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Climate Change Primer

Climate change could have catastrophic effects globally and in BC, the Prairies and Canada's North. This paper discusses key issues related to oil and gas production/use and climate change, including the role of natural gas as a transitional, "clean energy" fuel, the impact of the Kyoto protocol on oil and gas production, and policy issues likely to arise with the progression of climate change.

Climate change and the future of the world

Human emissions of greenhouse gas emissions, primarily from fossil fuel combustion, are changing the world's climate. Globally, average temperatures have risen by 0.6° C over the 20th century.

Global average temperature increases comparable to change since last ice age. Global Average temperatures are projected to increase by another 1.4 to 5.8° C over the next century. (In comparison the global temperatures have only risen 4-5° C since the last ice age, 10,000 years ago, when Vancouver was under a kilometre or more of ice).

Economic development patterns account for the differences in projected future climate change. The reason for the wide range of projected temperature changes is largely due to difficulty in predicting how the global economy will evolve. In a world where economies tend to grow and integrate and rely predominantly on fossil fuels, temperature increases of 4.5°C are expected. Shifts toward a less material intensive economy or an economy of local solutions to sustainability are likely to yield changes in the range of 1.7 to 2.5° C. In other words, global economic patterns are key to avoiding climate change.

Impacts extend to drought, flooding, disease and sea level rise. Climate change means not only warming, but also sea level change, increased storm activity, more extreme droughts in some areas and more extreme floods in others. Its projected effects include massive changes in ecosystems, extinction of many species that cannot adapt to rapid changes in, severe impacts on agricultural production (especially in countries where the world's poor and hungry are located), inundation of large areas of some countries due to sea level rise and storm surges, loss of some small island nations due to sea level rise, increased forest fires and the spread of diseases beyond their current range.

Climate change in the Canadian North and West

Impacts in BC

Temperatures and precipitation shift. As predicted by climate change scientists, night time minimum temperatures in BC are warmer on average that they were a century ago, as much as 2.1° for the northern boreal mountains. Over the next century most climate models predict significant increases in average temperature for BC –- one to four degrees on the coast and three to five degrees inland. Models also predict a shift to wetter years, greater year-to-year variability in precipitation, more extreme precipitation events, and reductions in snow pack.

Hydrological system changes with impacts on salmon survival. Retreat and loss of glaciers in the Columbia River system could reduce water flow during low water season by twenty to 90%. The combination of these events are projected to lead to more spring and winter flooding in the Peace River, Fraser River and Columbia systems, combined with lower summer river flows and higher water temperatures. The temperature of the Fraser River at Hell's Gate has already increased by the equivalent of 2.2° from 1953 to 1998. Continuation of this trend is expected to have a profound negative impact on salmon stocks in the Fraser River. Projected increase in sea surface temperatures will also have a profound negative impact on Fraser River fish stocks forcing salmon north toward the Bering Sea. According to one federal government report "it may be unfeasible to prevent the extinction of some local salmon stocks in the Fraser River watershed."

Greater disturbances and more pests in forests. Changes in forests are also projected with increased forest fires in interior and boreal areas, and increased pest problems. The BC government reports that climate change is already responsible for infestations of forest-destroying mountain pine beetles.

Impacts in the Prairies

Average temperature increases greater in Prairies. Average temperatures in areas of North-Central Alberta have increased by over 0.5° C from 1965 to 1995, with and additional 3 to 5° projected over the next 100 years. Less precipitation, more evaporation and less snowmelt are projected for the summer, meaning more frequent and extreme drought.

Boreal forests shift northward as much as 1100 kilometres. Forest temperature patterns are expected to shift northward by about 3 to 5 kilometres per year, a rate much faster than many tree species' ability to migrate. As a result, some regions of forest may become mismatched with their surrounding environment. These forests would likely die or be ravaged by fires. Forests will also be stressed by forest pests which migrate northward, and against which existing forests have no natural defences. The southern edge of the boreal forest could be pushed northward as much as 1100 kilometres. Many of the trees along the southern edge might die out as grasslands that thrive under warmer temperatures overtake them.

Wetland habitat in danger of drying out. Canada's vast wetlands provide important wildlife habitat for waterfowl and a host of other species. Prairie wetlands will be in danger of drying out.

Their loss will seriously threaten the immediate survival of many North American waterfowl species.

Canada's North

Greatest temperature increases in Arctic. In the arctic certain areas of land have increased in temperature by as much as 5° over the last century. Precipitation has also increased. As the world continues to warm, temperature changes will be greater in the North, and they will be greater in winter than in summer. Winters in the Canadian Arctic are expected to average 5 to 7°C warmer by 2100 than they are today. Over water the change will be even greater -- with winter temperatures estimated to be as much as 10°Cwarmer over Hudson Bay and the Arctic Ocean.

Changes in hydrology will impact river and delta systems. Increased rain, reduced river ice and melting of permafrost are expected to radically change northern ecosystems. Reduced flooding due to ice jams is likely to impact on highly productive river deltas where periodic flooding is critical to survival of lakes and ponds.

Ice dependant species threatened. Species dependent on sea ice for breeding and feeding – e.g walruses, sea lions, some seal species and polar bears – are likely to decline. Longer ice-free periods would make it difficult for the Hudson Bay bear population to hunt (the bears hunt during the winter and mainly fast during the summer months), and they may become unable to store enough fat to survive. Should the Arctic Ocean become seasonally ice-free for a long period, the polar bears may face extinction.

What will it take to avoid catastrophic climate change?

Greenhouse gas cuts of 60 to 80% needed to stabilize climate. To stabilize the climate requires stabilization of greenhouse gas concentrations in the atmosphere. Because greenhouse gases persist in the atmosphere for decades to 100s of years, building-up over time, stabilization will require dramatic cuts in greenhouse gas emissions -- cuts of over 60% globally. It is widely assumed that these reductions cannot occur immediately; instead, the goal is to stabilize atmospheric concentrations at a level that is higher than natural levels but avoids the worst of climate change.

Earlier reductions reduce risk. From an environmental perspective, it is highly desirable to begin significant emission reductions early. Early reductions will result in a slower rate of change climate change in the medium term, and will allow future generations to choose lower concentration levels as they gain a fuller understanding of climate impacts. Any delay in reducing emissions will necessitate future emission reductions that are much deeper and steeper, and may prove economically or politically unachievable.

Rapid reductions are also needed to reduce the risk of catastrophic climate change. Most climate change models predict climate change will occur with linear relations between greenhouse gas concentration and negative impacts. However, the climate has "gone off the rails" in the past, with huge changes happening in decades. So-called catastrophic climate change would have negative effects far more severe than the normally projected impacts, and scientists

have no way of predicting what decreases in emissions are needed to avoid catastrophic climate change.

Oil, Natural Gas and Greenhouse Gases

Production and use of fossil fuels create greenhouse gases. Both the production and use of oil and gas produce greenhouse gases that contribute to climate change. Major sources of greenhouse gases from upstream oil and gas production include flaring of waste gas, venting of sweet gas, leakage at the well site and venting of carbon dioxide removed from gas during processing. Other sources include transmission and processing. Emissions from producing, processing and transporting oil and gas ("upstream emissions") amount to 200 to 350 kg of carbon dioxide equivalent[1] ("CO2 eq") for every 1000 cubic meters ("m3") of gas produced. An additional 1,888 kg is emitted when the gas is burned for energy. In the case of gasoline produced from tar sands, 1000 litres of gas produces 2.36 tonnes of CO2 eq when burned, and another tonne when produced.

Upstream oil and gas emissions: high and growing. As a result of BC's rapid expansion in oil and gas production, BC's greenhouse gas emissions from this sector have escalated significantly. From 1990 to 1996 BC natural gas production increased from 14 to 23.5 billion m3. At the same time upstream emissions from oil and gas increased from 3 million tonnes ("mt") CO2 eq to 5.1 mt. By 1996 upstream oil and gas accounted for 8% of BC's greenhouse gas emissions. This number is likely higher today. Nationally, oil and gas production released 80 mt CO2 eq in 1990, growing to 98 mt in 1998. In 1998 these emissions accounted for 16% of Canada's 612 mt total emissions.

Increased production meets US demand. Expansion of Canadian fossil fuel production is largely aimed at meeting the American demand for energy. From 1990 to 1998 natural gas exports from Canada to the US increased from 39 billion m3 to 95 billion m3. By 2010 exports of natural gas from Canada are expected to reach 135 billion m3, providing the US with 18% of its natural gas. From 1990 to 1999 there was a similar 95% increase in oil exports to the US.

Natural gas least harmful of fossil fuel options. While natural gas is a major contributor to greenhouse gas emissions, it is generally better than other fossil fuels. The emissions of CO2 from burning natural gas ("downstream emissions") amounts to 49 tonnes of CO2 per terra joule ("TJ") of energy. In comparison gasoline, diesel oil and heavy oil all emit about 70 t/TJ, and coal emits 82 to 95 t/TJ. The comparison of different fuels becomes more complicated when they are compared on a life-cycle basis. Upstream emissions vary according to the source of fossil fuels, production methods and the amount of gas leaked and burned during transmission to markets. Upstream emissions from natural gas production will be higher if the gas is sour and further away from market. And, gasoline produced from tar sands oil has much greater upstream emissions than gasoline produced from light oil.

Emissions from Different Fossil Fuels (based on cursory literature review)

	Upstream Emissions (from production and transport)	**Downstream Emissions** (from combustion)	**Total Emissions**			
Fuel	Emissions per unit fuel	Emissions per unit energy (kg/TJ)	Emissions per unit fuel	Emissions per unit energy (kg/TJ)	Emissions per unit fuel	Emissions per unit energy (kg/TJ)
Natural Gas	200-350 kg/ 1000 m3	5263-8159	1,888 kg/ 1000 m3	49,680	2,088-2,238 kg/1000 m3	54,943 – 57,839
Gasoline from Tar Sands	1000 kg/ 1000 litres	28,800	2,360 kg/ 1000 litres	67,968	3,360 kg/ 1000 l	96,768
Coal	Widely variable	1,520 – 2,520 kg/tonne	81,600-95,000			

Trend toward higher emitting crude oil and natural gas sources. A disturbing trend is increased North American reliance on oil and gas sources that have higher associated emissions – e.g. a shift from light to heavy crude and tar sands, and a shift to gas reservoirs that are further from markets.

Reductions in upstream oil and gas emissions possible. Lifecycle emissions can be improved somewhat through process changes, practices to avoid fugitive emissions, and practices such as re-injection of acid gas (injecting CO2 and HS stripped from raw gas back into gas wells).

Is natural gas a transition fuel toward renewable energy?

Natural gas is adding to US energy supply, not replacing coal. Because of its lower emissions per unit of energy, natural gas is often referred to as a transition fuel in the battle against climate change, and it is often argued that Canada's exports of natural gas displace dirty coal for electricity generation. In fact, natural gas is not being used to replace coal. Instead, both gas and coal are being used to fuel a voracious American appetite for cheap energy. From 1999 to 2010 US demand for natural gas is expected to increase 32%, but demand for coal is expected to increase at the same time by 21.5%.

Not clear what US would do in absence of natural gas supply. At the same time it is difficult to predict what would occur if Canadian natural gas exports to the US were curtailed. It is possible that the US would meet its energy needs by increasing coal fired power generation more rapidly and relying on "dirty oil" from Venezuela. But a decrease in supply could also mean

higher costs in the US and an increased focus on truly clean alternatives like renewable energy and energy efficiency.

The extent to which US and Canada rely on fossil fuels versus energy efficiency and renewables is a more a matter of government policy, not economics. Repeated studies show that US and Canada could radically shift away from fossil fuels at little or no cost to the economy. The problem is a reluctance within government to take the necessary policy steps – mandating improvements in energy efficiency of motor vehicles, using tax policies to encourage shifts to more efficient energy use, shifting research money from fossil fuels to renewables etc, and shifting the human health costs of fossil fuel pollution from victims and government to the polluters.

Expanding production in Canada simply plays into hands of Bush Administration. By meeting US demand for cheap energy, Canada simply perpetuates an economy and way of life that is unsustainable. Reduced production in Canada could potentially increase emissions by a greater amount in the US, but Americans would pay the price in air quality and human health. It is also possible that reduced production in Canada would force Americans to increase energy efficiency.

Expansion of natural gas infrastructure locks economies into reliance on fossil fuels. Expanding natural gas infrastructure is also problematic for the long-term battle against climate change. Investments in new gas infrastructure create an economy based on natural gas, and makes it increasingly difficult to shift toward renewables and energy efficiency. Once institutions, businesses, physical infrastructure and consumer demand are based on natural gas or oil, it is far harder to shift the economy to cleaner alternatives.

What does the Kyoto Protocol Do?

Prelude to Kyoto: commitments but no action. The UN Framework Convention on Climate Change ("FCCC") committed the industrialized world to adopt policies and measures with the aim of returning emissions to their 1990 levels by 2000. Despite this commitment, emissions from industrialized countries continued to grow through the 1990s — especially Australia (15% increase from 1990 to 1998), Canada (13% increase), the United States (11% increase), and Japan (10% increase).

Kyoto Protocol: legally binding quantifiable commitments. Unlike the somewhat vague commitments of the FCCC, the 1997 Kyoto Protocol contains clear emission reduction commitments for developed nations. If the Protocol is ratified by a sufficient number of nations, these commitments will be binding in international law. The commitments will, however, only be binding on the Parties that ratify the Protocol. The US has announced that they will not ratify and thus commitments will not be enforceable against them.

Canada's commitment significant. The Protocol establishes a commitment period between 2008 and 2012 during which the industrialized nations must limit their emissions of six greenhouse gases. Parties are given a quota of allowable emissions. Canada's emissions quota is 94% of 1990 emissions.[2] The European Union's is 92%. The Kyoto Protocol does not set

targets for after 2012, but is based on the assumption that Parties will negotiate subsequent commitment periods that will start in 2013. Given the continuous expansion in Canada's greenhouse gas emissions since 1990 and projections for future increases, the Kyoto Protocol is very significant. Business as usual projections would see Canada's greenhouse gas emissions rise to approximately 809 MT annually by 2010. Canada's allowable emissions per year are 571 MT, creating a "gap" of 240 MT to be reduced.

Protocol provides flexibility to reduce cost of implementation. The Kyoto Protocol includes several mechanisms that are intended to reduce the costs of achieving reduction targets. Under emissions trading industrialized parties to the Protocol can, at a low or negative cost, reduce emissions beyond what is required by the treaty can sell parts of their assigned amount to other industrialized nations who cannot reduce their emissions as easily. Under the Clean Development Mechanism, developing nations that can reduce emissions cheaply are also allowed to generate "certified emission reductions" which they can sell to industrialized nations. The nation acquiring the assigned amount or the certified emission reduction is then allowed to emit more. Countries are also allowed to expand their allowable emissions through increasing the amount of carbon stored in their managed forests. These mechanisms are intended to reduce the cost of meeting an emission limit defined by international law. The cost savings and flexibility offered by these mechanisms have been essential to achieving a politically viable Kyoto Protocol.

Environmental integrity and flexibility protected under final rules. Between 1998 and 2001, during negotiation of rules for implementing the Kyoto Protocol, Canada consistently sought the maximum amount of flexibility under the Kyoto Protocol, often with little regard to environmental effectiveness. A November 2000 Report by West Coast Environmental Law evaluated Canada as having the 2nd worst negotiating position in the OECD in terms of maintaining environmental integrity. In the end result, under rules negotiated in 2001, Canada received most of what it wanted. In particular it received major concessions in terms of credit from forests. Nonetheless, the rules ensure that the Protocol had some integrity and will ensure real emission reductions.

But protocol is only a first step. While the Kyoto Protocol will have an impact, it is a small first step to averting climate change. By itself, it would likely only delay climate change by a decade over the next century. Real climate protection will require far deeper emission cuts in the industrialized world and will require developing nations (who currently have per capita emissions that range from 1/90th to 1/5th of Canadian levels) to take on reduction commitments.

What will the Kyoto Protocol mean for the economy and oil and Gas Production?

Impacts on economy marginal. The impacts of the Kyoto Protocol on the economy, and different provinces and sectors will depend on how Canada goes about reducing its emissions. A very recent federal discussion paper outlines four options for meeting the Kyoto commitments. Modelling of impacts is only presented for two of these options but they clearly indicate the limited economic impact of meeting Canada's commitments. Under the least cost design (a

design which, subject to some changes, has been advocated by West Coast Environmental Law) the Canadian economy would actually benefit, with GDP and employment growing slightly faster. Alberta would suffer slightly with the economy growing by only 26.8% compared to the projected 27.3%. Under the more expensive option, GDP would only increase by 30.4% rather than the business as usual projection on 31%. Even in the absolute worst case scenario, where international emission permits cost far more than predicted, the economy would still grow by 29.3%.

Impacts on oil and gas production, significant but marginal. Assuming the international price for a one tonne emission permit is $10 (close to the average anticipated by international experts), the Canadian oil and gas sector would still grow by 24.3% to 24.6% from 2000 to 2012, compared to 26.9% in a business as usual scenario. Even in the absolute worst case scenario, GDP in the oil and gas sector still grows by 15%. The real significance of the Kyoto Protocol is likely to be over the longer term, as emission targets become deeper and there is an increasing shift away from coal and tar sands to less carbon intensive alternatives.

Credit for "Clean Energy Exports"

Despite limited impacts Canada is insisting on credit for "clean energy exports" of natural gas and hydroelectric. Canada has said that it should get credit for exports of so called clean energy – i.e. hydroelectric and natural gas. Canada says that it should receive 70 million tonnes CO2 eq of credit per year based on the assumption that the US would meet its energy needs with coal if Canada did not export electricity and natural gas. To receive this credit Canada will need the support of the European Union. Canada has indicated that it may not ratify the Kyoto Protocol if it does not get clean energy credits.

Clean Energy Credits will increase pollution in Canada. Such credit would allow Canadian industry to **emit an extra 70 million tonnes of greenhouse gases per year from 2008 to 2012.**

Clean Energy Credits will not impact pollution in the US. Credit for clean energy exports will not significantly effect exports to the US or US emission levels. With or without clean energy exports Canada is expected to expand its exports of natural gas and power to the US. Moreover, as noted above, our energy exports are not being used to reduce emissions in the US, they are meeting the increasing American appetite for cheap energy. Even if Canada eliminated exports of hydro and natural gas, it is unlikely that the US would make up the gap solely from coal.

BC Energy Policy Review

In August2001 Premier Campbell established a Task Force to review British Columbia energy policy. The interim report of the task force included the following recommendations:

- ***Encourage pilot projects for coal fired power generation***. The task force also recommends changes to both the environmental assessment and permitting processes to ensure timely permitting and to meet concerns of coal industry and coal power proponents.

- ***Shift to a competitive electricity market***. From an environmental perspective this has pluses and negatives. On the one hand, a shift to market prices will encourage conservation and efficiency. And allowing free access to the transmission grid will facilitate energy efficient co-generation projects. On the other hand, in a competitive power generation market, generators are likely to invest less in green power than under a provincially owned monopoly. There is likely to be an increased reliance on natural gas. Also, if deregulation extends to distribution (i.e. consumers can choose their supplier) it will become increasingly difficult for utilities to provide Power Smart type services that encourage energy efficiency. Both these problems can be solved --through mandatory "green energy portfolios" and line charges devoted to funding energy efficiency. However, the government has shown an aversion to these regulatory interventions.
- ***Allow natural gas residential and commercial customers to choose from among suppliers***. This is likely to reduce energy efficiency services provided by natural gas distributors.
- ***Eliminate requirements for Energy Removal Certificates. Energy removal certificates are currently needed for exports of natural gas***.

Policy Issues Arising

Protected Areas to Protect Biodiversity in a Changing Climate. As discussed above, today's wildlife habitats may shift or alter. Some adaptable species may be able to fill new niches or find their habitat expanding. However, often parks or other areas of wilderness are islands of natural habitat in a landscape that has been changed by human activities. Many species could be stranded because of a lack of safe migration routes through populated or developed areas. Because of this, there will not be much chance for species to leave the protected areas if their habitat changes. Improving connectivity between protected areas will be essential to successful adaptation to climate change.

Ratification of the Kyoto Protocol. The Kyoto Protocol is the only option being discussed that will have any impact on emissions. Canada has not made a decision on whether or not to ratify. Environmentalists are pushing for ratification prior to the August 2002 World Earth Summit. The Bush and Alberta plans only aims to slow the growth in emissions by a very small degree. It is likely that any Alberta or federal alternative to Kyoto will be similarly limited.

Engage in Energy Policy Review. Environmentalists could:

- either oppose competition in the power sector or insist that competition be accompanied by strict green power portfolios and line charges for energy efficiency services.
- Oppose coal.
- Oppose expansion of oil and gas operations.
- Call for stringent CO2 standards for all thermal generation.

Regulations to Reduce Upstream Greenhouse Gas Emissions. As noted above recent federal government discussion paper outline four options for reducing greenhouse gas emissions in Canada. Option 2 involves reliance on regulations, incentives and targeted government spending. Under Option 2 emissions from the oil and gas sector could be reduced by 18 mt annually.

Measures would include provincial regulations requiring leak reduction, reduced flaring, acid gas re-injection and use of most energy efficient equipment. Incentives could also be created to encourage CO2 capture and storage from oil sands production, and use of energy efficient equipment. The discussion paper suggests that reliance on regulations is the most expensive and least reliable option for meeting Canada's Kyoto target. It is an unlikely option for the federal government to rely on, but it does indicate the potential for regulating CO2 emissions from the oil and gas sector.

Design of a Domestic Emissions Trading System. Options 1, 3 and 4 involved domestic emissions trading system. As noted above, in the short term, implementing the Kyoto Protocol using a domestic emissions trading system is unlikely to have major impacts on the oil and gas sector. Nevertheless, the impacts on the oil and gas sector could be larger over the longer term, especially if Canada accepts more stringent targets for post 2012. The extent of impacts will depend in part on how Canada designs an emissions trading system. Two issues are particularly important:

- *Allocation of emission permits based on current production will have less of an impact on tar sands, oil and gas production*. Emission permits can either be auctioned (Option 1), given out free based on past production or emissions (Option 3) or given out free based on current production -- i.e. an emitter receives more permits if they produce more (Option 4). Option 1 and 3 will be more effective in encouraging a shift in investment away from new oil and gas production. This is because producers will incorporate the full value of permits into their investment decisions. Under option 4, production of oil and gas is partially subsidized by the giving out of free emission rights for every unit of production. Option 4 fails to encourage a re-orientation of the economy toward renewable energy.
- *Price surcharge for use of international emission permits.* Under Options 1, 3 and 4 it was assumed that emitters are free to meet their reduction targets through the purchase of international emission permits and international emission reduction credits. It is projected that 118 – 128 MT of Canada's 240 MT reductions needed by Canada would come from purchases of international permits and credits. These permits and credits may have less environmental integrity than domestic permits or credits, representing, for instance, reductions in emissions in Russia that have already occurred due to economic collapse, or representing questionable reductions from hypothetical scenarios in developing countries. To curtail the use of international emission permits and encourage investments in Canadian reductions, Canadian emitters could be charged a surcharge for use of international permits. This would help shift new energy production away from carbon intensive fossil fuels. So long as the surcharge is not too high this would also benefit the Canadian economy. The possibility of a surcharge, is not, however, on the federal provincial "radar screen".

Notes:

[1] Different greenhouse gases have different impacts on the atmosphere. Carbon dioxide has a fairly long life in the atmosphere but measured on a per tonne basis is not very powerful. Methane has a much shorter lifetime in the atmosphere but is very powerful. The standard way of comparing gases is to look at impact over 100 years. On this basis, methane is 21 times as powerful as CO2. Greenhouse gases are typically expressed as an equivalent in C02 over a 100 year time frame ("CO2 eq").

[2] The actual quota is 94% of 1990 emissions times five to reflect the five years from 2008 to 2012.