CONTINUOUS PROCESS FOR CAPTURING CO_2 FROM A FLOW BY ADSORPTION AND REGENERATION USING SOLID COUNTERCURRENT ADSORBENT CELLS

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Context

It is now well known that achieving the objectives of the Paris Agreement requires a significant reduction in GHG emissions. First and foremost, this requires an improvement in energy efficiency as well as the massive deployment of clean energy. However, due to their nature, it is obvious that many industries will be challenging to decarbonize in the short or medium term (e.g., steel and cement production, air transport). To neutralize these unavoidable GHG emissions, the United Nations Environment Programme estimates that, in these particular situations, CO_2 will need to be captured at the source of the emissions, if possible, or directly from the atmosphere.

CO_2 capture and sequestration is a category of negative emissions that aims to remove CO_2 from the atmosphere using physicochemical separation processes. According to the International Energy Agency (IEA), it is estimated that by 2050 CO_2 capture directly from the atmosphere will need to reach a level of nearly 1 billion tonnes of CO_2 per year.

Note that Canada has already committed to achieving carbon neutrality by 2050 and has a carbon tax that will reach \$170/t_{CO2} in 2030. Needless to say, this market will need to grow significantly over the next few decades to meet global targets.

Although some CO_2 capture technologies are already under development, these conventional processes are still too expensive and exceed \$500/t_{CO2}. New technologies such as the one presented below are required to successfully enter this emerging atmospheric CO_2 capture market.

Description

The proposed technology is an integrated capture and sequestration system comprising a modular apparatus for capturing CO_2 from the atmosphere or from industrial effluents. The system uses a CO_2 capture process based on specially designed porous materials in a continuous cycle of adsorption and regeneration. The adsorbent material is functionalized to provide a large capture surface area in a small volume, allowing the CO_2 molecules in the treated gas to be fixed quickly and efficiently. By modifying the surrounding pressure and temperature conditions of the material, the captured CO_2 is then released in concentrated form. Once released from the material, the high purity CO_2 can then be used or sequestered. Sequestration can be achieved through a low temperature chemical carbonation reaction, which reacts CO_2 dissolved in water with finely ground mining or industrial debris. This system can be installed directly on an industrial or mining site with the process powered 100% by electricity, including Hydro-Quebec's renewable hydroelectricity.

In the era of the ecological shift, this innovation is therefore part of a very favorable socio-economic context with a strong growth market trend. This innovation was awarded a US\$250,000 prize to further its marketing at the COP26 conference in Glasgow in November 2021, as it won over the jury of the prestigious international XPRIZE Carbon Removal competition.

Applications

- Capture of CO_2 directly from the atmosphere
- Capture of CO_2 from large emitters
  - e.g. manufacturing, mining, oil industry, etc.
- Distribution of high purity CO_2 (>90%) for use or sequestration
- Offset of carbon credits

Commercial Advantages

- **Low capture and sequestration costs** (\$50-150/tCO_2)
  - Due to reduced OPEX and CAPEX
  - Due to overall technical benefits (see next section)

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- **Low operating costs (OPEX)** ;
  - More efficient system requiring less energy
- **Low capital costs (CAPEX).**
  - Configuration requiring less adsorbent material
  - Modularity of the system and easy scaling up
- **Flexibility** of the system to be relocated
- **Modularity and scalability** of the system based on a single stand-alone capture unit that can be adapted to the needs by adding units.
- **High concentration** CO_2 production (>90%)

Technical Advantages

- **Increased performance;**
  - Continuous process
  - Optimal heat recovery
  - No thermal cycling of reactors
  - Minimization of flow pressure losses
  - Minimization of the amount of adsorbent material required
  - Low temperature regeneration
- **Integrated solution** for *in situ* capture and sequestration.
- **Versatility** allowing the decontamination of asbestos mine tailings via CO_2 sequestration by carbonation.
- **Universality** applicable to a wide range of CO_2 concentrations.
- **Synergy** when coupled with industrial and sequestration systems
  - Revalorizes low temperature thermal discharges ($T \approx 100°C$)

Keywords

- GHG reduction solution
- Carbon capture and sequestration
- Carbon Credits
- Carbon neutrality
- Fighting climate change

Technology Readiness Level (TRL)

Technology Readiness Level 5 in 2022: validation of the technology in a representative environment. The basic technological components are integrated with reasonably realistic elements so that the technology can be tested in a simulated environment. Projected production of the commercial system with a capacity of 1000 t_{CO2}/year in 2027

Intellectual Property

Patent request filed Canada, United States, Europe, China; *System and Method for Continuous Gas Adsorbate Capture using Adsorption/Regeneration Cycle*)

Seeking

- Collaborative research for prototype development
- Business partners
- First-time investors
- Financing

Contact inventor

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Annex

Example :

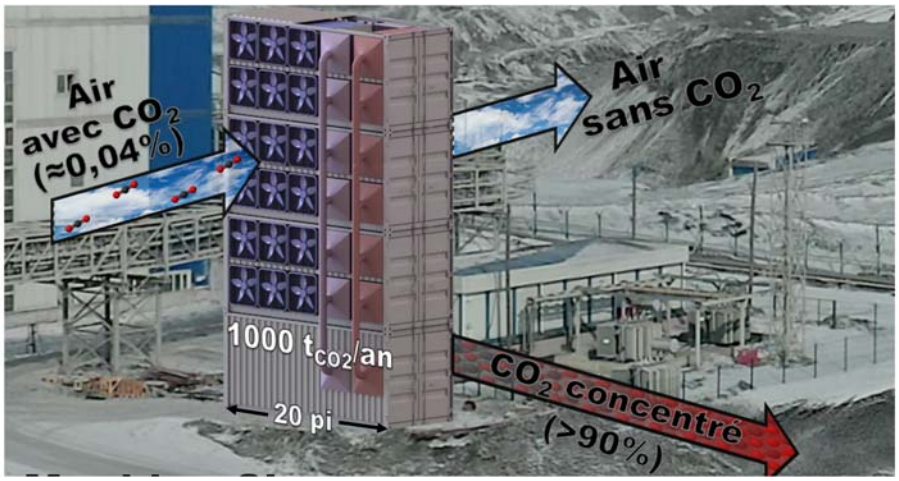

Figure 1 – Representation of a modular CO_2 capture system of 1000t_{CO2}/an.

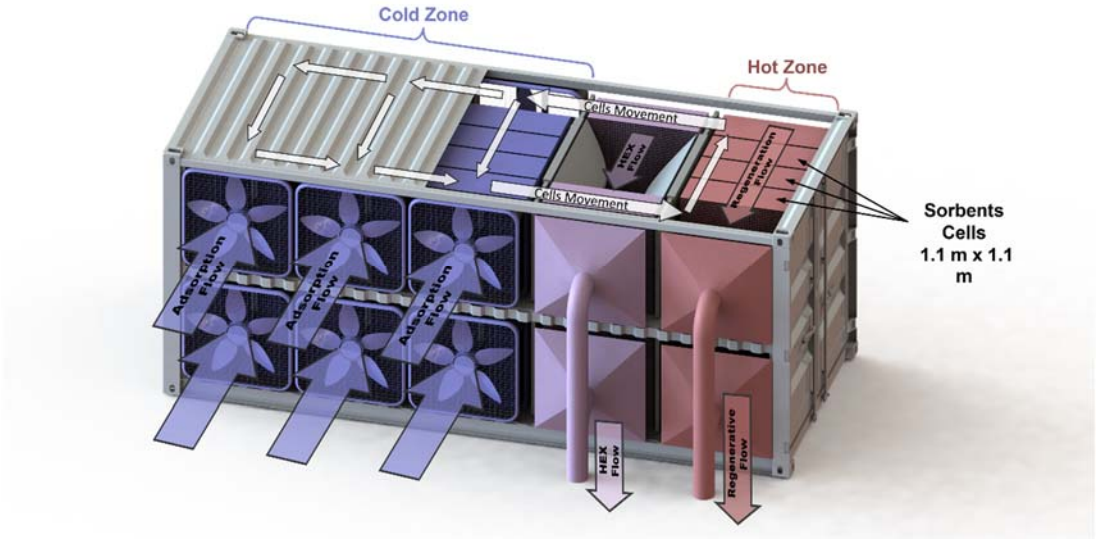

Figure 2 - Functional principle of the collection technology

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