# The Political-Economic Potential of CCS in Canada[1]

## *A Framework for Prospective Assessment*

James Gaede, Ph.D Candidate, Political Science, Carleton University

One of the challenges in taking action to address climate change is determining which actions are likely to most effective and efficient. A key question thus concerns the potential of various different technological options, many of which are in their infancy, to serve as emissions reductions tools. The notion of technological potential has many dimensions but to date considerations of this question have looked mainly at its technical and economic aspects. This approach, while certainly useful, neglects the important roles that social and political forces can have in determining what is 'effective and efficient', and thus in influencing the overall potential of a technology.

The relationship between politics and economics is likely to be one of the main determinants of the likely future development of a technology and, given the amount of work down in the latter field, promises to be a fruitful area for interdisciplinary collaboration. The question this paper thus asks is: how can we assess the potential of a technology to serve as an emissions reduction tool from a political-economic standpoint, in the general absence of the successful implementation of that technology? The technology in question is carbon capture and storage, and the aim is to develop a framework for assessing potential prospectively and that interfaces nicely with methods used by economics to address a similar question.

Developing such a framework requires a methodological inversion of what might be considered the conventional approach for assessing key variables driving an outcome – given the absence of CCS projects in Canada (and worldwide), we must walk a fine line between the inclusion of arbitrary or irrelevant factors to the main question and the over-determination of the outcome based on what presently appears to be the most likely case. In other words, we must construct a framework that is on its face plausible but that still allows for some degree of surprise in the results of analysis.

To conduct such an analysis requires setting a context for policy decision-making. As such, we proceed upon an assumption that each province is committed to meeting its self-ascribed emissions targets (found in current provincial energy and/or climate change plans). Building literature in economics and technological potential, socio-technical transitions and the political economy of

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carbon capture and storage, we thus identify a range of political-economic factors that are plausible candidates to influence the direction of strategic energy and climate change policy decision-making in the provinces, propose a metric for the direction of influence of each factor, and the score the provinces for their political-economic potential for CCS.

As a final note, it is important to remember that the findings we present are not an analytical or causal proposition about the key drivers of CCS potential, but neither are they predictions about the future. Rather, they are a prospective assessment of potential based on plausibly important factors that may eventually be shown to be more or less important than as allowed for in this study.

## CCS and Technological Potential

Carbon capture and storage (CCS) is a collection of techniques to capture emissions of carbon dioxide from large, point-source emitters (LPSEs), transport them to a desired location, and store them deep underground. As the International Energy Agency (IEA) notes, most of the sub-technologies that comprise CCS have been proven to work effectively and have been in use for some time (decades, in some cases), though at relatively small scales.[2] Though there may be potential in the future for CCS techniques to be deployed in more diffuse or smaller-scale settings, presently the focus is LPSEs in select industries, such as fossil-fuel electricity generation; cement manufacturing; pulp and paper mills; natural gas processing; oil refineries and oilsands upgrading plants; fertilizer manufacturing; and some iron and steel manufacturing. Many of these can be referred to as "emissions intensive and trade-exposed" industries (EITE), indicating the high degree of susceptibility of these industries to policy that would affect their global competitiveness.[3]

Given the range of industries in which it can be deployed CCS could be an important part of the portfolio of technological and other options that most of Canada could utilize to reduce emissions of $CO_2$, but its potential is uncertain. Of the widely recognized 'key uncertainties' that presently constrain CCS potential in Canada and abroad, the focus to date has been mainly on identifying ones that constrain the economic potential (i.e., factors that influence the decision-making of industry actors). These include:[4]

- At present, is a **financial gap** between the cost of implementing CCS and the returns companies could hope to attain. There are basically two ways of addressing this: to place a value on carbon dioxide (e.g., cap-and-trade, carbon taxes), or to directly subsidize or

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[2] International Energy Agen*cy, Technology Roadmap: Carbon Capture and Sto*rage, 8.

[3] The definition of EITE industries can be found in now defunct legislation proposed in the US by Congressmen Waxman and Markey. See Waxman, *Greenhouse Gas Legislation*.

[4] These are compiled from numerous contemporary sources, including International Energy Agen*cy, Technology Roadmap: Carbon Capture and Sto*rage; ICO*2N, Carbon Dioxide Capture and Storage: A Canadian Clean Energy Opportu*nity; ecoEnergy Carbon Capture and Storage Task Forc*e, Canada's Fossil Fuel Energy Future: The Way Forward on Carbon Capture and Sto*rage; Global CCS Institut*e, The Global Status of CCS:* 2011.

incentivize CCS (grants and R&D funding, feed-in tariffs and renewable portfolio standards, private-public partnerships, etc).

- Comprehensive **regulatory frameworks** will need to be developed for CCS, specifically addressing ownership and liability issues, but also health and safety, environmental assessment and protection, waste management and groundwater protection, pipeline and oilfield operations, and infrastructure abandonment and decommissioning.

- **Infrastructure** to transport emissions from capture to storage sites will need to be developed. One question is whether to rely on independent, operator-specific transportation solutions or to build larger, integrated transportation systems. If the latter, the complex legal and regulatory issues surrounding access rights, ownership, and liability will need to be addressed.

- Resolving all of the other uncertainties might still not be enough to facilitate the development of CCS if the **public perception** is that it is too risky, dangerous or unnecessary. Efforts must thus be taken to educate and communicate to the public the science around CCS and the reasons why it is a desirable technology.

- Lastly, the long-term commercial potential of CCS depends in large part on successful **demonstration** of the technology at scale. The IEA estimates 130 CCS projects will be needed by 2020, and 3000 by 2050, if the world is to ward off serious global warming.

Though these may seem at first glance to be primarily political determinants of technological potential (they are mostly policy issues), they nonetheless are all key factors in determining economic potential. A discussion of technological potential in general may help to elucidate this point.

Technologies are designed to accomplish a task, and their potential refers to their ability to do so given the range of constraints that impinge upon them. Technological potential, like an onion, therefore tends to get smaller as more and more layers of constraint are peeled back, eventually approximating the most probable efficiency, productivity, or whatever other factor defines 'potential' of the technology in question. [5] Typically one begins with the maximum *theoretical potential* of a technology, an upper limit based on characteristics of the physical world and assuming

[5] See for example: Monique Hoogwijk and Wina Graus, *Global Potential of Renewable Energy Sources: A Literature Assessment*, sec. 2.3; Teske, Zervos, and Schafer, *Energy [R]evolution: A Sustainable Global Energy Outlook*, 122; Wijk and Coelingh, *Wind Power Potential in the OECD Countries*.

maximization of all other technical characteristics.[6] Of course, no technology is 100% effective at accomplishing its goals so it makes sense to distinguish a secondary *technical potential* that includes additional constraints that limit the realistic application of the technology, ranging from geographic or structural barriers to implementation to legislative restrictions that prohibit the use of the technology in certain areas. For instance, whatever the theoretical potential efficiency of an individual photovoltaic panel, its technical potential will be quite a bit less in a relatively cloudy location and in a system with plenty of peaking power potential already in place.

Beyond technical potential, one might also want to consider the economic potential of a technology. At the core of the concept of economic potential is the idea of competitiveness vis-à-vis alternatives or substitutes, reflecting an assumption that, at least to some extent, technological choice in the absence of non-economic (mainly political) intervention is made on the basis of cost ('cost' can however be interpreted either narrowly, as financial costs only, or broadly, incorporating other 'social' factors like perception and discount rates into the relative competitiveness of the technology).[7] Economics thus often further reduces potential, since it makes little sense to produce energy according to technical potential if the net energy gain is negative (that is, it takes more energy to produce than is available for use after production), if it's not profitable, or if it costs more than the production of other, potential substitute forms of energy.

Yet economics might also be a positive driver for a specific technology, since the range of things that impact upon the relative costs of technologies are not all beholden to the technologies themselves - or to economics for that matter: a hypothetical province with an electricity system that for historical reasons is relatively decentralized (perhaps because the cost of transmission in a mountainous region) may tip the economic scales towards technologies otherwise more costly on a per-kilowatt hour basis. In other words, the dynamic economic context influences the competiveness of technologies, and thus can accentuate or constrain the potential of the technology itself. The policy environment is a key determinant of economic potential therefore, since it influences costs in many ways – indeed, forward-looking assessments of economic typically aim to demonstrate the likely competitive consequences of a proposed policy. The above mentioned uncertainties, though mostly policy issues, are as such important factors in determining the economic potential of CCS in Canada. We might ask therefore, what factors influence the likely development of the policies themselves?

To answer this question requires stepping into the realm of politics; i.e., it is a question of the *political potential* of CCS. This is especially the case considering that of the range of policy actions

[6] For example, as noted in the Greenpeace "Energy Revolution" study, for solar energy the utmost limit on its potential is the amount of solar radiation that falls on a surface.Teske, Zervos, and Schafer*, Energy [R]evolution: A Sustainable Global Energy Outlo*ok, 122.

[7] Bataille et al., "Towards General Equilibrium in a Technology-rich Model with Empirically Estimated Behavioral Parameters," 94.

that could be taken to address the above mentioned uncertainties, few are really 'technologically neutral': an economy-wide carbon price to address the financial gap is perhaps the only one, though on its own would likely be insufficient to drive uptake of CCS. Other measures, such as direct or indirect subsidies to industry, building CCS-related infrastructure, conducting public education campaigns or crafting an adequate regulatory framework – these are all options that would require a political decision to support CCS, and in some cases to support it and to not pursue alternatives. In Canada that decision must come - to some extent - from the provinces.[8]

Given that the time and resources of governments are limited and they cannot support all emissions-reducing technologies equally, it is plausible to assume that as provincial government decision-makers are required to flesh out and implement their climate change and energy plans they will need to subtly pick technological 'winners' by directing their time and resources into efforts that are beneficial for only a select few energy technologies. The contrast between Alberta and Ontario is informative: Alberta is very explicitly supportive of CCS (indeed, one could argue that their climate change/energy plan *is* CCS) and is taking concrete steps towards making this a reality, whereas in Ontario the climate change / energy strategy is specifically renewable energy-oriented (e.g., feed-in tariffs for wind and solar generated electricity). These trajectories do not simply emerge naturally, but require explicit decisions among political decision-makers to move the energy system in a specific direction. The focus in the following sections is on identifying the *political-economic* factors that might underpin such decisions – factors which are therefore relevant in assessing the overall future potential of CCS in Canada – and articulating a methodology by which to assess them.

## Prospective Assessment Methodology

Where there 100 operating CCS plants across Canada in a range of industries, we could develop a hypothesis about causality based on observation and the literature of the key political-economic factors which influenced relative success of the technology by region, and proceed to test it using relatively straightforward statistical techniques. Presently however there is only one operating project and two proposed CCS projects that have been given the green-light by their developers in the country.[9] As such, we cannot rely on past observations to conduct an analytical or causal assessment of the key factors driving the potential of the technology, and instead must attempt *a prospective assessment* of the potential based plausibly important factors.

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[8] Jurisdiction over energy resources and electricity belongs to the provinces, except in cases of interprovincial or international trade, or if the resources are offshore. Though the federal government has and continues to intervene in provincial energy systems through a variety of policy channels, the provinces nevertheless possess a large degree of latitude in which to carve out their own strategies.

[9] The operating plant is the Weyburn-Midale project in Saskatchewan, and the greenlighted projects are Shell's Quest project outside of Edmonton; Swan Hills Synfuels in White Court, Alberta; Saskatchewan's Boundary Dam, and Enhance Energy's Alberta Carbon-Trunk Line. See ICO2N, "CCS in Canada."

A prospective assessment differs from a causal approach in several respects: for one, we do not propose that the provincial potentials identified below are proven by our analysis and neither do we submit that proposed potential exists independently of analysis thereof. In other words, it is through studies like this one that potential is partially (though not wholly) constructed. Furthermore, we do not propose any necessary or sufficient relationships between the factors given below and either the direction of their influence, or their overall contribution to influence, for CCS. It is entirely plausible that something that constrains the potential of CCS politically today could become a positive driver tomorrow, or might cease to have any influence whatsoever if the context under which it made sense to include the factor initially changes itself. For example, if the constraint of meeting self-ascribed emissions targets were removed or trade relationships and economic structure changed significantly, the context for policy-making that would be beneficial for CCS would also change. Finally, a prospective assessment differs from an analytical one in that we have very little means by which to test the validity of our, admittedly cautious, claims. Though we can observe some variation amongst provinces in their stated commitment to CCS at present (i.e., potential isn't completely constructed), this variation can hardly be considered from an analytical standpoint because it is so 'early in the game', so to speak.

Why might we want to undertake a prospective assessment of the potential of CCS in Canada, given these constraints and qualifications? Prospective assessment is essentially the practice of looking at the future in an attempt to derive useful information from it in order to influence decision-making in the present.[10] This does not presuppose that there is one 'real' future that will inexorably follow from the current trajectory, but rather that there are multiple possible 'futures' that could attain, depending on how we manage to steer our current trajectory.[11] In the literature of the field dedicated to studying such practices (i.e., Futures Studies), it is common to distinguish between three kinds of 'futures': the probable, the preferable, and the plausible.[12] Whereas analytical or causal studies truck more in the domain of the probable, a prospective assessment aims at defining the latter two kinds of futures – futures which are deemed possible, but not unchangeable. In other words, a prospective assessment can contribute to the governance of a transition towards a preferable future by envisioning plausible futures that are neither entirely contrived nor completely determined.

This brings to the fore a major challenge in conducting a prospective analysis when if we have little to go on aside from literature in analogue cases and observed variation in intent: how can we contribute to the development of a framework for understanding political-economic potential of technology that is neither arbitrary nor over-determined (or circular)? Our approach addresses this question by striving to take a middle ground between confirming what we observe to be the case

[10] Schwartz, *The Art of the Long View*.
[11] Baumgartner and Midttun, "The Socio-Political Context of Forecasting."
[12] Bell, *Foundations of Futures Studies*; Jouvenel, *The Art of Conjecture*.

now (i.e., Alberta and Saskatchewan clearly demonstrate strong political-economic potential for CCS) and proceeding on the basis of literature alone. Accordingly we set out to identify a range of indicators for potential, based partly on political-economic literature on CCS but also on observation of the regions where CCS is progressing most quickly. The result is a framework that shows not what the inherent potential for CCS is across the provinces, but rather what the medium-term (i.e., 5 to 10 years) potential for the technology could be in each provinces based on what is plausibly relevant in influencing potential.

A second challenge was to develop an influence-scoring system that reflects the middle ground between analytical neutrality regarding the importance of each factor and what we might observe or speculate as being more influential than other factors. Given the difference in types of indicators and the formats and scales at which data for them are available, we thus needed a scoring practice that would, a) give data in a format that made sense for the indicator; b) calculate the influence of these indicators using a fair ratio to the data used; and c) also make sure that the ratio did not drastically overstate the potential of indicators not converted to percentages, or those with extreme amounts of variance across the provinces. The vast differences in indicators and data formats made a universal scoring system impossible.

As a result, we used a set of principles to keep arbitrariness or bias from skewing the results. Each of the four categories of indicators has several sub-categories, and within those several indicators – many of which were converted to a ratio scale (i.e., in most cases, a percentage share of a provincial or national total). Each indicator was assigned one negative or positive potential point, depending on the direction of its proposed influence, at a ratio to the indicator's value that would give a potential score between 0.01 and 1. Sub-categories were summed in such a way as to keep the aggregate potential of negative and positive indicators contained within it between 0 and 1 as well, and then summed to give a total for the category that could exceed one. In most cases, indicators were given in a percentage format that was relevant only to the province, but for some the share taken was of the Canadian total. No one indicator can thus contribute more than 1 point to a category total that doesn't exceed 2 for any province. Further discussion of the exact method used to score potential is given below in the discussion of the framework for political-economic potential.

## The Framework for Political-Economic Potential

The foundation for the development of the framework below is the literature on socio-technical transitions. The concept of a socio-technical transition is meant to convey that technological change is not a mere product of technological and economic optimality, not simply a case of the best-fit and cheapest technologies coming to dominate the way society accomplishes a given task. Instead, the process is characterized equally by competing social and political values, beliefs and norms about the task or social function in question,[13] along with the regulatory/legal/policy institutions and political/economic interests in a specific arrangement of technology as well.[14] These factors interact in a complex and non-linear fashion to shape the way society arrives at certain technological 'regimes' – relatively stable, 'status quo' arrangements for satisfying the social function which bounds the socio-technical system in question. Pressure on any existing regime can come from a variety of locations: from 'niches' in which potentially competing technologies, if properly insulated from regime dynamics (e.g., market pressure), can eventually come to destabilize the regime; from the broader 'landscape' of general trends (e.g., globalization, liberalization) in which the regime finds itself; or from within the regime itself.

At its most basic, political economy pertains to the relationship between the state (the public sphere) and the economy (the private sphere), though the distinction between the two has become increasingly muddied in recent decades.[15] Some make a distinction between true political economy and comparative public policy studies, the latter of which looks more at institutional determinants of policy outcomes (i.e., policy as a dependent variable), whereas the former focuses on the relationships between policy processes, institutions, and 'extra-institutional' factors like factor endowments (e.g., oil reserves), and the distribution of capital or political power.[16] Despite this, there is perhaps a general recognition that the politics and economics are indeed related, even inextricably so, and therefore that any explanation or argument concerning the way in which political or economic phenomena occur or develop must involve reference to both sets of factors in shaping the preferences of actors – better yet, the interplay between these factors. So what are these factors?

Torvanger and Meadowcroft provide a useful summary of political-economic factors that influence CCS in such a context.[17] The authors start from a similar premise as in this study and proceed to identify a range of factors that could shape government decision-making surrounding CCS. "Assuming that governments are serious about dramatically reducing greenhouse gas emissions,"

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[13] The boundaries of a socio-technical 'system' are set by its dedication to fulfilling a social function. For example, the plethora of processes and techniques involved in the production, transmission and distribution of energy for the provision of energy services (heat, light, transportation, etc) together comprise the socio-technical energy system, along with the social and political values, norms, beliefs, institutions and interests that are associated with these processes.

[14] See Geels, "The Dynamics of Transitions in Socio-technical Systems: A Multi-level Analysis of the Transition Pathway from Horse-drawn Carriages to Automobiles (1860–1930)" for an example of this perspective.

[15] Gamble et al., "Editorial"; Also, Hall, "Policy Paradigms, Social Learning, and the State."

[16] Pontusson, "From Comparative Public Policy to Political Economy."

[17] Torvanger and Meadowcroft, "The Political Economy of Technology Support: Making Decisions About Carbon Capture and Storage and Low Carbon Energy Technologies," 309; Meadowcroft and Langhelle, *Caching the Carbon: The Politics and Policy of Carbon Capture and Storage*.

they begin, “important considerations that influence their political choices about technology in the energy and greenhouse gas mitigation field include:

1. The character of existing energy system, infrastructure investments and expertise; existing scientific/technical/industrial/financial capacity that might be mobilized for alternative technologies

2. Remaining domestic fossil fuel resources and potential rents; other resource endowments of potential energy/mitigation significances (hydro, wind, solar)

3. Significance of fossil fuel imports and regions from which imports arise (security concerns)

4. Economic development potential of various energy options (potential for domestic industrial growth, new export markets, creating jobs)

5. Regional distributional issues (resources concentrated in certain geographic regions, subnational political units, etc.)

6. Economic/political strength of existing energy incumbents, energy intensive industries

7. International linkages, energy choices of neighbours, competition policy

8. Perception of relative environmental burdens of large-scale deployment of different low carbon technological options (risks/pollution associated with different tech), Public receptivity to different energy technologies”

| | **GROUPS** | | | |
|---|---|---|---|---|
| | **Emissions & Climate Change** | **Energy System** | **Economy & Employme nt** | **Politics & Policy** |
| FACTORS | Emissions Profile | Production | EITEs (GDP) | Elections |
| | LPSEs | Generation | Labour & Revenue | Policy |
| | Challenge | Structure | Trade | Public Awareness |

Based this literature and our approach to ‘prospective assessment’, we developed a framework to capture the regime-level factors that impinge upon political decision-making regarding strategic climate change and energy policy considerations in the Canadian provinces. For ease-of-use, indicators have been divided into four ‘sectors’ (Emissions Profiles; Energy Systems; Economy; and Politics) and grouped into three ‘factors’ (or sub-categories) per category.  In all, the 12 factors comprise a total of 49 indicators. Table 1 provides shows only the Groups and Factors - consult Appendix A for a more detailed account of all the groups, factors indicators, and measurements, year of data and source of data.

*Emissions & Climate Change*

This category is divided into three factors: emissions, large point-source emitters, and 'challenge' – a factor representing the difficulty the province will have in meeting its stated targets, given projected growth in population. These sub-categories are composed of 12 indicators (three negative and nine positive).

Four indicators were chosen for the 'challenge' category: the carbon intensity of the economy, emissions per capita, the difference between the provinces 2020 emission target and present emissions (i.e., how far they have yet to go), and the difference between the same emissions target and a simple, business-as-usual forecast of where provincial emissions will be based on Statistic Canada's medium growth population forecast, 2006-2008 trends (both differences are expressed as a percentage). Our reasoning is that the more stringent the emissions target and the more carbon intensive the economy, the more pressure there will be on policy-makers to utilize all available options in order to meet it. Furthermore, carbon intensity is presumed to be relatively more important than emissions per capita because economic structure (indicated by carbon intensity) is assumed to be less flexible (and thus more incentive to adopt technologies to preserve present sectors) and also because emission per capita doesn't address the differences in affluence among provinces, itself a strong driver of overall environmental impact.

Another important thing to consider is the overall amenability of the jurisdiction's emissions profile to CCS as an emissions reduction technology. Some emissions-producing sectors are more susceptible to CCS than others, but this alone should not drive potential – the relative share of the emissions profile each sector produces should have an influence on the strategy a province takes to meeting its target. If, for example, a jurisdiction has a high share of emissions from agriculture, and a lower but still significant share deriving from primary energy production, it may concentrate the bulk of its efforts and valuable resources in achieving reductions in agriculture rather than in energy production. CCS, though technically viable, may not receive as much attention from policy makers as other technologies or practices.

In the emissions profile sub-category, we take the share of total emissions contributed by each of the main sectors (transportation, electricity generation, end-uses, fossil fuel production and fugitive emissions, non-energy industrial emissions and agriculture and waste emissions) and assign 1 positive point for every percentage point for electricity, fossil fuel production and fugitive emissions, and industry and 1 negative point for transport, end-uses, and agriculture and waste. The difference between the positive and negative indicators was divided by the sum of all. Our reasoning is that the susceptibility of emissions in a given sector to be reduced through CCS should not be the only consideration in assessing potential; the share of provincial emissions from each sector is important as well. This may be because decision-makers might want to focus on the sectors that produce the largest share of emissions in addition to taking a 'lowest hanging fruit' approach.

The last sub-category looks at the proportion of emissions in the province that come from large point-source emissions (since CCS is only applicable in this setting). Two indicators were considered: the number of and contribution to emissions from large point source emitters (LPSE). But because the number of LPSEs varies so much across the provinces and the difficulty associated with fairly scoring influence between raw figures and the percentage values used elsewhere, the share of total Canadian LPSEs was calculated for each province instead. This is plausibly an indicator for political potential however, since the Federal government might be inclined to direct its actions and resources to provinces in which most emissions are produced.

### *Energy Systems*

This section looks more closely at the structure of a province's energy sector in particular, weighing potential less on the relationship between energy and GHG emissions on more on the economic or political sensitivity of the factor in question. Three sub-categories (primary energy production, electricity generation, and political structure) contain four negative and five positive indicators.

Of all primary energy production, it is mainly oil and gas production that is associated with emissions in Canada. These sectors are also those in which CCS could be most effectively utilized. Two indicators (current production and estimated reserves) for both oil and gas were considered, measured by their economic value at current prices. One positive point was allocated for each percentage of the Canadian total for that indicator, thus making this a provincial/federal indicator like the LPSE measure above. Reserves were considered because the estimated value of developing them may be a strong incentive on policy-makers to devise strategies to have them developed, albeit in as low-carbon a fashion as possible.

In electricity generation, three indicators include the share of provincial thermal generation from fossil fuels, the share of thermal generation from non-fossil fuels (i.e., nuclear), and the share from non-thermal generation (e.g., hydro and other renewables). The latter two indicators where considered negative influences on CCS potential, partly because they don't require CCS to be low-carbon but also because they present an entrenched interest against future fossil-fuel generation projects (i.e., it is more likely that a strongly hydroelectric system will remain so, partly because of technological familiarity, public preferences, and desire to maintain a 'clean' energy system in choosing new supply).

The third factor is also an electricity system one, though in this case we sought to measure influence based on the structure of the system in question, i.e., to what extent is the system a public monopoly versus a competitive private market? Three indicators were considered: the share of total capacity owned by private utilities (negative), the share owned by public utilities (positive), and the share coming from industrial generators (negative). Our reasoning was that a publicly-owned system dominated by one player would be both less susceptible to market pressures in adopting niche technology and more likely to be utilized by political decision-makers to accomplish political goals. These forces, we reasoned, would magnify the direction of influence stemming from the generation portfolio. In other words, if the province in question had an electricity system with a high proportion of electricity coming from fossil fuels, this positive influence on potential would be strengthened if it was also a publicly-owned monopoly, but weakened if a more competitive system.

### *Economy & Employment*

Whereas the previous section looked more closely at the extent to which the energy sector creates additional influence on the potential of CCS outside of the emissions profile, this section looks at the other emissions-producing sectors in which CCS can be utilized. These sectors are sometime referred to as 'emissions intensive, trade-exposed' (EITE), the definition of which can be found in the now defunct Waxman-Markely cap-and-trade bill in the US. The sectors include: oil and gas extraction; mining; chemical manufacturing; pulp and paper; industrial minerals (i.e., cement production); and iron and steel. Our basic reasoning is that these sectors will create political potential for CCS in proportion to their share of: a) the provincial economy (positive); b) labour force and the extent of government revenues that derives from them (positive); and c) provincial trade with the United States (negative).

For the EITE GDP factor, we simply took the share of the provincial GDP that each sector provides and scored it positive according to the method noted above. Similarly, for the 'Labour and Revenue' factor, we considered employment in the energy industry and revenues from natural resources (as a share of total provincial revenues) as positive indicators for CCS potential. This is because political decision-makers will be disinclined to take actions that hurt them and will have more incentive to ease the financial burden on these industries that would be associated with increasing GHG reduction pressure. Given our core assumption is that decision-makers want to hit their emissions targets, they will need to address emissions from these sectors while also not hurting them economically – public support of CCS is one of the few ways they could accomplish this, and therefore these presence and scale of economic contribution from these industries is considered a positive force.

In the trade factor however we considered the share of provincial GDP stemming from oil and gas exports, electricity, or other EITE exports as negative indicators for CCS. This is perhaps a more tenuous assumption than the directions of influence reasoned for the above indicators. For example, a trade-exposed industry is especially threatened by climate policy in the event that our closest trading partner (and/or main competitor) did not take similar measures, thus making decision-makers' less likely to address emissions in these sectors (and hindering CCS). This is what we assumed would be the direction of influence. However, if pressure to address climate change is heightened in the U.S., the direction of influence could run the other way, as decision-makers take action to assure our exports can access the more carbon-conscious market to the South. This is what appears to be taking place with the recent reticence in the U.S. to approve construction the Keystone pipeline, which has evidently influenced Alberta to propose stronger carbon policies to mitigate environmental concerns about the oilsands. Nevertheless, we retain our initial assumption that the overall direction of influence is negative because even though political decision-makers could be induced into taking stronger actions in some EITE sectors with high trade values with the US, the economic actors in these sectors might simultaneously be less-inclined to play along. It will be interesting to see how the steps towards stronger carbon policies in Alberta will be received by industry actors - judged not by their official statements, but by their willingness to implement CCS projects in sectors exposed to an environment of low gas prices and increased domestic oil production in the US.

*Politics & Policy*

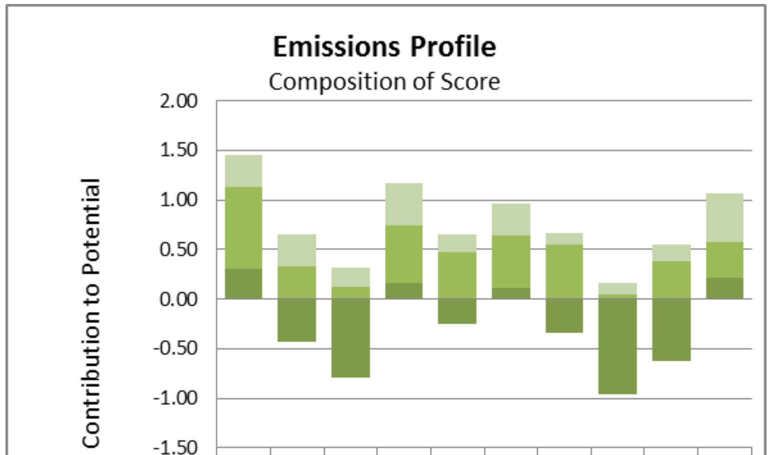
The last set of factors to consider concern the political system and policy in particular and are divided into electoral behaviour and political preferences, policy, and public awareness. The aim is to identify indicators which will create a beneficial political climate for CCS to succeed, including things like policy stability and certainty, emphasis on markets and unwillingness on the part of politicians to 'interfere' with questions about energy technology choice, climate and energy planning to date, or the present energy policies in place. Also considered in this section are indicators which could influence the public's perception of the technology. Data for these indicators is taken from the only national-level survey of attitudes and awareness of CCS in Canada, the IPAC CO2 Research Inc. sponsored report "Public Awareness and Acceptance of Carbon Capture and Storage in Canada".

On electoral / political preferences, this study considers that jurisdictions that tend to vote conservative will be friendlier to CCS for two reasons. For one, conservative parties – at least in the last six federal elections – are predominately Western-based parties, drawing their heritage policy positions from their earlier Reform and Canadian Alliance pasts. Given that this is where the oil and gas is, support for the federal Conservative parties might be associated with national support for these industries. Conservative parties are thus less likely to impose a Canada-wide vision for energy/climate change futures that does not benefit (or harms) the West. Secondly, we suppose that conservative support is indicative of more public concern for the health of the economy and less for accomplishing social goals irrespective of the costs. These jurisdictions would thus be more likely to opt for CCS since it aligns closely with the energy system we have rather than the one we might wish to have in the future. Though some might argue that a conservative party would be less likely to introduce the carbon policy necessary to incentivize CCS uptake, we would counter by reiterating that, in the context of our core assumption (i.e., that provinces will meet their emissions targets), CCS is the more likely technology that a conservative government would choose in order to do so.

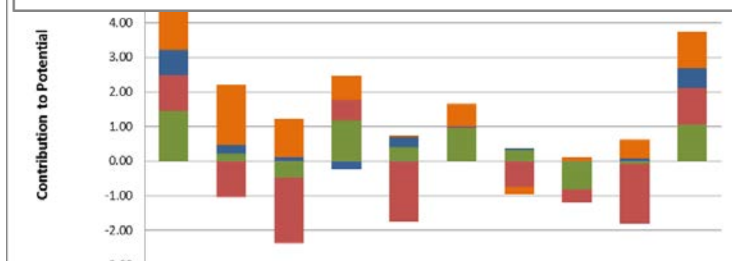
Another electoral-related indicator is the relative volatility of the politics in the provinces. The reasoning here is that a more volatile jurisdiction – that is, one which swings back and forth between 2 or more parties or people change their support for different parties relatively often – detracts from the potential of CCS for two reasons, stemming from the same issue: 1) the winning party is more likely to try to change the policy trajectory the former party was trying to realize to differentiate the new government from the past one; and 2) the lack of stable support for one party creates general uncertainty leading up to elections which can inhibit investment in new energy technologies that the former government supported. To measure volatility we use the Pedersen Index, which is equal to the net percentage of voters who changed their votes. We calculated this value for three indicators: the percentage of the popular vote received by five 'aggregate' parties in the past five federal elections; the share of the ridings available in each provinces won by the five 'aggregate' parties in the past five federal elections; and the share of the provincial ridings won by each party in the past three provincial elections. The average volatility for each province was calculated for these three indicators and assigned 1 point for every percentage point. Both the conservative party support and volatility measures comprise the Elections factor, the total for which was given by taking the difference between the positive indicators (conservative support) and negative indicators (volatility) and dividing by the sum of all.

We would be remiss not to consider present energy and climate change planning and policy as an indicator of the trajectory the province sees itself to be on. Here we look at three indicators: does the province have a carbon pricing policy in place (a step towards closing the financial gap of CCS); is the province a participant in the Western Climate Initiative (important if no coordinated federal-level action between the US and Canada); and the overall tenor and direction of the provinces most recent energy and climate change action planning. For the first, one point was allocated if the province had policy in place and zero if they did not. For the second, one point was allocated if the province was a supporter of the Western Climate Initiative, and zero if they were not. For the final indicator, points were allocated based on the general tenor of the province's energy and climate change plans, specifically regarding development versus conservation or environmental protection and the importance given to CCS. Scores range from one whole point allocated to Alberta to -0.5 points for several provinces.

Last, we consider the results for three of the questions from the survey noted above: whether the respondent thought CCS would be effective; whether the respondent thought CCS would benefit his or her province or not; and the extent to which the respondent was worried about nearby storage siting. For strongly negative responses to the first question (i.e., CCS will be 'not at all'), -1 points were assigned for every percentage point of the sample surveyed, while strongly positive responses were given 1 point on the same basis. The same scoring was used for negative and positive responses to the second question, respectively, and for the third question -1 points was assigned for every percent of the total sample that reported they were 'very' or 'fairly' worried about nearby siting. As for other factors with a mixture of positive and negative indicators, the difference between the negative and positive ones was divided by the sum of all to arrive at the aggregate contribution to CCS potential, which for all provinces was near nil.




| | AB | BC | MB | NB | NL | NS | ON | PE | QC | SK |
|---|---|---|---|---|---|---|---|---|---|---|
| Challenge | 0.33 | 0.32 | 0.19 | 0.43 | 0.18 | 0.31 | 0.12 | 0.12 | 0.16 | 0.48 |
| LPSEs | 0.83 | 0.33 | 0.13 | 0.58 | 0.48 | 0.54 | 0.55 | 0.04 | 0.39 | 0.37 |
| Emissions Profile | 0.30 | -0.4 | -0.7 | 0.17 | -0.2 | 0.11 | -0.3 | -0.9 | -0.6 | 0.21 |



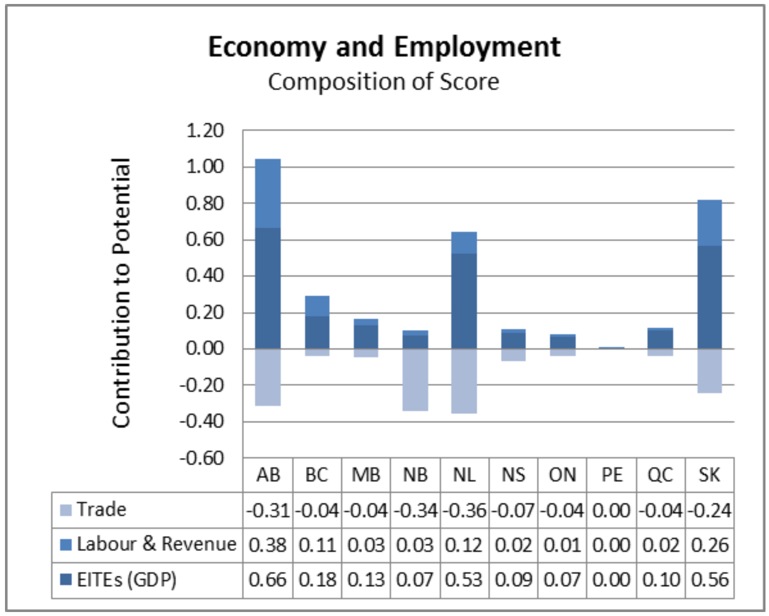

| | AB | BC | MB | NB | NL | NS | ON | PE | QC | SK |
|---|---|---|---|---|---|---|---|---|---|---|
| Politics | 1.84 | 1.73 | 1.10 | 0.67 | 0.05 | 0.65 | -0.19 | 0.11 | 0.56 | 1.04 |
| Economy | 0.73 | 0.25 | 0.12 | -0.24 | 0.28 | 0.04 | 0.04 | 0.01 | 0.08 | 0.58 |
| Energy Systems | 1.02 | -1.05 | -1.89 | 0.61 | -1.74 | 0.01 | -0.75 | -0.39 | -1.72 | 1.05 |
| Emissions Profile | 1.46 | 0.22 | -0.47 | 1.17 | 0.40 | 0.96 | 0.33 | -0.80 | -0.07 | 1.07 |

## Results & Discussion

Figure 1 shows the summary potential for each province based on the four main categories of emissions and climate change, energy systems, economy, and politics. Not surprisingly, Alberta (4.66) and Saskatchewan (3.52) have the highest political-economic potential for CCS. The scores of most of the other provinces are dragged down by their negative scores in the energy system category. There is no category which has a uniformly positive influence on the potential for CCS across Canada.

While the highest scoring provinces are not surprising, the second place finishers are perhaps slightly more so: New Brunswick (2.11) and Nova Scotia (1.55). A significant portion of this potential stems from the relatively restrictive emissions targets the Eastern provinces have retained from the earlier Kyoto days (with baselines of 1990), while most other provinces have revised their baselines to a later year. The only other net-positive province is British Columbia, whose potential is bolstered by reserves of natural gas and a relatively strong policy regime for pricing carbon. Manitoba and Quebec have the lowest potential for CCS, mainly because of the predominance of public hydroelectricity in the two provinces.

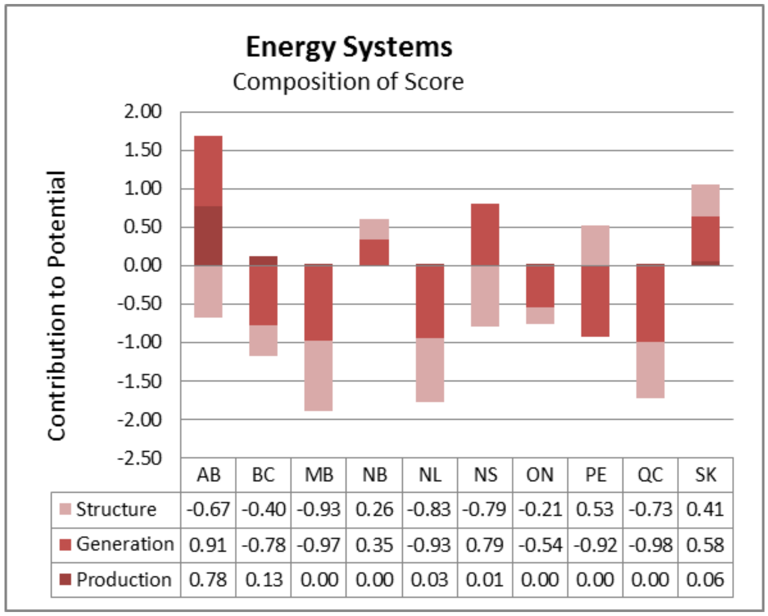
Looking more closely at the Emissions Profile category, we can see that the LPSE is typically the largest contributor to potential in each province, and contributes to significant positive potential in Alberta, New Brunswick and Nova Scotia, but also Ontario. The emissions reduction challenge is strongest in Saskatchewan and New Brunswick, and the weakest in Ontario and PEI (both provinces stand out as having negative influence in the forecasted emissions indicator, mainly because of decoupling between population growth and emissions trajectories between 2000 and 2009). The emissions profile of Manitoba and PEI create the most negative potential for CCS, in both cases because of the relatively large share of emissions from Agriculture (35.5% and 22.2% respectively) in both provinces (where CCS is not useful). Though the four provinces with the most aggregate potential score high in this category, Ontario, British Columbia and Newfoundland also show positive potential. Figure 2 shows a breakdown by province for the three factors contained in the Emissions Profile category.



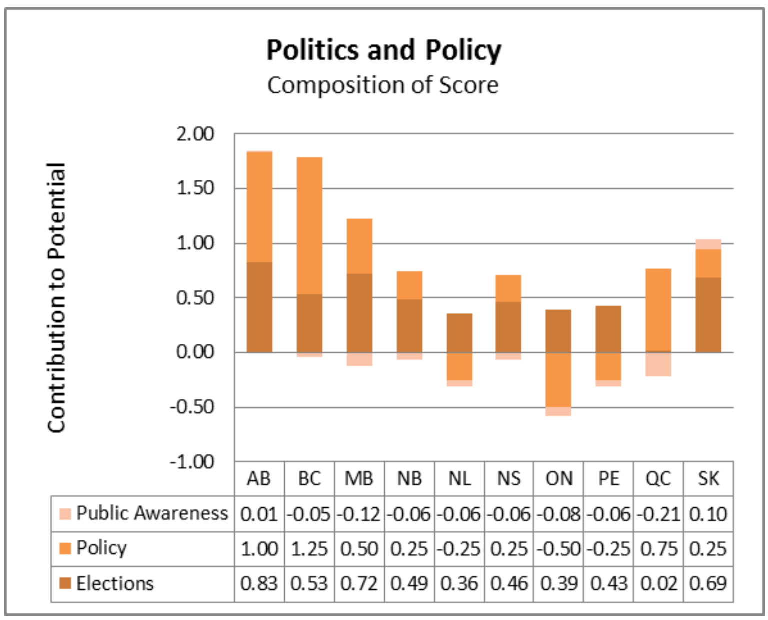

| | AB | BC | MB | NB | NL | NS | ON | PE | QC | SK |
|---|---|---|---|---|---|---|---|---|---|---|
| Trade | -0.31 | -0.04 | -0.04 | -0.34 | -0.36 | -0.07 | -0.04 | 0.00 | -0.04 | -0.24 |
| Labour & Revenue | 0.38 | 0.11 | 0.03 | 0.03 | 0.12 | 0.02 | 0.01 | 0.00 | 0.02 | 0.26 |
| EITEs (GDP) | 0.66 | 0.18 | 0.13 | 0.07 | 0.53 | 0.09 | 0.07 | 0.00 | 0.10 | 0.56 |

In the energy system category, we find that Alberta, Saskatchewan and New Brunswick lead the pack while all other provinces score significant negative potential for CCS (save Nova Scotia, which is near neutral in this category at 0.01). Interesting, Saskatchewan's positive potential comes not from energy production, but the combination of a fossil-fuel based electricity system and public ownership of the generation portfolio. For the three provinces with the lowest potential (Manitoba, Quebec, and British Columbia), it is the large predominance of public-owned hydroelectricity that could constrain CCS development. It is important to recall that this is not only because these provinces already have 'clean' electricity systems (and thus no place for CCS to reduce emissions), but rather because the combination of a predominant energy source and a non-competitive system could act to preclude new generation being sourced from CCS-applicable energy supply options.

Though Alberta receives the bulk of its potential from its large reserves of oil and gas in this category, it is only marginally positive when considering its electricity system generation and structure since this could act to make the electricity system too competitive to allow for CCS development (an argument partially borne out by the cancellation of a prominent proposed electricity generation CCS project last year in the province, while a similar project is moving ahead in Saskatchewan).



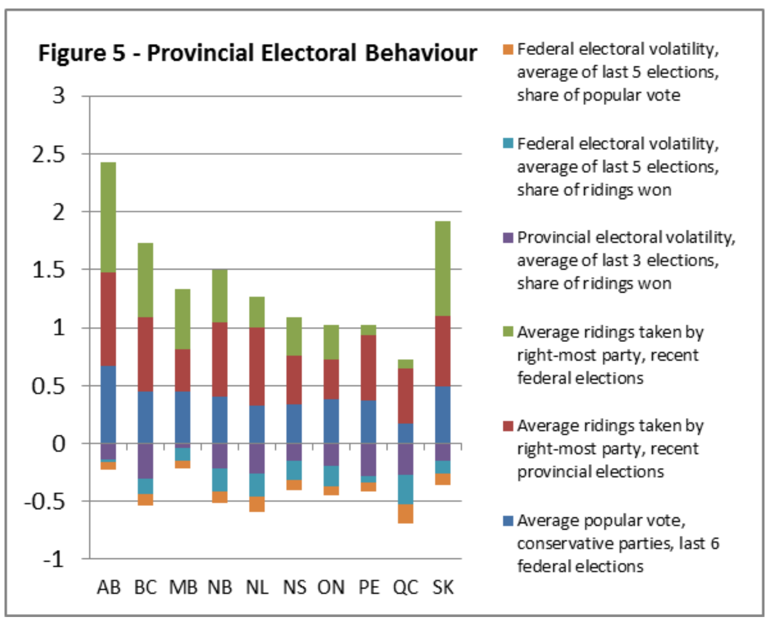

Moving on to the 'economics and labour' category, we find a surprise third place finisher in Newfoundland, while the other provinces (except Saskatchewan and Alberta) show very low potential. The bulk of the positive potential for the top three provinces comes from the value of EITE trade as a proportion of the provincial GDP. In each case, this potential stems from only 1 or 2 industry sectors – energy (which includes electricity production) and oil and gas manufacturing. Newfoundland's potential comes mainly from the former, and only a small amount from mining. These results suggest that an undiversified economy could be a strong positive influence on CCS. Taking the top three out of the picture shows British Columbia has relatively high potential in this category when compared with the remaining provinces, most of which comes from relatively high EITE GDP shares and natural resources contribution to government coffers. The natural resources in question are probably not ones that are relevant to consider for CCS potential however, but the analysis was constrained on this point by the available data.



Last, we find in the Politics and Policy category much lower variation in score than in the other three. Surprisingly, British Columbia scores second-place, mainly because of the trifecta of support for the Western Climate Initiative, carbon pricing policy, and an energy strategy document that was moderately supportive of CCS. Manitoba similarly received high marks in the electoral and party preferences factor, in part because of relatively low electoral volatility (especially pronounced at the provincial level). High volatility and low support for conservative parties scores Quebec firmly in last place in this factor. Overall, Ontario scores the lowest for this category however, in large part because of the policy factor which suggests CCS is not likely to be supported in this province.

## Conclusion

Conducting a forward-looking assessment of the potential of technological solutions to addressing climate change is an important activity as it helps to inform better decision-making. By considering multiple plausible 'futures', we can help to identify things in the present that will influence the development of our energy systems but that have yet gone unconsidered or unnoticed. The goal of prospective assessment is thus not to predict the future and neither is it to gauge the statistical significance of key drivers – to approach the problem in this way assumes that the future is too much determined by things in the present that we have no power to chance. A more open look at the range of things that could affect the development of CCS in the years to come encourages people to start thinking about what can and should be changed in order to achieve their goals for the future – it is the activity itself of looking at the future, not the certainty of the statements made about, that is valuable.




This paper was intended to be a first step in conducting a prospective assessment of the political-economic potential of CCS in Canada. As of yet, the literature is sparse on the meaning of 'political potential' for a technology, though the same cannot be said of economic potential. In general, the concept of the economic potential of a technology looks at the cost of the technology vis-à-vis potential competitors or substitutes, assuming as it assess the future development of that technology that decisions concerning it will be made on the basis of cost. The policy context for a technology is thus a key determinant of its competitiveness. Our aim was to supplement the economic aspects of technological potential by translating some of the key economic drivers into political ones. This required a different context for decision-making and a different motivation for decision-makers (rather than to optimize costs).

The core assumption we chose to inform the subsequent assessment was that political decision-makers will take the necessary actions to meet their self-ascribed emissions targets. Based on this assumption and literature concerning socio-technical transitions and the political economy of CCS, we identified a series of indicators that could impact the potential of CCS either positively or negatively. As there are so few instances of successful CCS projects in the world today, we had to walk a fine line between the inclusion of arbitrary, irrelevant indicators and over-determining the assessment by assuming the present situation is not going to change. We accomplished this by attempting to reduce the variance of the indicators and to fairly assign them potential points on a case-by-case basis. Again, the aim was not to identify which indicators are most significant, but rather to assess how they might contribute to aggregate potential for CCS in each province. We found that Alberta and Saskatchewan have the most political-economic potential, followed by New Brunswick and Nova Scotia. Looking at each factor in turn, we found some relatively surprising variations from this trend that should be important to consider as industry and policy-makers work towards resolving some of the challenges currently forestalling greater action on climate change.

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## Appendix A: Summary of Factors & Data Sources

| Indicators | | | Year | Measurement | Source | Weighting |
|---|---|---|---|---|---|---|
| **Emissions Profile** | Emissions Profile | Fossil fuel production / fugitive | 2008 | Kilotonnes of CO2 | Environment Canada, "Canada's Greenhouse Gas Inventory" | 1 |
| | | Electricity | 2008 | Kilotonnes of CO2 | | 1 |
| | | End-use | 2008 | Kilotonnes of CO2 | | -1 |
| | | Transport | 2008 | Kilotonnes of CO2 | | -1 |
| | | Industry (non-energy) | 2008 | Kilotonnes of CO2 | | 1 |
| | | Agriculture / waste | 2008 | Kilotonnes of CO2 | | -1 |
| | LPSEs | Share of Canada Total | 2009 | % | Environment Canada, "Reported Facility GHG Data" | 1 |
| | | Share of emissions from LPSEs | 2009 | % | | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Challenge | Carbon intensity | 2008 | Kilotonnes of CO2e / $1m GDP | Environment Canada, "Canada's Greenhouse Gas Inventory"; Statistic Canada, CANSIM Table 379-0025; Provincial Climate Change Action Plans | 1 |
| | | Emissions per capita | 2008 | Kilotonnes of CO2e / Person | | 1 |
| | | Difference between Emissions target and present emissions | n/a | % | | 1 |
| | | Difference between emissions target and forecasted emissions | n/a | % | | 1 |
| **Energy Systems** | Production | Total crude oil equivalent production, share of Canadian total | 2008 | % | Centre for Energy, Statistics Compilation (Online) | 1 |
| | | Total crude oil equivalent reserves, share of Canadian total | 2008 | % | | 1 |
| | | Total natural gas production, share of Canadian total | 2008 | % | | 1 |
| | | Total natural gas reserves, share of Canadian total | 2008 | % | | 1 |
| | Generation | Thermal generation (fossil fuels), share of provincial total | 2008 | Megawatt hours | Statistics Canada, CANSIM Table 127-0007 | 1 |
| | | Thermal generation (non-fossil), share of provincial total | 2008 | Megawatt hours | | -1 |
| | | Non-thermal generation (wind, hydro), share of provincial total | 2008 | Megawatt hours | | -1 |
| | Structure | Share of total capacity, private utilities (kilowatts) | 2008 | % | Statistics Canada - Table 127-0009 | -1 |
| | | Share of total capacity, public utilities (kilowatts) | 2008 | % | | 1 |
| | | Share of total capacity, industrial generators (kilowatts) | 2008 | % | | -1 |
| **Economy** | EITEs (GDP) | Energy, share of total provincial GDP | 2008 | Current dollars, 000,000s | Statistics Canada, CANSIM Table 379-0025 | 1 |
| | | Oil & Gas, share of total provincial GDP | 2008 | Current dollars, 000,000s | | 1 |
| | | Mining, share of total provincial GDP | 2008 | Current dollars, | | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | 000,000s | | |
| | | Chemical Manufacturing, share of total provincial GDP | 2008 | Current dollars, 000,000s | | 1 |
| | | Pulp & Paper, share of total provincial GDP | 2008 | Current dollars, 000,000s | | 1 |
| | | Industrial Minerals, share of total provincial GDP | 2008 | Current dollars, 000,000s | | 1 |
| | | Iron & Steel, share of total provincial GDP | 2008 | Current dollars, 000,000s | | 1 |
| | Labour & Revenue | Employment in energy industry, share of total provincial employment | 2010 | - | Statistics Canada, CANSIM Table 379-0006 | 1 |
| | | Revenues from natural resources, share of provincial total revenues | 2008 | Current dollars, 000,000s | Statistics Canada, CANSIM Table 385-0002 | 1 |
| | Trade | Oil and gas exports to US, share of total provincial GDP | 2008 | Current dollars, 000,000s | Industry Canada, "Trade Data Online Database" | -1 |
| | | Electricity exports to US, share of total provincial GDP | 2008 | Current dollars, 000,000s | | -1 |
| | | Other EITE exports to US, share of total provincial GDP | 2008 | Current dollars, 000,000s | | -1 |
| **Politics** | Elections | Average popular vote, conservative parties, last 6 federal elections | n/a | % | Elections Canada<br>Federal data - Elections Canada; Provincial data, About.com | 1 |
| | | Average ridings taken by right-most party, recent provincial elections | n/a | % | | 1 |
| | | Average ridings taken by right-most party, recent federal elections | n/a | % | | 1 |
| | | Provincial electoral volatility, average of last 3 elections, share of ridings won | n/a | % | | -1 |
| | | Federal electoral volatility, average of last 5 elections, share of ridings won | n/a | % | | -1 |
| | | Federal electoral volatility, average of | n/a | % | | -1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | last 5 elections, share of popular vote | | | | |
| | Policy | Carbon pricing (taxes, cap and trade) | 2012 | 1=Yes, 0=No | Provincial energy and climate change plans; independent research | 1 |
| | | Western Climate Initiative | 2012 | 1=Yes, 0=No | | 1 |
| | | Energy / Climate Change Plan | 2012 | 1, 0.5, 0, -0.5, -1 | | 1 |
| | Public Awareness | Awareness of CCS | 2011 | Scale | IPAC CO2 Research Inc., "Public Awareness and Acceptance of Carbon Capture and Storage in Canada" | 1 |
| | | "CCS Not at all Effective" | 2011 | Scale | | -1 |
| | | "CCS Very Effective" | 2011 | Scale | | 1 |
| | | "CCS Would Benefit my Province" | 2011 | Scale | | 1 |
| | | "CCS Would not Benefit my Province" | 2011 | Scale | | -1 |
| | | Very or Fairly Worried about nearby storage siting | 2011 | Scale | | -1 |