Carbon Capture in Alberta: Costs, Benefits, and Policy

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Summary

Alberta's industrial and power sectors have many facilities classified as large emitters, with high-concentration carbon dioxide emissions from large point sources. Carbon capture and storage (CCS) is a technically feasible technology that reduces greenhouse gas emissions in existing industries by reducing high-concentration carbon dioxide (CO2) emissions from large point sources, and is recognized as a key factor for reaching international climate change targets. Alberta hosts two commercial-scale CCS projects jointly funded by the provincial government and private industry, but there are no additional projects for the foreseeable future. CCS deployment is often obstructed by high project costs and risks in developing an emerging technology to commercial scale. This research reexamines CCS in Alberta and provides governments with the opportunity to consider complementary policies for CCS deployment that can benefit Albertans as a whole.

This research presents a Multiple Account Benefit-Cost Analysis[1] of carbon capture and storage projects in Alberta, from the perspective of Albertans. There is a significant cost to private firms and industry to invest in CCS. However, as carbon prices escalate to $50 per tonne by 2022, CCS becomes more economical for the cement industry, hydrogen processing, ammonia and chemical production. When impacts in the taxpayer, environment, social, and economic activity accounts are considered, there is an overall benefit to Albertans in using CCS to reduce emissions. However, public perception of CCS projects remains a crucial factor.

To reduce barriers to CCS development and increase investment in CCS, a policy strategy is needed. The policy strategy needs to address both the market failures that lead to emissions and underinvestment in research. Therefore, in addition to carbon pricing, environmental taxation such as tax credits specifically for CCS projects can encourage research and development. To also signal government support to the public and investors, existing provincial and federal government incentives for low-carbon and clean-energy projects should extend to include CCS in both the industrial and power sectors.

Introduction

Alberta has a strong natural resource sector that drives the provincial and national economy.[2,3] Alberta has the highest level of greenhouse gas (GHG) emissions compared to other provinces, in part because of a large industrial sector. Industrial sources of CO2 include natural gas power generation plants, fertilizer operations, hydrocarbon refineries and upgraders, oil sands operations, cement production, and chemical facilities. Both Canada and Alberta have set emissions reduction targets, and both levels of government have recently phased in or announced carbon pricing regimes. Although the two targets are not aligned, they both share the same overall goal to reduce GHG emissions.

Carbon capture and storage (CCS) is a technology recognized by the United Nations Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA) as a key solution in meeting global emission reduction targets.[4,5] By capturing emissions at the source, and storing or utilizing the captured emissions, CCS can reduce GHG emissions while maintaining industrial activity that provides an economic benefit.[6] However, CCS development at the commercial scale in Alberta is progressing slowly. Large-scale CCS is needed to meet international targets of limiting global temperatures to less than 2°C above pre-industrial levels, even with recent growth and projected increases in renewable energy.[7] Recently expanded carbon pricing in Alberta may provide an incentive for CCS investment, and an updated cost-benefit analysis of CCS in Alberta will help inform this decision.

Barriers to CCS development are the same faced by new first-generation technologies: cost and risk. Government tax policies could provide incentives for private firms to invest in CCS and share risk with the government. Carbon pricing and tax credits specifically for CCS development offer near-term policies to support commercial CCS project development by 2030 – when Canada is obliged to meet its emission reduction targets.

This research examines the industrial and power sectors in Alberta, to determine which types of facilities are best suited to utilize CCS as a technology to reduce emissions. This research also identifies the relative costs and benefits of CCS to large emitters in Alberta's power and industrial sectors, and to the province as a whole. The following are considered: the cost of CO2 emissions avoided from carbon capture, carbon pricing, and the social cost of carbon. Furthermore, factors that have created barriers and stalled development of CCS in Alberta are discussed, and policy instruments that facilitate and accelerate deployment of CCS are identified. Environmental taxation combined with tax credits is identified as a policy option to address the underinvestment in research and development for CCS.

Methodology

Multiple account benefit-cost analysis (MABCA) [8], from the perspective of Albertans, is used to identify the trade-offs from implementing CCS in the industrial and power sectors. MABCA is preferred to traditional benefit-cost analysis, as alternative perspectives of stakeholder groups are evaluated. Costs and benefits to each group are accounted for, including how they are distributed, and decision-making alternatives are considered. MABCA recognizes that not all consequences have a monetary metric, and that the summation of costs and benefits to obtain a net bottom line is often not as important as understanding the trade-offs.[9]

The relative costs and benefits to industrial facilities that emit over 300,000 tonnes of CO2 in Alberta's power and industrial sectors and to the province as a whole are explored to identify with whom the maximum net benefit resides. Facilities with emissions over 300,000 tonnes CO2 were selected as a cut-off point that is large enough to support large-scale CCS demonstration projects. The multiple account evaluation of overall benefits and costs considers various stakeholders affected by the project: the private market value of CCS project development to firms, and the public perspective of Albertans with regards to their overall welfare and direct interests, including economic impacts related to CCS projects. The evaluation accounts used are described in Table 1.

Table 1. Multiple account benefit-cost analysis evaluation accounts

Account	Purpose
Market Valuation Account	Assesses private project costs and benefits.
Taxpayer Account	Benefits and costs to taxpayers in Alberta.
Environmental Account	Environmental impacts in Alberta
Social Account	Consequences for communities and their interests.
Other Considerations	Public perception and opposition of CCS projects.

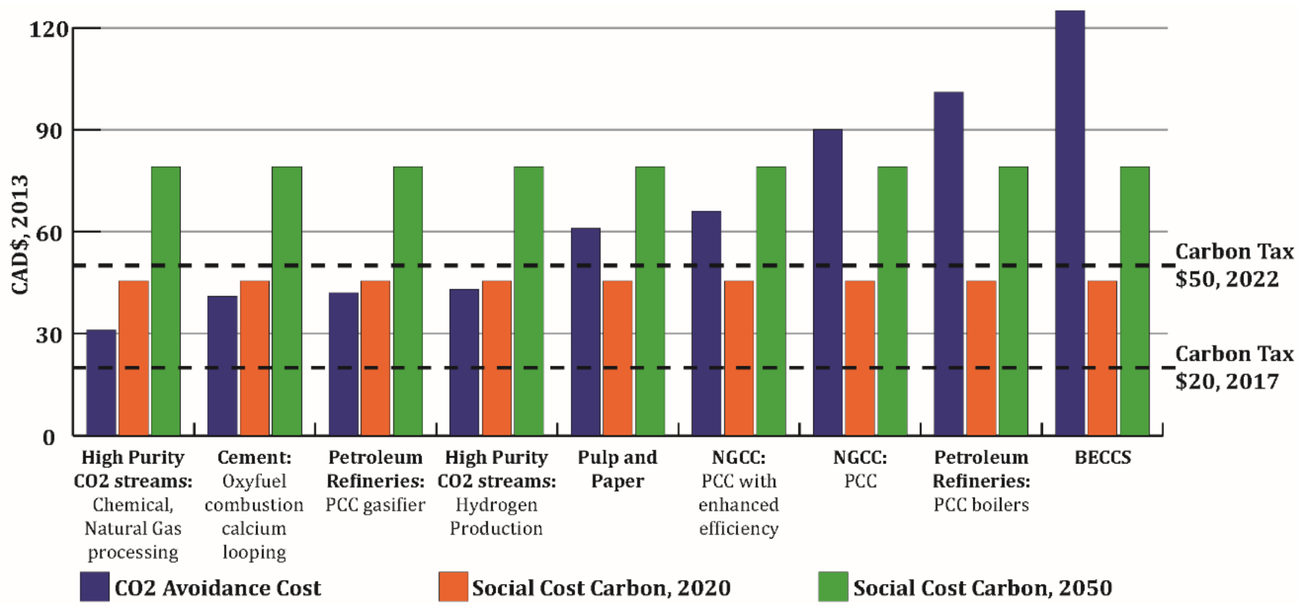
A review of recent literature is conducted to explain the uncertainties and assumptions made in carbon capture cost estimates, assess the costs of CO2 avoidance by sector and technology, and the costs associated with CO2 transportation and storage. Next, the costs and benefits of CCS projects in Alberta's power and industrial sectors are evaluated. The cost of CO2 avoided for selected industries, the social cost of carbon, and the carbon tax in Alberta are assessed to identify which industries should consider carbon capture technologies to reduce emissions; otherwise a carbon tax will have greater financial cost than the cost of CO2 emissions avoided.

This research also provides a rationale for government involvement by identifying market failures that lead to inefficiently allocated resources. Policy strategies are presented to correct negative externalities, such as pollution; and, positive externalities, such as information spillovers that contribute to underinvestment of research and development for new technologies.

Results

The cost of CO_2 avoided for selected industries, the social cost of carbon (an estimate of social damages), and the carbon tax in Alberta are illustrated in Figure 1. By 2020, for the cement industry and high purity CO_2 sources it costs less to avoid emitting one tonne of CO_2 with carbon capture than the estimated social damage that results for emitting one tonne of CO_2. By 2022, the carbon tax of $50 per tonne is higher than the cost of avoidance (COA) for high purity CO_2 sources, the cement industry, and post-combustion capture (PCC) gasifiers in petroleum refineries. These sectors should consider carbon capture technologies to reduce emissions, as paying a carbon tax will have greater financial cost than the avoided cost of CO_2. If these sectors invest in CCS, it is a benefit to Albertans as the COA is less than the social cost of carbon. Bio-energy with CCS (BECCS) may also be feasible, depending on the feedstock type.

Figure 1. Cost of CO2 avoided and the social cost of carbon ($CAD 2013).



The benefits and costs from each account are summarized below. Rather than calculate a bottom line, this MABCA provides information on the impacts of CCS projects to Albertans, but also shows there is a significant cost to private firms and industry that invest in the technology.

Market Valuation Account: The cost of CO_2 avoided for the industrial and power sectors is estimated for the lifetime of a facility. This cost measure is used to compare a reference facility without carbon capture to the same facility that utilizes carbon capture. Carbon capture from high purity streams (hydrogen processing, ammonia and chemical production), are the most financially feasible CCS projects at $30 to 40 per tonne of CO_2 avoided. Future scenario forecasting by Leeson et al. (2017) revealed that the cement industry has significant potential to avoid emissions, where by 2050 the avoidance cost could be reduced by half.[10] Additional costs from transportation, storage, and monitoring are project dependent. There is also risk and liability of investing in first-of-a-kind (FOAK) projects while CCS is in the development and demonstration stage. Benefits are gained through financial returns if a firm avoids paying a carbon price on emissions that is higher than the avoidance cost, and if revenue from CO_2 utilization is earned.

Alberta Taxpayer Account: Costs include reduced government revenue of corporate tax income if the cost for carbon capture reduces annual industrial profits. If firms use carbon capture to reduce emissions by industrial emitters, then government revenue is also reduced from firms that participate in Alberta's output-based allocation system. Additional costs are incurred when the government funds CCS projects. Benefits include linear tax revenue to municipalities that host CO_2 pipeline infrastructure, and royalties collected from incremental natural gas production and EOR.

Environmental Account: The most significant impact of CCS is a benefit as it reduces emissions, which impose damages on Albertans. Other potential negative environmental impacts were identified, such as post-injection CO2 leakage from geologic formations into aquifers and induced seismic events, however the risk of this happening is cited from several sources as low.[11,12,13,14,15]

Social Account: There is a benefit to communities if CCS is utilized in nearby facilities, as health impacts are reduced from local air contaminants and particulate matter.

Economic Activity Account: If CCS is deployed in the near-term there is a potential benefit to Alberta's labour market, which has seen unemployment rates rise to 9.0 percent in 2016 in the resource sector due to the oil crash mid-2014. If CCS is not used, it is business-as-usual and there is no impact to economic activity.

How each account is ranked in terms of importance or whether the accounts have equivalent weight is subjective. What is important is that the results in each account are considered separately to explicitly outline costs and benefits to each group. Overall, the cost and risk involved to invest in CCS is high; however, there is a benefit to Albertans to reduce carbon emissions with CCS. For some industrial products, such as cement and high purity CO2 sources (i.e. ammonia and chemical production), there are no close substitutes and their demand is relatively inelastic. With no alternatives to these products, CCS is a viable option for these industrial sectors to reduce emissions. However, public perception of CCS is often met with resistance, and should not be underestimated. Public opposition of CCS have the power to cancel CCS projects. If CCS projects are to succeed, support is needed from Albertans, especially landowners who may store CO2 deep beneath their soil.

A policy strategy is needed to increase investment in CCS and reduce barriers to successfully mitigating carbon emissions in existing industries. Environmental taxation, such as carbon pricing, provides market demand for CCS technology. In addition, environmental taxation such as tax credits specifically for CCS projects can incentivize industrial CCS projects by promoting R&D and earlier market entry for carbon capture technologies. More firms would invest in a technology "if the expected rate of return exceeds the market rate of return".[16] Each policy alone is insufficient, and should be used to complement each other.

Conclusions

CCS presents an opportunity to significantly reduce CO2 emissions in both the industrial and power sectors, and meet future emissions targets set by the international community. However, once the Alberta Carbon Trunk Line is completed, there are no other large CCS demonstrations or commercial scale projects planned in Alberta. CCS projects face deployment barriers related to high project costs, and risks related to bringing first-of-a-kind projects to commercial scale. This research shows that as the carbon price in Alberta escalates, CCS becomes more economical – particularly for the cement industry if oxyfuel combustion calcium looping is used, and CO2 emissions are captured from high purity streams such as hydrogen processing, and ammonia and chemical production. With technological improvements, increased scale, and more nth-of-a-kind projects, other sectors may soon benefit from lower CO2 avoidance costs.

The multiple account benefit-cost analysis performed is from the perspective of Albertans, and evaluates and provides transparency of the cost and benefits for CCS projects to taxpayers, the environment, communities, and economic activity in Alberta. The analysis shows that CCS projects provide an overall benefit to Albertans, yet an increasing carbon price and the identified benefits of CCS projects in Alberta does not ensure CCS project deployment.

Additional policy action is needed to overcome the high-costs and risks associated with CCS projects through environmental taxation, using both carbon pricing and a tax credit designed specifically for carbon capture. In addition, CCS projects should explicitly be included in existing policies that support low-carbon initiatives, but currently favour and incentivize renewable energy and other clean energy projects and technologies. Regardless of these recommendations, resistive public perception of CCS projects presents an obstacle to deployment. The public may be more willing to support CCS projects if there is more confidence in the technology via increased project demonstrations. Both the government and industry need to inform and engage the public to provide a sense of fairness and gain trust. It is also recognized that global collaboration is needed to accelerate progress in CCS development and mitigate climate change.[17]

Notes

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[1] Marvin Shaffer, *Multiple Account Benefit-Cost Analysis: A Practical Guide for the Systematic Evaluation of Project and Policy Alternatives*, Kindle (Toronto: University of Toronto Press, 2010).

[2] Alberta, “Our Business,” *Alberta Energy*, December 28, 2006, http://www.energy.alberta.ca/OurBusiness.asp.

[3] Alberta, “Alberta’s Economic Recovery Bolsters National Growth | Alberta.ca,” *Alberta Government Announcement*, 2017, https://www.alberta.ca/release.cfm?xID=4835270BD3670-00AA-800E-34DDE78949A0A6EA.

[4] IPCC, *Climate Change 2014: Mitigation of Climate Change*, *Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 2014, doi:10.1017/CBO9781107415416. 53.

[5] International Energy Agency, “Carbon Capture and Storage,” accessed August 28, 2017, https://www.iea.org/topics/ccs/.

[6] Alberta Department of Energy, “Carbon Capture and Storage: Why Do We Need CCS,” accessed December 5, 2016, http://www.solutionsstarthere.ca/20.asp.

[7] Glen P. Peters et al., “Key Indicators to Track Current Progress and Future Ambition of the Paris Agreement,” *Nature Climate Change* 7, no. 118 (2017), doi:10.1038/nclimate3202.

[8] Shaffer, *Multiple Account Benefit-Cost Analysis: A Practical Guide for the Systematic Evaluation of Project and Policy Alternatives*.

[9] Ibid. Kindle locations 119-121.

[10] D. Leeson et al., “A Techno-Economic Analysis and Systematic Review of Carbon Captureand Storage (CCS) Applied to the Iron and Steel, Cement, Oil Refining and Pulp and Paper Industries, as Well as Other High Purity Sources,” *International Journal of Greenhouse Gas Control* 61 (2017): 71–84, doi:http://dx.doi.org/10.1016/j.ijggc.2017.03.020.

[11] Bhawna Singh, Anders H. Strømman, and Edgar G. Hertwich, “Comparative Life Cycle Environmental Assessment of CCS Technologies,” *International Journal of Greenhouse Gas Control* 5, no. 4 (2011): 911–21, doi:10.1016/j.ijggc.2011.03.012. 919.

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[13] Stefan Bachu and Theresa L. Watson, “Review of Failures for Wells Used for CO2 and Acid Gas Injection in Alberta, Canada,” in *Energy Procedia*, vol. 1, 2009, 3531–37, doi:10.1016/j.egypro.2009.02.146. 3532.

[14] James P. Verdon, “Using Microseismic Data Recorded at the Weyburn CCS-EOR Site to Assess the Likelihood of Induced Seismic Activity,” *International Journal of Greenhouse Gas Control* 54 (2016): 421–28, doi:10.1016/j.ijggc.2016.03.018. 427.

[15] Steven T Anderson, “Risk, Liability, and Economic Issues with Long-Term CO2 Storage---A Review,” *Natural Resources Research*, 2016, 1–24, doi:10.1007/s11053-016-9303-6.

[16] Kenneth Arrow, “Economic Welfare and the Allocation of Resources for Invention,” *National Bureau of Economical Research: The Rate and Direction of Inventive Activity: Economic and Social Factors* I (1962): S. 609-626, doi:10.1521/ijgp.2006.56.2.191. 613.

[17] Peters et al., “Key Indicators to Track Current Progress and Future Ambition of the Paris Agreement.”

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