The Challenge in Developing Geological CO_2 Storage for Industrial Southern Ontario

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The Challenge from the P.M.

At an international climate summit convened by U.S. President Joe Biden, Prime Minister Justin Trudeau said Canada will reduce emissions by 40 - 45 % below 2005 levels by 2030

Apr 22, 2021

NRCan given $319 million over 7 years in 2021 budget to implement this pledge out of an $8 bn Net Zero Accelerator account

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To accomplish a 40% CO_2 reduction we must consider:

1. Location of emitters and storage sites
2. Technology readiness and financial incentives for CCS
3. Time required to plan and construct CCS

"Our biggest challenge is to match sequestration sites to CO_2 sources."

Benson, S.M. and Cole, D.R. 2008, *CO_2 Sequestration in Deep Sedimentary Formations,* Elements 4:325-331.

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CSA Guidelines for Geological CO_2 Storage Sites

1. >800 m deep to allow $p_{max} \rightarrow 9$ MPa
2. sealed by competent caprock with minimal groundwater inflow from surrounding rock
3. *Preferably,* near major CO_2 emitters & pipelines
4. *Preferably,* penetrated by few oil and/or gas wells requiring plugging
5. *Preferably,* large pore volume available for CO_2 storage so limited Δp
6. *Preferably,* few critically-stressed faults that might slip with fluid injection → *felt earthquakes*!

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What sites do we have for Geological CO_2 Storage?

Saline Cambrian Aquifers

- *North Shore of Lake Erie* ✓

Depleted Oil & Gas Fields

- *Innerkip gas field?*
- *Cambrian sandstone oil fields ?*
- *Ordovician carbonate oil fields ?*
- *But, these are penetrated by hundreds of legacy wells*

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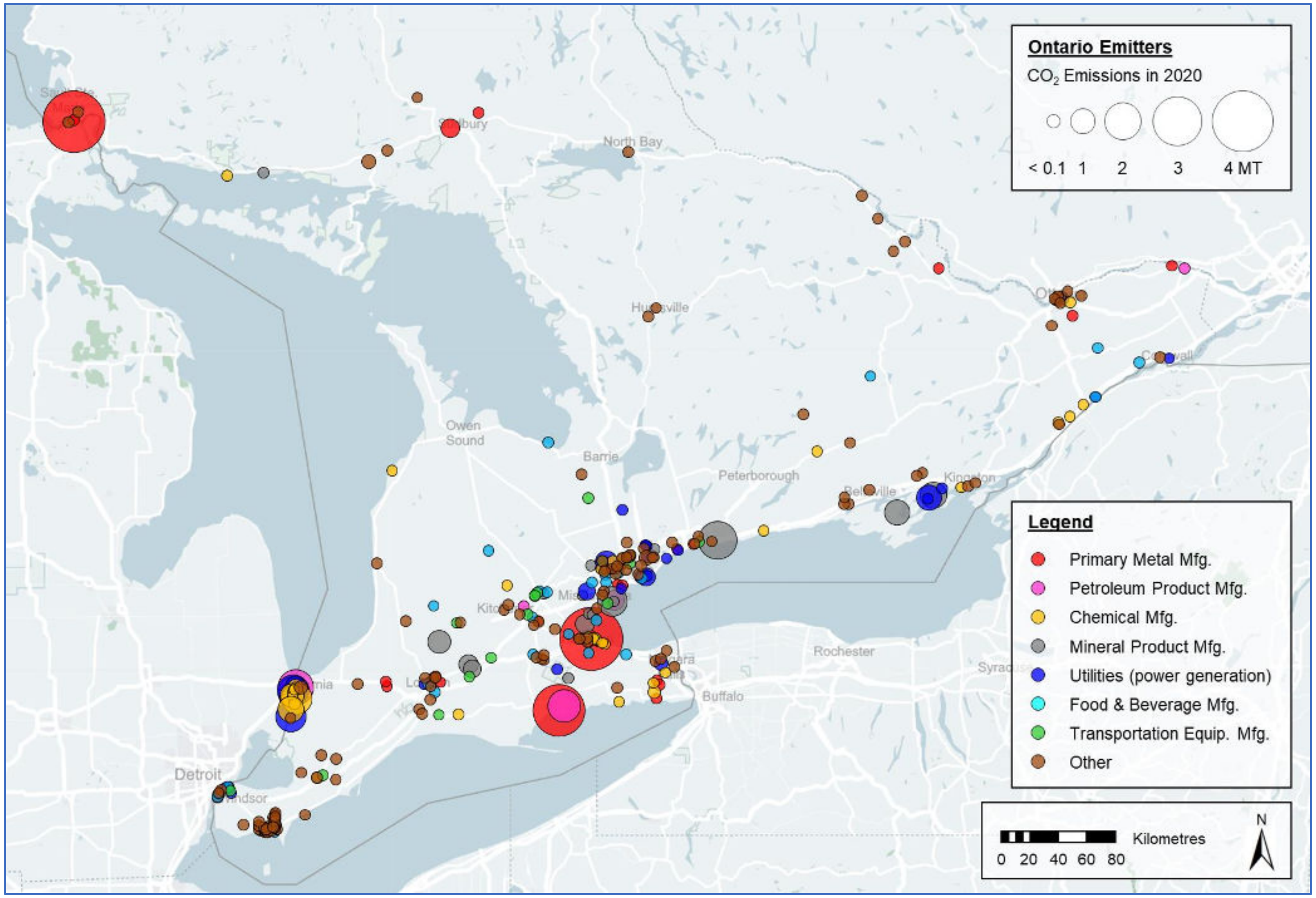
Location of emitters and storage sites



Industrial CO_2 sources are widely distributed but geological storage sites are limited to the north shore of Lake Erie

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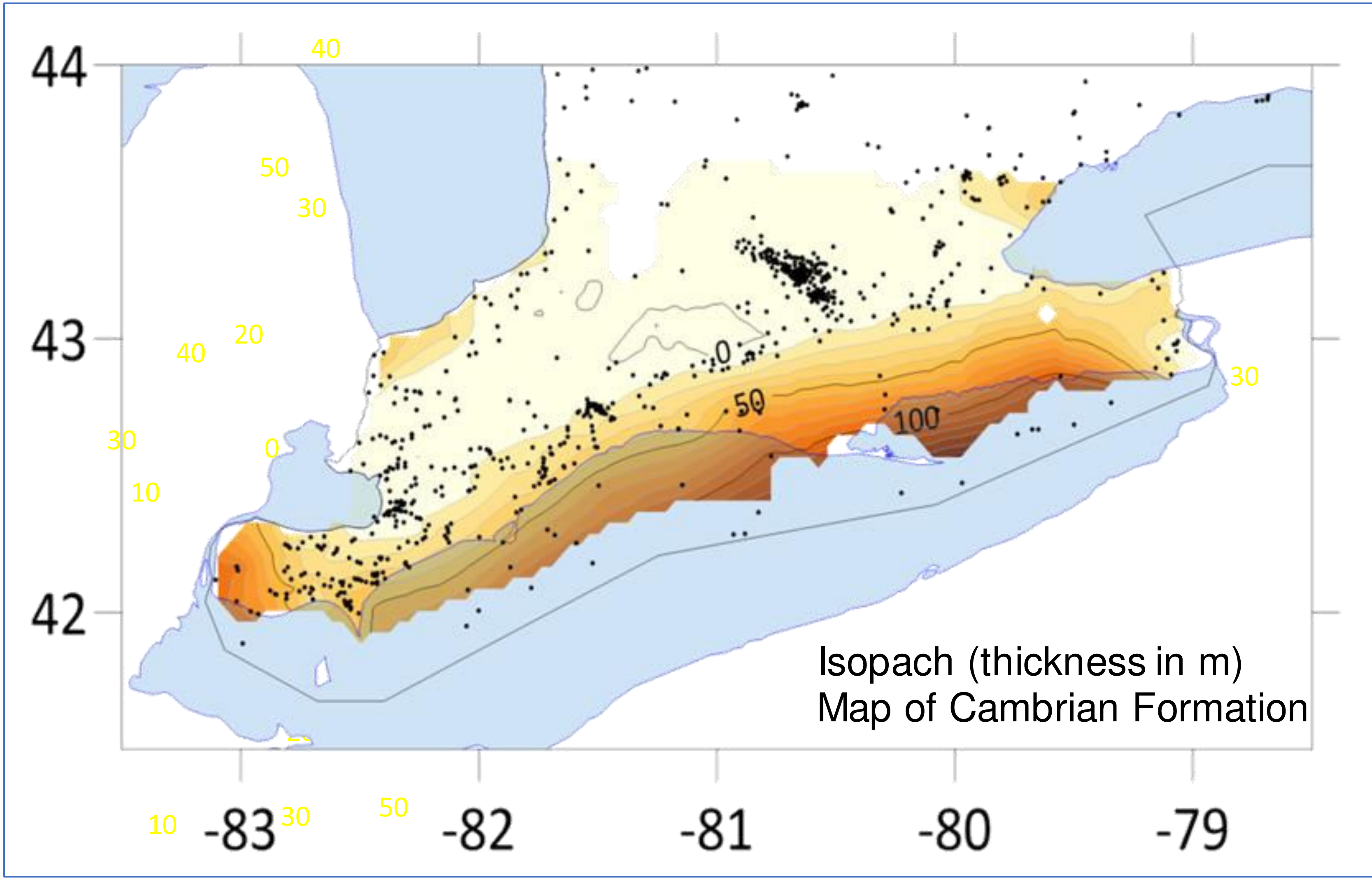
Location of emitters and storage sites



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Prepared by Bruce Hart, Western University

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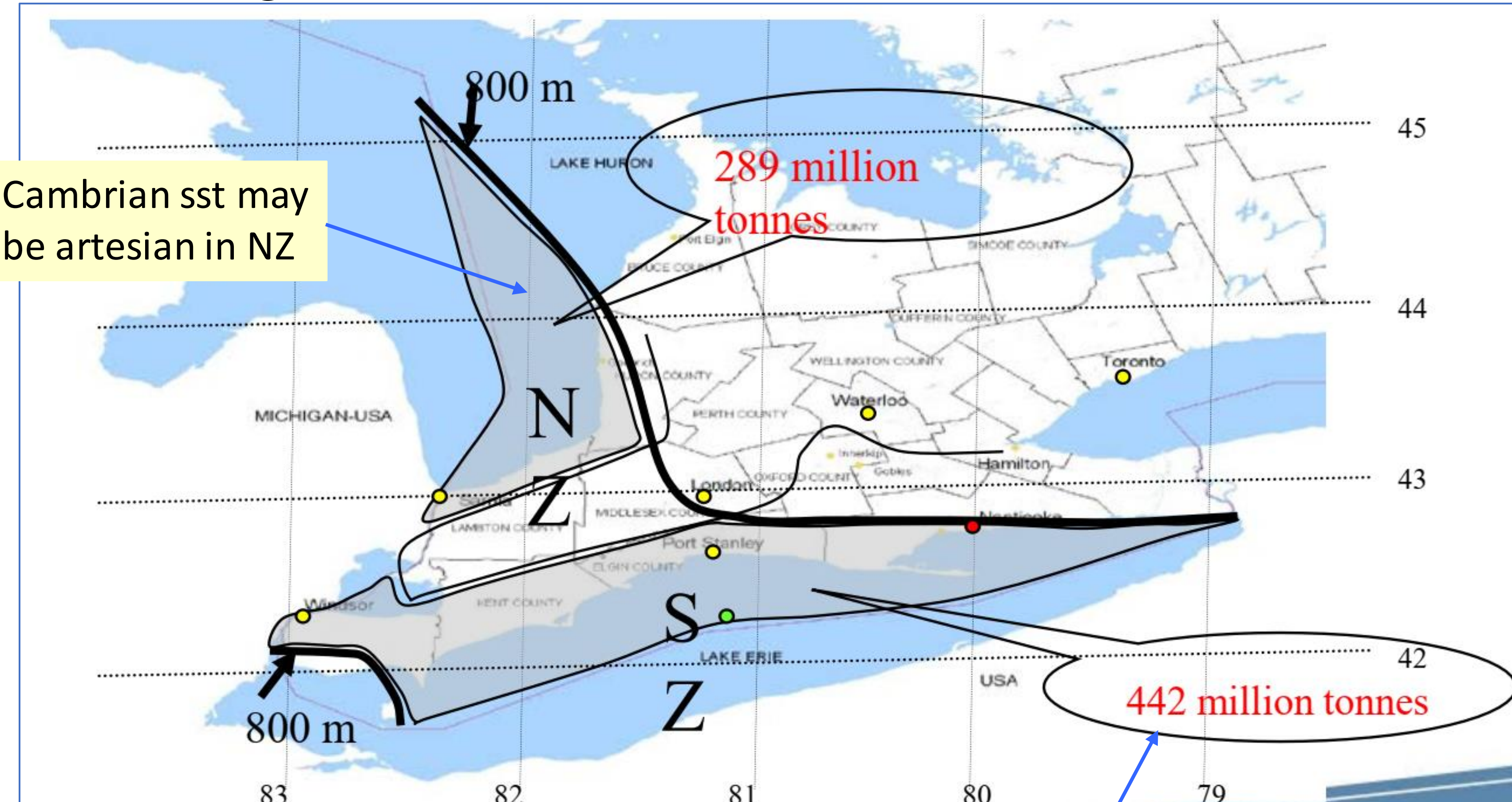
Shafeen's 2004 estimate of Pore Volume storage in Cambrian sandstone



Shafeen's 2004 Cambrian sst PV estimate of 442 MT in SZ based on 10% storage efficiency and sub-lake injection

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CCS investment decisions of $1B+ require more than simple prospective volumetric estimates

- CO_2 storage hubs must be PROVEN by exploratory drilling and testing + seismic
- Followed by numerical simulation of CO_2 migration through the storage reservoir
- Cost per borehole $5M+
- Two boreholes minimum to estimate reservoir transmissivity & compressibility
- A storage hub will require ~ $30M

Technology readiness and financial incentives for CCS

Environ. Res. Lett. **16** (2021) 014036 https://doi.org/10.1088/1748-9326/abd19e

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LETTER

Explaining successful and failed investments in U.S. carbon capture and storage using empirical and expert assessments

Ahmed Abdulla[1,2], Ryan Hanna[2,3], Kristen R Schell[1], Oytun Babacan[4] and David G Victor[2,5,6]

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Results of Deep Decarbonization Initiative study:

1. Capital cost:
   - high CAPEX projects more likely to fail
   - Canadian ITC covers<25% of CAPEX, while 45Q provides ~⅔ (BMO, 8/2022)
2. Technological readiness:
   - mature technologies are best, e.g., amine absorption capture
   - dedicated geological storage requires long development times
3. Credibility of project revenues:
   - Usually EOR projects or
   - dedicated geological storage at ADM Decatur project supported by DOE
4. Transport & CO_2 storage planning:
   - "*the degree of documentation and visibility around features like CO_2 disposal is endogenous to eliminate any risks before FID*"
   - i.e., planning the pipeline and the proving the geological storage is critical to success

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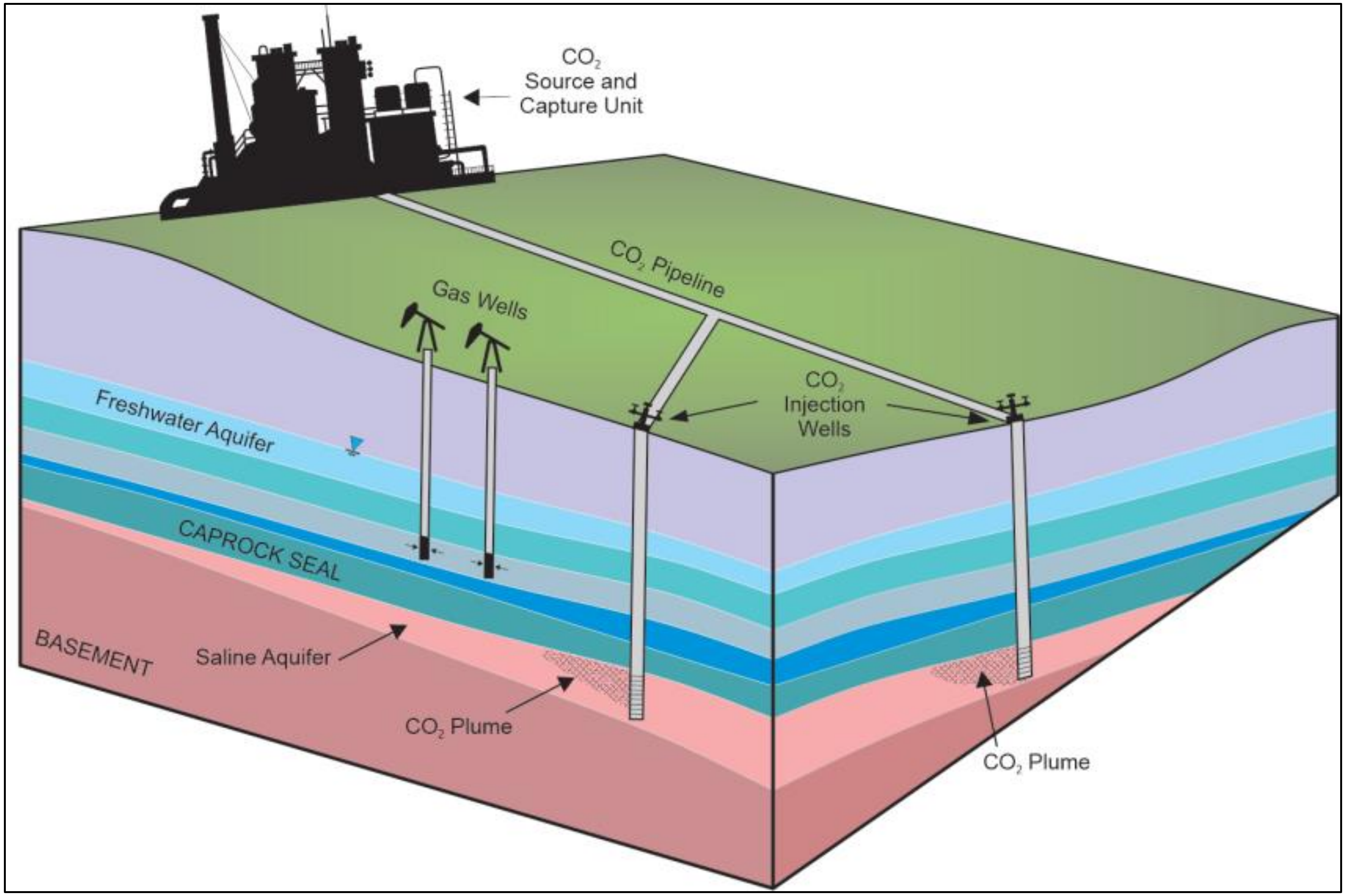
Time required to plan and construct CCS



Can we develop CCS capture, transmission, and injection systems by 2030?

Storage hubs for dedicated geological storage require:

1. 3-8 years to develop and prove injection sites
2. ~ $30M to prove available PV and CO_2 injectivity
3. Large-scale numerical simulation to determine Δp effects – "the pressure dome" – and CO_2 migration
4. Evaluation of reservoir continuity/compartmentalization
5. Hydraulic interference of neighbouring hubs?
6. Δp effects on caprock & basement faults?
7. Sealing of any penetrating legacy wells

In SW Ontario we need to prove ~10 MT annual CO_2 storage by 2025 to allow planning & construction to begin storage before 2030

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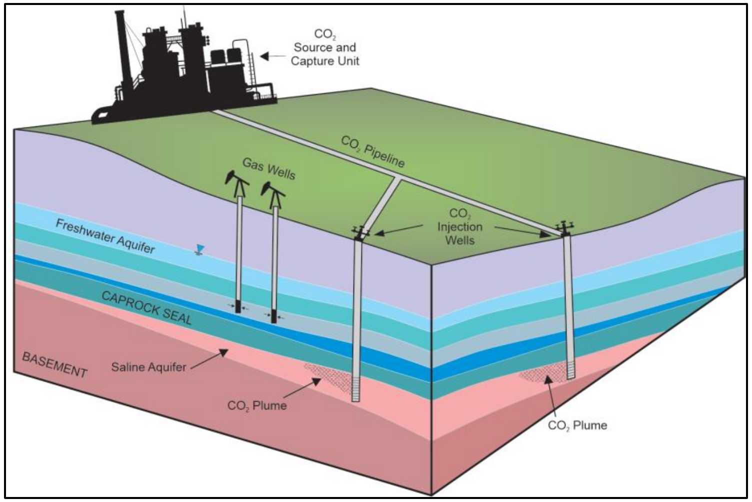
Time required to plan and construct CCS



Geological Sequestration of Carbon Dioxide: A Technology Review and Analysis of Opportunities in Ontario

1996 Sleipner

2004

2006

2007

2010

2020

2023

2026

2030

Shafeen report

Toronto CCS Workshop

Quest & BD3 startup

Site characterization?

Construction?

Cost analysis + FID?

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The Challenge in Developing Geological CO_2 Storage for Industrial Southern Ontario

- 10+ years work to be done in 7 to meet 2030 deadline
- Province has yet to establish policy & regulations
- Assuming CO_2 injection rates ~200 kT/well/yr
- 10 MT annual storage PV requires ~40 injection wells
- The first was drilled in 2022

There's always decarbonization by deindustrialization!

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