Issues of Liability During the Post-Abandonment Phase of Carbon Capture and Storage

The Case of Alberta*

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ABSTRACT
Carbon capture and storage (CCS) has been proposed in Alberta as a solution to climate change.[1] If legal barriers exist, however, they could delay progress on the development of CCS. Six critical elements of the long-term liability framework for CCS are examined in this paper: (1) ownership of sequestered CO_2, (2) classification of CO_2, (3) industry regulations, (4) possibilities for legal action, (5) government assumption of long-term liability, and (6) liability under emissions trading regimes and carbon taxation. This paper finds that Alberta's current framework for assigning the long-term liability for damages arising from CCS is neither clear nor realistic. It concludes with policy recommendations to Alberta's government, including a quick resolution to regulatory uncertainties and an immediate increase in the price of carbon.

Introduction

Carbon capture and storage (CCS) is a technique that scrubs CO_2 from the post-combustion exhaust gases of industrial facilities, such as fossil-fuel refineries, and then injects it into geological formations. Since CO_2 is the principal gas responsible for climate change, CCS can mitigate the environmental impact of polluting industry. The provincial government of

Alberta has proposed making CCS a key part of the province's climate change strategy by providing considerable up-front funding to the energy sector to develop CCS. Alberta is a centre of global oil production, with many large greenhouse gas emitting facilities and empty oil and gas reservoirs suitable for CO_2 storage.[2] The development of CCS may allow Alberta to continue its fossil fuel production while lowering overall greenhouse gas emissions.

CCS is not an established technology. In fact, the former Auditor General of Alberta, Fred Dunn, has suggested that CCS projects could potentially waste billions of dollars with little or no greenhouse gas reduction.[3] Other greenhouse gas reduction strategies, such as reduced fossil fuel production or wide-spread energy-efficiency upgrades, are expensive and may thus require Alberta to make program cuts in other areas. Therefore, CCS appears to be the best remaining option if government and citizens are unwilling to make such financial sacrifices.

Until a framework is constructed that addresses the long-term liability problems of CCS, business, government, and citizens will be unlikely to accept CCS. This reluctance is already evident in Alberta: largely because of regulatory and legal uncertainty, Shell's Quest project near Scotford, Alberta, will not start injecting CO_2 before 2015.[4]

Risks of CCS

The risks of CCS will vary from site to site, depending on both geology and the purity of gas injected; however, the risks are likely to decrease over time as the pressure of the stored gas diminishes.[5] The Intergovernmental Panel on Climate Change (IPCC) predicts with 90 to 99 per cent certainty that well-designed reservoirs will hold 99 per cent of CO_2 injected for 100 years.[6] Since there are so many technological unknowns in the field of CCS, however, the risk of leaks must be addressed. While the government-sponsored Alberta CCS Development Council suggests, "extensive experience among government and industry... forms a solid foundation for providing assurances around the safe and reliable storage of CO_2," it endorses a cautious approach.[7] Inadequate geological analysis and construction could dramatically increase risks. It will be important for Canadian policy-makers to remain as unbiased as possible and make rational, science-based risk assessments when writing regulations for post-abandonment liability.

The effect of a CO_2 leak on human health is the most obvious concern related to CCS. This threat has garnered much public scrutiny due to the 1986 Lake Nyos disaster, when a naturally occurring CO_2 cloud was

released from the Cameroonian lake, killing 1,700.[8] A massive leak from a geological storage facility could pose a threat in low-lying areas, though there is a low probability of this happening.[9] A slow CO_2 leak through a wellhead or fracture in a reservoir could also endanger the local wildlife and agriculture industry.[10] Underground seepage of the gas into aquifers could increase their acidity, ruining them as sources of potable water; this acidity could also eat away at the cement of wellheads, resulting in leaks into the environment.[11] The high level of pressure in a CCS reservoir could induce seismic activity even in areas distant to the site.[12] Though Elizabeth Wilson, assistant professor of energy and environmental policy and law at the Hubert H. Humphrey Institute of Public Affairs, characterizes the likelihood of this happening in a well-planned location as small, geophysicist Dave Eaton suggests that injection techniques have caused earthquakes that have almost damaged houses.[13]

The global environment is at risk as well. An accidental release of CO_2 would result in higher concentrations of atmospheric greenhouse gases, rendering the process counterproductive and increasing the rate at which climate change occurs. Though a catastrophic failure of a reservoir is unlikely, even a slow leak, especially if multiplied over many sites, could substantially diminish the efficiency of the CCS process.

Ownership

The complexity of CCS projects will require the participation of several organizations, however, determining which party owns the CO_2 and is thus liable for damages will be difficult. While oil-producing corporations who sequester CO_2 after using it for Enhanced Oil Recovery (EOR) operations would likely own and operate all aspects of the process, other smaller industrial operators are unlikely to be as vertically integrated. In such cases, the project operator is the most likely defendant for leaks or other hazards of CCS, but other liable parties might include the owners of the storage space and surface land. Upstream organizations such as the source of CO_2 and the operators of the pipelines or vehicles that transport it to storage might also consider it liable for damages.[14] Due to this uncertainty, some parties will write indemnification clauses into their contracts to restrict their liability. Nigel Bankes, Professor of Law at the University of Calgary, remarks that it would be reasonable for an emitter to demand such indemnity since the risk should be reflected in the operator's charges.[15]

Classification of CO_2

The federal classification of CO_2 could increase liability in the post-abandonment phase of CCS, which will unnecessarily discourage firms from developing CCS projects. While Alberta defines CO_2 under the *Climate Change and Emissions Act* only as a "gas that traps heat near the earth's surface," the federal government now classifies CO_2 as toxic under the *Canadian Environmental Protection Act*. Consequently, a CCS operator is strictly liable for leaks, even if it takes "proper care."[16] A similar problem exists in the United States as elucidated with the case of *Massachusetts v. EPA*, where the US Supreme Court defined CO_2 as an "air pollutant" yet a statement before the US Senate Committee On Energy and Natural Resources explains that the CCS industry would be undermined if Congress labeled sequestered CO_2 as 'waste.'[17] Stringent regulations intended to reduce CO_2 emissions could hamper the nascent CCS industry by increasing its liability from CO_2 leaks. Provincial and federal regulations should be standardized in order to facilitate CCS development, but Stefan Bachu from the Alberta Energy and Utilities Board, contends that the Government of Alberta is not willing to negotiate with the federal government on issues relating to the environmental impact of the fossil fuel industry. Bachu stresses that in addition to being an initiative against climate change, the *Climate Change and Emissions Act* is also an assertion of provincial rights to regulate in this area.[18]

Regulations for CCS Projects

The Alberta CCS Development Council suggests that existing regulatory frameworks for other injection techniques are largely adequate for dealing with CCS. The private sector is generally responsible for any costs or remedial action during the active injection period of a storage site.[19] However, the Council flags the potential difficulties in determining long-term liability—in the Council's words, the "key gap" in regulation. Bachu points out that in Alberta, the *Oil and Gas Conservation Act* and the *Environmental Protection and Enhancement Act* do not clearly account for post-abandonment leaks.[20] He suggests as long as regulations for CCS projects remain unclear, investors will hesitate to fund the industry for fear of being held liable for health or environmental damages. The timelines certainly require environmental regulations drastically different from those in most industries, and the Alberta CCS Development Council calls for planning thousands of years into the future.[21]

One often-cited analogy to CCS is the injection and storage of acid gas, a refining by-product

composed of hydrogen sulfide and CO_2. When industry is disposing of acid gas in government-owned geological formations, the government claims indemnity.[22] Section 56(2) of the 2009 *Alberta Mines and Minerals Act* states that "a person who exercises [the right to inject acid gas] shall indemnify the Crown in right of Alberta for loss or damage suffered by the Crown in respect of any claims or demands made by reason of anything done by that person."[23] This requirement remains the same in the post-abandonment period: "abandonment of a well or facility does not relieve the licensee, approval holder or working interest participant from responsibility for the control or further abandonment of the well or facility or from the responsibility for the costs of doing that work."[24] The literature showcases a variety of opinions regarding the applicability of acid gas storage regulations to CCS, but the potentially massive scale at which CO_2 will be sequestered will require new and specific regulations regarding long-term liability. At the same time, current regulations under the *Oil and Gas Conservation Act* account for leaks through or beside a well but do not necessarily apply to leaks from natural geological faults.[25] Given that CO_2 in storage will be highly compressed, it is possible that the pressure from the sequestered CO_2 will fracture the surrounding rock and allow gas to escape into adjacent geological formations, if not the atmosphere. The International Panel on Climate Change (IPCC), for example, reports that at the experimental CCS facility in Weyburn, Saskatchewan, the sequestered CO_2 reaches up to 90 per cent of the pressure required to deform the surrounding rock. Albertan regulatory agencies will need to account for this possibility when designing the liability framework for CSS.

Possibilities for legal action

In Alberta, there are multiple causes of action which may trigger a suit against a CCS project, including: negligence, nuisance, and trespass.[26] Several uncertainties exist that must be resolved before CCS development can move forward.

The requirements for negligence include proof that a standard of care has been broken, causing damage to another party.[27] Because the CCS industry and accompanying regulations are so new, standards of care may not be fully established for a court to find that they have been broken.[28] Furthermore, if several CCS projects are built in close proximity, as they may be in Alberta given the high density of tar sands extraction operations, it will be difficult to determine who is responsible for the specific leaks that are causing harm.[29] This concern exists for trespass, as well, which covers

property damage from CO_2 gathering in low-lying areas of adjacent properties.[30]

Bachu cautions that public or private nuisance claims may also be filed "when the use and enjoyment of land is unreasonably interfered with" by CCS projects.[31] While Wilson also raises the possibility of nuisance claims, she contends that courts may be inclined to limit the damages for which CCS operators are responsible, given the generally positive nature of CCS: "a balancing test might find the public benefit from mitigating climate change outweighs the harm or cost of the action."[32]

Government assumption of liability

In order for CCS projects in Alberta to proceed, regulations must be altered so that long-term liability from private CCS projects is transferred to the government. The long timeframes involved increase the probability of owner bankruptcy or disappearance, and even long-lived firms often transfer their outstanding liabilities to smaller firms with shorter life spans.[33] The general consensus in the literature, therefore, is that government should assume at least some liability in the CCS process.[34] The Alberta CCS Development Council is of the view that government and industry should share liability over the active lifetime of the project, with the government assuming full liability "after an appropriate term" after abandonment.[35] This transfer would require that the safety measures taken at a storage site fully satisfy a government regulator. The Council calls for industry to be responsible for the costs of monitoring a site for a ten-year period after ceasing to inject CO_2, with adjustments possible according to specific circumstances and further experience with the safety of commercial CCS.[36] After this period, responsibility would revert to the government.

The provincial government is a proponent of CCS as a means to reduce greenhouse gas emissions without crippling the energy industry. Therefore, assuming liability of CCS projects could also simply be a way of subsidizing the industry. The Alberta CCS Council endorses "a sharing of the risk between government and industry to support the development of this technology."[37] Jeff Sansom from the University Of Alberta School Of Business suggests that since the reduction of greenhouse gases is a public good, the long-term liability for CCS projects should be acknowledged through government assumption of risk.[38] Bachu compares this situation to the nuclear industry in the United States, where the liability of operators is limited under the federal *Price-Anderson Nuclear Industries Indemnity Act* to encourage investment.[39] Under the Act, industry liability is capped at a specific amount (the current level is just over $10 billion); this brings the

risk to investors down to an acceptable level while ensuring that industry still has a strong incentive to operate safely.[40]

Three major problems exist with government assumption of liability. First, holding industry permanently responsible for all monitoring or remedial costs seems fair. Writing 28 years ago on the nuclear waste disposal industry, the then Economist Associate at the Rand Corporation, Linda Cohen, called this a "theoretically pleasing solution."[41] Second, transferring liability away from the operator at any stage of a CCS project will be a disincentive to plan for long-term safety—why build a storage facility that will maintain its integrity for 500 years when one is only liable in the first five? Third, if the government assumed liability over private CCS projects to increase their profitability, it could possibly face a challenge under Canada's free trade agreements. In particular, World Trade Organization or North American Free Trade Agreement panels might find it problematic that subsidized Albertan CCS projects whose stated purpose is to sequester greenhouse gases can also use their supply of CO_2 to extract additional oil from depleted reservoirs through Enhanced Oil Recovery (EOR) techniques. Subsidized EOR would give Albertan companies a substantial competitive advantage: one source estimates that EOR can increase oil field yields by as much as 15 per cent.[42] Skeptical opposition members of Alberta's legislature assume that CCS is primarily intended to support EOR, one of whom comments that "the government is trying to dress-up an industrial project as a solution to our critical greenhouse gas problem."[43] Most of these problems, however, can be countered with technical solutions (CCS construction requirements, for example) and should not interfere with government assumption of liability.

If CCS liabilities are transferred to government, different funding regimes can pay some or all of the costs incurred from leaks in the post-abandonment phase so that government does not have to bear all the costs.[44] For example, the Alberta CCS Council proposes that the costs to government of long-term monitoring and liability could be partially offset if each CCS developer paid 50 cents per ton to support each of these.[45] The appropriate size of payment is a technical question that is beyond the scope of this paper, but it is enlightening to note that surcharges on nuclear waste for post-abandonment funds in the early days of the industry were extremely low. In 1971, the most expensive levy on nuclear waste in any American state was only eight cents per cubic foot.[46] Policy-makers must make sure that levies on injected CO_2 are high enough to cover in full the liabilities from CCS. Rates, however, will have to remain well below Alberta's $15 per ton charge on CO_2 emissions for CCS to be at all economically worthwhile.[47]

Under this framework the size of the total payment would depend solely upon the total tons of CO_2 injected. This poses a risk of unfunded liability. For example, if a site closed prematurely, before the full amount of CO_2 estimated during the approval process has been injected, then the total payment will be smaller than anticipated. This could happen due to unforeseen technological problems, such as increased seismic activity, poorly-sealed storage sites, or operator bankruptcy. Considering the experimental nature of the industry none of these problems can be ruled out. If the long-term risks rise proportionally with the amount of CO_2 injected, then a lower payment might not be a problem. This might be the case, for example, under a carbon tax where the cost of the tax is directly related to the amount CO_2 leaked, which is in turn related to how much CO_2 was injected before the premature closure of a site. Some costs associated with long-term risks are fixed, such as site monitoring, and might not be fully covered by a 50 cents per ton fund. Cohen points out that just such a gap in funding has hampered the creation of new nuclear waste disposal sites in the United States, since state regulatory agencies hesitate to grant approval to operators without a guaranteed liability-funding process in place.[48]

Should a CCS project cause more environmental or health problems than anticipated, or if a catastrophic event should happen, the payments may simply be inadequate. In this case, Wilson assumes those affected will file civil suits to reclaim costs over and beyond these 50-cent payments. CCS operators who are already in financial trouble may be unable to pay.[49]

Raising rates under this scheme would be one way to deal with premature closure. A more sophisticated solution, however, might be found in the 'Orphan Fund' set up by Alberta's *Oil and Gas Conservation Act*.[50] Under the Act, all industry participants pay into a single fund to deal with abandoned oil and gas extraction facilities, thus pooling the risk. If an appropriate levy went into such a fund, with an increased rate for companies with poor credit ratings or safety records, the government might have a stable source of funding for unexpected damages caused by CCS.

A second possibility for funding long-term liabilities is requiring CCS projects to purchase insurance. Because the coverage the insurance industry will provide remains unclear, government intervention is imperative.[51] There are numerous industries that handle liability through government-mandated insurance or pooled funds; the American nuclear industry under the *Price-Anderson Act* is one. Wilson suggests, however, that insurability requires, among other criteria, "a sufficient number of similar and uncorrelated events to allow for risk pooling," "clearly calculable losses," and "frequent enough losses to calculate premiums."[52]

The nature of the CCS industry is such that each project has unique geological characteristics, and these dissimilarities make risk pooling difficult. Nuclear power plants, by contrast, may be built using slightly different designs but basically have identical risks. Additionally, scientific and regulatory uncertainties regarding global climate change will make the losses from CCS leaks not clearly calculable. While risks may be more precisely calculated as experience with CCS increases, the newness of the industry means that there are no 'frequent losses' to analyze.

CCS under emissions trading

Alberta has established a provincial emissions trading regime, the Offset Credit System, which allows large emitters to reduce their CO_2 emissions through CCS or purchase carbon emission credits from CCS projects. Therefore, before CCS can be developed, government and industry alike will need clarification on how to deal with leaks from CCS facilities. As even well-planned CCS facilities will likely leak at least small amounts of CO_2, someone will have to be liable for these emissions.[53] Presumably, any leaks in the post-abandonment phase of a CCS project will be the responsibility of the facility and not the purchaser of the credits, but the provincial and federal governments will have to appoint regulators to handle such decisions, regardless of whether trading programs are regional, national, or international in scope.[54] The IPCC points out that regulations for unanticipated leaks are much needed.[55] Furthermore, there have been few formal evaluations or analyses of regulatory policies in this area.

Some authors suggest that the most appropriate way to account for future leaks is to presume a certain annual rate of leakage and deduct it from the initial carbon emission offsets earned by a CCS project, thereby avoiding, or at least diminishing, the question of future liability.[56] Because of the experimental nature of the industry, the specific rate of deduction will have to be adjusted as leakage rates are studied, and presumably they will be lowered as injection technology improves. The equation is still more complicated, since our timeframe is so large, and it is reasonable to suggest that once we have placed the global economy on a low-carbon trajectory, small leaks from CCS projects over the long term—100 or 200 years in the future—will be easily handled by the earth's natural carbon sinks. Such leaks will thus be inconsequential. Even if such a sustainable economy is unrealistic, some measures of discounting must surely be applied when considering future leaks from CCS. Despite the many technological and economic uncertainties of CCS, some authors have attempted to estimate a

reasonable discount rate. Economists Minh Ha-Duong and David W. Keith use a discount rate of four per cent to calculate that CO_2 sequestered in small-scale projects with one per cent annual leakage rates should be worth 80% of actual carbon reductions.[57] According to IPCC projections, one per cent is a fairly pessimistic number, but this is not a fatal flaw for the model. To encourage CCS operators to surpass the presumed rate of leakage, it would be important for the regulating agency to institute some mechanism for giving out retroactive credit for better-than-expected performance. A rate erring on the high side would simply delay, and not deny, credit for offset emissions. The IPCC calls for just such a "margin of conservativeness" in discounting credits.[58] Rates would have to be adjusted to each individual project according to the specific risk levels they present.

Another option for dealing with CCS reservoirs is to assume that any sequestered CO_2 is permanently stored and then require operators to buy back emission credits as leaks are detected.[59] This method is simpler economically, but as it pushes liability costs into the future, it lengthens the time frame over which owners may go bankrupt. This increases the possibility of unfunded liability. If this method is adopted, CCS operators will likely have to purchase emission credits for their leaks at the current rates rather than the rates that existed when the CO_2 was originally injected. Just because a CCS project's CO_2 was at one point stored doesn't mean it should be treated differently under an emissions trading system.[60] Also, to the extent that the price of carbon rises, holding owners liable at the higher rates gives them added incentive to minimize leaks.

Finally, the Offset Credit System requires that "emission reduction[s] must be real and demonstrable."[61] More significantly, to demonstrate that CO_2 is permanently stored, companies would have to monitor a site for a certain period to confirm that there were no leaks. But how long would that period be? One month, one year, one thousand years? Notwithstanding the enthusiasm for CCS that is written into the Act (the technology fund it creates can specifically subsidize "demonstration and use of specified gas capture, use and storage technology"), giving immediate full credit for sequestered CO_2 may be legally problematic.[62]

CCS under carbon taxation

Carbon taxes may be set up as taxes on the fossil fuels that produce CO_2, or they may apply to all emissions generally, excluding those already covered by Cap and Trade programs.[63] The former exist in British Columbia and Quebec and are gaining popularity globally as simple and effective alternatives to Cap and Trade programs.[64] When these measures

do not count emissions but rather the fuels that produce them, they will not directly affect CCS. Because Alberta currently places a $15 charge on emissions from large stationary facilities, however, the applicability of carbon taxation to the long-term liability of CCS must be resolved.

In their study *A Simple Approach for Bettering the Environment and the Economy: Restructuring the Federal Fuel Excise Tax*, Jack Mintz and Nancy Olewiler stress that tax breaks for CCS projects could help the industry deal with the cost of a carbon tax and ensure regional equity.[65] It is clear that the rate of tax exemption would have to be adjusted to account for CO_2 leakage. The carbon tax in BC allows for tax breaks to be given to CCS projects, but it does not promise that full credit will be given for sequestered CO_2, thus giving provincial regulators the option to account for leakage. The law "provid[es] for exemptions from the payment of tax, or for refunds of all *or part of* the tax paid, with respect to a fuel or combustible that is the source for greenhouse gas emissions... if equivalent emissions are captured and stored."[66] While it is thus possible under the law for regulators to account for leakage, they may choose not to exercise this option. For example, a BC government that was particularly zealous about CCS might decide to ignore the possibility of future leaks from CCS projects and give them full credit for all CO_2 injected.

A carbon tax on emissions, by contrast, has deeper implications for CCS since CO_2-producing companies will look for ways to reduce their emissions and will likely examine CCS as a possibility. The National Round Table on the Environment and the Economy points out that, unlike taxes on fuels, this option would stimulate the development of CCS.[67] Generally, the higher the tax, the more investments in CCS since a higher price on carbon emissions will increase the economic returns to sequestration. Future leaks, however, will in all probability be taxed at the future rate. Therefore, if a potential CCS operator currently faces a low tax on CO_2 emissions, but anticipates that it will quickly rise, they will be seriously discouraged from entering the industry.[68]

Whether a tax increase is realistic, given the current political environment in Alberta, is unclear. The Pembina Institute has recently called on Alberta to raise carbon prices to a minimum of $200 per ton by 2020, over ten times the current rate of $15 per ton.[69] If a hypothetical million-ton CCS project completed in 2019 saves a CO_2 producer $15 per ton in taxes but taxes itself for leaking CO_2 at $200 per ton in 2020, it will take only 7.75 years[70] for the cost of the leak to outweigh the tax savings, assuming a leakage rate of one percent (see Table 1). This is the rate used by Keith and Ha-Duong, and, as discussed, it is a high but not inconceivable rate.[71] Applying their 4% discount rate only extends

profitability until 2034. It should be noted, however, that CCS projects may inject CO_2 over several years. This will somewhat hedge the risk of a sudden rise in carbon taxes, since the higher rate of tax exemptions earned from injecting CO_2 post-hike will help defray the higher rate at which leaks are penalized. Potential CCS investors will, nonetheless, be seriously concerned about the effect of carbon tax hikes on liability.

Table 1. Effect of Carbon Tax Hikes on CCS Profitability

Year	CO_2 leaked in thousands of tons	Cumulative leakage cost in millions ($)[72]	Tax savings in millions ($)[73]	% of savings remaining	Cumulative leakage cost with 4% discount rate in millions ($)	Tax savings in millions ($) with 4% discount rate	% of savings remaining with 4% discount rate
2019	0	0	15.00	100	0	15.00	100
2020	10.0	2.00	13.00	87	1.92	13.08	87.2
2021	19.9	3.98	11.02	73	3.67	11.33	75.55
2022	29.7	5.94	9.06	60	5.26	9.74	64.96
2023	39.4	7.88	7.12	47	6.69	8.31	55.38
2024	49.0	9.80	5.20	35	7.99	7.01	46.72
2025	58.5	11.70	3.30	22	9.16	5.84	38.92
2026	67.9	13.59	1.41	9	10.21	4.79	31.93
2027	77.2	15.45	-0.45	-3	11.15	3.85	25.69
2028	86.5	17.30	-2.30	-15	11.98	3.02	20.14
2029	95.6	19.12	-4.12	-27	12.71	2.29	15.24
2030	104.7	20.93	-5.93	-40	13.36	1.64	10.93
2031	113.6	22.72	-7.72	-51	13.92	1.08	7.18
2032	122.5	24.50	-9.50	-63	14.41	0.59	3.94
2033	131.2	26.52	-11.52	-75	14.82	0.18	1.18
2034	140.0	27.99	-12.99	-87	15.17	-0.17	-1.15

Investor reluctance is a serious problem, since a CCS project with a slow leak is better than no project at all, and the earlier that global greenhouse gas reductions through CCS are made, the better. If a CCS operator is confident that the risk of leaks from a given site is negligible, tax hikes may not be a deal-breaking issue. A site with greater potential to leak will likely be scrapped if the investors anticipate a rapid rise in the price of CO_2. Such anticipation could also cause investors to delay their

projects because they will make a larger profit from sequestering CO_2 at the higher rate. Clearly, neither of these results are desirable for the environment.

The best solution to this dilemma is to raise the carbon tax to a rate that will have a meaningful effect on CO_2 producers. Subsequent increases may then be necessary, but they will hopefully be guaranteed to be moderate so that investors do not face substantial disincentives to enter the CCS industry. To avoid unfairly punishing early movers, it would also be important for policy-makers to raise carbon taxes before any full-scale industrial CCS projects have come online. If projects happen to be built before a carbon tax hike becomes politically feasible, retroactive credits could make up the difference between the low tax rate at which they were credited and the high tax rate at which they are charged for leaks. Finally, if the government assumed liability immediately after abandonment, the problem of an increased carbon tax is not applicable since the revenues from a carbon tax would be going to the government anyway.

Recommendations and Concluding Thoughts

The current long-term liability framework in Alberta is neither clear nor reasonable. There are some reasonably effective strategies that Alberta can enact to ensure that damages to the environment, health, and industry will be compensated fairly and appropriately. This paper recommends that the Alberta government adopt these policies in order to eliminate uncertainties about the long-term liability of CCS:

1. Carefully analyze risks to property, health, and the local (and global) environment to develop a strong regulatory framework for CCS. This framework can build on previous industry experience but must account for important differences between CCS and traditional oil and gas operations, including the magnitude and longevity of CCS projects. In particular, ownership of CO_2 during all phases of sequestration must be clarified.

2. The federal 'toxic' classification is too strict. Provincial policy-makers should negotiate with the federal government and other provinces to agree on a less strict, harmonized classification of CO_2 that will acknowledge its danger without forcing CCS projects to face excessive liabilities.

3. Develop a framework for transferring liability from private CCS

operators to the government while ensuring that private owners still face much or all of the final cost of liability. The provincial government has two viable options. First, it could levy a per-ton charge on sequestered CO_2 that is high enough to fund post-abandonment monitoring and liabilities but does not exceed the price of carbon (currently $15 per ton in Alberta). Second, it could mandate that industry participants pay into an 'Orphan Fund' for abandoned CCS sites. Either option can properly fund CCS liability.

4. Immediately raise the price of carbon. It is important that potential CCS operators face somewhat stable CO_2 prices so that they are not deterred by the threat of paying for leaked CO_2 at a higher rate than they were paid to sequester it. The current rate in Alberta is too low to be a very effective penalty for emitters.

There are financial and environmental reasons why policymakers should be skeptical of CCS. The technological unknowns are many and will take much time to resolve, while the time for action on climate change is now. If the Alberta government is indeed going to encourage industrial-scale CCS projects a clear and fair liability framework is necessary for investors and citizens alike to have confidence in the future of the industry.

NOTES

* A version of this paper was also submitted to and appears jointly in the Fall 2010 edition of *The Current*, the graduate-student public policy journal of the Cornell Institute of Public Affairs at Cornell University. *The Current* can be found online at: http://www.cipa.cornell.edu/cip_publ.taf?pt_id=1.

[1] While the focus of the paper is restricted to the Alberta context, it is important to note that CCS also figures prominently into the federal government's policy framework for achieving international commitments for CO_2 reductions. The framework estimates the potential of reductions via CCS initiatives to yield 50-55 megatons of CO_2 annually by 2020. Use of CCS will be facilitated through a combination of industrial benefit incentives within the energy sector as well as a specific mandate for CCS to be used in all new coal-fired electricity plants, which begin operation as of 2012 or later. See: Canada, *Turing the Corner: Regulatory Framework for Industrial Greenhouse Gas Emissions*, Ottawa: Environment Canada, 2008.

[2] Mary Griffiths, *Closing the Liability Gap* (Drayton Valley: The Pembina Institute, 2008).

[3] Kelly Cryderman, "Alberta Billions Lead Carbon Fight," *Calgary Herald*, November 18, 2008.

[4] Bob Weber, "Alberta announces $850M carbon capture project," *The Record.com*, October 8, 2009.

[5] Elizabeth J. Wilson et al, "Assessing a Liability Regime for Carbon Capture and Storage," *Energy Procedia,* 1, (2009).

[6] International Panel on Climate Change, *Carbon Dioxide Capture and Storage* (Cambridge: Cambridge University Press, 2005).

[7] Alberta Carbon Capture and Storage Development Council, *Accelerating Carbon Capture and Storage Implementation in Alberta* (Edmonton: by author, 2009).

[8] Wilson, 2007.

[9] Nigel Bankes, Jenette Poschwatta, and E. Mitchell Shier, "Legal Framework for Carbon Capture and Storage in Alberta," *Alberta Law Review*, 45, No. 3, (2008).

[10] Wilson, 2007.

[11] Curtis M. Oldenburg, "Migration Mechanisms and Potential Impacts of CO Leakage and Seepage," in *Carbon Capture and Sequestration: Integrating Technology, Monitoring, and Regulation*, edited by Elizabeth J. Wilson and David Gerard (Iowa: Blackwell Publishing, 2007); International Energy Agency, *CO_2 Capture and Storage: A key carbon abatement option* (OECD/IEA: 2008). CCS could also pose risks to mineral rights if stored CO_2 leaks into adjacent oil or gas fields. While this problem will require resolution to encourage CCS development, it has few environmental implications, and as such will not be further studied in this paper.

[12] Stefan Bachu, "Legal and regulatory challenges in the implementation of CO2 geological storage: An Albertan and Canadian perspective," *International Journal of Greenhouse Gas Control*, 2, (2008).

[13] Wilson; CBC News, "Links between oil activity, Alberta quakes studies," by author, November 13, 2009.

[14] Bankes 2008. Also, there is an international dimension to the uncertainty of ownership of the CO_2 in CCS projects. CCS facilities in developing countries may be financed using the Kyoto Protocol's Clean Development Mechanism (CDM), though these countries

themselves do not have obligations under the Protocol. If ownership of the projects is fully transferred to those countries, then the liability for any future leaks may be unclear. Presumably, the transfer of ownership ensures that the developing countries themselves are liable for local environmental or health damages, but they may not accept responsibility for this additional contribution to global emissions.

[15] Bankes 2008.

[16] Government of Alberta, *Climate Change and Emissions Act* (Edmonton: by author, 2008); Griffiths.

[17] Kip Coddington, statement before the US Senate Committee On Energy and Natural Resources, April 16, 1997.

[18] Bachu, 2008.

[19] Alberta CCS Council; Griffiths.

[20] Bachu, 2008.

[21] Alberta CCS Council.

[22] Bankes 2008.

[23] Government of Alberta, *Mines and Minerals Act* (Edmonton: by author, 2009).

[24] Government of Alberta, *Oil and Gas Conservation Act* (Edmonton: by author, 2000).

[25] Griffiths, 2008.

[26] Ibid.

[27] Bachu, 2008.

[28] Wilson, 2007.

[29] Ibid.

[30] Bachu, 2008.

[31] Ibid.

[32] Wilson, 2007.

[33] Ibid.

[34] Jeff Sansom, "A Regulatory Perspective on Carbon Capture and Storage in Alberta," unpublished paper (2005).

[35] Alberta CCS Council.

[36] Ibid.

[37] Ibid.

[38] Sansom, 2005.

[39] Bachu, 2008.

[40] American Nuclear Society, *The Price-Anderson Act: Background Information* (by author, 2005).

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[42] Tom Nicholls, *Fundamentals of Carbon Capture and Storage Technology* (London: The Petroleum Economist Ltd, 2007).

[43] Alberta's NDP, "Environment Minister Full of Hot Air," by author, 2006.

[44] Griffiths, 2008.

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[46] Cohen, 1981.

[47] Alberta Energy, "Climate Change and Emissions Management Fund," by author, 2009.

[48] Cohen, 1981.

[49] Wilson, 2007.

[50] Bachu, 2008.

[51] Nigel Bankes and Jenette Poschwatta, "Carbon Capture and Storage in Alberta: Learning From the Acid Gas Analogy," *Canadian Institute of Resources Law: Resources*, 97, (2007).

[52] Wilson, 2007.
[53] Alberta Environment, *Carbon Offset Solutions* (Edmonton: by author, 2009).
[54] Griffiths, 2008.
[55] IPCC.
[56] Ibid.
[57] Minh Ha-Duong and David W. Keith, "Carbon storage: the economic efficiency of storing CO_2 in leaky reservoirs," *Clean Technologies and Environmental Policy*, 5, (2003).
[58] IPCC.
[59] Ibid.
[60] While this is an issue that will not be taken up in this paper, there may be benefits from storing CO_2 even if it is later released, since this gives the economy more time to adopt low-carbon strategies. If this is the case, perhaps the leaked CO_2 from CCS projects should be penalized at a lesser rate than CO_2 from other sources. In any case, there should be some sort of financial recognition of the sequestration, however impermanent.
[61] Government of Alberta 2008.
[62] Ibid.
[63] National Round Table on the Environment and the Economy (NTREE), *Getting to 2050: Canada's Transition to a Low-emission Future* (Ottawa: by author, 2007).
[64] Shi-Ling Hsu and Robin Elliot, "Regulating Greenhouse Gases in Canada: Constitutional and Policy Dimensions," *Social Science Research Network* (2008).
[65] Jack Mintz and Nancy Olewiler, *A Simple Approach for Bettering the Environment and the Economy: Restructuring the Federal Fuel Excise Tax* (Ottawa: Sustainable Prosperity, 2008)
[66] Government of British Columbia, *Carbon Tax Act* (Victoria: by author, 2008) (emphasis added).
[67] NTREE, 2007.
[68] Such a scenario is possible under emission trading schemes as well: an environmentalist government could sharply restrict the number of emission credits auctioned, driving their price up steeply.
[69] Pembina Institute, "New study shows Canada can meet global-warming reduction targets while growing jobs and economy," by author, 2009.
[70] Where t is years elapsed after project completion. Calculations by Christopher Finlay.
$1 - 0.99t = 15/200$
$0.925 = 0.99t$
$\log(0.925) = t\log(0.99)$
$t = \log(0.925)/\log(0.99) = 7.75$ years
[71] Keith, 2003.
[72] This cost only includes the taxes due because of the CO_2 leak. In reality, there may be other costs from the leak: compensation to landowners, environmental remediation, etc.
[73] Tax savings ignore the costs of sequestration.

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