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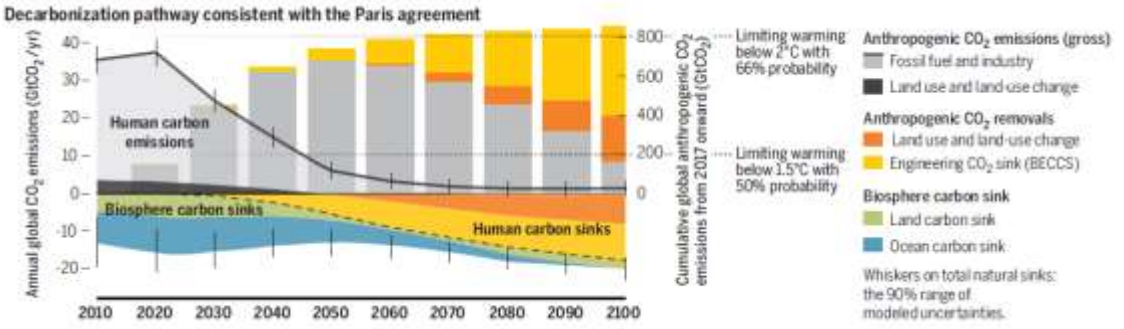
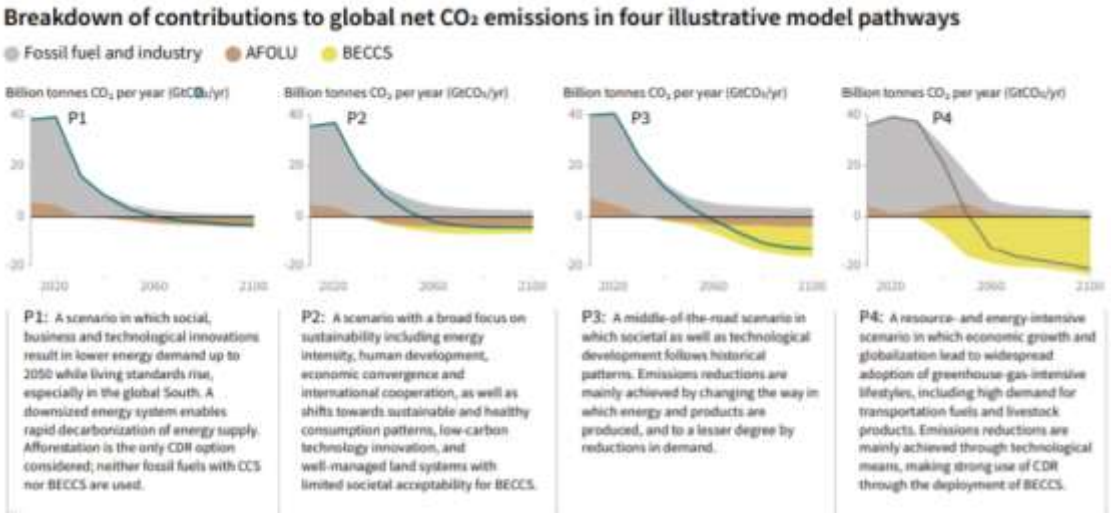
THE ROLE OF GEOLOGICAL STORAGE FOR ACHIEVING PARIS AND FUTURE CLIMATE GOALS: A REVIEW OF CANADIAN PROJECTS AND OPPORTUNITIES IN A GLOBAL CONTEXT

STORAGE, EOR, CONVERSION & TECHNOLOGY ROADMAPS

- Fossil fuels are efficient and the “clean” energy feedstock for:
  - Electricity,
  - H_2 and
  - Synthetic petroleum.
- Shell’s “Sky Scenario” infers >50% of demand is met by fossil fuels until ~2050, with 10,000 “large” CCS projects.
- An optimistic Paris Roadmap (Rockström et al., 2017) halves CO_2 emissions in this and future decades, with ~5.4 Gt CO_2eq storage/yr.
- Sustainable GHG emissions intensity, <5 MtC/PWh occurs ~2100 (De Paolo, 2015).
- Utilization, both EOR and Conversion are potential cost mitigation strategies and business opportunities.



(Rockström et al., 2017)



IPCC: https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf

RELATIVE SCALES OF OPERATION

- Pore space storage (CCS) and geological utilization (EOR) predominate currently over conversion technologies (CCU).
- Conversion although not currently large volumetrically provides an opportunity for cost mitigation.
- Conversion could be much larger if "CO_2 to fuel" develops, but this probably also needs CCS support.

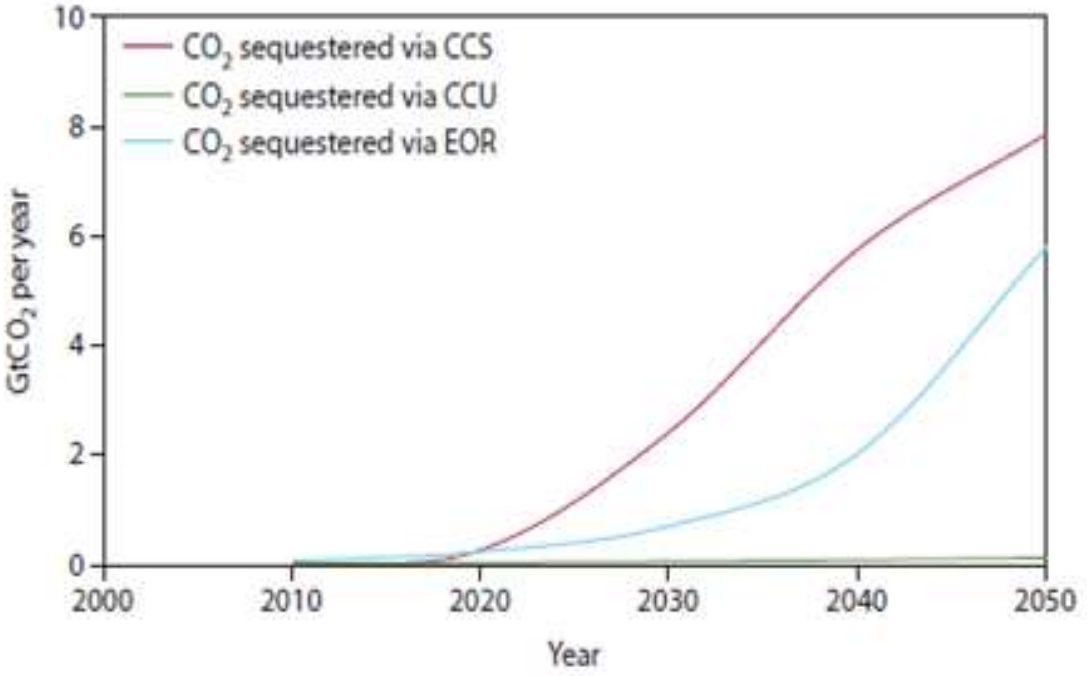


Figure 4 | CCS versus CCU—a perspective for the period 2010 to 2050. CO_2-EOR has the potential to materially contribute to the sequestration of CO_2 whereas the contribution of CCU is negligible.

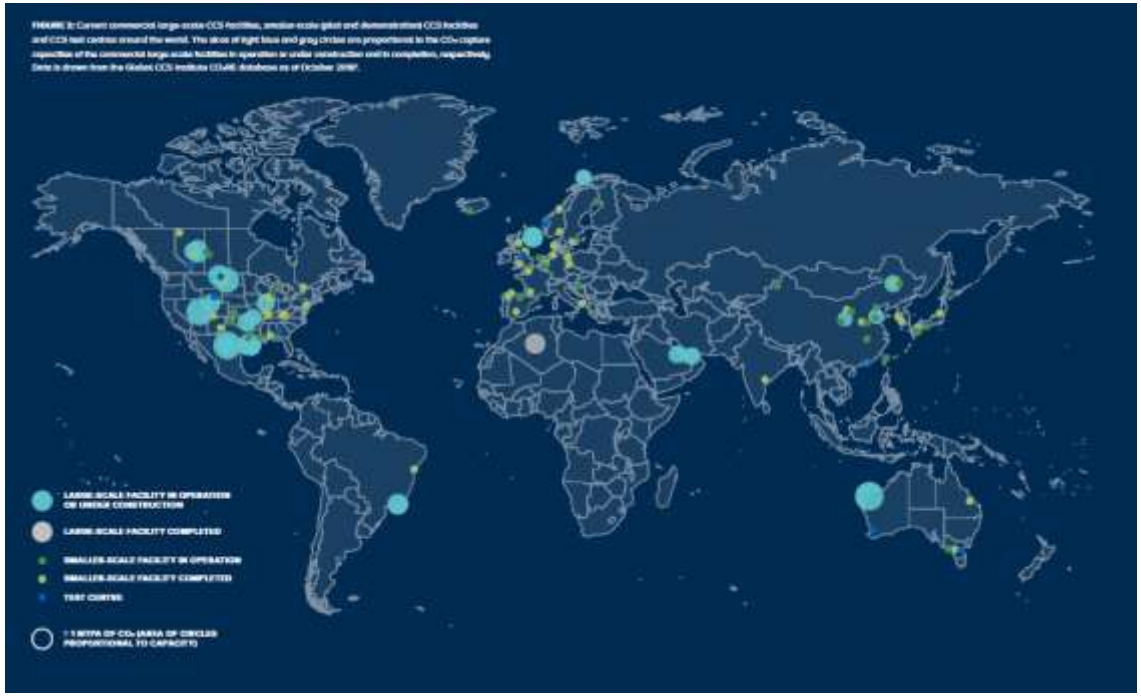
(MacDowell et al., 2017, their Figure 4).

CONVERSION AND EOR: POTENTIAL FOR COST MITIGATION

- All emissions reductions are desirable and many provide potential business opportunities.
- Industry uses ~80 $MtCO_2$equ/year, for EOR (37.4 $MtCO_2$/yr: 13.6 MtC/a), carbon black (14 MtC/a) and graphite (1 MtC/a), compared to anthropogenic emissions (37.1 $GtCO_2$equ).
- Many promising technologies, for example the “CarbonCure” concrete application, base their emissions savings primarily on avoidance rather than actual utilization. (https://www.carboncure.com/).
- CO_2 use in synthetic fuel manufacture probably occurs as an additive to syngas-based Fischer-Tropsch synthesis, with the syngas manufacturing requiring CCS.
- While conversion technology breakthroughs can and will occur their progress to hard to predict.

PORE SPACE STORAGE IN GEOLOGICAL MEDIA

- In 2018, 23 large-scale CCS facilities were operating or under construction with a capacity of ~64 Mt CO_2eq/yr and storage of ~40 Mt CO_2eq/yr.
- 28 additional pilot and demonstration projects are operating or under construction and these capture >3 Mt CO_2eq/yr.
- In carbon alone, CCS currently sequesters about 15.6 MtC/yr., compared with 13.6 MtC/year EOR utilization.
- Most EOR CO_2 is produced from natural sources although CO_2 from anthropogenic sources is increasing due to US Code 45Q.



Source: https://www.globalccsinstitute.com/resources/global-status-report/
For the current large project list see: https://co2re.co/FacilityData

CANADIAN CCUS PROJECTS

- The long history of acid gas processing and subsurface disposal was a model for CCS (e.g. Bachu and Watson, 2009).
- Western Canada CCUS projects include:
  - Shell/CNRL Scotford/Quest,
  - Saskpower Boundary Dam/Aquistore/Weyburn-Midale,
  - CNRL Horizon H_2 Plant/Tailings and Hays/Enchant CCUS/EOR.
  - CMCRI's Newell County Field Research Station (primarily a monitoring technology development site).
  - Agrium/NWU/Alberta Carbon Trunk Line/Enhance's EPR (another talk).
  - Carbon Engineering Direct Air Capture (another talk), among others.

ENABLING A WESTERN CANADIAN CARBON MANAGEMENT INDUSTRIAL CLUSTER: THE CURRENT COST CHALLENGE

- Achievable CCS operating targets are $25/t for capture and $10/t for transportation and storage.
- Full deployment of EOR and CCS could result in expenditures and work that are comparable in size and type to that in the upstream natural gas sector.
- Storage and EOR at scale could create 9,000 to 27,500 new, additional, full-time, HQP positions and result in investment of >$1 billion by 2030.
- 90-100% of the investment phase and 100% of operational spending on labour will occur in Canada, with most occurring in Western Canada.

- By May, 2019 Quest had stored 4 Mt CO_2.
- Capture, EOR and Geological Storage are at TRL 9+.
- Future projects should cost 20-30% less.
- Western Canada is a world leader in CCS.

- Storage and EOR have costs, but there is no alternative at scale.
- Stop waiting and resume doing.
- Activity currently requires public support.
- Consider incentives like a Canadian equivalent of US Code 45Q.
- Hope for improved light and medium crude prices.
- Have policies and regulations that facilitate CO_2 EOR (e.g. Gunter and Longworth, 2013).