

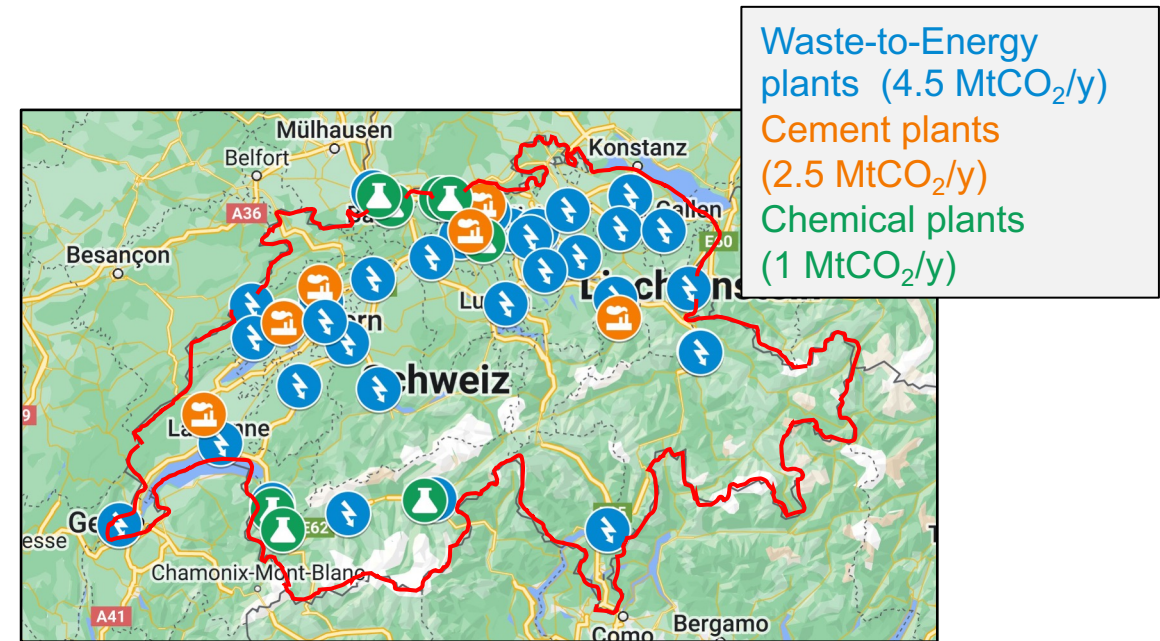
# DemoUpCARMA: Carbon dioxide management solutions for a net-zero Switzerland

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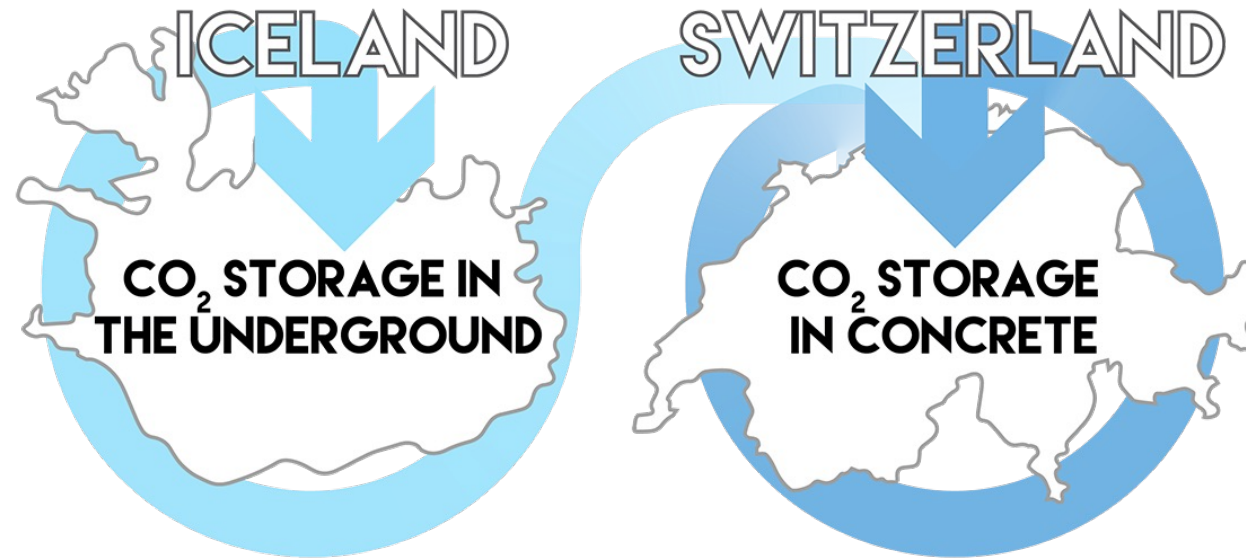
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## Towards net-zero emissions: Carbon dioxide management solutions for Switzerland

- In 2050, 7 MtCO<sub>2</sub> will have to be captured, transported, and stored, from small and large point sources (between 30 and 400 kt CO<sub>2</sub>/y) spread all over the country
- CO<sub>2</sub> could be permanently stored:
  - In demolition concrete in Switzerland → a feasible solution, with limited capacity
  - In the underground abroad → no near-term, large-scale inland geological storage solution; need for very long supply chains to storage hubs in North Europe
- Closing the gap to meet the 2050 goal requires demonstrating and implementing solutions as early as possible



## Concept and partners



ETH zürich EPFL PSI Empa eawag aquatic research UNIVERSITÉ DE GENÈVE FACULTÉ DES SCIENCES RISIKO DIALOG ZUKUNFT GESTALTEN. GEMEINSAM.

Academia, research, NGO

JURA materials arxada Lonza aqubern scienceINDUSTRIES SWITZERLAND Stadt Zürich Entsorgung + Recycling VBSA ASIR

Emitters

CASALE PLANTS FOR A NEW PLANET. SINCE 1921. ChemOil SBB CFF FFS Cargo CO2 NEUTRAL KSTLI SULZER Salzmann AG TRANSPORTE south pole perspectives climate research

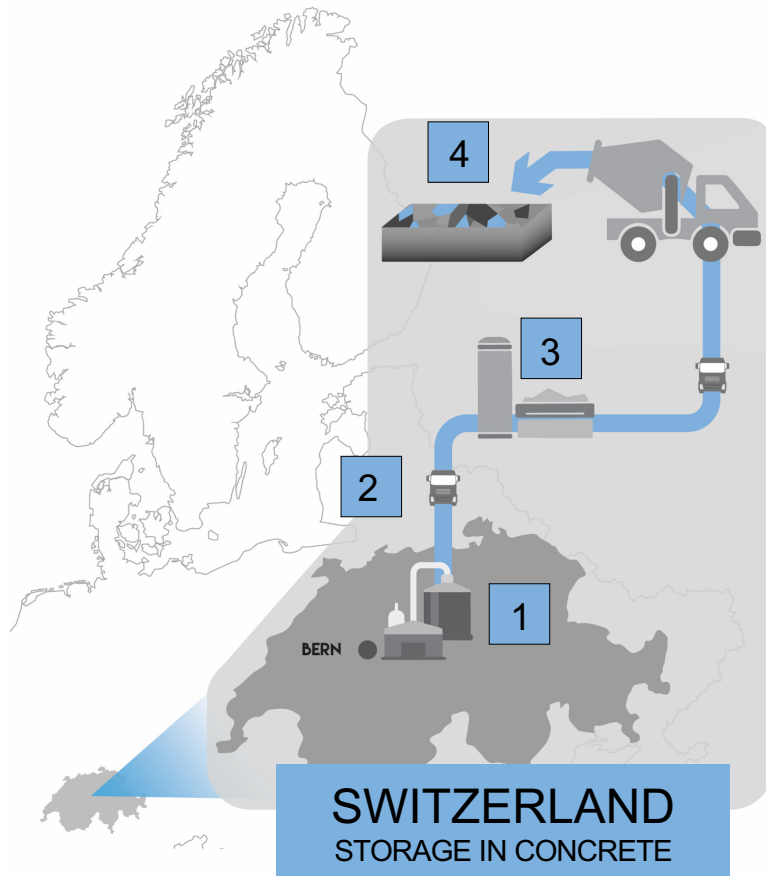
Solution providers

neustark Carbfix climeworks

Climate tech companies



## Domestic solution: CO<sub>2</sub> utilization and storage in demolition concrete



**CO<sub>2</sub> capture and liquefaction**  
at a waste-water treatment plant  
with biogas upgrader



**CO<sub>2</sub> permanent storage** via  
carbonation of recycling concrete  
aggregates (RCA)



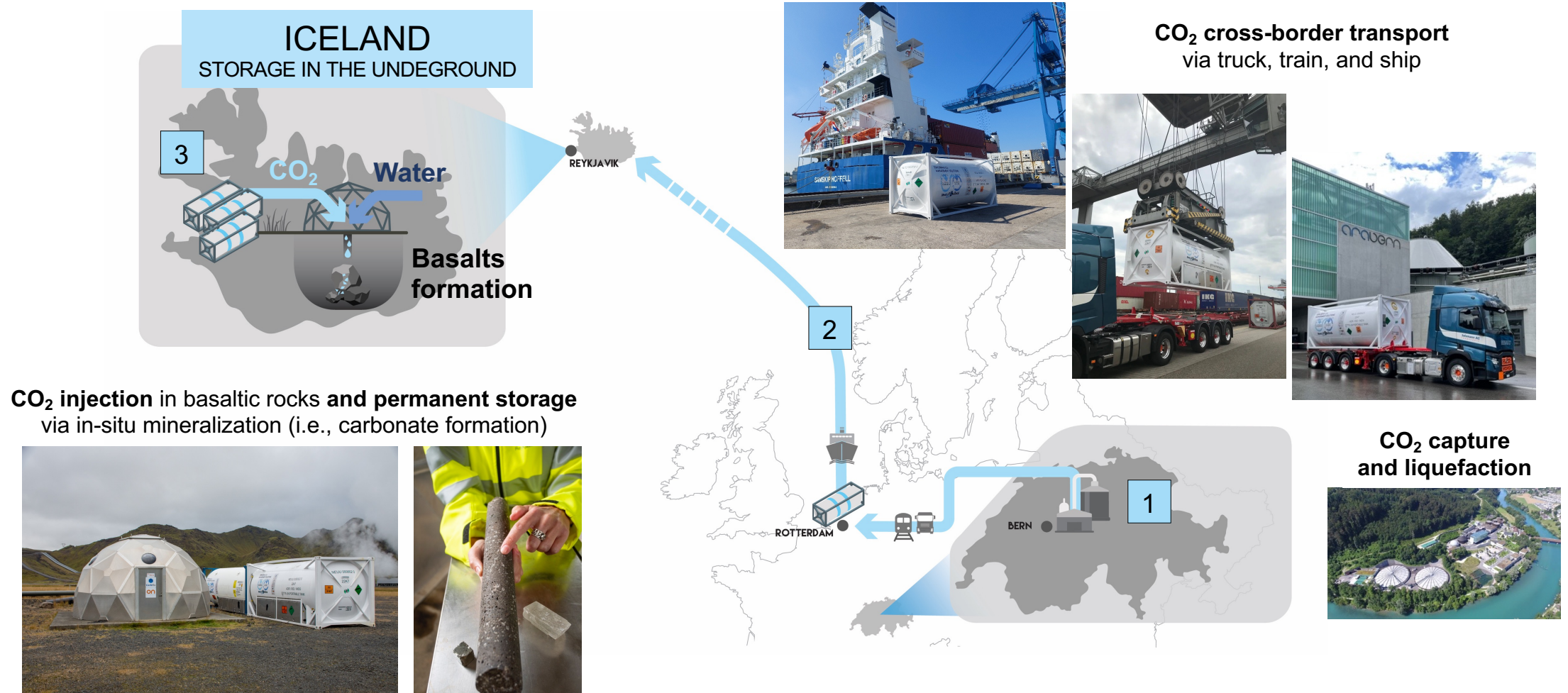
**CO<sub>2</sub> transport** to concrete recycling facility and  
intermediate storage



**CO<sub>2</sub> utilization** of carbonated recycling concrete for new  
buildings construction



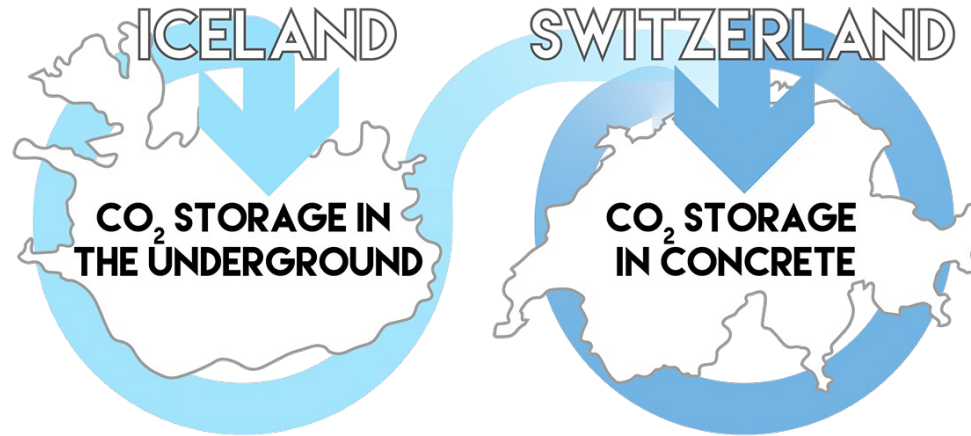
## International solution: CO<sub>2</sub> transport and underground storage



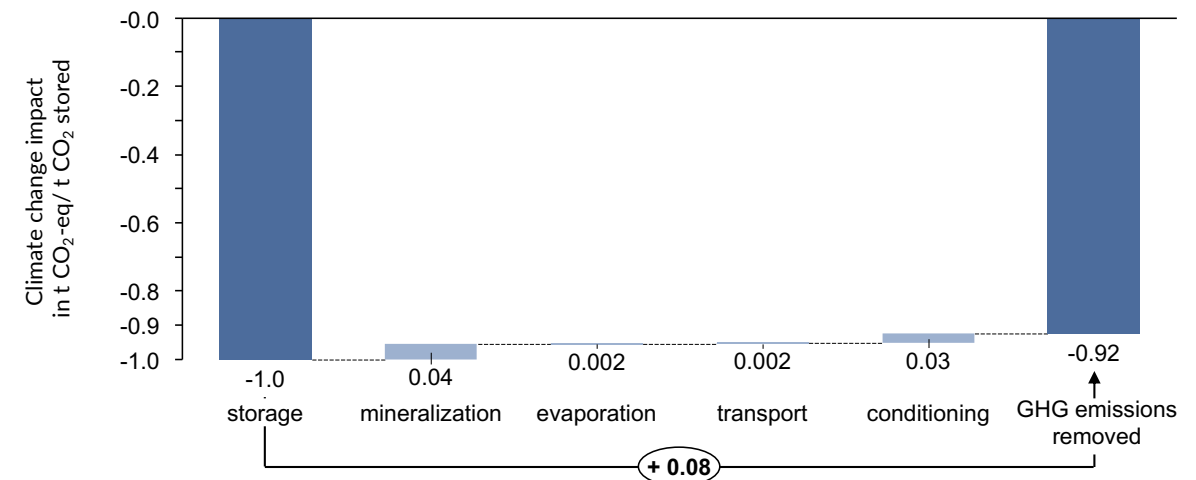
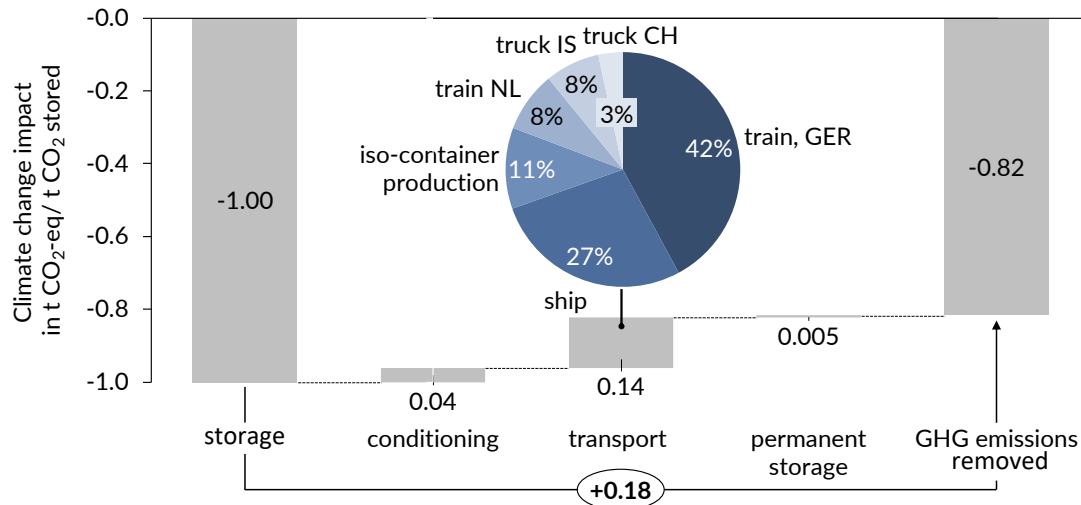


## Are these solutions environmentally efficient?

- ✓ For each ton of CO<sub>2</sub> stored in the Icelandic underground, **180 kgCO<sub>2</sub>** are re-emitted
- Largest contribution due to transport, especially ship and train, in Germany
- As transport sector is decarbonized, this impact will decrease



- ✓ For each ton of CO<sub>2</sub> stored in recycling concrete, **80 kgCO<sub>2</sub>** are re-emitted
- Although this solution results in a lower environmental impact, it is limited by the storage capacity of concrete (up to ca. 150 000 tCO<sub>2</sub>/y in Switzerland)



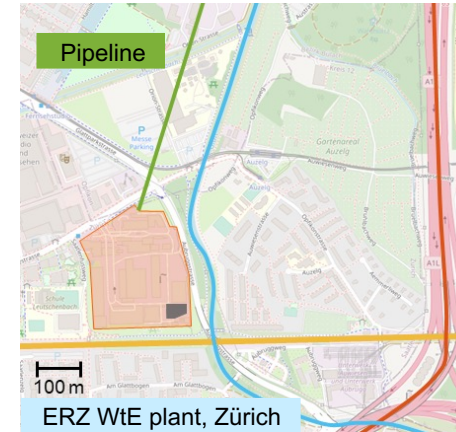
## Upscaling of CO<sub>2</sub> management solutions: CO<sub>2</sub> capture, integration and transport



- Amine-based capture process (BASF, Germany)
- **District heating network not affected** by capture integration due to sufficient waste heat available and electricity generation enabling the use of heat pumps
- Sufficient space available for capture but not for a logistic hub

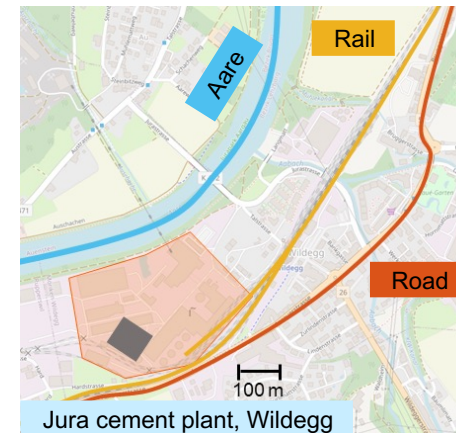


- Hot Potassium Carbonate capture process (Capsol, Norway)
- Due to limited heat available on site, **electricity driven process** is more suitable
- Sufficient space available on site for capture and conditioning for transport



### Storage at Northern Lights, Norway:

- 300-380 CHF/tCO<sub>2</sub>
- Environmental efficiency: 75-80%
- 3.2 GJ<sub>th</sub>/tCO<sub>2</sub>
- 1.3 GJ<sub>el</sub>/tCO<sub>2</sub>



- 220-310 CHF/tCO<sub>2</sub>
- Environmental efficiency: 75-80%
- 0.5 GJ<sub>th</sub>/tCO<sub>2</sub>
- 2.0 GJ<sub>el</sub>/tCO<sub>2</sub>

## Upscaling of CO<sub>2</sub> management solutions: systemic approach

### Climate policies

- To precisely quantify carbon reductions and removals, a **robust and modular carbon accounting** infrastructure is key for unlocking revenue from carbon markets
- **High-quality standards and environmental integrity** needed for long-term credibility

### Legal and regulatory frameworks

- **Alignment between CH and EU regulations** on CO<sub>2</sub> classification is required
- No extensive technical regulations for CO<sub>2</sub> pipeline transport implemented in CH so far, and no constitutional basis at the federal level

### Financing mechanisms

- The **cost of CO<sub>2</sub> management solutions** is found **higher than previous estimates**
- **No clear viable business model** exists today (even for emitters under the ETS)

### Social acceptance

- The **relatively small group of experts** in the field has a shared basic understanding and generally supports these solutions, more critical voices could emerge in the future
- **Swiss citizens are generally unfamiliar** with this topic, with acceptance and support influenced by personal and social factors





## Conclusions and learnings

- The CO<sub>2</sub> management solutions are both **technically and environmentally viable**; both solutions are needed to meet climate goals
- Pilot projects enable to **identify shortcomings** and offer crucial insights for the establishment of a new industry
- Implementing these solutions on a large scale presents several challenges that require a **systemic approach** for resolution
- The project has contributed significantly to:
  - Creating a **platform for national stakeholders** to exchange on this topic both at country level and with international stakeholders
  - **Capacity building**: 30+ students engaged in CO<sub>2</sub> management solutions at industrial scale