Building Integrated Carbon Capture (BICC)

Jacques Gilbert de Cauwer[1]*, Salar Fakhraddinfakhriazar[1], Vincent Lemort[2], Gregoire Léonard[1]

Abstract

The great question regarding the renewable energy transition revolves around how to accelerate and successfully implement the shift from traditional, fossil-fuel-based energy sources to renewable and sustainable alternatives. This transition is crucial for addressing climate change, reducing environmental impact, and ensuring a more sustainable future. The disproportionate consumption of energy, coupled with the inadequate capacity of plants to recycle emitted CO_2, contributes to its rising atmospheric concentration and climate change. Consequently, to change the fossil energy paradigm, we have to develop a circular economy for carbon.

This research project is setting the hypothesis that capturing CO_2 in the ventilation system of buildings could contribute significantly to decrease its carbon footprint. The 2 main objectives are:

1. Design an “air contactor” functionalized for CO_2 adsorption.
   a. A new concept for DAC (direct air capture) fully integrated in the ventilation.
2. Simulate the interaction between the DAC system and the HVAC system.
   a. Study the synergy with the heating/cooling flows, considering air recirculation.

Methodology

Experimental work

Phase one : material design/characterization: using BET, SEM, TGA, FTIR,

Phase two : material testing: run small sample in the designed test bench to determine :

-Adsorption capacity

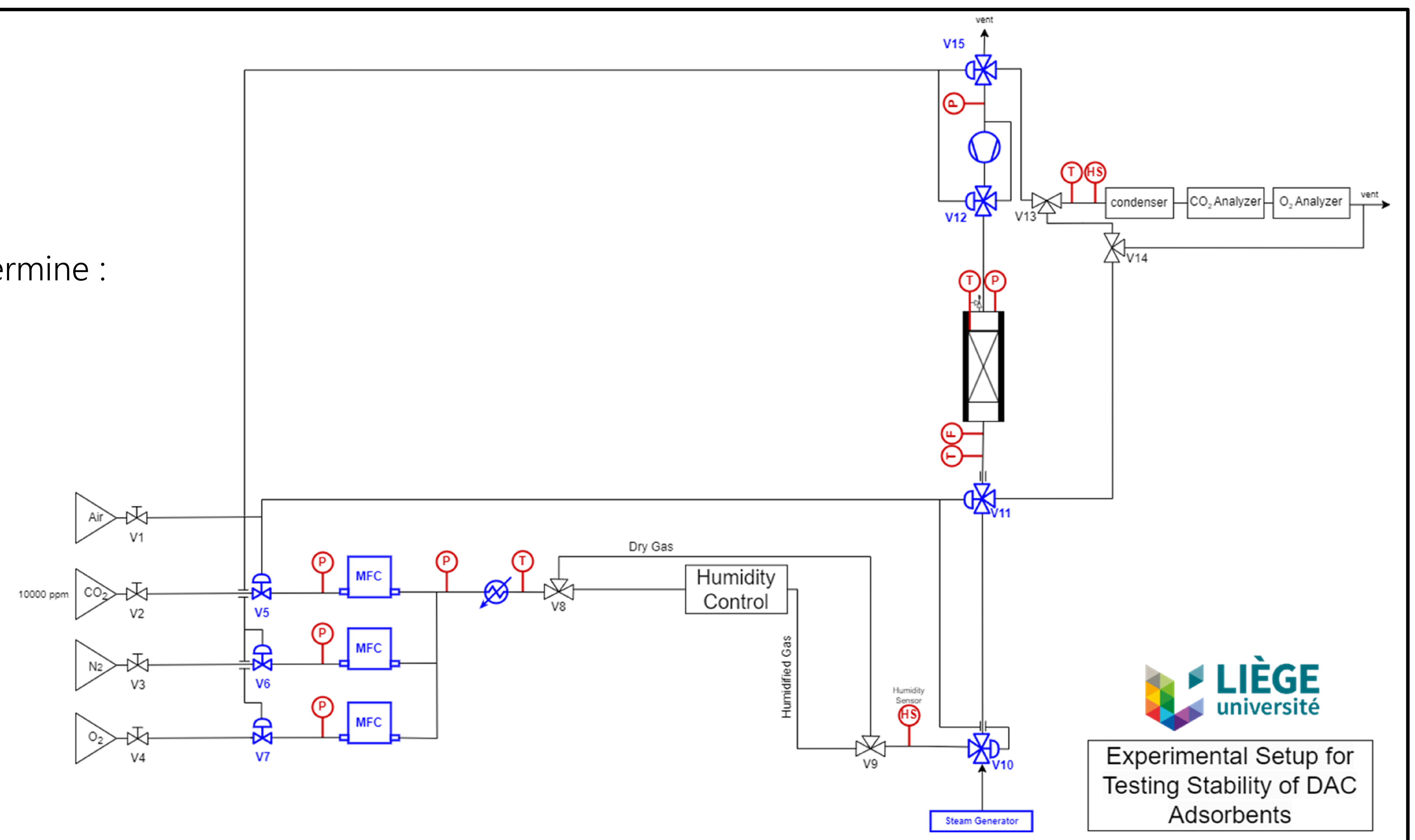
-Adsorption/desorption kinetics

-Desorption energy

-Material stability and cyclic performance

Modelling work

Work with Dymola/Modelica™ to simulate interaction between different building technical systems (HVAC, PV,…) and the DAC unit.



Experimental Setup for Testing Stability of DAC Adsorbents

First results and discussion

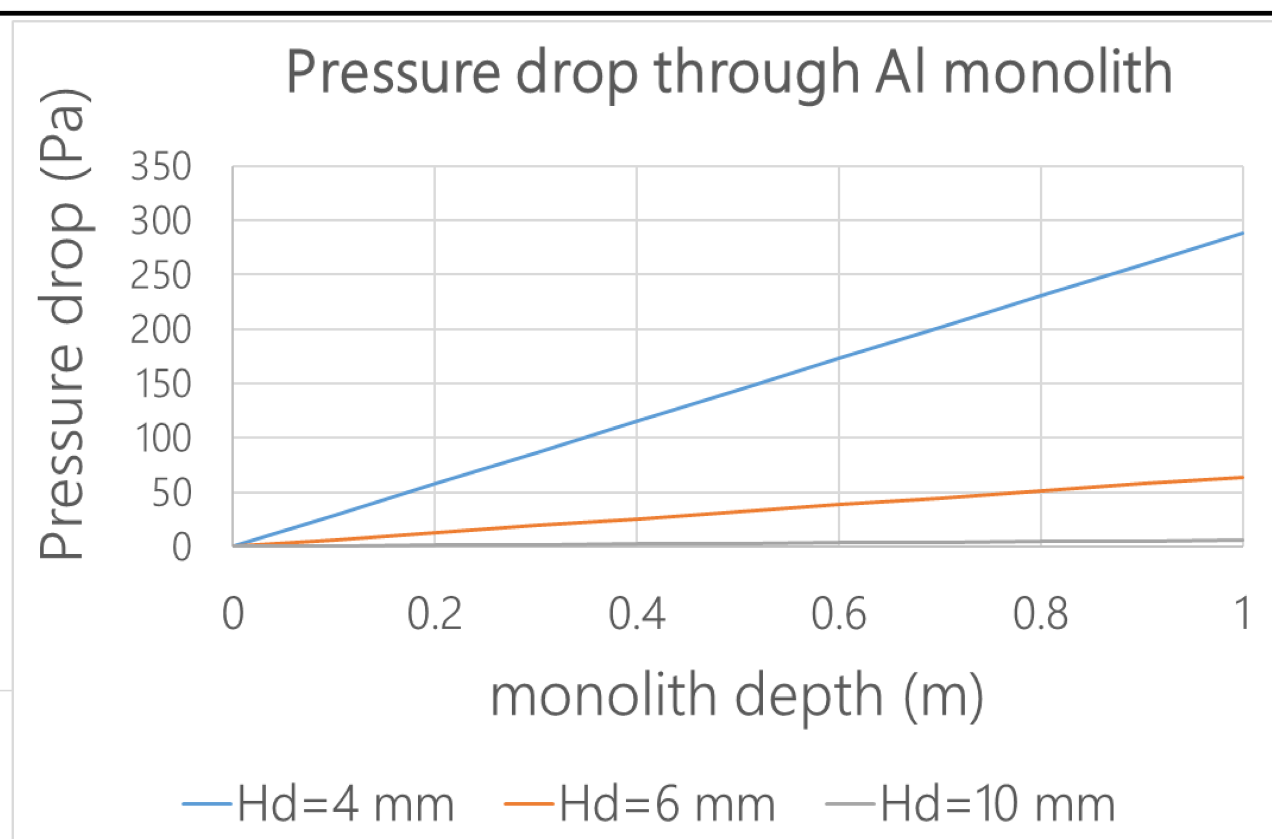
Scenario (Alu monolith)

Location : Brussels (B),

Building : 4000 m², 12 000 m³

ventilation = 10 000 m³/h @ 1000ppm CO_2

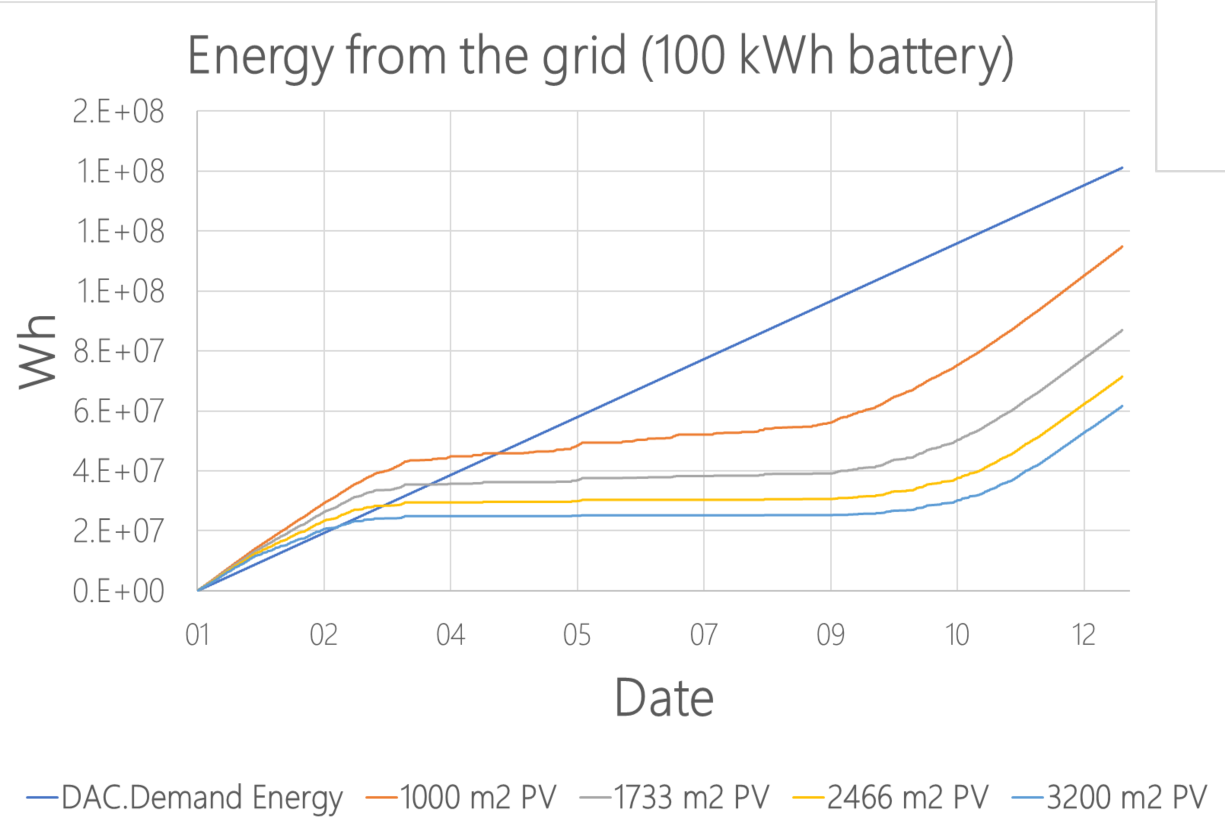
3200 m² PV



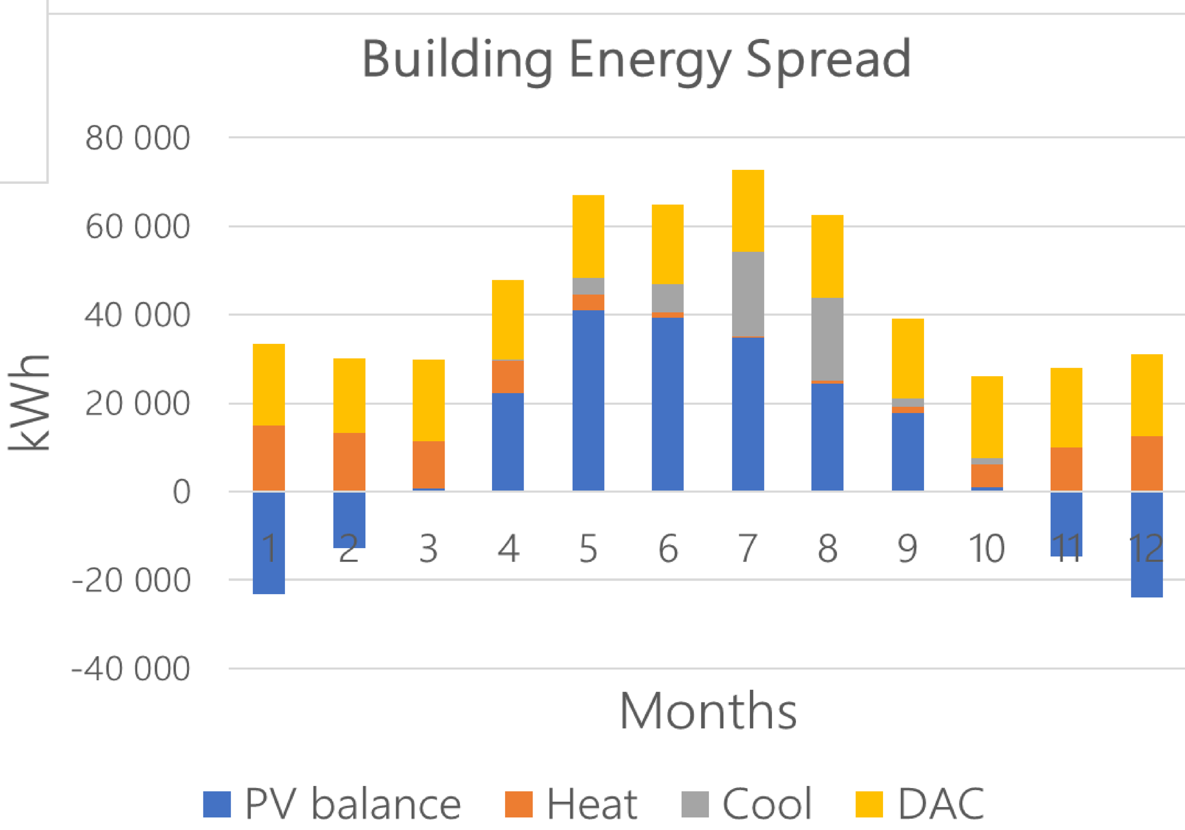
-Alu monolith provides very high porosity compared to carbon or ceramic

-Not enough PV energy during 4 months in winter, increasing PV capacity is not a solution.

-Opportunity to utilize over production in summer (other uses : electric car charging , H_2 production)



DAC and regeneration (12h/day), P = 50 kW,
Contactor mass = 110kg, S/V = 720/1 m⁻¹
High Porosity = 96%
CO_2 captured/cycle = 2.24kg
(228 kg/day, 83T/year)



Conclusion

- BICC potential for DAC : +- 10 % of building emissions in the EU
- Potential synergy with HVAC to reduce energy consumption
- Need to estimate the cost of building integrated DAC.
- Need to develop DAC with efficiency > 1kg CO_2/kWh to be more attractive than replacing kWh from fossil fuel power plant, with PV source.

References

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[1] University of Liège, Chemical Engineering, Liège, Belgium
[2] University of Liège, LaboThAp, Liège, Belgium
*Corresponding Author: jgilbert@uliege.be