Proposed NDP Climate Policies for BC:

Estimating Their Effect

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Executive Summary

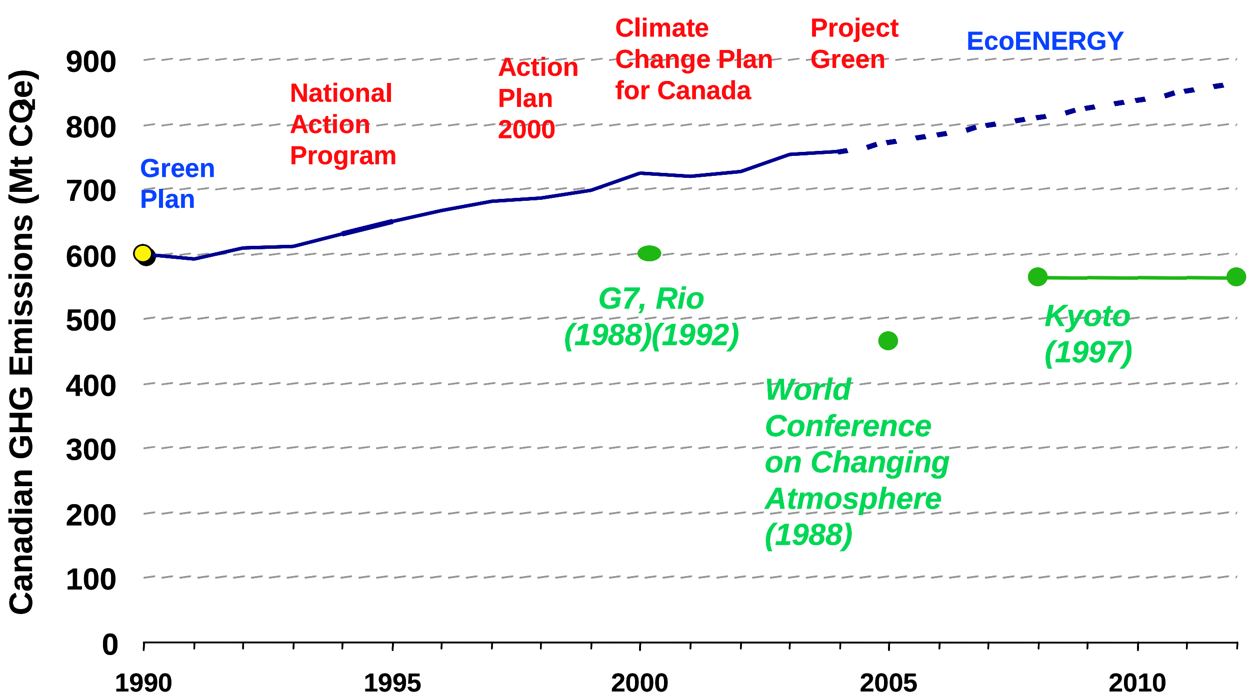
This report provides a preliminary estimate of the likely effect of the key climate policies proposed by the BC NDP in 2008-2009. The estimate is based on a simulation using the CIMS energy-economy-environment model. The results indicate that the NDP policies, which exempt about 65% of BC's GHG emissions from emissions pricing (be that via a carbon tax or a cap-and-trade system for fuels used by final consumers), can only achieve the intended emissions reduction target in 2020 (33% reduction from current levels) by causing dramatic reductions in industrial output, with attendant job losses, especially in industry-dependent communities. This outcome – loss of an estimated 60,000 direct and indirect jobs – results from the extremely high GHG prices that would be faced by BC's industrial emitters under the NDP policies.

[1] Professor at Simon Fraser University specializing in sustainable energy modeling and policy, Dr. Jaccard has been appointed by NDP, Conservative and Liberal governments to energy-environment policy advisory and decision making positions over the past two decades. The BC NDP government of the 1990s appointed him to chair the BC Utilities Commission (1992-1997), the Electricity Market Review (1995), the Public Inquiry into Gasoline Pricing (1996), and the Task Force on Electricity Market Reform (1997). An abridged CV is provided in Appendix A.

1. The challenge of implementing effective climate policy

Implementing effective climate policy has proven to be extremely difficult. For over two decades, governments in industrialized countries have promised to achieve targets for reducing greenhouse gas (GHG) emissions, but have failed. Canada has performed worse than most countries. The following figure shows that, since 1988, successive Canadian federal governments have set targets (shown below the emissions line) and implemented policies (named above the line) that they promised would achieve these targets. Instead, emissions continued to climb.

Canadian Targets, Policies and Emissions

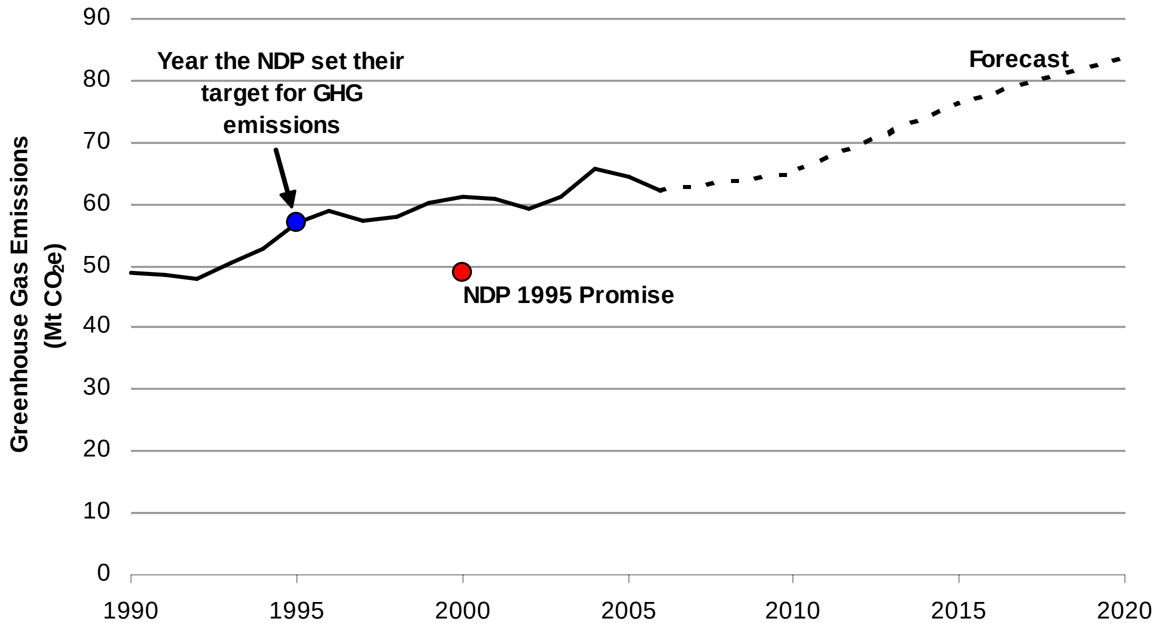


(Source: J. Simpson, M. Jaccard and N. Rivers, *Hot Air*, McClelland and Stewart, Douglas Gibson, 2008)

A similar failure occurred in BC, where the NDP government in 1995 promised that by 2000, its policies would reduce provincial GHG emissions back to their 1990 levels.[2] The following figure shows that emissions instead climbed through the final six years of the NDP mandate, a trend which has continued through most of the first decade of this century.

[2] BC Government, *British Columbia Greenhouse Gas Action Plan: Meeting the Challenge of Climate Change*, 1995.

BC GHG Targets and Emissions



(Source: Environment Canada, *National Inventory Report*, 2008; BC Government, 1995)

Climate policy experts have studied closely the ineffective policies of the past two decades. Virtually all of the leading, internationally-recognized experts now agree that if our climate policies fail to price GHG emissions they will not succeed. According to William Nordhaus of Yale University, widely recognized as one of the world's leading climate policy analysts, if a politician's proposal does not "raise the price of carbon, … you should conclude that the proposal is not serious."[3] Likewise, Nicholas Stern, chair of a climate inquiry for the UK government, argues that, of the requirements for effective climate policy, "the first is the pricing of carbon."[4]

In essence, there are three ways to price carbon emissions. A carbon tax is the most direct way. A second direct pricing mechanism is to set a regulated cap on emissions and then allocate permits that firms (and perhaps individuals) can trade among themselves in order to achieve the cap at the lowest total cost. If the trading system covers virtually all emissions in the economy, then the permit trading price has the same effect on the price of gasoline or natural gas for home heating as would an economy-wide carbon tax. Finally, the third way to price emissions is indirect. This involves setting regulations on technologies or fuels which force firms and households to choose options that emit less GHGs but are usually more expensive to acquire and/or operate. Thus, BC's current electricity policy prohibits new GHG-emitting electricity generation, resulting in a rising electricity price as BC Hydro acquires supply from higher cost,

[3] W. Nordhaus, 2008, quoted in the New York Review of Books.
[4] N. Stern, 2009, *The Economics of Climate Change*, http://www.hm-treasury.gov.uk/sternreview_index.htm.

zero-emission sources. This rising electricity price is an indirect form of emissions pricing, the result of regulating technologies and fuels.

Policy analysts refer to all three of these as “compulsory policies” in that firms and households cannot escape the direct or indirect pricing of carbon, which in turn influences the millions of decisions each year that have implications for our GHG emissions. These policies stand in contrast to the “non-compulsory” approach, which has dominated our ineffective climate policies of the past two decades. The non-compulsory, non-pricing approach generally includes a mix of information programs (advertising, demonstration projects, product labeling, websites) and subsidies (grants, low interest loans, tax rebates) which promote voluntary GHG reductions by firms, households and institutions. They have been largely unsuccessful because (1) information programs to conserve energy and/or reduce emissions cannot hope to counter the barrage of conventional advertising that encourages mobility and the acquisition of products, and (2) subsidy programs can only hope to influence a tiny portion of our energy-using and/or GHG-emitting decisions, and even then the effect of subsidies is often blunted by “free-riders” (people receiving a subsidy for insulating their house when they were going to do this anyway) and “rebound effects” (people receiving a subsidy for insulating their house while expanding its size by say 30%, which more than offsets the efficiency savings).[5]

Policies of information and subsidies can make a contribution if they are combined with emissions pricing, but in the absence of the latter, these policies are largely ineffective. And experts agree that this is the main reason why past climate policies have failed to significantly reduce emissions.

Moreover, evidence for the ineffectiveness of non-compulsory policies comes not just from two decades of failed climate policies. Research on the information and subsidy programs that dominated the energy efficiency efforts of electric utilities in North America during the past three decades has also shown the undermining effect of free-riders and rebound effects.[6] This hindsight analysis now suggests that these non-compulsory policies were not nearly as effective as previously hoped.

Given the strength of this evidence on the failure of non-compulsory policies, and its widespread acceptance by climate policy analysts, it might be difficult to imagine why politicians might still opt for this ineffective approach. But the reason is obvious to political analysts. Policies that price GHG emissions cause rising energy prices for consumers. Consumers are also voters. Thus, while an economist or an environmentalist might express dismay and even shock that politicians would continue to promote and implement clearly ineffective policies, a skeptical political analyst or media pundit might argue that Canadian climate policies have been, from the perspective of some politicians, a “political success.” The setting of aggressive GHG targets and the reliance on ineffective information and subsidy programs have enabled politicians to speak convincingly about their deep concern for the climate while, at the same time, not causing rising energy prices for which they might be blamed at election time. If, a decade or two later, it is

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[5] These conclusions and the research literature supporting them are described in greater detail in M. Jaccard, 2006, *Designing Canada’s Low-Carb Diet: Options for Effective Climate Policy*, CD Howe Institute Benefactors Lecture.
[6] D. Loughran and J. Kulick, 2004, “Demand-Side Management and Energy Efficiency in the United States,” *The Energy Journal*, 24(1):19-43.

shown that the political promise to reduce emissions failed, that day of reckoning is likely to come long after the politician has left office.

2. The Public Interest in Independent Review of Climate Policy Promises

Climate policy is thus especially challenging in that it requires politicians to implement compulsory policies that immediately price carbon, which in turn increase fuel prices, in pursuit of a reduction in climate risk that will only materialize long after they have left office. This apparent "conflict of interest" has led some impartial observers to call for agencies and processes that provide an independent check on the climate policy promises of politicians. In Canada, this has been proposed in a recent report of the National Roundtable on the Environment and the Economy, where it says, "Use of an independent forecasting agency is preferable to provide more accurate and transparent emission forecasts for consideration by government policy makers, external analysts, and Parliamentarians and to facilitate ongoing audit and evaluation."[7] Such an entity could provide some of the functions of the Energy Information Administration (EIA) and/or the Environmental Protection Agency (EPA) in the US. Both of these agencies have policy evaluation responsibilities that are exercised independently from the legislative and executive branches of the US government. Thus, both of them provided estimates of the likely GHG reductions from bills that were recently under consideration in the US congress.[8]

Lacking an equivalent administrative arrangement in Canada, some academics and think tanks have occasionally provided independent assessments of the climate policy claims of Canadian politicians. As an academic at Simon Fraser University and a research fellow at the CD Howe Institute, I have contributed to several reviews of Canadian climate policy.[9] For these assessments, I used an energy-economy-environment model (called CIMS) that is very similar to those applied in the US by the EIA and the EPA.[10] These types of models account for free-riders, the rebound effect and other policy implementation challenges that explain why compulsory, emissions-pricing policies are so much more effective than non-compulsory policies. They can provide an independent check on the unsubstantiated, potentially biased claims by politicians or other interests about the likely effectiveness of their policy proposals.

In the last few years, some evidence is emerging that the exposure of the failed non-compulsory policies of the past, in concert with a greater public recognition that GHG emissions reduction will not be cost-free, has led to a shift in the willingness of some politicians to openly promote compulsory emissions pricing policies. In the 2008 Canadian federal election, the Liberal leader Stephan Dion campaigned, albeit unsuccessfully, for the introduction of a carbon tax. But even

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[7] National Roundtable on the Environment and the Economy, 2008, *Greenhouse Gas Emissions Forecasting: Learning from Best International Practices*, p.2.
[8] Visit their websites to see some of these reviews, notably the assessments of the Lieberman-Warner bill in 2008.
[9] See M. Jaccard and N. Rivers, 2007, *Estimating the Effect of the Canadian Government's 2006-2007 Greenhouse Gas Policies*, CD Howe Institute, 15 pages. See also M. Jaccard, N. Rivers, C. Bataille, R. Murphy, J. Nyboer and B. Sadownik, *Burning Our Money to Warm the Planet: Canada's Ineffective Efforts to Reduce Greenhouse Gas Emissions*, Toronto: CD Howe Institute, 2006
[10] CIMS is described briefly in Appendix B. For an overview of modeling approaches, see J-C. Hourcade, M. Jaccard, C. Bataille and F. Ghersi, 2006, "Hybrid Modeling, New Answers to Old Challenges: Introduction to the Special Issue of the Energy Journal," *The Energy Journal*, Special Issue, p.1-12.

his replacement as Liberal leader, Michael Ignatieff, openly acknowledges that Canada must implement an economy-wide cap on emissions with a permit trading system that, in effect, prices all GHG emissions. And Prime Minister Stephen Harper has publically made overtures to the new US administration of President Barack Obama to work together in creating a harmonized, economy-wide emissions cap and trading system in North America. This too will results in GHG emissions pricing for the fuels that heat homes and domestic water and for the fuels used in private and commercial vehicles.

3. Climate Policy Debates in British Columbia

Since early 2007, the BC government has proposed and implemented several compulsory policies that are in marked contrast to the non-compulsory policies of the past. These include a requirement that almost all electricity be from zero-emission sources and a carbon tax that prices fossil fuel-related emissions in all sectors of the economy. The government seems to have accepted the argument of the world's leading independent experts, like Stern and Nordhaus, that carbon pricing is essential if significant reductions of GHG emissions are to occur. For this reason, the climate policies of the government have placed it among the world's leading jurisdictions in terms of the policy prescriptions of climate policy experts.

To estimate the effectiveness of its climate policies, the BC government has used the CIMS model, without adjusting its parameters in any way. The estimated effect of its policies were recently reported in the government's 2008 Climate Action Plan.[11] Other governments and policy advisory bodies have begun to follow this example. In recent years, the CIMS model has been used in a similar fashion by the government of Alberta, the government of Saskatchewan, the Ontario Power Authority, Environment Canada, Natural Resources Canada, the National Roundtable on the Environment and the Economy, and several non-government organizations such as the Suzuki Foundation and the Pembina Institute.[12]

Most of the BC government's climate policies, including the carbon tax, are supported by BC's Green Party. However, the official opposition, the NDP, claim that they can achieve the same GHG emissions reduction targets as the government while eliminating the carbon tax and without replacing it with a cap and trade system for final consumers. They propose instead to provide low-interest loans and subsidies to final consumers for energy efficiency and fuel switching investments – the very policies that have proven ineffective in the past. Unfortunately, the NDP have not yet provided details on the assumptions and modeling tools they used to evaluate their proposals. This appears to be a case where once again the public interest would benefit from an independent assessment of the claims of politicians.

In this report, I provide the assumptions and results of a policy simulation exercise I conducted, using the CIMS model, to assess the likely impacts of the key NDP climate policies. These estimates are preliminary, based on information on the NDP website that provides a general description of the NDP climate policy proposals.[13] (The release of the NDP election platform on

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[11] BC Government, 2008, *Climate Action Plan*. See especially the appendix, which explains the use of CIMS.
[12] CIMS was offered freely to the NDP in 2008 for this purpose, but was not used.
[13] See www.realclimateaction.ca.

April 9 required a rerun of the model to adjust to the announcement of lower transit fares and a tax on flaring from the oil and gas industry.) If the NDP subsequently provides greater detail on its policies, then the exercise can be repeated. For this initial analysis, where I am uncertain of some details of the NDP's policy, I have made assumptions that would err in the NDP's favour, giving it credit for greater policy effectiveness than one would normally estimate for such policies.

4. Key NDP Climate Policy Proposals for BC

The NDP have claimed that they would replace some of the BC government policies with their own set of policies and yet achieve the same GHG emissions reduction targets that the government's policies are forecast to achieve by 2020 – 33% below 2007 levels.

The NDP's major critique of the BC government's climate policies has focused on the carbon tax. The NDP argue that it is unfair to charge individuals and households for the GHG emissions they cause when heating their home or driving their car – "consumers should not have to pay both at the pump and in increased prices passed on by industry."[14] Presumably, therefore, the NDP also opposes a cap and trade system that covers any fuels purchased by final consumers – retail gasoline, retail diesel, home heating oil and residential natural gas – because such a system would cause the same level of GHG emissions pricing for individuals and households as the carbon tax.

The NDP claims it would either retain the carbon tax for industry or, more likely, replace it with a cap and trade system which would cover all industrial emissions (thus including process-related emissions in cement and aluminum production as well as methane leaks from natural gas pipelines and processing facilities). The "cap-and-trade system must: … target all significant polluters, including oil and gas, big industry, aviation and shipping; …"[15]

In place of the carbon tax for final consumers, the NDP claim it would be fairer to provide subsidies to individuals and households who make energy efficiency or fuel switching investments to reduce their GHG emissions. The NDP would thus provide "A comprehensive home and small business retrofit program to encourage the replacement of old furnaces and hot water systems, and the installation of solar panels and other technologies that will conserve energy."[16] Since the NDP opposes GHG emissions pricing, this "program" will presumably comprise subsidies in the forms of grants and low-interest loans. Moreover, the NDP says its industrial cap and trade policy will force industry to purchase its permits in an auction that will provide revenue to finance the consumer-focused initiatives. It says "… a cap-and-trade scheme must: … auction carbon credits, using revenue to give people the tools to cut fuel use and energy bills, build better transit, support energy-saving retrofits and other conservation initiatives to help consumers;…"[17]

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[14] www.realclimateaction.ca.
[15] www.realclimateaction.ca
[16] www.realclimateaction.ca.
[17] www.realclimateaction.ca

A second mechanism to subsidize non-industrial emitters is provided by the NDP's recently proposed "Green Bond" policy, which would provide about $600 million per year in low-interest loans from bond holders to households, individuals and small firms for efficiency and fuel switching – with the spread between the interest payments to bond holders and the low-interest loan payments from consumers presumably covered by government subsidy. The Green Bond would also provide millions of dollars per year toward even more transit infrastructure and public transit equipment than has already been promised by the current government. I include the Green Bond and some other NDP promises of investment in transit infrastructure and equipment in the policy simulation.

5. Specific Assumptions of the NDP Policy Simulation Using the CIMS Model

In this modeling exercise, key assumptions were retained at the values that have been previously applied in other CIMS simulations of BC and indeed other jurisdictions. Thus, behavioural parameters internal to the model, engineering and economic data in the model, and the external assumptions about economic growth rates and future international oil prices were set at levels that the BC government and other jurisdictions have used when conducting similar policy simulations with the CIMS model.

Initially, I simulated the Green Bond proposal by itself in order to compare the CIMS estimates with the NDP claims for the policy's likely effect on GHG emissions. Then, I simulated the Green Bond in conjunction with the other NDP policies in order to estimate the carbon prices facing BC industry under the cap and trade approach suggested by the NDP and the incremental effect of the NDP policy on industrial output in the province. In this case, I assumed that the carbon price in the industrial emissions auction and trading system would rise to the levels necessary to achieve the NDP promise of a 33% reduction in total provincial emissions from 2007 levels by 2020 – again assuming that all revenue generated from the industry permit auction is used to subsidize energy efficiency, fuel switching and some emissions capture investments in the rest of the economy, as described on the NDP website.

Green Bond. I assumed the Green Bond would provide $600 million per year in low interest loans to retrofit residential and commercial buildings for all actions that improve the energy efficiency of space heating (building shell retrofits, installation of air and ground source heat pumps, etc.) and for some on-site fuel switching. In the CIMS model, I reduced the discount rate on high efficiency shells and heating systems by 3%.[18] I also assumed the Green Bond would include $350 million per year invested in transportation, especially buses, light rail, and Skytrain. The incremental effect of this additional expansion depends on the number of people who switch from private vehicles to transit because of these service improvements, even though the price of vehicle fuels is not increasing more than it otherwise would have (because of no GHG emissions pricing for final consumers). I assumed the Green Bond would include $2.5 million per year toward loans to convert vehicles to low emission models. However, since the policy occurs simultaneously with the current government's tightening of vehicle emission standards, the

[18] The 3% reduction in discount rate is estimated from the spread between the mortgage rates offered by the private market (~ 6% for a 5 year fixed rate mortgage from TD Canada Trust) and the yield of BC government bonds with maturity in 5 years (~ 3% according to TD Waterhouse).

incremental effect of the policy in the CIMS simulation is small. Much of the reduction over the next 11 years would have occurred anyway, so the subsidy mostly goes to free-riders, people who would have purchased lower emission vehicles because of the tightening standards. Finally, I assume that the $40 million per year in funds toward research and development will lead to almost no additional reductions in the 2020 timeframe. This is consistent with most research on the incremental effect of public sector R&D over such a short timeframe, especially in the absence of emissions pricing for final consumers.

Cap-and-trade system. I assumed the cap-and-trade system applies only to industrial emitters ("significant polluters") and that permits are auctioned without any revenue returning to industry. The revenue is used to subsidize reductions in the rest of the economy via the NDP's comprehensive program of subsidies to small businesses and consumers for energy efficiency and fuel switching. The CIMS model applies standard assumptions about the rates of free-riders and the rebound effect from energy efficiency, which in turn determine the subsidy level per unit of CO2 reduction and the level to which industrial permit prices must rise (in the annual auction) in order to achieve the 33% reduction by 2020.

Other regulatory policies. I assumed the NDP keep all other regulatory policies that the government is currently pursuing, including zero-emission electricity, low carbon fuel standard, California-level vehicle emission standards, and tightening efficiency standards for equipment, appliances and commercial and residential buildings. To give the NDP the benefit of the doubt, I further assume little overlap between the new NDP policies and the existing government's policies (i.e., the NDP's policies will lead to additional reductions in GHG emissions).

6. Results of the NDP Policy Simulation Using the CIMS Model

Green Bond

The CIMS simulation indicates that the NDP have substantially overestimated the effectiveness of their Green Bond proposal. The NDP claim that it will reduce 1 megatonne (Mt) of emissions per year (10 Mt over 10 years), but the estimate from the CIMS simulation is much lower, at 0.15 Mt per year. The policy is likely to be less effective than claimed especially because the NDP's estimate does not appear to have accounted for free-riders and for the lengthy evidence showing that it is not lack of financing that has hindered energy efficiency and fuel switching investments. It is that most of these investments are not profitable from a personal or business perspective, especially when consumers do not expect a rising price for GHG emissions.

NDP Climate Policy Package

The NDP has promised that its policies would reduce GHG emissions in 2020 by 33% from their 2007 levels – identical to the reductions for which the current government has established its policies. This is a very significant reduction because it is comparable to a 50% reduction from where emissions would have otherwise climbed to by the year 2020. Yet, the NDP intends to achieve this major reduction by applying emissions pricing only to the industrial side of the economy, while using rather ineffective information and subsidy programs to reduce the emissions from non-industrials. When free-riders and rebound effects in the subsidized, non-industrial sectors are accounted for – as they are in CIMS – the results show that the cap on industrial emissions must be tightened dramatically in a very short period of time if the provincial economy as a whole is to reach the aggregate reduction target for 2020. Accordingly, the auction prices for industry emission permits must rise to very high levels to fund rather ineffective subsidy programs for energy efficiency and fuel switching. Since the CIMS model includes macro-economic feedbacks, this simulation of the NDP policy package also estimates the reduction in output from BC industrial emitters as their costs of production rise in step with the rising auction price for GHG emissions. This reduction in output is due to loss of domestic sales but especially from a loss of exports.

The following table shows what happens to the permit auction price for industrial emitters and the subsidy per unit of emission reduction under the NDP policy package. The auction permit price rises dramatically to $368 per tonne of CO2 by 2020. The revenue from these permits is used to subsidize energy efficiency and fuel switching by non-industrial emitters throughout the province. Given the magnitude of revenue available, this money is provided at subsidy levels that start at $18 per tonne of CO2 in 2010 and rise to $110 by 2020. Although free-ridership as high as 80% may be likely with subsidies of this magnitude, I capped the maximum possible level of free-riders in the CIMS simulation at 50%. Again, this means that the results err in favour of the NDP's claims.

Emission Permit Price for Industrials and Per Unit Subsidy for Non-Industrials

	2010	*2011-2015*	*2016-2020*
Emissions Permit Price (2005$ / tonne CO_2e)	$41	$164	$368
Unit Subsidy Level (2005$ / tonne CO_2e)	$18	$73	$110

Under the NDP policy proposal, BC's industrial emitters face full emissions pricing and the revenues generated from this pricing are used to finance rather ineffective emissions reductions (because of free-rider and rebound and no emission pricing) by non-industrial emitters. This means, that to achieve the same target for GHG emissions reduction as an economy-wide pricing policy, the reductions of emissions from industry must be especially large. Some of these reductions will come from in-house energy efficiency, fuel switching and other actions by industry, but a large portion will come from industry shutting down or reducing its operations because of the dramatic increase in production costs caused by high GHG pricing. The next table shows the estimates from the CIMS simulations of output reductions from the levels that were otherwise forecast for 2020. BAU means the business-as-usual forecast of industry physical output in the year 2020 without the NDP policies.[19] The table also shows the communities most impacted by the resulting job losses as industry reduces operations and closes plants.

[19] Output is measured in physical units, such as tonnes of market pulp or cubic metres of natural gas.

Reduction in Sectoral Output Under the NDP Policy

	Reductions from BAU		*Impacted Communities*
	2015	*2020*	
Chemical Products	6%	6%	
Industrial Minerals	63%	97%	Delta, Richmond and Kamloops
Metal Smelting	12%	14%	Kitimat and Trail
Mineral Mining	8%	14%	
Paper Manufacturing	18%	19%	Many facilities (e.g., Nanaimo, Prince George, Kamloops, Powell River, Port Alberni, etc)
Petroleum Refining	55%	94%	Prince George and Burnaby
Natural Gas Extraction	18%	25%	Northeastern BC (Fort St. John)
Coal Mining	11%	13%	Sparwood and Elkford

Note: industrial minerals includes cement and lime manufacturing; metal smelting includes aluminum, lead and zinc smelting, mineral mining includes the mining of lead, zinc, etc.

The closure of industrial facilities and the reductions in industrial output will have adverse effects on employment in BC. The closure of industrial facilities will cause job losses directly (i.e., lay-offs from the facility) and indirectly, as there will be less demand for businesses selling goods and services in the impacted communities. For example, if people are laid off from a pulp mill in Prince George, they either have less income to spend in the community or move to another town. As a result, businesses selling groceries or electronics in Prince George will receive less revenue, and will be forced to lay-off workers at their stores.

To estimate total job losses from the NDP's climate plan, I built simplified input-output model for BC using data from Statistics Canada and BC Stats.[20] Input-output analysis is typically used to estimate impacts on employment, because it can estimate both direct and indirect impacts from shocks to the economy. The reduction in industrial output, as shown in the table above, would likely cause over 60,000 job losses, with 31,000 direct losses. These losses would be avoided with a more comprehensive GHG pricing policy.

7. Conclusion

This report presents a preliminary estimate of the implications of the NDP's alternative policy approach to reducing BC's GHG emissions, in particular its claim that emissions reductions can occur without recourse to emissions pricing (via tax or cap-and-trade) for non-industrial emitters. The simulation is crude because it lacks fine details of the NDP's proposed policies. If the NDP makes these available, the simulation exercise can be updated.

The simulation results indicate that if BC were to try to reach its aggressive GHG emissions reduction target without emissions pricing for non-industrial emitters, relying instead on industry

[20] Statistics Canada, 2009, "Input Output tables"; BC Stats, 2009, "Employment by Industry", http://www.bcstats.gov.bc.ca/.

and government funds to subsidize relatively ineffective energy efficiency and fuel switching by non-industrial emitters, the outcome is likely to be a dramatic reduction in BC industrial production. This would have significant negative repercussions for employment levels, especially in some key BC communities that are dependent on one or two specific large industrial GHG emitters. The loss of jobs will be substantial.

Appendix A – Abridged CV of Mark Jaccard

Bachelors of Arts, Simon Fraser University, 1978.
Masters of Resource Management, Simon Fraser University, 1984.
Doctorate of Energy Economics, Institute of Energy Economics and Policy, University of Grenoble (now called Universite Pierre Mendez-France), 1987.
Professor, School of Resource and Environmental Management, Simon Fraser University, 1986 – present.
Panel Member, Blue Ribbon Panel of the Royal Society of Canada on Canadian Options for Greenhouse Gas Emission Reductions, 1992.
Chair and CEO, BC Utilities Commission, 1992-1997.
Chair, BC Utilities Commission Electricity Market Review, 1995.
Chair, BC Public Inquiry on Gasoline Pricing, 1996.
Chair, BC Task Force on Electricity Market Reform, 1997-1998.
Lead Author, Intergovernmental Panel on Climate Change, Second Assessment Report, 1993-1996.
International Member, Energy Technologies and Strategies Working Group, China Council for International Cooperation on Environment and Development, 1996-2002.
Editorial Board Member, The Energy Journal, 1997 – present.
Editorial Board Member, Energy Studies Review, 2001 – 2006.
Top Policy Book in Canada awarded by the National Policy Research Institute for The Cost of Climate Policy (University of BC Press, 2002).
Editorial Board Member, International Journal of Energy Sector Management, 2006 – present.
Top Policy Book in Canada awarded by the Donner Foundation for Sustainable Fossil Fuels (Cambridge University Press, 2006).
Panel Member, National Roundtable on the Environment and the Economy, 2006 – present.
Simon Fraser University Outstanding Alumni Award, 2007
Nobel Peace Prize, awarded in 2007 as a contributing author to the Intergovernmental Panel on Climate Change.
British Columbia 2008 Academic of the Year, awarded by the Confederation of University Faculty Associations of BC.
Convening Lead Author for Policy, Global Energy Assessment, 2007 – present.
Special Advisor, BC Climate Action Team, 2008.
Co-Chair, Task Force on Clean Use of Coal in China, China Council for International Cooperation on Environment and Development, 2008 – present.
Lead Author for Policy, Intergovernmental Panel on Climate Change, Special Report on Renewables, 2008 – present.

Publications: Over 90 publications in peer-reviewed academic journals.

Appendix B – Synopsis of the CIMS Model

Introduction to the CIMS model

CIMS has a detailed representation of technologies that produce goods and services throughout the economy and attempts to simulate capital stock turnover and choice between these technologies realistically. It also includes a representation of equilibrium feedbacks, such that supply and demand for energy intensive goods and services adjusts to reflect policy.

CIMS simulations reflect the energy, economic and physical output, greenhouse gas emissions, and criteria air contaminant (CAC) emissions from its sub-models. CIMS does not include solvent, or hydrofluorocarbon (HFC) emissions. CIMS covers nearly all CAC emissions in Canada except those from open sources (like forest fires, soils, and dust from roads).

Model structure and simulation of capital stock turnover

As a technology vintage model, CIMS tracks the evolution of capital stocks over time through retirements, retrofits, and new purchases, in which consumers and businesses make sequential acquisitions with limited degree of foresight about the future. This is particularly important for understanding the implications of alternative time paths for emissions reductions. The model calculates energy costs (and emissions) for each energy service in the economy, such as heated commercial floor space or person kilometres travelled. In each time period, capital stocks are retired according to an age-dependent function (although retrofit of un-retired stocks is possible if warranted by changing economic conditions), and demand for new stocks grows or declines depending on the initial exogenous forecast of economic output, and then the subsequent interplay of energy supply-demand with the macroeconomic module. A model simulation iterates between energy supply-demand and the macroeconomic module until energy price changes fall below a threshold value, and repeats this convergence procedure in each subsequent five-year period of a complete run.

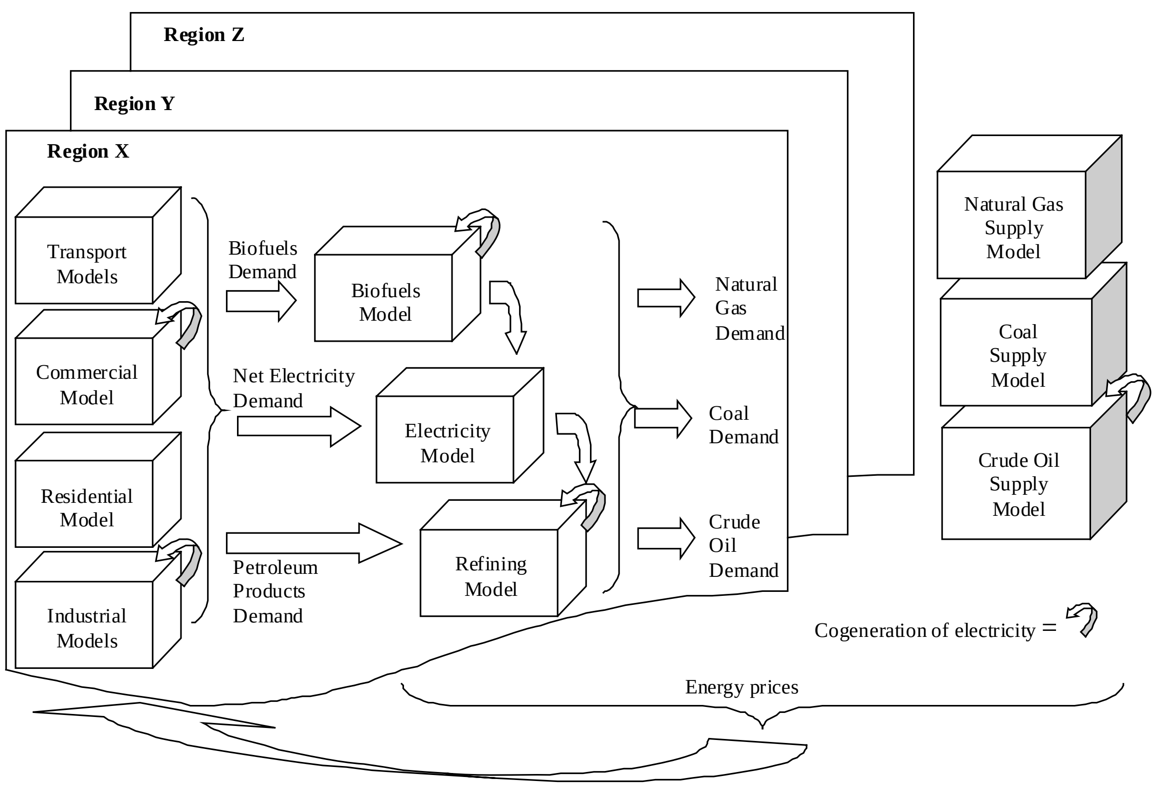
CIMS simulates the competition of technologies at each energy service node in the economy based on a comparison of their life cycle cost (LCC) and some technology-specific controls, such as a maximum market share limit in the cases where a technology is constrained by physical, technical or regulatory means from capturing all of a market. Instead of basing its simulation of technology choices only on financial costs and social discount rates, CIMS applies a definition of LCC that differs from that of conventional engineering-based analysis (called “bottom-up”) by including intangible costs that reflect consumer and business preferences and the implicit discount rates revealed by real-world technology acquisition behaviour.

Equilibrium feedbacks in CIMS

CIMS is an integrated, energy-economy equilibrium model that simulates the interaction of energy supply-demand and the macroeconomic performance of key sectors of the economy, including trade effects. Unlike most computable general equilibrium models, however, the current version of CIMS does not equilibrate government budgets and the markets for employment and investment. Also, its representation of the economy’s inputs and outputs is skewed toward energy supply, energy intensive industries, and key energy end-uses in the residential, commercial/institutional and transportation sectors.

CIMS estimates the effect of a policy by comparing a business-as-usual forecast to one where the policy is added to the simulation. The model solves for the policy effect in two phases in each run period. In the first phase, an energy policy (e.g., ranging from an emissions price to a technology specific constraint or subsidy, or some combination thereof) is first applied to the final goods and services production side of the economy, where goods and services producers and consumers choose capital stocks based on CIMS' technological choice functions. Based on this initial run, the model then calculates the demand for electricity, refined petroleum products and primary energy commodities, and calculates their cost of production. If the price of any of these commodities has changed by a threshold amount from the business-as-usual case, then supply and demand are considered to be out of equilibrium, and the model is re-run based on prices calculated from the new costs of production. The model will repeat this procedure until a new equilibrium set of energy prices and demands is reached. The figure provides a schematic of this process. For this project, while the quantities produced of all energy commodities were set endogenously using demand and supply balancing, endogenous pricing was used only for electricity and refined petroleum products; natural gas, crude oil and coal prices remained at exogenously forecast levels since Canada is assumed to be a price-taker for these fuels.

CIMS Energy Supply and Demand Integration



In the second phase, once a new set of energy prices and demands under policy has been found, the model measures how the cost of producing traded goods and services has changed given the new energy prices and other effects of the policy. For internationally traded goods, such as lumber and passenger vehicles, CIMS adjusts demand using price elasticities that provide a long-run demand response that blends domestic and international demand for these goods (the "Armington" specification).[21] Freight transportation is driven by changes in the combined value added of the industrial sectors, while personal transportation is adjusted using a personal kilometres-travelled elasticity (-0.02). Residential and commercial floor space is adjusted by a sequential substitution of home energy consumption versus other goods (0.5), consumption versus savings (1.29) and goods versus leisure (0.82). If demand for any good or service has shifted more than a threshold amount, supply and demand are considered to be out of balance and the model iterates using these new demands. The model continues iterating until both energy and goods and services supply and demand come into balance, and repeats this balancing procedure in each subsequent five-year period of a complete run.

Empirical basis of parameter values

Technical and market literature provide the conventional engineering and economic data on the costs and energy efficiency of new technologies. Because there are few detailed surveys of the annual energy consumption of the individual capital stocks tracked by the model (especially smaller units), these must be estimated from surveys at different levels of technological detail and by calibrating the model's simulated energy consumption to real-world aggregate data for a base year.

Fuel-based greenhouse gas emissions are calculated directly from CIMS' estimates of fuel consumption and the greenhouse gas coefficient of the fuel type. Process-based greenhouse gas emissions are estimated based on technological performance or chemical stoichiometric proportions. CIMS tracks various types of greenhouse gas emissions and reports these in terms of carbon dioxide equivalents.[22]

Both process-based and fuel-based CAC emissions are estimated in CIMS. Emissions factors come from the US Environmental Protection Agency's FIRE 6.23 and AP-42 databases, the MOBIL 6 database, calculations based on Canada's National Pollutant Release Inventory, emissions data from Transport Canada, and the California Air Resources Board.

Estimation of behavioural parameters is through a combination of literature review, judgment, and meta-analysis, supplemented with the use of discrete choice surveys for estimating models whose parameters can be transposed into behavioural parameters in CIMS.[23]

Simulating endogenous technological change with CIMS

CIMS includes two functions for simulating endogenous change in individual technologies' characteristics in response to policy: a declining capital cost function and a declining intangible cost function. The declining capital cost function links a technology's financial cost in future periods to its cumulative production, reflecting economies-of-learning and scale (e.g., the observed decline in the cost of wind turbines as their global cumulative production has risen). The declining capital cost function is composed of two additive components: one that captures

[21] CIMS' Armington elasticities are econometrically estimated from 1960-1990 data. If price changes fall outside of these historic ranges, the elasticities may be less reliable.
[22] CIMS uses the 100-year global warming potential estimates from Intergovernmental Panel on Climate Change, 2001, "Climate Change 2001: The Scientific Basis," Cambridge, UK, Cambridge University Press.
[23] For empirical methods of behavioural parameter estimation, see N. Rivers and M. Jaccard, 2006, "Useful models for simulating policies to induce technological change," *Energy Policy*, 34:2038-2047.

Canadian cumulative production and one that captures global cumulative production. The declining intangible cost function links the intangible costs of a technology in a given period with its market share in the previous period, reflecting improved availability of information and decreased perceptions of risk as new technologies become increasingly integrated into the wider economy (e.g., the "neighbour effect" in markets for new technologies); if a popular and well respected community member adopts a new technology, the rest of the community becomes more likely to adopt the technology.