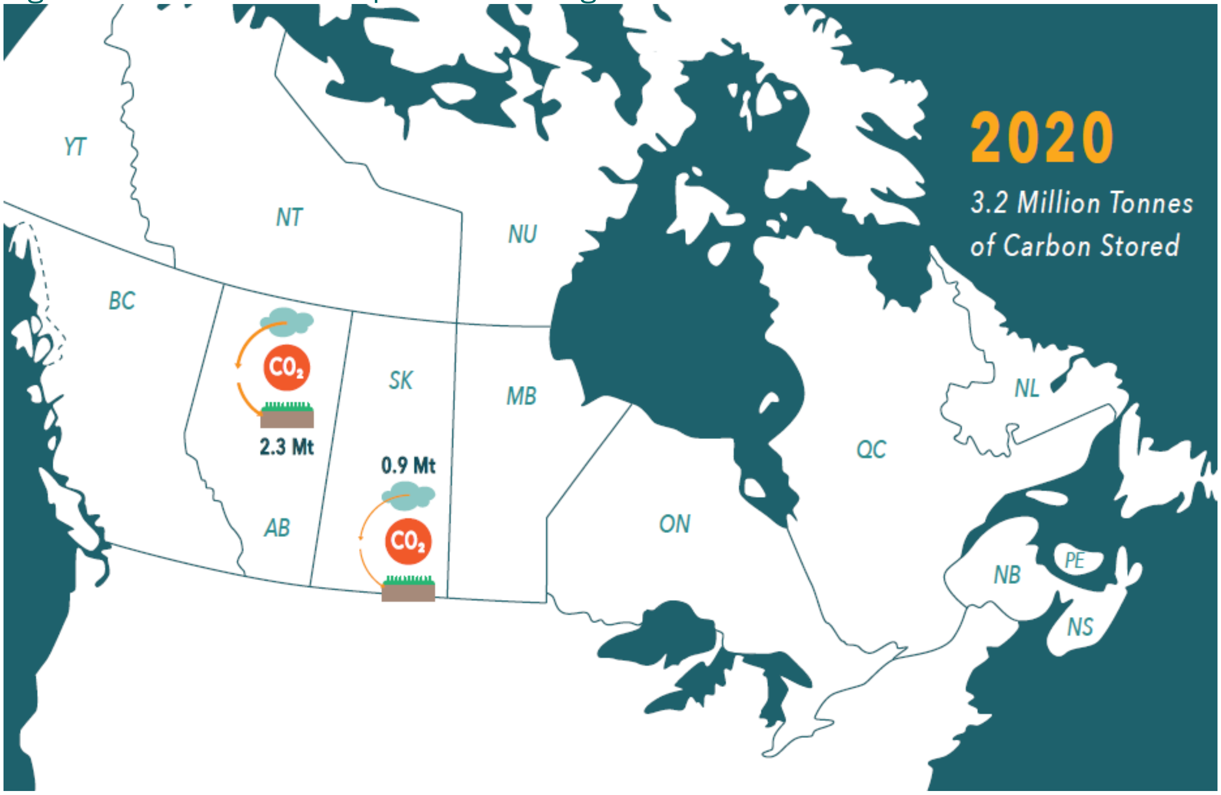
If you build a CO2 pipeline, capture and storage will come

Achieving net zero greenhouse gas emissions in Canada by 2050 is likely to require a significant carbon capture and storage (CCS) industry in almost every province across the country. CCS provides an important opportunity to achieve deep emissions reductions at the lowest possible cost. **Developing shared pipeline infrastructure to transport carbon dioxide will be key to unlocking the CCS opportunity in Canada.**

Canada's current CCS industry

Canada currently captures and stores 3.2 million tonnes of CO_2 each year from three operating CCS projects (Figure 1). In Alberta, the Quest project captures CO_2 from an oil sands upgrader and transports it 65 kilometers north by pipeline for storage in a deep saline aquifer[1], and the Alberta Carbon Trunk Line captures CO_2 from a refinery and fertilizer plant and transports it 240 kilometers for use in enhanced oil recovery and storage in depleted oil reservoirs.[2] In Saskatchewan, the Boundary Dam coal-fired power plant has been retrofit to capture CO_2, which is transported 50 kilometers for use in enhanced oil recovery at nearby oil fields or stored in naturally occurring brine-filled sandstone close to the power plant.[3,4]

Figure 1. Current carbon capture and storage in Canada



The challenge of developing a CCS industry in Canada

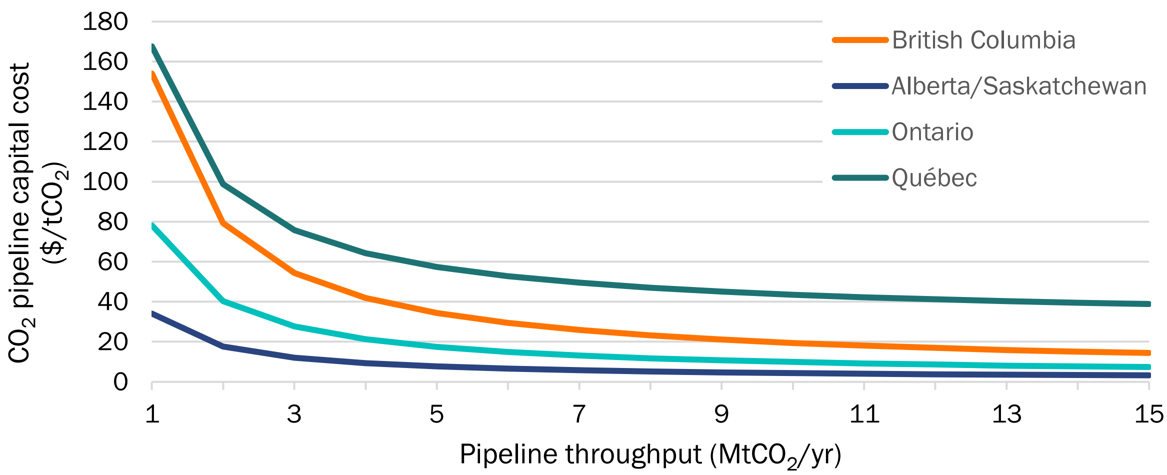
Although strong climate policy could make carbon capture an economically viable emissions reduction action in Canada, it could be a lack of CO_2 transportation infrastructure that constrains development of a CCS industry. CO_2 capture alone currently costs between $20-150/tCO$_{2e}$, depending on the application in which it is used (CAD 2020)[5,6], while carbon prices in Canada are expected to rise from $40/tCO$_{2e}$ in 2021 to $170/tCO$_{2e}$ by 2030. However, there are additional costs for the transport and storage of CO_2.

Captured CO_2 must be transported to suitable geological storage. Deep porous rocks covered by a solid "cap rock" can permanently store CO_2 underground. Unfortunately, the source of CO_2 emissions is not always in a location with suitable storage. Consequently, transportation infrastructure is required to connect the point of capture to the point of storage (usually with pipelines).

The need for CO_2 transportation creates a "chicken-and-egg" problem. The development of a CCS industry in Canada requires three activities to emerge simultaneously across the country – capture, transport and storage. Without a significant CCS industry in place, investment in pipeline infrastructure is hard to justify. At the same time, investment in a capture plant requires assurance that there is a way to transport the CO_2 to a location where it can be stored.

The cost of CO_2 transportation is very sensitive to the volume of gas being transported. The economics of pipeline transport mean that the unit cost ($/tCO$_2$) of transport goes down as throughput in the pipeline goes up. Consequently, the cost of transporting CO_2 starts high when the industry is small, given the fixed cost of the pipeline infrastructure, and becomes less expensive as throughput increases. This will be a challenge during the early development of a CCS industry, as CCS becomes most affordable only once the industry reaches a certain size (Figure 2).

Figure 2. Capital cost of CO_2 transport relative to pipeline throughput[7]

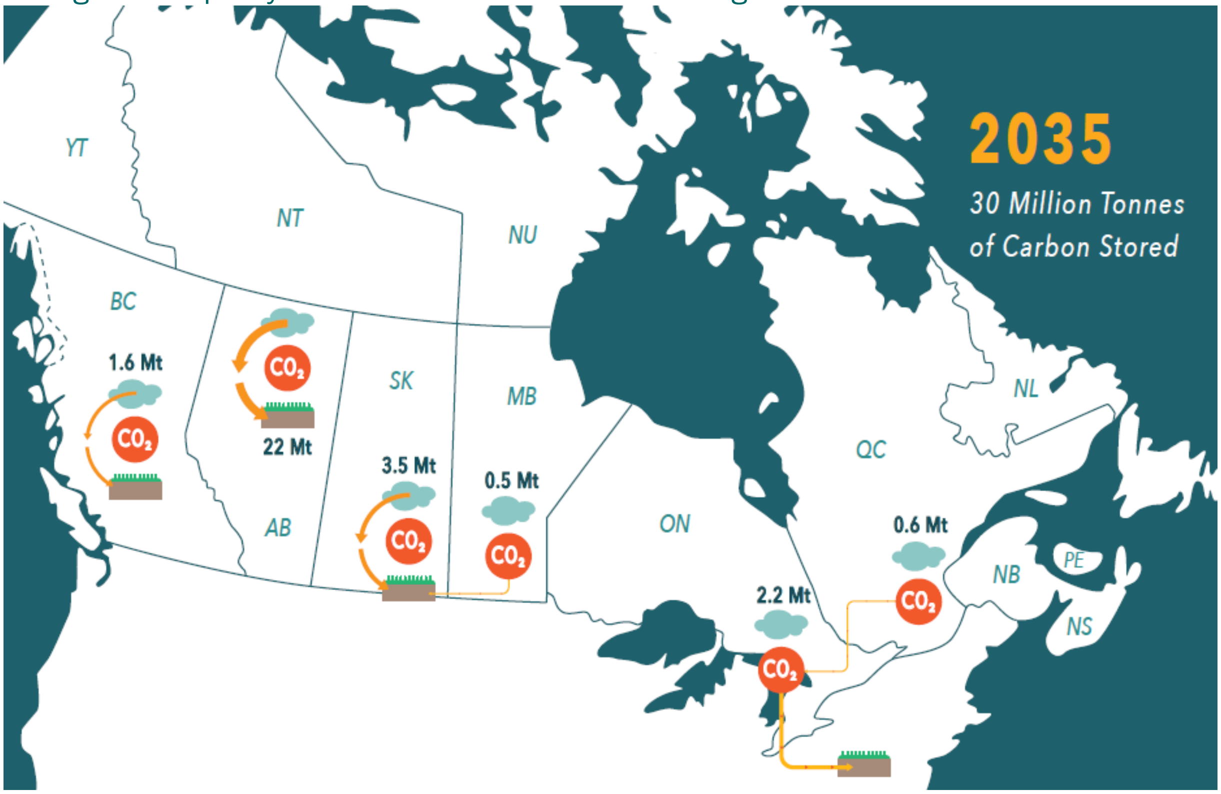


Canada's future CCS industry

To explore how Canada's CCS industry could grow as a result of strong climate policy, we simulated achievement of Canada's 2030 emissions target (a 30% reduction in emissions from 2005 levels by 2030) and net zero emissions by 2050 in over 100 modeling scenarios.[8] Canada's CCS industry grows significantly in all net zero scenarios and is facilitated by a network of CO_2 pipeline infrastructure.

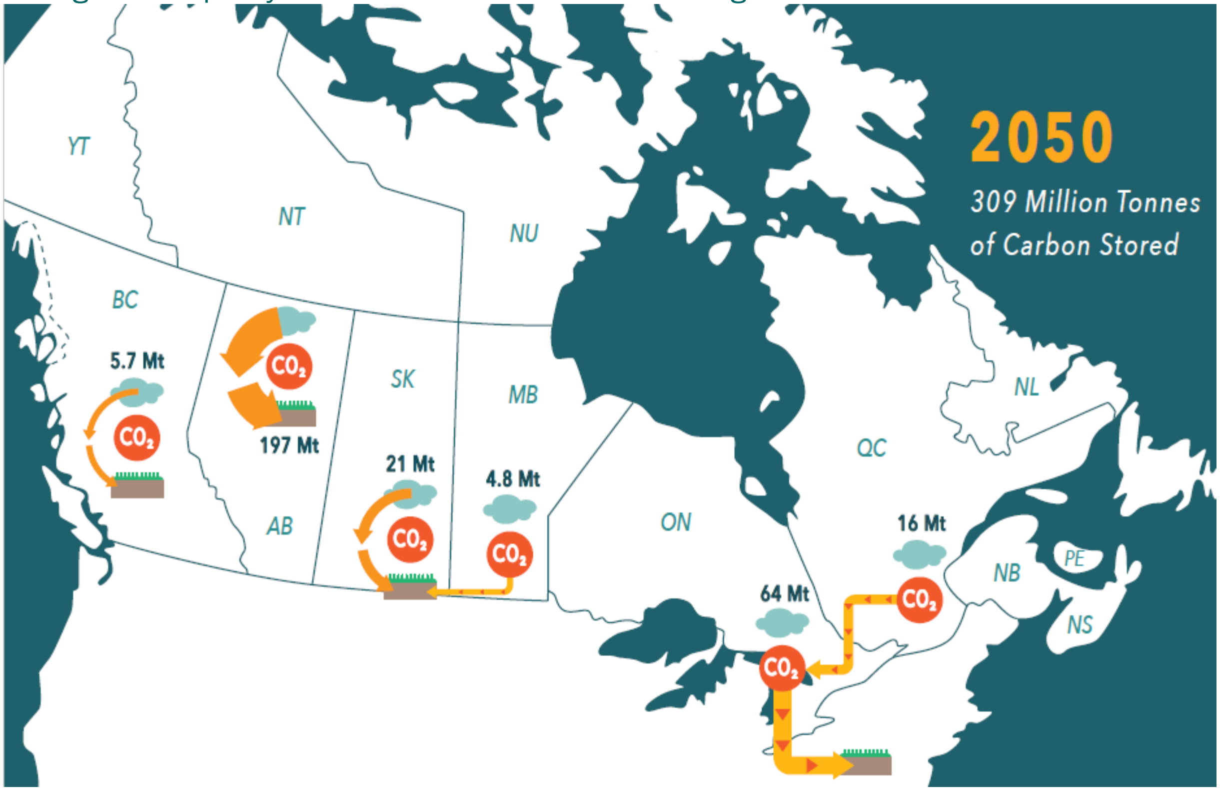
Looking at one net zero pathway[9] as an example, we see capture occurring in almost every province across Canada by 2035 and pipeline transport of CO_2 to locations with suitable storage (Figure 3). At this market size, our model estimates the transport and storage portion of the CCS abatement cost to be \$182/tCO_2 in BC, \$31/tCO_2 in Alberta, \$45/tCO_2 in Saskatchewan, \$105/tCO_2 in Ontario and \$189/tCO_2 in Québec (2020 CAD). Transportation and storage costs, per tonne of CO_2, are high in many regions given that throughput in the nascent CCS industry is low and this constrains the use of CCS.[10]

Figure 3. One possible scenario for carbon capture, transport and storage in 2035 under strong climate policy in line with Canada's net zero target



By 2050, this simulation indicates Canada's CCS industry could grow by over 100 times compared to today, to 309 million tonnes of CO_2 captured and stored across the country (Figure 4). At this market size, the cost of CCS transport would come down to \$171/tCO_2 in British Columbia, to \$26/tCO_2 in Alberta, to \$25/tCO_2 in Saskatchewan, \$50/tCO_2 in Ontario and \$92/tCO_2 in Québec. Transportation and storage costs have declined as the throughput of a maturing CCS industry grows, creating a much larger role for CCS in Canada's net zero future.

Figure 4. One possible scenario for carbon capture, transport and storage in 2050 under strong climate policy in line with Canada's net zero target



How to unlock Canada's CCS opportunity

Our simulations suggest an important role for CCS in achieving Canada's net zero commitment and find that **availability of pipeline infrastructure is critical for development of a CCS industry.** Just as the automotive industry relies on road infrastructure, the CCS industry will rely on pipeline infrastructure. The cost of CCS declines significantly as the industry grows and the amount of throughput in CO_2 pipelines increases. As a result, early investment in pipeline infrastructure is necessary to overcome the "chicken-and-egg" problem and support widescale deployment of this technology in Canada. Federal and provincial policies could help overcome this barrier by ensuring a clear market signal for CCS, and governments could consider strategically investing in, or financing, early deployment of CO_2 transportation infrastructure to help unlock Canada's CCS opportunity.

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References

[1] Alberta Government. (2020). Quest Carbon Capture and Storage project: annual report, 2019. Available at: https://open.alberta.ca/publications/quest-carbon-capture-and-storage-project-annual-report-2019

[2] Alberta Government. (2020). Alberta Carbon Trunk Line. Available at: https://majorprojects.alberta.ca/details/Alberta-Carbon-Trunk-Line/622

[3] International CCS Knowledge Centre. (2021). Boundary Dam 3 Carbon Capture and Storage Facility. Available at: https://ccsknowledge.com/bd3-ccs-facility

[4] Note that there is a precedent in Saskatchewan for cross-border CO_2 pipelines to import CO_2 to Canada. The Weyburn-Midale CO_2 monitoring and storage project involved a 320 km pipeline carrying CO_2 from North Dakota to Saskatchewan for use in enhanced oil recovery. Source: Petroleum and Technology Research Centre. (2021). The IEAGHG Weyburn-Midale CO_2 Monitoring and Storage Project. Available at: ptrc.ca/projects/past-projects/weyburn-midale

[5] Global CCS Institute. (2017). Global Costs of Carbon Capture and Storage: 2017 Update.

[6] International Energy Agency. (2011). Cost and Performance of Carbon Dioxide Capture from Power Generation.

[7] Costs as estimated by gTech. Cost estimates by region are based on the cost of transport along hypothetical routes from the largest point of industrial consumption to storage locations. For example, for British Columbia, cost estimates represent transport from the lower mainland to storage locations in the northeast. For Ontario and Québec, cost estimate represent transport to storage locations in the northeast USA based on: International CCS Knowledge Centre. (April 2021). Canada's CO2 landscape: A guided map for sources and sinks. Available at: https://ccsknowledge.com/pub/Publications/CO2_Sources_Sinks_Canada_April2021.pdf

Cost estimates exclude the cost of operation and maintenance of pipelines, which vary by region and by fuel/electricity price. Capital costs are based on estimates from the Alberta Trunk Link pipeline (using a 15% discount rate), and capital costs scale as a function of throughput based on: Parker, Nathan C. (2004). Using Natural Gas Transmission Pipeline Costs to Estimate Hydrogen Pipeline Costs. Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-04-35. Available at: https://itspubs.ucdavis.edu/download_pdf.php?id=197

[8] Navius' gTech model was used to conduct this analysis. gTech is an energy-economy model that combines technology, macroeconomic and fuel system modeling to simulate the impacts of climate and energy policy across Canada. gTech was used to simulate a cap on emissions at 511 Mt in 2030 (Canada's 2030 target) and net zero emissions in 2050. Differing assumptions about uncertainties such as future commodity prices, technology availability and technology costs were varied across scenarios to simulate a total of 102 different net zero pathways for Canada.

[9] One example pathway is used to demonstrate one potential future of Canada's CCS industry. This scenario uses the best available information to make assumptions about the most likely future oil price, clean technology costs, including CCS costs, and assumes direct air capture technology does not become widely available.

[10] Costs as estimated by gTech. gTech assumes a 90% capture rate for CCS technology, and capture costs refer to $/t$CO_2$ reduced. Storage and transport cost estimates vary by region and are based on the cost of transport along hypothetical routes from the largest point of industrial consumption to storage locations. Transport cost estimates include the cost of operation and maintenance of pipelines, which vary by region and by fuel/electricity price.