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Direct air carbon capture and storage (DACCS): Challenges for up-scaling

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DAC technologies
(Fasihi et al. 2019; NRC 2019)

- DAC: direct air capture (DAC) of carbon dioxide
- DACCS: direct air carbon capture and storage = DAC & storage
  - Carbon dioxide removal or negative emissions
- CO_2 from DAC can be used to produce fuels, etc. (utilization)

Liquid solution technologies

- Capture CO_2 (weak acid) with alkaline solution (e.g., KOH, NaOH)
- High-temperature heat is required
- Carbon Engineering (Canada)
  - Developing a (max) 1Mt-CO_2/yr Plant in the Permian Basin, USA

Solid sorbent technologies

- Use solid sorbent (amine, etc.) with temperature/moisture/vacuum swing
- Low-temperature heat is sufficient
- Climeworks (Switzerland)
  - Just completed a 4kt-CO_2/yr plant in Iceland

Upsides and challenges

- Upsides
  - No significant, inherent environmental side effect
    - Small land footprint, no competition with food production
  - Locational flexibility (you can build a plant in a desert to avoid NIMBY)

- Challenges
  - High cost
    - Uncertain but ~600 USD/t-CO2 or so as of today
    - 100-300 USD/t-CO_2 in the long term (review by Fuss et al. 2018)
  - High energy requirement
    - 40–100 EJ/yr at 10Gt-CO_2/yr (cf. current primary energy of ~600 EJ/yr)

Current policy environment and upscaling challenges

- Upscaling challenges
  - Ideally, ~ Gt-CO_2/yr by 2050
  - Now, ~10 kt-CO_2/yr or maybe ~ Mt-CO_2/yr in early 2020s
  - 1000^(1/30) = 1.26 ➔ CAGR of 20-30%/yr for 30 years

- Niche markets
  - Voluntary markets
  - Some policy support (US 45Q tax credit + California LCFS)
- Prize (100 million USD X Prize by Elon Musk)
- RD&D efforts (e.g., US DOE (incl. DARPA), UK, Moonshot in Japan)

- Can we repeat the “success of solar” with DACCS?
  (Nemet, 2019, *How Solar Energy Became Cheap*)
  - (Solar did cost money but it did grow and get cheaper phenomenally)