British Columbia's Carbon Tax: By The Numbers

A Carbon Tax Center report

By

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December, 2015

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The **Carbon Tax Center** was founded in 2007 to support enactment of a U.S. carbon pollution tax at the earliest possible date, in the most transparent and equitable form possible, rising briskly enough to eliminate 80% or more of U.S. emissions of carbon dioxide from fossil fuel combustion by 2050.

CTC works to educate and mobilize advocates, stakeholders, public officials and other concerned citizens on the need for, benefits from and mechanics of such a tax. Fundamental to these activities is CTC's web site (www.carbontax.org), which distills and links to authoritative sources on the theory and practice of carbon taxing and to reports on politics, progress and obstacles to enacting carbon taxes worldwide, particularly in the U.S.

CTC maintains and disseminates a carbon tax model (Excel file) — a non-proprietary and uniquely accessible spreadsheet for gauging how effectively carbon tax proposals will reduce carbon emissions and generate revenues.

Through our web site, blog posts, papers, economic modeling and networking, CTC informs and tutors citizens and public officials to help them advocate for taxes on carbon pollution at both the federal and state levels.

This report was written by CTC director **Charles Komanoff** and CTC consultant **Mathew Gordon.**

Komanoff's work encompasses economic analysis, writing, organizing, direct action and mathematical modeling. His early career as an environmental economist included pioneering work documenting and interpreting cost escalation in the U.S. nuclear power industry. Komanoff later rejuvenated urban bicycle activism as president of the NYC-based advocacy organization Transportation Alternatives and as co-founder of the safer-streets group Right of Way. He also helped found, and performs economic modeling for, the Move New York campaign to reform traffic tolling in NYC. Komanoff co-founded the Carbon Tax Center in 2007.

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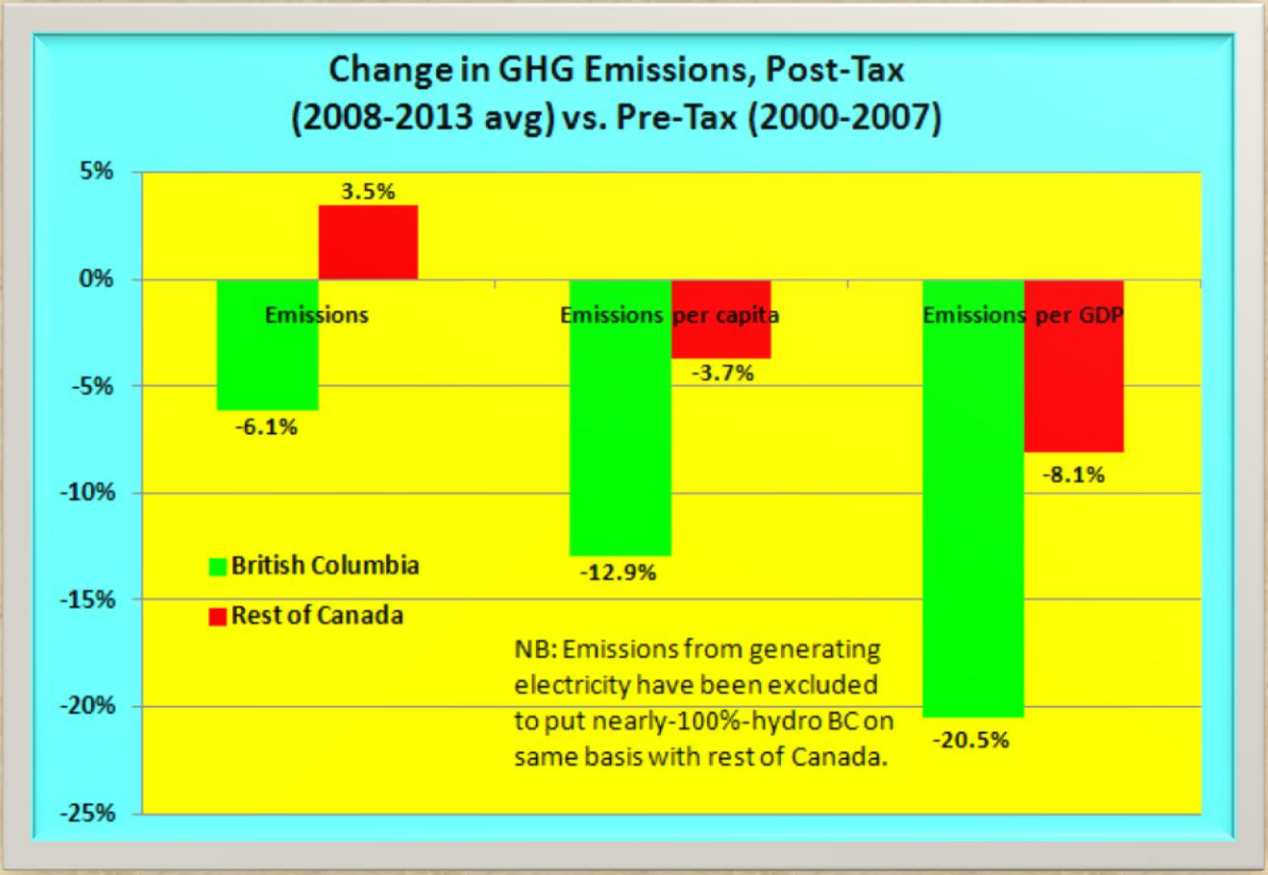
CTC gratefully acknowledges the intellectual contributions to this report from Kyle Aben, the climate change and energy policy analyst at the David Suzuki Foundation in Vancouver, British Columbia. The report also benefited greatly from suggestions from climate activists Eoin Madden and Rachael Sotos and CTC senior policy analyst James Handley.

Executive Summary and Key Findings

British Columbia introduced a carbon tax in 2008. Since then, per capita emissions of carbon dioxide and other greenhouse gases covered by the tax have declined, continuing a downward trend that began in 2004. Averaged across the period with the tax (2008 through 2013; no data are available for 2014), province-wide per capita emissions from fossil fuel combustion covered by the tax were nearly 13 per-cent below the average in the pre-tax period under examination (2000-2007).

The 12.9% decrease in British Columbia's per capita emissions in 2008-2013 compared to 2000-2007 was three-and-a-half times as pronounced as the 3.7% per capita decline for the rest of Canada. This suggests that the carbon tax caused emissions in the province to be appreciably less than they would have been, without the carbon tax.

Figure 1



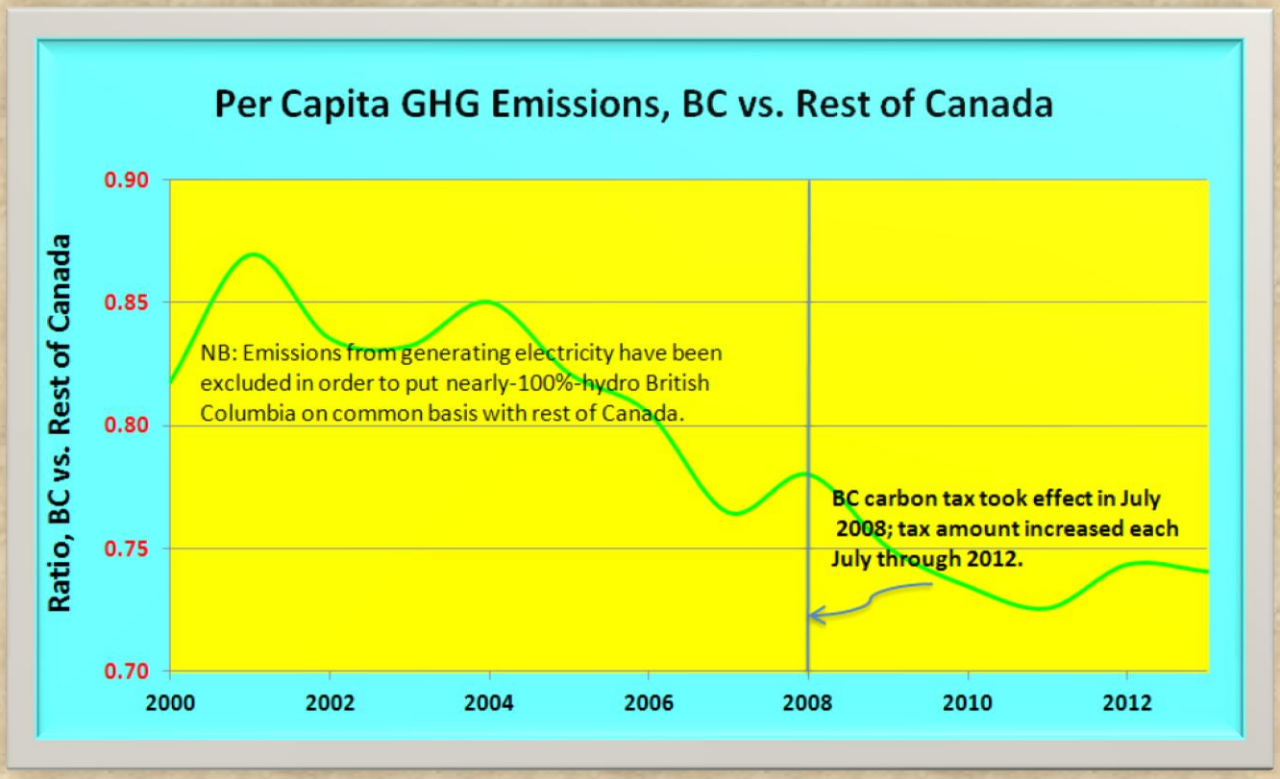
To allow comparability, the above figures are per capita. They also exclude emissions from electricity production — a minor emissions category for British Columbia, which draws most of its electricity from abundant (and zero-carbon) hydro-electricity, but a major emissions source for much of Canada. On a total emissions basis (not per capita), British Columbia emissions of CO2 and other GHGs covered by the

carbon tax but excluding the electricity sector averaged 6.1% less in 2008-2013 than in 2000-2007. (The reduction was 6.7% when electricity emissions are counted.) The 6.1% contraction is roughly what would be expected from a small carbon tax such as British Columbia's. (See sidebar on page 5.)

The carbon tax does not appear to have impeded overall economic activity in British Columbia. Although GDP in British Columbia grew more slowly during 2008-2013, the period with the carbon tax, than in 2000-2007, the same was true for the rest of Canada. From 2008 to 2013, GDP growth in British Columbia slightly outpaced growth in the rest of the country, with a compound annual average of 1.55% per year in British Columbia, vs. 1.48% outside of the province.

GHG emissions increased in British Columbia in 2012 and again in 2013, not just in absolute terms but also per capita. This suggests that the carbon tax needs to resume its annual increments (the last increase was in 2012; its bite has since been eroded by inflation) if emissions are to begin again their downward track.

Figure 2



Introduction

British Columbia, Canada's third-most populous province, began taxing carbon dioxide and other greenhouse-gas emissions from combustion of fossil fuels nearly seven and a half years ago, pursuant to the province's Carbon Tax Act.[1] The province-wide tax commenced on July 1, 2008 at a level of $10 (Canadian) per metric ton ("tonne") of CO2 and increased by $5 per tonne in each of the next four years, reaching its current level, $30/tonne, in July 2012.[2]

It is both the most comprehensive and transparent carbon tax in the Western Hemisphere, if not the world.[3] A recent assessment by two leading environmental economists stated that "British Columbia has given the world perhaps the closest example of an economist's textbook prescription for the use of a carbon tax to reduce [greenhouse gas] emissions."[4]

Moreover, the BC tax is gaining adherents. On the eve of the Paris climate summit, in November 2015, Alberta Premier Rachel Notley committed to a similar carbon tax. Alberta's tax will begin in 2017 at $20 per metric ton and rise in 2018 to $30, matching the current level in British Columbia.[5] Although Canada's two most populous provinces, Ontario and Quebec, are moving toward carbon cap-and-trade systems, the new Trudeau administration in Ottawa could choose to fashion a national carbon tax from British Columbia's, with the possibility of higher tax levels to evoke larger emission reductions.

In this report we quantify the reductions in British Columbia's emission since its tax began. We also provide context and interpretation.

Caveats

Evaluating the emissions impact of British Columbia's carbon tax is more complicated than might be expected, for several reasons.

First, the tax level is modest, as can be seen by considering its effect on the price of gasoline. The final carbon-tax rate reached in July 2012 equates to a mere 20 cents (U.S.) per gallon. Averaged from mid-2012 to the present, this tax increment amounts to less than 6 percent of the pre-tax British Columbia retail gasoline price; the percentage add-on was even less in prior years, when the tax level was lower.

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[1] Carbon Tax Act [SBC 2008] Chapter 40, http://www.bclaws.ca/Recon/document/ID/freeside/00_08040_01#section12.

[2] The Canadian dollar was roughly equal to the U.S. dollar in 2008 but has since fallen to 75¢ at this writing (Nov. 15, 2015). A metric ton is roughly 10 percent greater than a U.S. (short) ton. Combining, the current British Columbia carbon tax of $30 (Canadian) per tonne equated to $20.40 (U.S.) per ton in mid-November 2015.

[3] Sweden and several other countries tax some carbon emissions at higher rates, whereas BC's carbon tax applies to essentially all emissions from fossil fuel combustion, and at a uniform rate.

[4] Brian C. Murray and Nicholas Rivers, "British Columbia's Revenue-Neutral Carbon Tax: A Review of the Latest 'Grand Experiment' in Environmental Policy." NI WP 15-04. Durham, NC: Duke University, May 2015. https://nicholasinstitute.duke.edu/sites/default/files/publications/ni_wp_15-04_full.pdf. See p. 17.

[5] National Observer, "Rachel Notley Announces Alberta's Climate Change Plan," Nov. 22, 2015, http://www.nationalobserver.com/2015/11/22/news/rachel-notley-announces-albertas-climate-change-plan.

CTC's Model and BC's Carbon Tax

The Carbon Tax Center's seven-sector model estimates the impacts of different-level carbon taxes on U.S. CO2 emissions, along with revenue generation. It factors changes in GDP, energy prices and taxes on carbon fuels through sector-specific income-elasticities and price-elasticities that reflect the rates at which changes in income and price affect usage. Supply-side elasticities capture the substitutability of lower-carbon fuels.

We ran the model with a future carbon tax trajectory intended to simulate British Columbia's tax. The tax starts in 2016 at $3.75 per metric ton of CO2 and rises stepwise to plateau at $22.50 ($20.40 per short ton) in 2021, reflecting today's 0.75-to-1.0 Canada/U.S. exchange rate. We excluded electricity sector emissions.

This trajectory yields a 5.6% reduction in U.S. CO2 emissions relative to what 2021 emissions would be without a carbon tax. This projection approximates the actual 6.1% drop in British Columbia non-electricity emissions covered by the tax in 2008-2013 vs. 2000-2007.

U.S. energy supply and demand differ from British Columbia's, of course, and the CTC model results are only projections. Nevertheless, the close match suggests that the BC tax has performed as expected, with, perhaps, a modest boost from "tax salience" (see discussion in main text on this page).

Price increases for other fuels subject to the carbon tax are also small. This suggests the possibility that the BC carbon tax has reduced emissions by changing business and household psychology as well as through the direct influence of price. ("Tax salience" is economists' term for the hypothesis that "tax-induced price changes generate distinct demand responses when compared with equivalent market-determined price movements."[6])

Second, very little fossil fuel combustion in British Columbia is for generating electricity. In 2007, the last full year prior to the onset of the carbon tax, less than 3 percent of province-wide carbon emissions from fossil fuel combustion were from electricity generation — vs. 32 percent for the rest of Canada and an even higher percentage in the United States. This difference is significant because compared to other sectors, electricity generation is highly responsive to carbon-tax price signals, owing largely to the relative ease of substituting lower-carbon for higher-carbon power sources. Ironically, then, if British Columbia had been generating a larger fraction of its electricity from fossil fuels, the observed impact of the tax would almost certainly have been greater.

These caveats point to limits on the emissions-reducing potential of British Columbia's carbon tax. The spreadsheet model developed and maintained by CTC to estimate the future effect of different carbon tax levels and trajectories in the United States suggests why. According to our model,[7] a U.S. carbon tax that covered only non-electric sources and rose annually before plateauing at $20.40 per short ton of CO2 (the U.S. non-metric equivalent of the current BC rate of $30/tonne) would reduce those emissions by under 6 percent (see sidebar). This suggests that it's unrealistic to look to BC's carbon tax for rousing emission reductions. The modest tax level also impedes definitive analysis of the tax's impact, since single-digit changes are inherently hard to account for.

A final caveat concerns the confounding effects of the 2008 financial collapse. During 2009, the first full year with the BC carbon tax,

[6] The quoted passage is from Nicholas Rivers and Brandon Schaufele, "Salience of Carbon Taxes in the Gasoline Market," Oct. 22, 2014, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2131468. For a broader discussion, see Yoram Bauman, "Carbon Taxes Are Even Better than You Think (Part I: Transportation)," Jan. 22, 2015, available at http://carbonwa.org/carbon-taxes-even-better-think-part-transportation/.

[7] CTC's carbon tax spreadsheet model is available as a downloadable Excel file.

the province's economy, like that of the United States, shrank by 3 percent. Notwithstanding the subsequent recovery, the disruptions emanating from such a contraction invariably add to statistical noise in the analysis.

A Political Success

From a political standpoint, the tax has been a solid success. The BC Liberal Party government that devised and imposed the tax won a rare third consecutive term the next year. Opinion polling indicates that the share of residents disliking the tax has shrunk over time.[8] This mirrors the standard pattern for "Pigouvian" taxes that "internalize" the social or environmental costs of a process or commodity into its price: initial grumblings give way to broad acceptance.[9]

Much of the favorable reception has likely been due to the handling of the tax revenues: the proceeds are funding more than a billion dollars annually of cuts in British Columbia's individual and business taxes, while a tax credit funnels additional aid to low-income households. Both provisions are politically popular. It also matters that province officials kept their two key promises: that the tax would rise stepwise and predictably for precisely four years; and that it would be revenue-neutral, which has defused concerns that the tax would be a means to finance government expansion.[10]

What About BC Emissions?

The point of the tax is to reduce emissions of carbon dioxide and other greenhouse gases. It is therefore surprising that very little detailed quantitative analysis of the tax's efficacy in reducing emissions has appeared to date. Answers haven't been readily available to fundamental questions such as: Have British Columbia emissions of carbon dioxide and other greenhouse gas actually fallen? If they have, by how much? How have the reductions in BC emissions stacked up against the rest of Canada, which does not tax carbon emissions (save for modest taxes in Alberta and Quebec)? How does the recent trajectory of British Columbia emissions compare to that prior to the onset of the tax? Which sectors have shown the biggest, or the smallest, declines?

The Carbon Tax Center searched for answers to these questions during 2015. Not finding definitive data, we set out to develop our own. The result is this report.

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[8] Environics Institute and David Suzuki Foundation, Focus Canada 2014: Canadian public opinion about climate change, 2014. See table on p. 7, "Support for Carbon Tax in B.C." While the Suzuki Foundation is an outspoken supporter of the British Columbia carbon tax, the constancy of the wording of the poll over time makes the poll an unbiased indicator of changes in opinion.

[9] See also Murray and Rivers, op. cit., pp 14-17, for appraisal of BC public acceptance. Note that a similar pattern has been observed for congestion charging, most notably in London and Stockholm.

[10] Opinion polling by the Pembina Institute suggests, however, that BC residents may not support raising the carbon tax if the additional revenues are allocated to further reduce business taxes. See Matt Horne, Kevin Sauvé and Tom Pedersen, British Columbians' perspectives on global warming and the carbon tax, Oct. 2012, at p. 5.

Prior Analyses and Available Data

The most widely read and cited analyses of the British Columbia carbon tax are the Nicholas Institute (Duke University) working paper by Murray and Rivers referenced (and footnoted) above, and articles and brief reports by University of Ottawa law and economics professor Stewart Elgie.

Elgie is an eloquent champion of the BC tax,[11] and his published finding[12] that sales of petroleum products subject to the tax fell by nearly 19 percent per capita compared to the rest of Canada has garnered considerable attention. (Other articles by Elgie have put the decline slightly lower but at a still impressive 16 percent.) Unfortunately, it has been difficult to verify his results, owing to a lack of specificity and detail in presentation. Moreover, petroleum products are only one component, albeit a major one, of fossil fuel usage in British Columbia, rendering those results incomplete.

The Murray and Rivers paper summarized other analyses rather than presenting its own. Except for Elgie's work, which the paper cites, those analyses employed economic modeling to estimate what emissions would have been absent the tax. The resulting figures of avoided emissions are necessarily inferential. While the Murray and Rivers paper is notable for its clarity — indeed, it's an essential read on this subject — it doesn't spell out actual and relative rates of change in British Columbia emissions before and since the carbon tax began.

Fortunately, Environment Canada, the national environment ministry, reports annual emissions of carbon dioxide and other greenhouse gases for individual provinces as well as the country as a whole back to 1990. (Unfortunately, the data now appear only every two years, and 2014 figures won't appear until 2016 — a severe limitation.) These are presented in detailed and consistent tables that classify emissions into several dozen sources — "heavy-duty diesel vehicles," "railways," "manufacturing industries," and "residential," to name some.[13] The national government also tracks population and economic output (Gross Domestic Product) annually, both nationally and by province. This makes it possible to compare British Columbia to the rest of Canada, not just in "raw" emissions of CO2 and other greenhouse gases, but also as emissions normalized for population and economic activity, and to do so both prior and subsequent to the onset of the BC carbon tax.

Methodology

Our quantifications follow these guidelines:

1. Emission figures in official Canada statistics and, hence, in this report as well, aggregate emissions of CO2, CH4 (methane) and N2O (nitrous oxide), with quantities of the latter two gases converted

[11] See especially the Yale 360 interview, "How British Columbia Gained By Putting a Price on Carbon," April 30, 2015. http://e360.yale.edu/feature/how_british_columbia_gained_by_putting_a_price_on_carbon/2870/.

[12] Elgie, Stewart, and Jessica McClay. 2013. "BC's Carbon Tax Shift Is Working Well after Four Years (Attention Ottawa)." *Canadian Public Policy* 39(2):1–10.

[13] The portal to these data is https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=1357A041-1. The Canada and British Columbia emissions spreadsheet noted on the Contents page has instructions for navigating it.

to CO2 equivalents per their respective "global warming potentials."[14] Methane and nitrous oxide are included in the greenhouse gas (GHG) totals because they too are heat-trapping gases that exacerbate global warming, and because British Columbia's Carbon Tax Act includes charges on their emissions as well as emissions of carbon dioxide. In any case, CO2 quantities dominate the totals, accounting for 94 percent of reported GHGs from stationary combustion sources and 96 percent from transport (and, hence, 95 percent overall, excluding fugitive emissions).

2. Emissions are compared over time between a pre-tax period spanning eight years, 2000-2007, and a "with-tax" period covering six years, 2008-2013. (The year 2000 is a natural starting point for the first period, while 2013, the most recent year with available data, must close the second.) We have chosen to compare annual averages for these entire periods, rather than simply taking the end points, both to encompass more data and also to avoid inadvertently biasing the analysis by having single years stand in for entire periods.

3. As noted, emissions may be expressed in per capita terms, per unit of GDP, and in raw (absolute) terms. While we report all three metrics here, we regard the first (per capita) as the most indicative of progress in reducing emissions and employ it as our "default" metric.

4. British Columbia is compared to "Canada less BC," rather than to Canada including the province.

5. Emissions calculations in this report draw on two "super-categories" in the Canadian accounts. One is Transport, which subsumes a dozen categories such as road transport, domestic aviation, railways, and so forth. The other is Stationary Combustion Sources, with eight categories including buildings and manufacturing. The combination of the two categories effectively covers all fossil-fuel combustion, which is the focus of BC's carbon tax.

6. Please note this caveat to the preceding point about Stationary Combustion Sources: The key findings in this report are calculated without emissions in one stationary combustion category: Public Electricity and Heat Production. This category, which is essentially electricity generation from burning fossil fuels, accounted for just 2 percent of total emissions from fossil-fuel combustion in British Columbia in 2013, but for nearly 20 percent — almost an order of magnitude more — in the rest of Canada. More importantly, that sector constitutes most of the "low-hanging fruit" for reducing carbon emissions, since electricity generation affords more opportunities for quickly and easily substituting low-carbon supply than any other major sector.[15] Eliminating this category lets

[14] The British Columbia Greenhouse Gas Inventory Report 2012 (BC Ministry of Environment) specifies a 100-year Global Warming Potential (GWP) of 25 for methane and 298 for nitrous oxide (Table 1), relative to the heat-trapping impact of carbon dioxide, for the same weight of gas. These factors, which are sourced to the IPCC Fourth Assessment Report (2007), are applied to the BC and Canada data in the downloadable BC-Canada data spreadsheet [Excel file] that underlies this report. A note to that table indicates that these factors will be revised in future Canadian data, based on new UNFCCC reporting guidelines approved at the COP 17.

[15] In the United States, from 2005 to 2014 electricity-sector emissions of carbon dioxide declined 2.5 times as fast as other sectors' emissions. (This calculation uses historical data compiled in CTC's carbon-tax spreadsheet model; the respective percentage drops were 15.5% for electricity and 6.0% for the other sectors.)

us compare changes in emissions over time — the heart of our analysis — on an equal basis between BC and the rest of Canada.

7. Our calculations exclude fuel for international air travel and international shipping. Both categories are excluded from the scope of the first period of the Kyoto Protocol, and this convention has tended to carry over to national and subnational carbon and greenhouse gas taxing and permitting schemes.

8. Our calculations also exclude fugitive emissions from coal mining and oil and gas extraction and processing, even though the Canadian accounts treat these as part of "Energy." We exclude as well non-energy categories that are not covered by the BC tax. These include "Mineral Products," "Chemical Industry" and "Metal Production"; also Agriculture, Waste, and "Land Use Changes" such as forestation and deforestation.

Data Conventions

All figures in the section directly below follow these conventions:

- All figures are greenhouse gas emissions (GHGs) covered by British Columbia's Carbon Tax Act. (See point #1 in preceding section, Methodology.)
- All figures are emissions from fossil fuel combustion, except that emissions from generating electricity and international travel are omitted. (See points #6 and #7 in preceding section.)
- "With-tax" emissions are annual averages for 2008 through 2013. Pre-tax emissions are annual averages for 2000 through 2007.
- All figures are per capita, unless noted.
- Emissions for "Canada" are for Canada without British Columbia.

Detailed Findings

1. Average annual BC per capita emissions in the with-tax period were 12.9 percent less than in the pre-tax period; this percentage drop was three-a-and-a-half times as great as the 3.7 percent fall in per capita emissions for the rest of Canada between the same periods. (See Figure 1 on page 2.)

2. The 12.9 percent decline in annual average BC per capita greenhouse gas emissions in 2008-2013 vs. 2000-2007 reflects double-digit reductions in each of the two emission "supercategories." Per capita emissions from "Stationary Combustion" sources fell by 16.0 percent from the pre-tax to the with-tax period. Within this grouping, the greatest decline, in both tons and in percentage terms, was in "manufacturing industries," which fell by 2.27 million tonnes, a per capita decrease of 40.1 percent. For "Transport" sources, which rely almost entirely on petroleum products, per capita emissions fell 10.3 percent, with the greatest absolute declines in gasoline cars, gasoline "light trucks" and off-road diesel vehicles used in construction and heavy industry.[16]

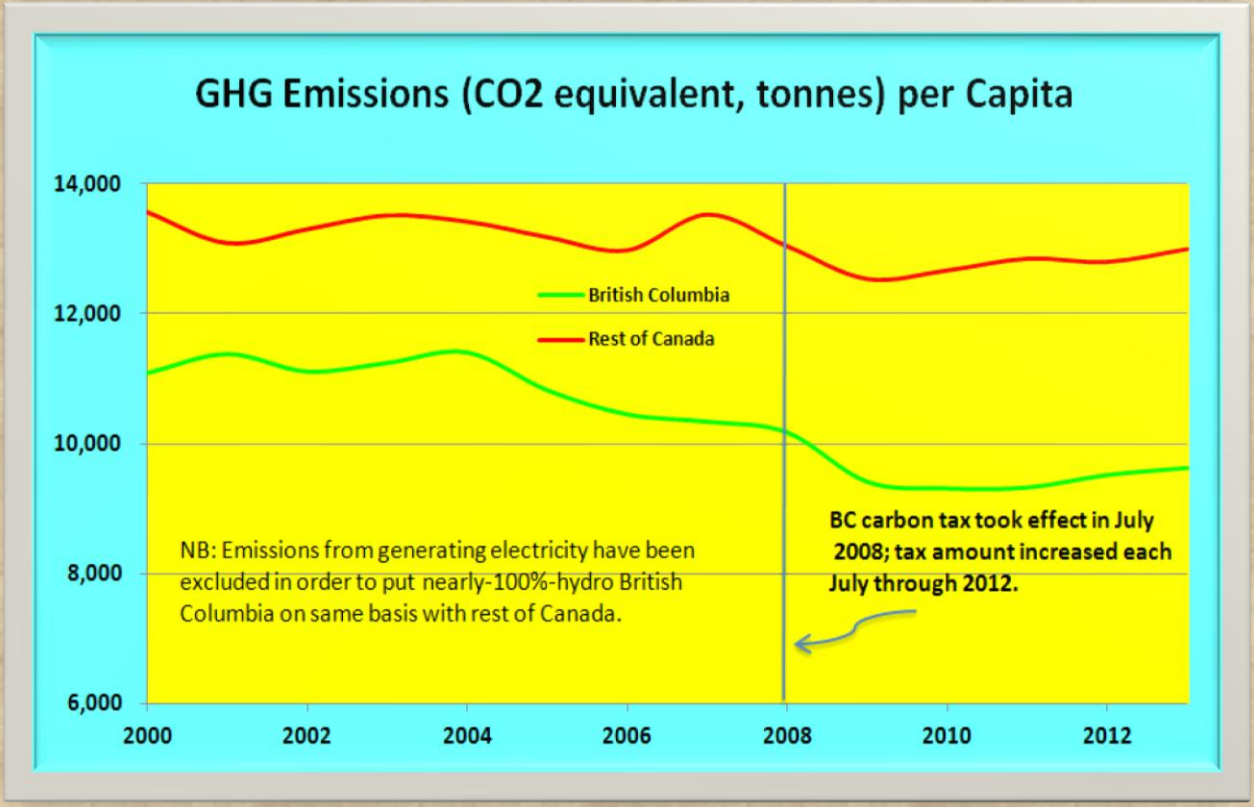
[16] These and all data presented here may be seen in the downloadable BC-Canada data spreadsheet [Excel file].

3. For both BC and Canada, emissions declined more steeply during the pre-tax period than in the with-tax period, for both BC and Canada. Indeed, for Canada, when per capita emissions are statistically smoothed,[17] they actually *increased* over the course of the latter period, albeit at a rate too small to register as statistically significant. (See Figure 3 below.)

4. Quantifying the previous point, over the entire 2000-2013 period, per capita emissions of greenhouse gases in British Columbia fell relative to those in the rest of Canada at an average rate of approximately 1 percent per year (as reflected in Figure 2 on page 3).

5. Notwithstanding the prior result, and even in the face of the carbon tax, per capita GHG emissions in British Columbia turned upward in 2012 and again in 2013, when they were 3.3 percent greater than in the lowest-emissions year, 2010. Most of this increase can be ascribed to the economic recovery, as indicated by the minuscule (0.75 percent) rise in BC emissions per unit of GDP during the same period. Nevertheless, the rebound in per capita emissions points to the need to again lift the carbon tax rate rather than letting it languish at the level reached in 2012.

Figure 3



6. Annual average BC emissions in the with-tax period (2008-2013) were nearly 2.8 million metric tons less than the annual average in the pre-tax period (2000-2007). By far the largest contributor to the decline was the category Manufacturing Industries, emissions from which declined by 2.27

[17] The statistical smoothing is by linear regression of per capita emissions against year. Regression results may be inspected in the downloadable BC-Canada data spreadsheet [Excel file].

million tonnes. Other sectors with big declines in British Columbia's emissions were Off-Road Diesel Vehicles, which shrank by 591,000 tonnes per year, and Commercial and Institutional Buildings, with a decline of 532,000 tonnes, as shown in Table 1, below. (Note that the overall net decline of 2.79 million tonnes in total provincial emissions is much less than the sum of these and other declines, due to increases in some categories, shown further below.) Sectoral analysis to determine why these emissions fell so sharply would be helpful.

7. Three categories showed sizeable increases in emissions in British Columbia from the earlier to the later period: Mining and Upstream Oil and Gas Production, which grew by nearly a million metric tons; Heavy-Duty Diesel Vehicles (18-wheelers and other large trucks), which grew by 885,000 tonnes; and Domestic Navigation, which increased more modestly. No other category had an emissions increase of as much as 100,000 metric tons. (See Table 2 below.) Further analysis is in order to determine the reasons for these anomalous increases.

Table 1: British Columbia sectors with largest emission decreases from pre-tax to with-tax period (figures are annual averages in thousands of metric tons)

Category	2000-07	2008-13	Change	Change, %
Manufacturing Industries	6,450	4,178	-2,271	-35.2%
Off-Road Diesel Vehicles	3,480	2,889	-591	-17.0%
Commercial & Institutional facilities	3,301	2,769	-532	-16.1%
Light-Duty Gasoline Vehicles (sedans)	4,270	3,883	-387	-9.1%
Pipeline Transport	1,232	863	-369	-29.9%
Public Electricity & Heat Production	*1,457*	*1,096*	*-362*	*-24.8%*
Residential buildings	4,763	4,514	-249	-5.2%
Light-Duty Gasoline Trucks (SUV's & pickups)	4,687	4,457	-230	-4.9%
Domestic Aviation	1,487	1,265	-223	-15.0%

Sectors are arranged in declining order of absolute decreases. Note that the category Public Electricity & Heat Production is *not* included in most totals and subtotals in this report.

Table 2: British Columbia sectors with largest emission increases from pre-tax to with-tax period (figures are annual averages in thousands of metric tons)

Category	2000-07	2008-13	Change	Change, %
Mining & Upstream Oil & Gas Production	5,391	6,370	979	18.2%
Heavy-Duty Diesel Vehicles	4,089	4,974	885	21.6%
Domestic Navigation	2,261	2,534	273	12.1%

Sectors are arranged in declining order of absolute increases.