Energy, at What Cost: Is $15 Billion per Year Enough to Bury Alberta's Carbon Footprint?

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Summary

Canada (together with the USA and Australia) has the largest emissions of CO_2 per capita in the world: about 21 tonnes CO_2 per capita equivalent. Alberta exceeds that amount significantly with close to 70 tonnes per capita. Because Alberta considers the rapid development of the oil sands important for its economy, it is unlikely that these numbers will decrease significantly in the foreseeable future. If anything, Alberta's CO_2 output is likely to increase. For this reason, Alberta is planning to store yearly 139 Mt of CO_2 by 2050 at a cost of $15 billion per year (at an average cost of $110/tonne). Leakage of natural gas can be observed in most petroleum reservoirs and potential leakage of stored CO_2 needs to be taken into consideration. Using storage of CO_2 for mitigating global climate change would cost the world $330 billion per year. CCS is remarkably expensive and is untested at these scales. Thus, it is more cost-effective to increase the contribution of energy conservation in obtaining reduced CO_2 emissions.

Introduction

Canada (together with the USA and Australia) has the largest emissions of CO_2 in the world per capita: about 21 tonnes CO_2 equivalent per year. Alberta exceeds that amount significantly with close to 70 tonnes per capita. Because Alberta considers the rapid development of the oil sands (containing petroleum resources equivalent in size to those of the Middle East) important for its economy, it is unlikely that these numbers will decrease significantly in the foreseeable future. If anything, Alberta's CO_2 output is likely to increase.

Government and private sector champions believe that CO_2 Capture and Storage (CCS) will play a significant role in future energy and climate change response strategies. Storage in saline aquifers, coal beds and salt caverns has been suggested (Figure 1). For example, the Government of Alberta has recently set out $2 Billion worth of investment for CCS projects to assist in the reduction of greenhouse gas emissions within Alberta (Alberta CCS Development Council, 2009). From this investment of $2 billion, reductions of 5 Mt of CO_2 are foreseen by 2015. The plan is to have reductions of 139 Mt per year by 2050.

It is estimated that CCS will cost somewhere in the range of $70-$150/tonne (Alberta CCS Development Council, 2009). This estimate is well above the current $15/tonne Alberta carbon price, which the Alberta Government charges to large emitters. This implies that 139Mt of stored CO_2 (Alberta CCS Development Council, 2009, p.19) will cost $15 billion per year at an average price of $110 per tonne of stored CO_2. Snieder and Young (2009) estimate that for mitigating global climate change, $150 billion per year is needed at an average cost of $50/tonne of stored CO_2 (or $330 billion per year at an average price of $110 per tonne). CCS is very expensive, would require large amounts of energy and is still untested at this scale.

Under these circumstances, CCS technology development faces many interdependent complexities such as current and future prices for hydrocarbons, climate change policy and geohazards. Adaptations and ways to mitigate risk are needed, such as supporting more scientific work on geohazards at potential CCS sites.

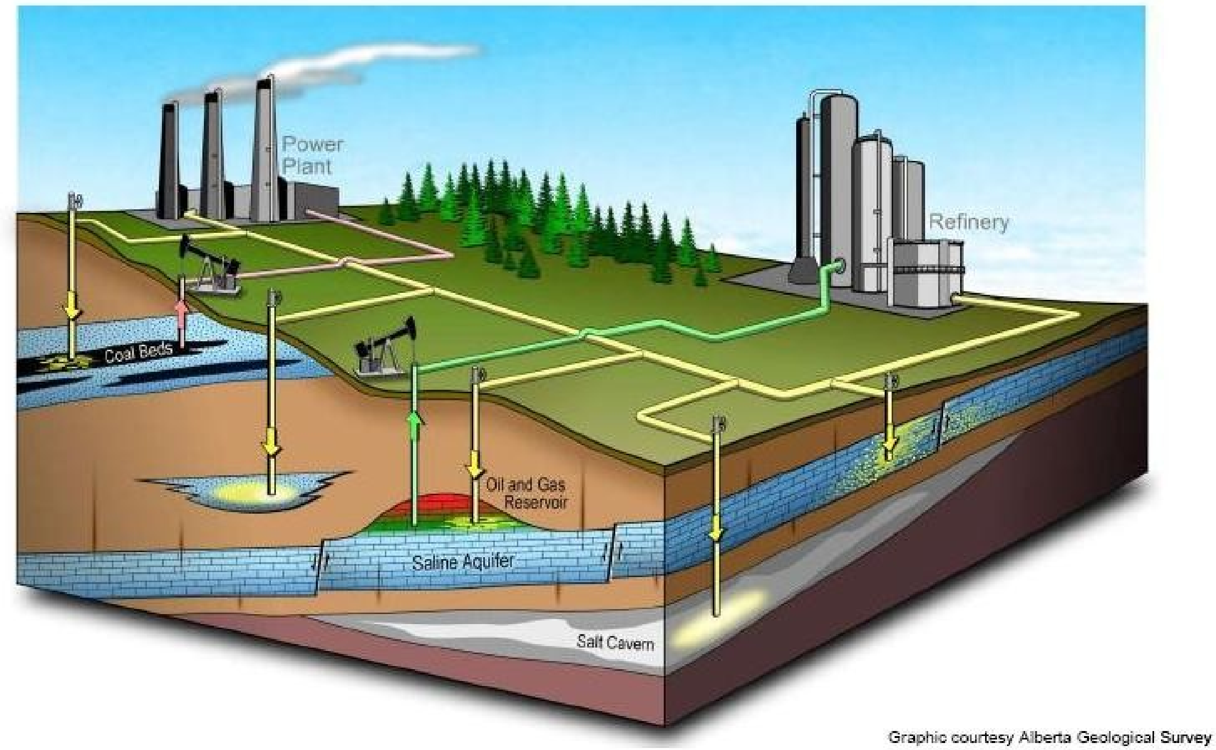

Figure 1: CO_2 capture from power plants and refineries and storage in saline aquifers, coal beds and salt caverns

Geohazards

In most petroleum reservoirs some migration of natural gas to the surface can be observed (Pagnier, 2009). Consequently, there will be a number of geological risks associated with the development of the CCS technology. These Geohazards include (see Figure 2):

Seal Leakage

This type of leakage is related to cap rock integrity. Work is underway in Alberta to assess the cap rock integrity of potential CCS storage sites in Alberta.

Spill leakage

Leakage along bedding can be expected along fractured zones.

Fault Leakage

Faults may provide a conduit for CO_2 to escape through cap rock. CO_2 leakage along faults will have three behaviors: upward migration from the storage formation along a fault, lateral movement from the fault into permeable layers, and a continued but attenuated CO_2 flux along the fault above the layers.

Well Leakage

There are hundreds of thousands of wells in Alberta, which could cause hazard for any CCS project in Alberta. New injection wells could also create leakage problems.

Induced seismicity

Hydrocarbon production could induce seismicity. Subsidence of 1 m is predicted by 2050 for the Groningen Gas Field in the Netherlands and earthquakes with magnitudes of up to 3.4 have been observed (Gussinklo, 2001) resulting from gas extraction. CO_2 injection can be expected to have similar effects with uplift instead of subsidence and fractures created by gas extraction could be reactivated. Open fractures and leakage could result from extension related to uplift. Onuma *et al.* (2008) saw surface heave for CO_2 injectors and subsidence for producers in Algeria. These hazards need further investigation before commercial application.

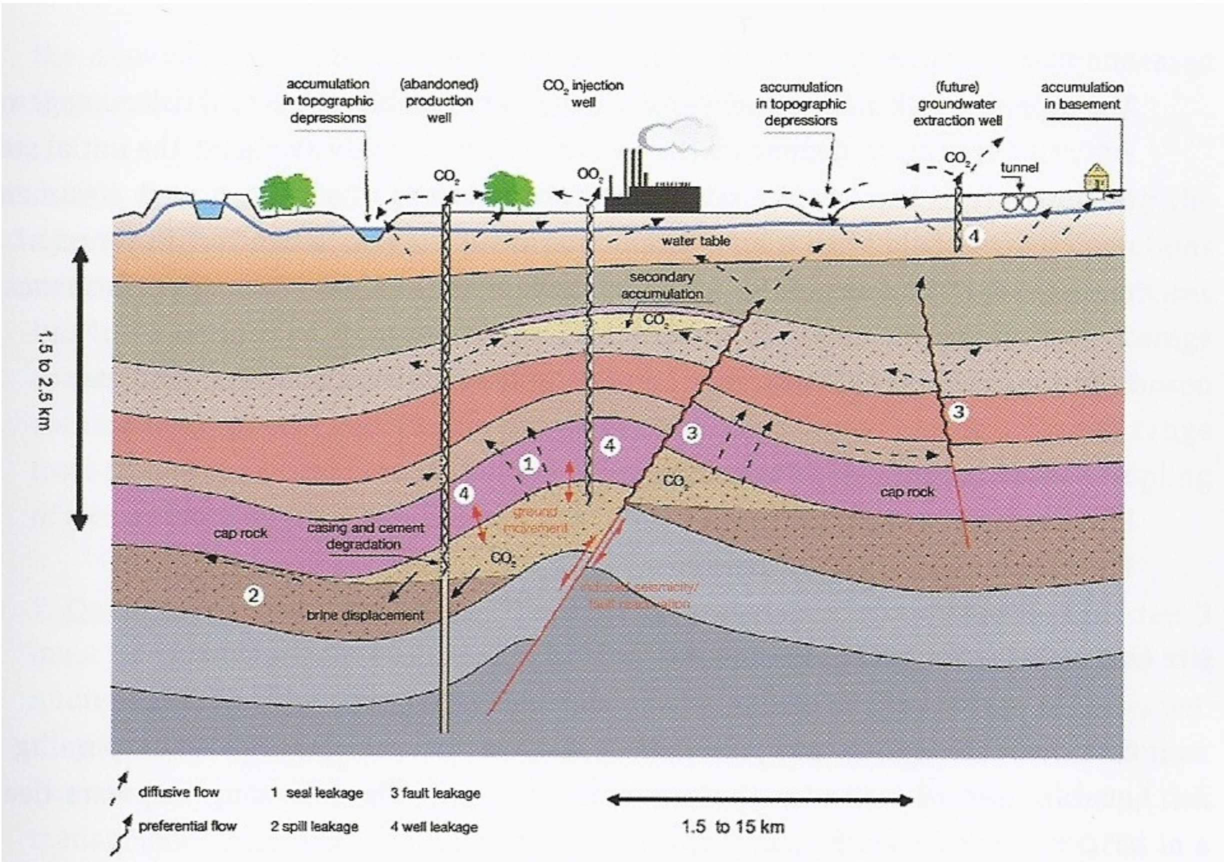

Figure 2: Main leakage paths for CO2 to move toward the surface: 1) Seal Leakage; 2) Spill Leakage; 3) Fault leakage; 4) Well leakage. From Pagnier, 2009.

Although no leakage was observed during ten years of monitoring at the Sleipner Test Site in the North Sea, leakage of methane above a shallow gas accumulation was observed by seismic data at a nearby site (Pagnier, 2009, p.28). The geohazards of CCS have not been considered in the recommendation of the CCS Development Council (Alberta CCS Development Council, 2009). Techniques developed by the Alberta Geohazard Program (Froese *et al.*, 2009) can assist CCS hazard assessments.

Energy Conservation

An Alberta Energy Efficiency Branch (1990) report concluded that a capital investment of $6.7 billion for retrofit energy conservation measures would result in $2.2 billion per year savings, so the average payback of the investment would have been 3.1 years. The annual CO_2 reduction resulting from these measures would be 61.5 Mt per year in the year 2005 (as opposed to the 24 Mt estimate by Alberta CCS Development Council, 2009, p.19). The Energy Efficiency Branch of the Department of Energy was eliminated by the Alberta Government during the budget cuts of 1994.

Conclusions

Alberta is planning to store yearly 139 Mt of CO_2 by 2050 at a cost of $15 billion per year (at an average cost of $110/tonne). Leakage of natural gas can be observed in most petroleum reservoirs and potential leakage of stored CO_2 needs to be taken into consideration. Using storage of CO_2 for mitigating global climate change would cost the world $330 billion per year. Carbon Capture and Storage (CCS) is remarkably expensive and is still untested at the scale presently envisioned. Thus, it is more cost-effective to increase the contribution of energy conservation in obtaining reduced CO_2 emissions.

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