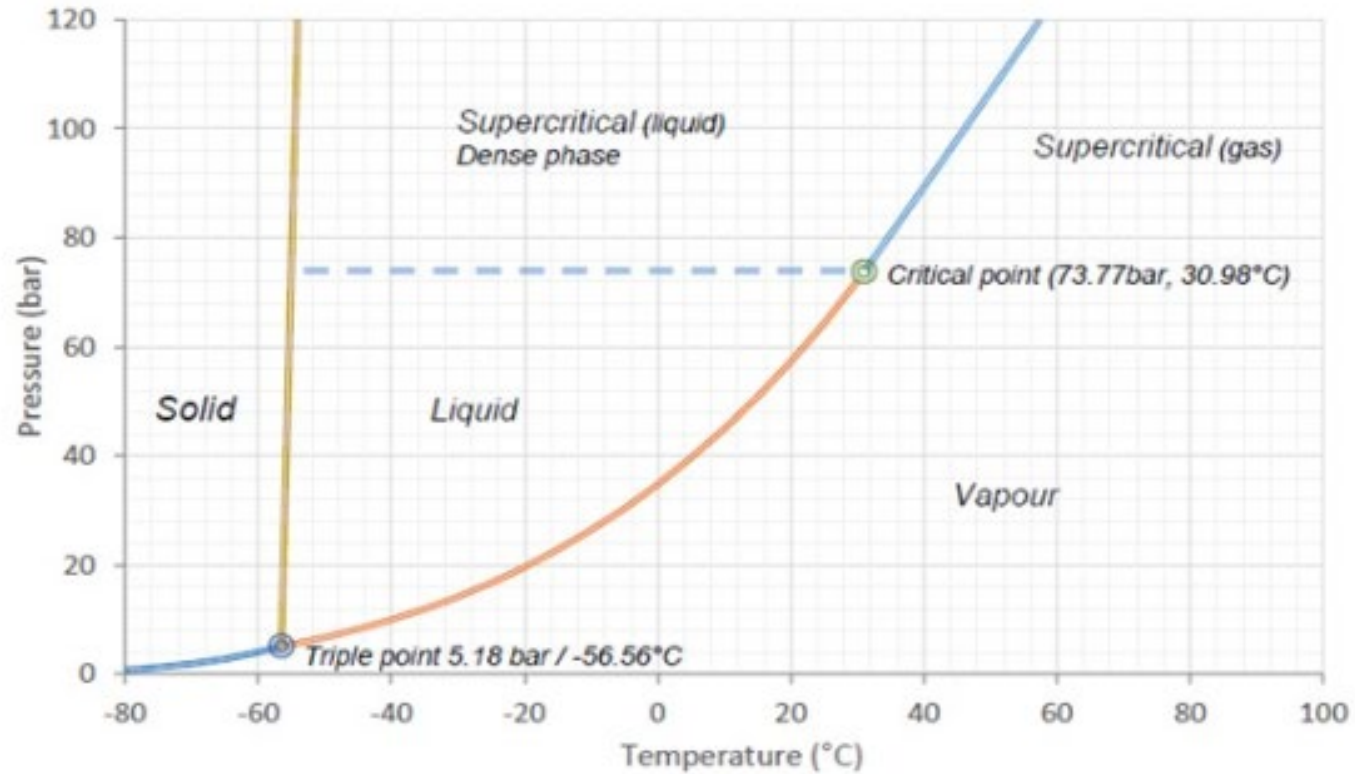


Figure 2: Phase diagram of pure CO₂ based on the Span and Wagner equation of state (Span and Wagner, 1996)