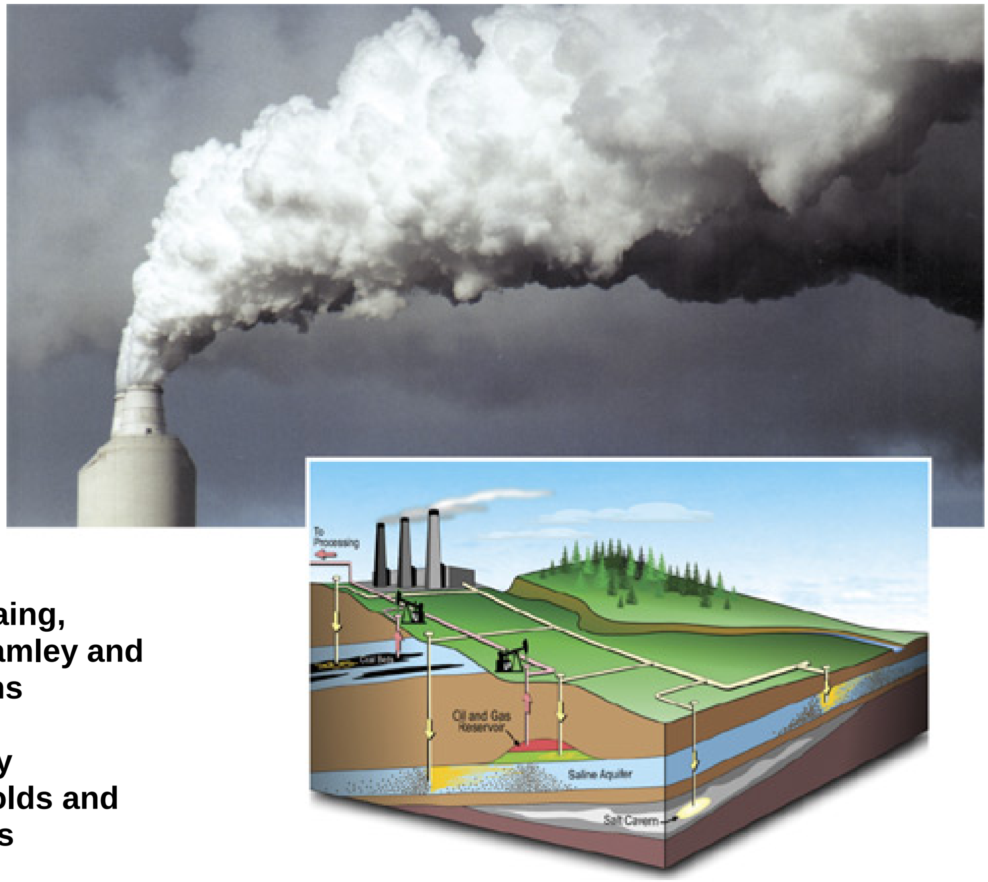
Carbon capture and storage

The Pembina Institute's position



Tom Marr-Laing,
Matthew Bramley and
Mary Griffiths

with input by
Marlo Raynolds and
Roger Peters

November 2005

Photo: Ontario Clean Air Alliance/Jesse Gibb Illustration: Alberta Geological Survey, Alberta Energy and Utilities Board

The Pembina Institute has recently published a public education primer on carbon capture and storage.[1] This primer provides an overview of the current status of development of CCS technology, its potential to contribute to greenhouse gas (GHG) emission reductions, economic costs, and associated risks. It summarizes the policy initiatives and perspectives being promoted by government, industry and some environmental non-governmental organizations (ENGOs).

As an outcome of its research to understand CCS, the Institute has also developed its own policy position on the role CCS should play in the urgent challenge to achieve deep reductions in GHG emissions. This paper provides an overview of our position.

[1] *Carbon Capture and Storage: An arrow in the quiver or a silver bullet to combat climate change? A Canadian Primer*. Download for free from the Pembina Institute website: www.pembina.org

Summary of key points

1. In order to play a responsible role in the prevention of dangerous climate change, there is an urgent need for Canada to embark now on a trajectory towards deep reductions in emissions of greenhouse gases.
2. There is no single “silver bullet” to do this; rather a portfolio of policy and technology tools will need to be used.
3. The most important tool is a system of mandatory, long-term restrictions on GHG emissions, particularly from industrial sources, commensurate with Canada’s national GHG targets.
4. Carbon capture and storage (CCS) can have a significant role to play — but only under certain conditions and with appropriate safeguards including the establishment of a strong regulatory framework to minimize the risk to people and the environment.
5. Who pays to set up CCS infrastructure (such as carbon dioxide (CO_2) pipelines) is an important question.
    a. The Pembina Institute believes governments’ priorities for public expenditures on GHG emission reductions should be sustainable energy initiatives (primarily low-impact renewable energy, energy efficiency and conservation) for which public investment is needed to mobilize large-scale deployment across the economy.
    b. It is also our assessment that it is politically pragmatic to use a small percentage of the public funds devoted to GHG emission reductions to leverage much larger investments by the private sector for significant reductions in GHGs from large point sources. Such a public investment should not only realize the establishment of GHG reduction infrastructure but also generate a return on political capital in terms of industry support for targets consistent with a trajectory towards deep reductions in GHG emissions.

Context

To prevent dangerous human interference with the climate and minimize the associated adverse impacts on the environment, people and economies, there is an urgent need for deep cuts in GHG emissions to stabilize and then reduce their concentration in the atmosphere. The increase in global average temperature associated with business-as-usual increases in GHG emissions by 2100 is projected to be accompanied by profound, widespread global impacts including a damaging rise in sea levels, rapid transformation of ecosystems and consequent large-scale loss of biodiversity, significant increases in extreme weather events, and major disruption to land- and ocean-based industries.[2,3] It is now clear that if major action to reduce emissions is not initiated within the next few years, it will become impossible, for practical purposes, to avoid these impacts.[4]

Using existing technology, a portfolio of tools is available, each of which could make a contribution towards achievement of deep reductions in emissions of carbon dioxide (CO_2), the most important long-lived GHG. Not all these tools may be considered socially and/or environmentally acceptable.

[2] Intergovernmental Panel on Climate Change. 2001. *Climate Change 2001: The Scientific Basis.* Cambridge University Press.

[3] Intergovernmental Panel on Climate Change. 2001. *Climate Change 2001: Impacts, Adaptation, and Vulnerability*. Cambridge University Press.

[4] See, for example, “Avoiding Dangerous Climate Change,” *International Symposium on the Stabilization of Greenhouse Gas Concentrations,* Hadley Centre, Met Office, Exeter, UK, 1-3 February 2005, Report of the International Scientific Steering Committee, http://www.stabilisation2005.com/Steering_Commitee_Report.pdf.

The main tools that have been proposed are

- Energy conservation
- Increased efficiency in both energy production and consumption
- A switch to energy sources with lower GHG intensity (as measured by emissions to the atmosphere), notably
  - renewable energy
  - nuclear energy
  - fossil fuel energy with carbon capture and geological storage
- Creation and enhancement of biological carbon sinks and protection of biological carbon reservoirs

In assessing these tools, it needs to be recognized that each has limitations, whether it be in terms of total potential emission reductions, the speed in which it can be implemented, economic costs and benefits, or collateral environmental, public safety and security risks posed.

An assessment of Carbon Capture and Storage as a tool in the GHG emission reductions portfolio.

CCS is a technological process in which CO_2 emissions from large point sources (such as coal-fired electricity power plants, oilsands facilities, cement plants, etc.) would be captured, compressed and shipped by pipeline to a location where the gas is injected into underground formations for long-term storage. For a detailed discussion of this process, its risks, costs, GHG reduction potential, etc. the reader is referred to the Institute's publication *Carbon Capture and Storage: An arrow in the quiver or a silver bullet to combat climate change?*[5]

A number of important issues need to be considered when evaluating the potential large-scale use of CCS as part of a portfolio of tools to reduce CO_2 emissions:

- CCS can be applied only by large point sources of CO_2, such as the oil and gas, electricity generation, cement and steel industries. These sources currently account for approximately 40% of Canada's GHG emissions, although not all of them are close to locations where CO_2 could be injected underground. Emissions from the end use of fossil fuels (such as for heating homes, vehicle transportation, etc.) need to be reduced via demand reduction and alternative technologies.[6]
- While some CCS projects could be in place before the end of the first Kyoto Protocol commitment period (2008–2012), the timelines for large-scale application of CCS are in the mid-2010s at the earliest and probably longer.
- CCS is essentially an end-of-pipe waste management response for CO_2 emissions. It does not reduce CO_2 production itself. Keeping carbon sequestered in its natural state below the earth's surface is inherently safer and more effectively prevents GHG emissions than burning the fossil fuel and subsequently capturing and re-injecting the carbon below the surface.
- The processes to capture, compress, transport and inject CO_2 significantly reduce overall plant efficiency, creating additional resource consumption and absolute CO_2 production.

---

[5] See www.pembina.org

[6] The oil and gas industry regularly makes note of the fact that "*While emissions occur throughout the chain of activities from exploration to consumption, end use consumption is the main source of emissions, accounting for 80-85% of the total.*" In light of this, it is important to note that CCS is only applicable to large, point-source emissions of CO_2, and hence is only applicable to a relatively small proportion of current CO_2 emissions from the lifecycle of fossil fuel production and consumption. However, if hydrogen is used in the future as a large-scale energy carrier, CCS could be used to address most or all of the CO_2 emissions from the lifecycle of fossil fuels.

Source: Upstream Oil and Gas Working Group, Industry Issues Table. 1999. *Upstream oil and gas industry options paper*.

- A focus on CCS could divert political and business leadership and policy and public financial resources away from the large-scale deployment of energy conservation, energy efficiency and low-impact renewable energy.
- The use of CCS could unduly perpetuate the use of fossil fuels, further increasing the environmental and climate impacts associated with fossil fuel energy.
- The pipeline transport and underground storage of CO_2 pose risks of leakage into the atmosphere — with corresponding impacts on both the environment and, potentially, public safety.
- The CO_2 will need to be stored for extremely long periods of time, which poses serious challenges to determining who will be accountable and pay for the long-term liabilities associated with underground storage, including long-term monitoring, inspection and remediation of any leaks.
- Use of CCS in preference to less expensive alternatives would be economically inefficient.

The above issues lead to the following question: ***To what extent should CCS be used as part of a portfolio of tools to reduce CO_2 emissions, and what policies and measures should governments implement in consequence?***

The Pembina Institute answers this question as follows:

In light of the urgent need to make deep cuts in emissions of GHGs to stabilize and then reduce their concentration in the atmosphere, the Pembina Institute considers CCS to have the potential to make a significant contribution to reducing GHG emissions, subject to the following factors and conditions:

- A portfolio of technologies and actions to reduce CO_2 emissions is advisable. The optimal combination of these tools for long-term reduction of CO_2 emissions cannot be determined in advance, given the uncertainty regarding future technology developments and economic factors.
- Governments must implement mandatory, long-term restrictions on GHG emissions, particularly for industrial sources. This is the single most important step to drive the technological and behavioural changes needed to reduce emissions. When implemented in combination with emissions trading, or via a tax, such restrictions will translate into a "price of carbon," allowing the market to determine the development and deployment of the most economically efficient GHG emission reductions technologies. The application of such restrictions should be commensurate with the national and global emission reduction targets needed to prevent dangerous climate change. Furthermore, industry should be required to take full responsibility for the GHG emissions associated with increases in its production volumes by paying the price of carbon for the full extent of these additional emissions (e.g., by purchasing credits to offset 100% of them). This is because these emissions represent a new addition to the total emissions load at a time when deep reductions are required.

- Fifteen years of climate change debate in Canada has amply demonstrated that for the political will to exist to establish meaningful GHG restrictions, solutions must be available to existing sectors of the economy that accommodate interests for economic growth within the environmental imperative to reduce GHG emissions.

- It is appropriate for governments to spend public money on the research, development and deployment phases of particular GHG reduction approaches to assist in accelerating their broad deployment across the economy. Such funding is supportable on the basis that a market price of carbon that reflects the magnitude of GHG reductions required is not yet in place, and because even if such a price of carbon were in place, it would not reflect non-GHG risks and benefits of different technologies and would not overcome non-price barriers (e.g., lack of awareness). However, the public funds available for this purpose are quite limited and are very small compared to the private funds that can be mobilized by mandatory restrictions on emissions and the creation of an adequate market price of carbon. Public funds should therefore be allocated only to those approaches that meet the highest standards of sustainability and inherent safety while also making sense from both a short- and long-term economic perspective. The highest priorities of these approaches are energy conservation, energy efficiency and low-impact renewable energy.

- Given the regulatory responsibilities of governments, it is reasonable to expect public money to be allocated towards developing a sound regulatory framework for the management of CCS and to set up a process for independent monitoring, inspection and reporting.

- If governments do spend public money on the development and deployment of CCS infrastructure (such as capture technologies or CO_2 pipelines), they should do so only as part of an overall strategy to reduce GHG emissions that reflects a reasoned balance between the various GHG reduction policy and technology tools, with justification provided for the resources devoted to each tool.

- Any public funds applied towards CCS infrastructure should be subject to the following conditions:[7]

    - That they be accompanied by publicly stated industry support for governments to establish and take action towards achieving long-term GHG reduction targets, both nationally and for industry, in both the 2020 and 2050 timeframes at a level consistent with a trajectory towards deep emission reductions.[8] Large industry currently accounts for approximately 50% of Canada's GHG emissions[9]. Future mandatory targets and complementary initiatives for large industry must add up to a total emission reduction that is in keeping with this 50% share of emissions.

    - That they represent a small percentage of total government funds devoted to GHG emission reduction.

    - That they contribute towards the initial start-up capital investment needed to "kick start" technologies and infrastructure, but not to ongoing operations. The goal of public funding is to assist with demonstrating viability and to accelerate the reduction of costs. The scale of this contribution should be modest to reflect that while climate change risk affects everyone and the demand for products is created by the broader economy, GHG emissions also pose a direct risk to the future earnings of industry and its shareholders. As these players will benefit significantly from the application of CCS, it is reasonable for them to bear the majority of the cost and risk of its implementation.

    - Where CCS could generate revenues (e.g., when combined with enhanced oil recovery projects), any public contributions should be further limited to the "non-economic" portion of a project and then scaled further to reflect a pro-rata share of the risks and net environmental benefits to be realized from CCS projects (as per the above point).

[7] The Pembina Institute has consistently argued against public subsidy of heavy industry on the basis that such subsidies distort the market and are driving increased environmental degradation (e.g., "Government Spending on Canada's Oil and Gas Industry: Undermining Canada's Kyoto Commitment" downloadable at: http://www.pembina.org/publications_item.asp?id=181) A key example is the current royalty relief program for the oil sands industry that is fueling an explosion in development that is imposing significant environmental and societal infrastructure costs. Public funding towards initiatives such as CCS (and other programs such as the Federal Wind Power Production Incentive) are materially different in that they direct industry activity towards activities that reduce environmental damage.

[8] See, for example, the May 27th, 2005 letter by 13 leading UK and international companies to British Prime Minister Tony Blair calling for UK leadership and offering to support development of long-term policies to tackle climate change, http://www.cpi.cam.ac.uk/bep/downloads/CLG_pressrelease_letter.pdf.

[9] These are the "Large Final Emitters" referred to in the Federal Kyoto plan. Some of these emissions come from relatively small sources in heavy industry sectors (such as small oil and gas facilities), hence our estimate on page two for 40% of Canada's emissions coming from the largest point sources.

- The amount of money from the federal government's Partnership Fund used for CCS infrastructure development should be reflective of the limited contribution CCS could make within the Kyoto timeframe. The federal government has stated that "priority in investments under the Partnership Fund will . . . be given to projects that will deliver reductions in the 2008–2012 period"[10] i.e., projects that contribute towards meeting Canada's Kyoto commitment. Funding already budgeted for Kyoto compliance must be reserved for that purpose, and funding for reductions in the post-2012 period should be provided through new and separate budget allocations.

- CCS projects must be subject to a strong regulatory framework that is properly enforced and strictly ensures the following:
  - storage of CO_2 only in geological formations where the risk of leaks is at a minimum and the carbon will eventually be sequestered in solution or the solid state (primarily deep saline aquifers);[11,12]
  - appropriate specifications for pipelines to take account of the corrosive effects of CO_2;
  - comprehensive monitoring for leaks before storage starts (to provide a baseline), during the injection period, and in perpetuity after closure;[13]
  - independent verification of monitoring results;
  - a clear determination of who will be liable if there are leaks; and
  - responsibility for full payment for baseline studies, measurement, monitoring and remediation if there are leaks, by the entity emitting the CO_2 if it were not stored, unless that responsibility is contractually transferred to another entity.

- Accounting for emissions avoided as a result of CCS, for purposes of emissions reporting, credit creation and compliance with mandatory restrictions, must be done on a net life-cycle basis. It must
  - fully account for emissions associated with the capture, transport and storage of the CO_2;
  - include discounting to allow for uncertainties in measurement and monitoring systems; and
  - provide for adjustments when leaks are detected.

- Further research must be conducted, and supported financially by private entities wishing to implement CCS projects, to
  - learn more about the way CO_2 moves underground;
  - improve monitoring techniques; and
  - estimate the risk of leaks to the surface and the potential impact of such leaks.

- Governments and private entities wishing to implement CCS projects must take steps to provide full, objective public information about CCS and give citizens a meaningful opportunity to determine whether they consider the benefits of CCS outweigh the risks for each proposed CCS project.

---

[10] Government of Canada. 2005. *Moving Forward on Climate Change – A Plan for Honouring our Kyoto Commitment*, p.26.

[11] Deep saline aquifers (more than 1 km deep) probably provide the best storage location. Over a period of 100 to 1000 years, the CO_2 will dissolve in the water, so that it will not be free to migrate back to the surface. While CO_2 can be stored in depleted oil and gas reservoirs, the many wells drilled into those formations make them less secure for long-term storage.

[12] Work on most CCS application s, including Canada, is focused on geological storage. Some countries however (notably Japan), are conducting research on storing CO_2 within the ocean itself. The Institute does not support ocean storage of CO_2 (in either the water column or on the ocean floor) because of the potentially significant ecosystem risks from increased acidity (lower pH) and likelihood that the CO_2 will eventually be released back into the atmosphere (as the atmosphere and oceans equilibrate).

[13] Recognizing that such monitoring will need to continue for centuries, this means establishing an industry fund to cover the long-term costs of monitoring after the closure of individual storage projects.

Enhanced Oil Recovery — a special case

As discussed in the Institute's CCS Primer, many of the current and proposed projects where CCS technologies are being tested involve Enhanced Oil Recovery (EOR) whereby CO_2 is being injected into oil reservoirs to increase the mobility and subsequent recovery of oil.[14,15] CO_2 storage associated with EOR will likely be the first major development of CCS because the opportunity to generate revenues from the sale of recovered hydrocarbons improves the overall economics of CCS.[16] The total volume of CO_2 stored during EOR will be relatively small compared with other storage options as the proportion of CO_2 retained underground with EOR varies between 20–67%.[17]

As outlined above, it is the Pembina Institute's view that CCS storage should be focused on deep saline aquifers rather than in oil or gas formations. However, the Pembina Institute is prepared to recognize that EOR may be a necessary step along the way to full implementation of CCS as a viable tool in the GHG reduction portfolio. This is because EOR may lower the price barrier for establishing CCS infrastructure (e.g., for capture and transportation), facilitating subsequent storage in deep saline formations. All of the other conditions described in this position paper for CCS must be applied equally to EOR projects.

The Institute does not hold the view that EOR using CO_2 increases the rate of oil and gas production because

1. alternative, non-CO_2-based EOR technologies exist and are in commercial use to recover these hydrocarbons;
2. the production of (and demand for) oil and gas is global so some other reservoirs will be developed if EOR is not undertaken.

EOR with CO_2 may or may not perpetuate access to economically accessible oil and gas reserves. However, the availability of known oil and gas supply, combined with exploitable coal reserves, is more than sufficient to result in dangerous climate change if produced and combusted. Thus, the critical issue is less one of supply than that of limiting demand for fossil fuel resources by satisfying human energy needs through alternative technologies and actions.[18]

[14] Natural gas is also potentially recoverable through Enhanced Coalbed Methane Recovery (ECM) techniques. The argument presented here for EOR would apply equally to ECM.

[15] IEA. 2004. *Prospects for* CO_2 *Capture and Storage,* p. 84.

[16] See IEA. 2004. *Prospects for* CO_2 *Capture and Storage,* p. 85, 87 for a discussion of costs and revenues associated with EOR.

[17] IEA. 2004. *Prospects for* CO_2 *Capture and Storage*, p. 81.

[18] It would then follow that the calculation of net life-cycle GHGs reductions from a project in which CO_2 is used for EOR instead of being emitted to the atmosphere should not include the carbon content of the oil and/or gas produced from such a project.