Court of Appeal File No.: C65807

COURT OF APPEAL FOR ONTARIO

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act*, *2018*, *No. 1*, SC 2018, c. 12

RECORD OF THE ATTORNEY GENERAL OF CANADA
Volume 4 of 4

ATTORNEY GENERAL OF CANADA
Department of Justice Canada
Prairie Region Office (Winnipeg)
301 – 310 Broadway
Winnipeg, MB R3C 0S6

Per: Sharlene Telles-Langdon,
Brooke Sittler, Mary Matthews,
Neil Goodridge, and Ned Djordjevic

Phone: 204-983-0862
Fax: 204-984-8495
E-mail: sharlene.telles-langdon@justice.gc.ca

Counsel for the Attorney General of Canada

TO:

THE ATTORNEY GENERAL OF ONTARIO
Constitutional Law Branch
720 Bay Street, 4th Floor
Toronto, ON M7A 2S9
Per: **Josh Hunter / Padraic Ryan / Thomas Lipton**
LSO Nos.: 49037M / 61687J / 60776V
Tel.: 416-326-3840 / 416-326-0131 / 416-326-0296
Fax: 416-326-4015
E-mail: Joshua.hunter@ontario.ca
Padraic.ryan@ontario.ca
thomas.lipton@ontario.ca
Counsel for the Attorney General of Ontario

AND TO:

ATTORNEY GENERAL OF SASKATCHEWAN
Ministry of Justice (Saskatchewan)
Constitutional Law Branch
820-1874 Scarth St,
Regina, SK, S4P 4B3
Per: **P. Mitch McAdam, QC, and Alan Jacobson**
Phone: 306-787-7846
Fax: 306-787-9111
Email: mitch.mcadam@gov.sk.ca
Counsel for the Attorney General of Saskatchewan

AND TO:

ATTORNEY GENERAL OF BRITISH COLUMBIA
British Columbia Ministry of Attorney General
Legal Services Branch
6th Floor - 1001 Douglas Street
Victoria, BC V8W 2C5
Per: **J. Gareth Morley**
Phone: 250-952-7644
Fax: 250-356-9154
Email: Gareth.Morley@gov.bc.ca
Counsel for the Attorney General of British Columbia

Goddard Nasseri LLP
55 University Avenue, Suite 1100
Toronto, ON M5J 2H7
Per: **Justin H. Nasseri**
LSO No.: 64173W
Phone: 647-351-7944
Fax: 647-846-7733
Email: justin@gnllp.ca
Toronto Agent for the Attorney General of British Columbia

AND TO:

ATTORNEY GENERAL OF NEW BRUNSWICK
Office of the Attorney General
Legal Services
PO Box 6000, 675 King Street, Suite 2078
Fredericton, NB E3B 5H1
Per: **William E. Gould, Isabel Lavoie Daigle, and Rachelle Standing**
Phone: 506-453-2222
Fax: 506-453-3275
Email: William.Gould@gnb.ca
Isabel.LavoieDaigle@gnb.ca
Rachelle.Standing@gnb.ca
Counsel for the Attorney General of New Brunswick

AND TO:

ASSEMBLY OF FIRST NATIONS
55 Metcalfe Street, Suite 1600
Ottawa, ON K1P 6L5
Per: **Stuart Wuttke and Adam Williamson**
Phone: 613-241-6789
Fax: 613-241-5808
Email: swuttke@afn.ca
awilliamson@afn.ca
Counsel for Assembly of First Nations

AND TO:

ATHABASCA CHIPEWYAN FIRST NATION
Ecojustice Environmental Law Clinic
at the University of Ottawa
216 – 1 Stewart Street
Ottawa, ON K1N 6N5
Per: **Amir Attaran**
Phone: 613-562-5800 ext. 3382
Fax: 613-562-5319
Email: aattaran@ecojustice.ca

Woodward & Company Lawyers LLP
200 – 1022 Government Street
Victoria, BC V8W 1X7
Per: **Matt Hulse**
Phone: 250-383-2356
Fax: 250-380-6560
Email:
mhulse@woodwardandcompany.com
Counsel for the Athabasca Chipewyan First Nation

AND TO:

CANADIAN ENVIRONMENTAL LAW ASSOCIATION, ENVIRONMENTAL DEFENCE CANADA INC. and the SISTERS OF PROVIDENCE OF ST. VINCENT DE PAUL
Canadian Environmental Law Association
1500 – 55 University Avenue
Toronto, ON M5J 2H7
Per: **Joseph Castrilli and Richard Lindgren**
Phone: 416-960-2284 ex 7218
Fax: 416-960-9392
Email: castrillij@sympatico.ca
rlindgren@sympatico.ca
Counsel for Canadian Environmental Law Association, Environmental Defence Canada Inc., and the Sisters of Providence of St. Vincent de Paul

AND TO:

CANADIAN PUBLIC HEALTH ASSOCIATION
Gowling WLG (Canada) LLP
1 First Canadian Place
100 King Street West, Suite 1600
Toronto, ON M5X 1G5
Per: **Jennifer King, Michael Finley, and Liane Langstaff**
Phone: 416-862-7525
Fax: 416-862-7661
Email: jennifer.king@gowlingwlg.com
michael.finley@gowlingwlg.com
liane.langstaff@gowlingwlg.com
Counsel for Canadian Public Health Association

AND TO:

CANADIAN TAXPAYERS FEDERATION
Crease Harman LLP
Barristers and Solicitors
800 – 1070 Douglas Street
Victoria, BC V8W 2C4
Per: **R. Bruce E. Hallsor, Q.C.**
Phone: 250-388-5421
Fax: 250-388-4294
Email: bhallsor@crease.com
Counsel for Canadian Taxpayers Federation

AND TO:

DAVID SUZUKI FOUNDATION
Ecojustice Environmental Law Clinic
at the University of Ottawa
216 – 1 Stewart Street
Ottawa, ON K1N 6N5
Per: **Joshua Ginsberg and Randy Christensen**
Phone: 613-562-5800 ext. 3399
Fax: 613-562-5319
Email: jginsberg@ecojustice.ca
rchristensen@ecojustice.ca
Counsel for David Suzuki Foundation

AND TO:

ÉQUITERRE / CENTRE QUÉBÉCOIS DU DROIT DE L'ENVIRONNEMENT
Michel Bélanger Avocats inc.
454, avenue Laurier Est
Montréal (Québec) H2J 1E7
Per: **Marc Bishai and David Robitaille**
Phone: 514-844-4646
Facsimile: 514-844-7009
Email: marc.bishai@gmail.com
david.robitaille@uottawa.ca
Counsel for Équiterre / Centre québécois du droit de l'environnement (CQDE)

AND TO:

CANADA'S ECOFISCAL COMMISSION
University of Ottawa
57 Louis Pasteur Street
Ottawa, ON K1N 6N5
Per: **Stewart Elgie**
Phone: 613-562-5800 ext. 1270
Fax: 613-562-5124
Email: selgie@uottawa.ca
Counsel for Canada's Ecofiscal Commission

AND TO:

INTERGENERATIONAL CLIMATE COALITION
Ratcliff & Company LLP
500 – 221 West Esplanade
North Vancouver, BC V7M 3J3
Per: **Nathan Hume and Emma K. Hume**
Phone: 604-988-5201
Fax: 604-988-1352
Email: nhume@ratcliff.com
ehume@ratcliff.com
Counsel for the Intergenerational Climate Coalition

AND TO:

INTERNATIONAL EMISSIONS TRADING ASSOCIATION
DeMarco Allan LLP
333 Bay Street, Suite 625
Toronto, ON M5H 2R2
Per: **Lisa DeMarco and Jonathan McGillivray**
Phone: 647-991-1190
Fax: 1-888-734-9459
Email: lisa@demarcoallan.com
jonathan@demarcoallan.com
Counsel for the International Emissions Trading Association

AND TO:

UNITED CHIEFS AND COUNCILS OF MNIDOO MNISING
Faculty of Law, University of Ottawa
57 Louis Pasteur St.
Ottawa, ON K1N 6N5
Per: **Nathalie Chalifour**
LSO No. 37766O
Phone: 613-562-5800, ext 3331
Fax: 613-564-5124
Email: nathalie.chalifour@uottawa.ca

Westaway Law Group
55 Murray Street, Suite 230
Ottawa, ON K1N 5M3
Per: **Cynthia Westaway**
LSO No. 37698V
Phone: 613-722-9091
Fax: 613-722-9097
Email: cynthia@westawaylaw.ca
Counsel for United Chiefs and Councils of Mnidoo Mnising

AND TO:

UNITED CONSERVATIVE ASSOCIATION
McLennan Ross LLP
600 McLennan Ross Building
12220 Stony Plain Road
Edmonton, AB T5N 3Y4
Per: **Steven Dollansky and Ryan Martin**
Phone: 780-492-9135
Fax: 780-733-9707
Email: sdollansky@mross.com
rmartin@mross.com
Counsel for United Conservative Association

Court of Appeal File No.: C65807

COURT OF APPEAL FOR ONTARIO

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1,* SC 2018, c. 12

RECORD OF THE ATTORNEY GENERAL OF CANADA

INDEX

Tab No. **Pages**

Volume 1

Volume 2

Volume 3

Volume 4

Court of Appeal File No.: C65807

COURT OF APPEAL FOR ONTARIO

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1*, SC 2018, c. 12

AFFIDAVIT OF WARREN GOODLET
AFFIRMED ON JANUARY 29, 2019
FILED ON BEHALF OF THE ATTORNEY GENERAL OF CANADA

ATTORNEY GENERAL OF CANADA
Department of Justice Canada
Prairie Region Office (Winnipeg)
301 – 310 Broadway
Winnipeg, MB R3C 0S6

Per: Sharlene Telles-Langdon,
Brooke Sittler, Mary Matthews, Neil
Goodridge, and Ned Djordjevic

Phone: 204-983-0862
Fax: 204-984-8495
E-mail: sharlene.telles-langdon@justice.gc.ca

Counsel for the Attorney General of Canada

Docket: C65807

COURT OF APPEAL FOR ONTARIO

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1,* SC 2018, c. 12

AFFIDAVIT OF WARREN GOODLET

I, Warren Goodlet, of the City of Ottawa, in the Province of Ontario, SOLEMNLY AFFIRM AND DECLARE THAT:

1. I am currently the acting Director General of the Economic Analysis Directorate of Environment and Climate Change Canada's Strategic Policy Branch, and as such have personal knowledge of the facts and matters deposed to herein, except where these are stated to be based upon information and belief, in which case I believe the same to be true.

2. I earned a Bachelor of Science degree in biological science (with minors in mathematics and economics) in 2001, a Master's degree in economics in 2002, both from the University of Guelph, and a Bachelor of Education from St. Thomas University in 2007. I worked for the Department of Finance as an economist and senior economist from 2002 to 2006, providing economic analyses of climate change proposals from Environment Canada and Natural Resources Canada, as well as proposals relating to international negotiations and adaptation. I returned to working for the Government of Canada in 2009, when I joined Environment Canada, which is now known as Environment and Climate Change Canada ("ECCC").

3. Since joining ECCC, I have worked as a policy analyst and manager in a number of areas dealing with greenhouse gas ("GHG") emissions, including work in developing regulatory policy options for the oil and gas, and coal-fired electricity sectors, as well as in the Deputy Minister's office. I joined the Economic Analysis Directorate in 2015 as acting Director of the Current Analysis and Economic Research Division, and became the Director of that Division on a permanent basis in 2016. I began working as the acting Director General of the Economic Analysis Directorate in 2018.

The Economic Analysis Directorate

4. As the acting Director General of the Economic Analysis Directorate, I am responsible for the work of four divisions which conduct economic analysis and create, develop, and modernize economic models and modelling tools to analyze and evaluate the economic and environmental impacts of ECCC's current and proposed policies. Three of those divisions – the Current Analysis and Economic Research Division, the Model Development and Quantitative Research Division, and the Analysis and Modelling Division – were particularly involved in the analysis of the economic and environmental impacts of pricing carbon pollution prior to the *Vancouver Declaration*, in the lead-up to the adoption of the *Pan-Canadian Framework on Clean Growth and Climate Change*, in Canada's reporting under the *United Nations Framework Convention on Climate Change* ("*UNFCCC*"), and in the lead-up to the introduction of the *Greenhouse Gas Pollution Pricing Act*.

5. The Current Analysis and Economic Research Division ("CAER") is responsible for qualitative and quantitative analysis of sectors, industries, and facilities to evaluate the effects of environmental regulation, including carbon pricing, on Canadian economic competitiveness. CAER also leads ECCC's work on valuing the costs of GHG emissions through measures of the global social cost (i.e. the cost to society) of GHG emissions, as well as leading ECCC's academic engagement in the area of environmental economics. Currently, CAER is supporting the development of the specific output-based emissions standards for the output-based pricing system ("OBPS") under Part 2 of the *Greenhouse Gas Pollution Pricing Act*. Specifically, CAER is performing economic analysis examine the proposed output-based emissions standards for various economic sectors to minimize competitiveness impacts and carbon leakage under the OBPS. I have been informed by counsel for Canada that the concept of carbon leakage will be explained in the Affidavit of Mr. John Moffet.

6. The Model Development and Quantitative Research Division is responsible for the development and modernization of a suite of quantitative analytical modelling tools, including ECCC's tools for macroeconomic modelling. Those tools include models to assess GHG emissions trends, mitigation activities (both Canadian and international), and their potential economic impacts on multiple regions and sectors within Canada.

7. The Analysis and Modelling Division is charged with the development of Canada's annual emissions projections and GHG reference cases. The Analysis and Modelling Division develops those projections using the Energy, Emissions, and Economy Model for Canada ("E3MC"), which incorporates a model of Canada's energy supply and demand structure, called Energy 2020, and a macroeconomic model of the Canadian economy, called The Infometrica Model, based on current emissions information, as well as provincial and federal emissions-reduction policies, and analyzes the potential effects of those proposed policies.

Forecasting the impacts of pricing carbon pollution

ECCC's Models

8. The models with which my group works are used to perform quantitative analyses of alternative policy scenarios to identify the need for and the impact of changes in ECCC policy. In order to support policy decisions around the use of carbon pollution pricing and the ongoing design of the federal carbon pollution pricing system, we thoroughly examined carbon pricing policies by modelling a series of approaches, including the effects of a carbon price or levy, an output-based pricing system, and cap-and-trade measures. In so doing, we examined the effects of various policies by modelling the GHG emission reductions they would achieve, their costs to households, consumers and industry, as well as their impacts upon Canadian industrial competitiveness.

9. Our main model for forecasting GHG emissions is E3MC. As discussed above, E3MC has two components: Energy 2020, which incorporates Canada's energy supply and demand structure, and The Infometrica Model, which reflects the dimensions of the Canadian economy. Instead of examining just the forms of energy purchased by consumers, industry, and government, the model ties the energy to its end use. For example, gasoline is not generally purchased for its own sake, but is used for transportation, and accordingly, demand for gasoline is driven by the interaction between the efficiency and cost of the vehicles that consume it, the cost of gasoline, and how much those vehicles are used for transportation. The E3MC model determines energy price and demand by simulating energy producers' and consumers' discrete choices to purchase equipment based on a comparison between the cost of the equipment and

its efficiency. The E3MC model also assumes that the equipment that can be purchased will improve in efficiency over time, at a rate based on the available literature. Among other macroeconomic information, the E3MC model provides forecasts of GHG emissions and energy demand, which are used both in Canada's reporting and in modelling the effects of carbon pricing policies.

10. Our primary model for assessing the effects on the Canadian economy and Canadian GHG emissions of alternative carbon pricing policies is a computable general equilibrium ("CGE") model called EC-Pro. EC-Pro incorporates both provincial and federal carbon pricing policies.

11. CGE models like EC-Pro simulate whole economies based on supply, demand, and pricing within a series of markets, and are used to forecast the effects of changes in policy (or other external factors). They are based on detailed input-output tables for industrial sectors, households, and government, showing goods and services necessary to produce that sector's output, with each sector's output linked to the inputs of the industries, households, or governments that consume the products of the industry in question. Because of those linkages, changes in input prices propagate through the remainder of the model, until the supplies and demands for each of those industries reach an equilibrium price. While many of the results produced by CGE models are intuitively predictable, the dense interconnections between sectors of the economy mean that small changes to an input price or provincial policies can have substantial effects which ripple through the remainder of the economy.

12. Our CGE model, EC-Pro, is built based on the detailed supply use tables compiled by Statistics Canada, which set out each of the inputs required for particular industries and their corresponding outputs. Further, the emissions from each industry are overlaid upon the supply use tables, to give a full correspondence of energy, emissions, and economic value. The model is iteratively calibrated by simulating each year forward from the base year of the supply tables and comparing the results to historical emissions and economic data, as well as the projections from the E3MC model.

13. The EC-Pro model allows us to explore the effects of pricing mechanisms on GHG emissions. Based on the effects of price on supply and demand throughout the economy as a whole, our forecasts accord with the intuitive expectation that price affects behavior: as the price for GHG emissions increases, GHG emissions themselves decrease.

Modelling for the Carbon Pricing Mechanisms Working Group

14. Following the meetings which resulted in the *Vancouver Declaration*, my group was actively involved in assisting the Working Group on Carbon Pricing Mechanisms (the "Working Group"), using our EC-Pro model to project the economic and GHG emissions impacts of the emissions-reduction methods and targets contemplated by the Working Group. The results of a series of scenarios analyzed using the EC-Pro model formed the basis of Part 4 of the *Working Group on Carbon Pricing Mechanisms Final Report*, which explicitly examines the economic and emissions impacts that additional carbon pricing could have in Canada. I have been informed by counsel for Canada that a copy of the *Final Report* will be attached as an Exhibit to the Affidavit of Mr. John Moffet.

15. To assist the Working Group's deliberations, my group projected Canada's GHG emissions through 2030 under a variety of scenarios, using the EC-Pro and E3MC models. Baseline GHG emissions were projected using E3MC, reflecting the carbon pricing policies in place or sufficiently well-defined and planned to be included within the model when the Working Group began its work. The baseline reflected Canada's likely GHG emissions through 2030, based on the measures then in place and without additional GHG emissions mitigation measures. This initial reference case was in line with the information Canada provided in its *2^nd^ Biennial Report* under the *UNFCCC* in 2016. The baseline projections provided to the Working Group of Canada's likely GHG emissions through 2030, by province or territory, were:

Reference Baseline Emissions (in megatonnes ("Mt"))				
	2017	**2020**	**2025**	**2030**
Alberta	291.3	297.0	302.9	320.0
BC	67.7	71.8	80.4	82.8
Manitoba	21.5	22.0	22.9	23.7

New Brunswick	16.7	16.9	16.8	16.5
Newfoundland & Labrador	9.0	9.3	9.9	7.8
Nova Scotia	16.9	15.2	14.7	13.6
Northwest Territories	1.7	1.8	2.0	2.1
Nunavut	0.3	0.3	0.4	0.4
Ontario	168.9	170.5	176.5	181.4
Prince Edward Island	1.9	1.9	1.9	1.9
Québec	83.9	84.7	87.4	90.3
Saskatchewan	75.0	75.3	75.8	73.2
Yukon	0.5	0.6	0.7	0.7
All of Canada	755.2	767.4	792.2	814.6

16. Each of the amounts in the above table are expressed as carbon dioxide (CO_2) equivalent (CO_2e) emissions, which reflects the amount of CO_2 that would have the same effect on the Earth's average temperature as the actual GHGs emitted. I have been informed by counsel for Canada that the concept of CO_2e will be further explained in the affidavit of John Moffet.

17. The impacts of three carbon pricing scenarios were then projected for the Working Group using EC-Pro. The specific scenarios modelled for the Working Group used prices of:

i. $15 per tonne of CO_2e emissions in 2018, rising to $30 by 2030;

ii. $30 per tonne of CO_2e emissions in 2018, rising to $40 by 2030; and

iii. $30 per tonne of CO_2e emissions in 2018, rising to $90 by 2030.

18. Those scenarios are discussed at pages 21 through 26 of the *Final Report* (an Exhibit to the Affidavit of Mr. John Moffet). Each of these pricing scenarios is different from the final design of GHG pollution pricing adopted under the *Greenhouse Gas Pollution Pricing Act*, and they do not include an OBPS. In addition, the scenarios reported in the *Final Report* do not account for the carbon pricing policies which were subsequently adopted by Alberta, nor the effects of Ontario and Québec joining the cap-and-trade program under the Western Climate Initiative ("WCI"). The three scenarios modelled for the Working Group estimated annual GHG emissions reductions from the baseline scenario by 38 to 95 Mt of CO_2e.

19. Working with the Department of Finance, my group also estimated the economic impacts of those three pricing scenarios for the Working Group. As set out at page 26 of the *Final Report*, the estimated reduction in GDP by 2030 averaged approximately 0.02% annually (0.28% in total) for the scenario with the lowest carbon prices, and approximately 0.08% annually (0.93% in total) for the scenario with the highest carbon prices.

20. The pricing model introduced in the *Greenhouse Gas Pollution Pricing Act* differs from the pricing scenarios studied by the Working Group. Instead of simply implementing a charge per tonne of CO_2e emissions, the *Greenhouse Gas Pollution Pricing Act* contains both a fuel charge based on a carbon price of $20 per tonne of CO_2e emissions for 2019, rising to $50 per tonne for 2022 and following years, as well as an OBPS for emissions-intensive and trade-exposed industries based on the same pricing trajectory as the fuel charge. Accordingly, while the modelling done for the Working Group is instructive, it does not predict the results under the *Greenhouse Gas Pollution Pricing Act*.

Modelling for UNFCCC Reporting

21. Since the Working Group's work concluded, Canada's GHG emissions projections have been updated annually on the basis of new emissions data, updated economic and demographic forecasts, and further federal and provincial policy changes affecting emissions. Using E3MC, my group models those policy changes and combines the results with updated emissions data to create a new baseline. In 2017, these policy changes included a number of provincial measures in Alberta, Ontario and Québec joining the WCI cap-and-trade regime, as well as further measures by Canada to increase equipment efficiency.

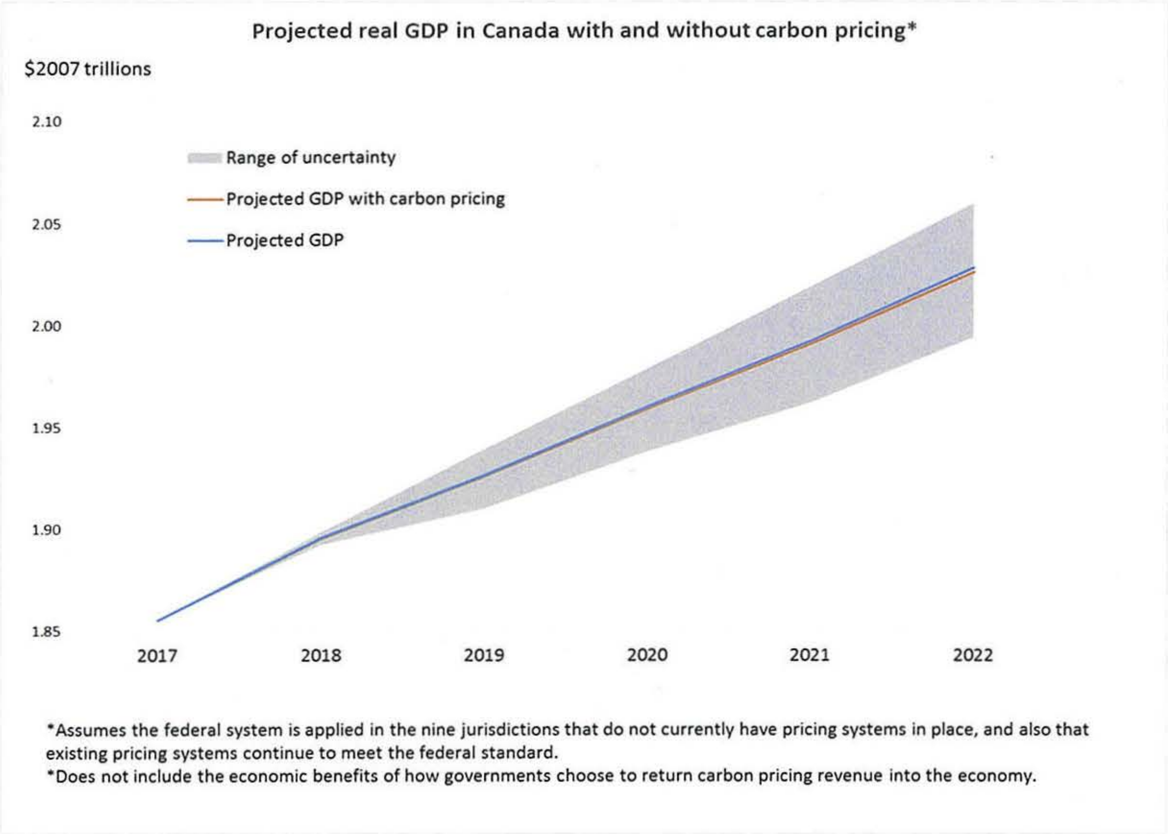
22. The results of that modelling were used in meeting Canada's reporting requirements under the *UNFCCC*, and were included in chapter 5 of Canada's *7th National Communication and 3rd Biennial Report* (the "*7th National Communication*"). The E3MC model was updated to project two GHG emissions scenarios, both of which were included in chapter 5 of the *7th National Communication*: a "with measures" scenario, and a "with additional measures" scenario. A copy of chapter 5 of Canada's *7th National Communication* is attached as Exhibit "A" to my affidavit.

23. Based on those policies and updated emissions information, the "with measures" scenario set out in the 7^{th} *National Communication* projected that Canada's GHG emissions in 2030 would be 722 megatonnes of CO_2e. That projection – which is 93 megatonnes of CO_2e less per year by 2030 than the initial baseline projection used by the Working Group – does not include carbon pricing resulting from the federal backstop under the *Greenhouse Gas Pollution Pricing Act*.

24. Canada's "with additional measures" scenario includes projections of the additional GHG emissions reductions resulting from the fuel charge portion of the *Greenhouse Gas Pollution Pricing Act* and other additional policies set out on page 166 of chapter 5 of the 7^{th} *National Communication*. The total impact of those additional measures, as set out on page 153 of chapter 5 of the 7^{th} *National Communication*, was estimated to provide additional GHG emissions reductions of 139 megatonnes of CO_2e in 2030.

Subsequent Modelling

25. Early in 2018, the Model Development and Quantitative Research Division prepared further estimates of the economic effects and emission reductions under the *Greenhouse Gas Pollution Pricing Act* for ECCC's Environmental Protection Branch. I am informed by Nick Macaluso, Director of the Model Development and Quantitative Research Division, and do verily believe, that he and his Division generated forecasts of Canada's GDP through 2022 both with and without the federal carbon pricing backstop under the *Greenhouse Gas Pollution Pricing Act*. Those forecasts were generated using the EC-Pro model and information from the Department of Finance, including Canada's actual 2017 GDP of $1.855 trillion (in 2007 dollars, the base year for inflation-adjusted economic parameters provided by Statistics Canada). They projected that, as of 2022, Canada's GDP without the federal carbon pricing backstop would be $2.028 trillion (in 2007 dollars), and that with the federal carbon pricing backstop, Canada's GDP in 2022 would be $2.026 trillion – a 0.1% reduction in GDP growth. The following graph was produced by ECCC based on their analysis:



*Assumes the federal system is applied in the nine jurisdictions that do not currently have pricing systems in place, and also that existing pricing systems continue to meet the federal standard.
*Does not include the economic benefits of how governments choose to return carbon pricing revenue into the economy.

26. That graph was incorporated in a document published by ECCC in April 2018, titled *Estimated Results of the Federal Carbon Pollution Pricing System* ("*Estimated Results*"). I have been informed by counsel for Canada that *Estimated Results* will be attached as an Exhibit to the Affidavit of John Moffet.

27. Using EC-Pro, the Model Development and Quantitative Research Division has continued to prepare and update projections of the effects on Canada's GHG emissions of the carbon pricing scheme set out in the *Greenhouse Gas Pollution Pricing Act*, incorporating both the fuel charge and the OBPS. A series of those projections were shared in meetings with ECCC's provincial counterparts to assist in the development of provincial carbon pricing systems. I am informed by Nick Macaluso and do verily believe that ECCC officials attempted to schedule meetings to discuss projections and impacts of climate mitigation policies with officials from Ontario last year, but received no response.

28. My team has continued to update the projections as details of provincial systems became available, and as the design of the federal system progressed. Significantly, we updated the projections after the July 2018 announcement by the Government of Ontario that it would be withdrawing from the WCI and terminating its cap and trade system. Our updates also accounted for decisions by the Government of Canada on where Part 1 and Part 2 of the *Greenhouse Gas Pollution Pricing Act* will apply, to incorporate the current iteration of the emissions limits under consideration for the federal OBPS, and to incorporate both feedback received from the provinces with respect to our modelling and changes to provincial systems.

29. The changes to Ontario policy have had a substantial impact on the effects of carbon pricing policies on Canada's GHG emissions. As of the most recent update of ECCC's projections, Ontario's change in provincial emissions targets and withdrawal from the WCI are forecast to result in an additional 30 Mt of CO_2e of GHG emissions per year in 2030, even when the federal backstop is applied. Broadly speaking, that change is based on the decrease in the total number of emissions credits that Ontario entities were projected to purchase from California, as well as indirect increases on emissions in other provinces related to changes in Ontario's forecast economic activity. Ontario's provincially-set emissions target had previously been a reduction of 37% below its 1990 emissions of 179 Mt; Ontario's new target is 30% below 2005 emissions of 205 Mt.

30. ECCC's most recent projections included both a reference case (based on policies implemented by Canada and the provinces and with sufficient detail to be modelled as of September 2018) and an additional measures case (based on announced policies that were not yet in place in September 2018). ECCC's additional measures case includes the application of the federal backstop, the federal Clean Fuel Standard, and other complementary federal measures.

31. Under the federal and provincial policies that were in place in September 2018 (not including the federal backstop, as it did not then apply in any provinces), emissions from Ontario are projected to only decrease by 1 Mt CO2e – from 161 Mt to 160 Mt – between 2016 and 2030. By contrast, under the additional measures case, including the application of the

federal backstop, ECCC predicts that Ontario's annual emissions would decrease by 18 Mt, to 143 Mt in 2030.

32. Although Ontario has set out a number of proposed policies since withdrawing from the WCI and terminating its cap and trade system, those policies are not detailed enough to allow ECCC to model their effects, if any, on GHG emissions. Specifically, of the policies that the government of Ontario has stated will allow them to meet their target (beginning at pages 23-24 of *Preserving and Protecting our Environment for Future Generations: A Made-in-Ontario Environment Plan*, which I have been informed by counsel for Canada is found at pages 35-36 of Volume 1 of the Record of the Attorney General of Ontario), Ontario has not provided ECCC with sufficient information to model the effects of:

i. the uptake of Low Carbon Vehicles;

ii. Industry Performance Standards (which appear to implement an output-based pricing system allowing for discretionary exemptions of entire industries);

iii. Ontario's Clean Fuels proposal (as opposed to Canada's Clean Fuel Standard);

iv. Natural Gas Conservation;

v. The Ontario Carbon Trust;

vi. Innovation; or

vii. Other Policies.

DECLARED UNDER OATH)
BEFORE ME at the City of)
Gatineau, in the Province of)
Québec, on January 29, 2019.)
)
_________________________) Warren Goodlet
Commissioner for Taking Affidavits
#224458

Warren Goodlet

This is **Exhibit A** referred to in the

affidavit of **Warren Goodlet**

affirmed before me on **January 29, 2019**

Commissioner for Oaths for Québec

#224458

CHAPTER 5

Projections and the Total Effect of Policies and Measures

This chapter provides projections of greenhouse gas (GHG) emissions through 2030, aligned to Canada's historical emissions from 1990 to 2015 as presented in Canada's 2017 *National Inventory Report* (NIR) and in this report in Chapter 3: Canada's Greenhouse Gas Inventory. The projections are presented by gas and by sector as well as selected subsectors. This chapter presents detailed projections according to Canada's economic sector categories, aligned with the presentation of policies and measures in Chapter 4: Policies and Measures. A short presentation of projected emissions by Intergovernmental Panel on Climate Change (IPCC) sector categories is also provided. A description of the relationship between Canada's economic sectors and IPCC sectors can be found in Chapter 3. Canada's GHG inventory is available both online on the Government of Canada website, as well as on the Government of Canada Open Data Portal website.

Under the Paris Agreement, Canada has formally committed to achieving an economy-wide target to reduce GHG emissions by 30% below 2005 levels by 2030, and under the Copenhagen Accord Canada committed to reducing GHG emissions by 17% below 2005 levels by 2020. The Government of Canada, in close collaboration with provinces and territories, has established the Pan-Canadian Framework on Clean Growth and Climate Change (Pan-Canadian Framework). As described in further detail in Chapter 4, this is a federal, provincial and territorial plan to grow the Canadian economy, reduce GHG emissions and help Canadian communities adapt to a changing climate.

Projections presented in this report represent both a "with measures" scenario and a "with additional measures" scenario.[a]

---

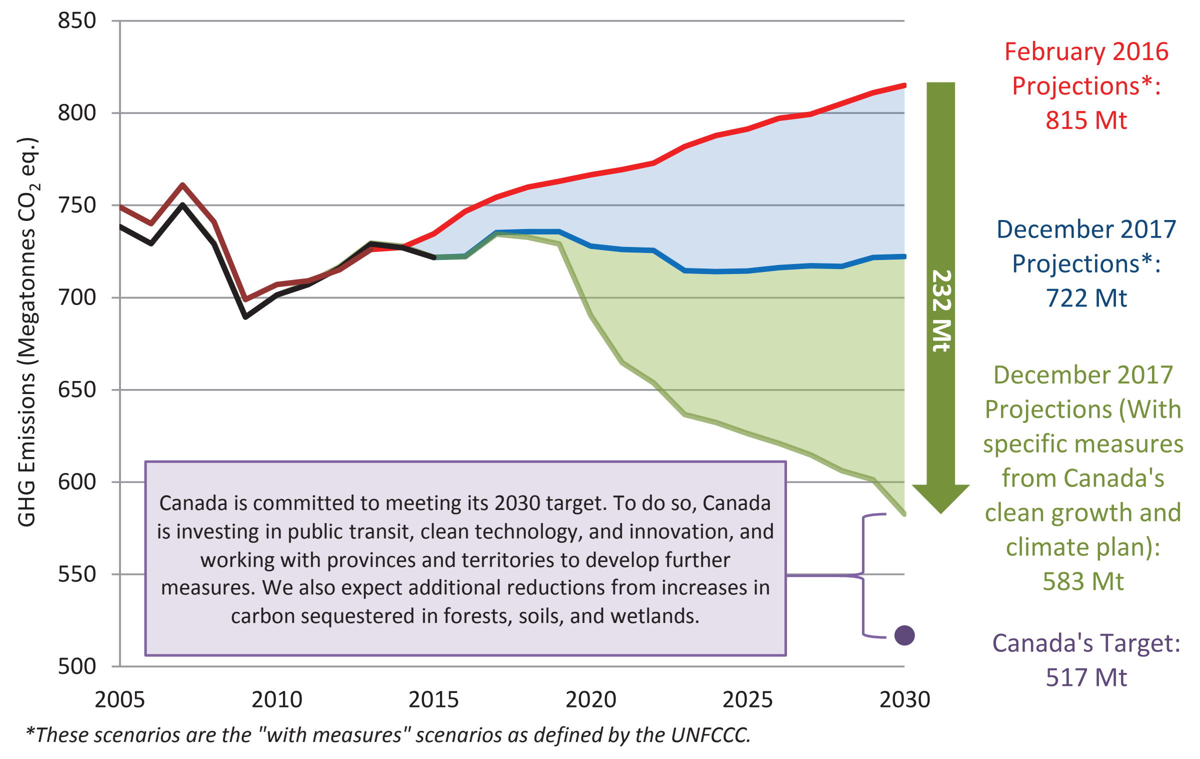
[a] The policies and measures modeled in each of these scenarios are listed in Table 5A.9 in Annex 1 of this chapter, and several are described in more detail in Chapter 4: Policies and Measures. It should be noted that the sum of emission reductions associated with individual policies and measures—as summarized in Table 1, Chapter 4: Policies and Measures of the National Communication—will not be equivalent to the overall projected emission reductions of policies and measures in this chapter due to the interaction effects between measures and different modeling approaches.

The "with measures" scenario, outlined in Section 5.3, includes actions taken by governments, consumers and businesses put in place over the last two years, up to September 2017 (see Section 5.3.2 for more details). This scenario does not account for all measures of the Pan-Canadian Framework as a number of them are still under development.

Taking into consideration all climate change policies and measures that have been announced in Canada and for which enough information is available, a "with additional measures scenario" has also been developed. As described in Section 5.5, the "with additional measures" scenario accounts for those additional policies and measures that are under development but have not yet been fully implemented, some of which were announced as part of the Pan-Canadian Framework (e.g., pan-Canadian carbon pricing). This scenario is provided for the purposes of presenting progress to Canada's 2030 target and to better demonstrate the expected impact of the Pan-Canadian Framework.

Under this scenario, emissions in 2030 would be 583 Mt, a 232 Mt decline from projections included in the "with measures" scenario in the *2nd Biennial Report* (BR2). This decline, equivalent to approximately a third of Canada's emissions in 2015, is widespread across all economic sectors, reflecting the breadth and the depth of the Pan-Canadian Framework.

Figure 5.1 shows the "with measures" and "with additional measures" projections, as well as the projections presented in Canada's BR2. Going forward, it is expected that further progress will take place, especially as current estimates do not include the full reductions from investment in public transit, clean technology and innovation. Potential increases in stored carbon (carbon sequestration) in forests, soils and wetlands will also contribute to reductions which, for a country such as Canada, could also play an important role in achieving the 2030 target.



Canada is committed to meeting its 2030 target. To do so, Canada is investing in public transit, clean technology, and innovation, and working with provinces and territories to develop further measures. We also expect additional reductions from increases in carbon sequestered in forests, soils, and wetlands.

**These scenarios are the "with measures" scenarios as defined by the UNFCCC.*

Figure 5.1: Scenarios of Canadian Emissions to 2020 and 2030 (Mt CO_2 eq) (Excluding Land Use, Land-Use Change and Forestry)

Moreover, these projected emission reductions do not account for additional mitigation measures that could be implemented by the provinces and territories between now and 2030. Emissions reductions from additional future actions will be assessed as new measures are implemented.

5.1 Comparing Activity Sector Categories to Economic Sectors

Canada's GHG projections are derived using a detailed bottom-up simulation model where energy data is allocated to individual subsectors using the North American Industrial Classification System. These subsectors are then aggregated into the economic sectors presented in this report. Considering that gross domestic product (GDP) and relative energy prices are a key driver of GHG emissions in most sectors, macroeconomic models are the primary tool for generating emissions projections in Canada. This method of energy and emissions allocation is essential for identifying possible impacts from current and future policies and measures implemented in a particular sector.

In line with United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines, Canada has chosen to use economic sectors to present policies and measures as well as projections in our *7th National Communication* and *3rd Biennial Report*. Examining the historical path of Canadian GHG emissions by economic sector allows for a better understanding of the connection between economic activities and emissions for the purposes of analyzing trends and for policy analysis. This approach is also more closely aligned with that taken in the Pan-Canadian Framework. This approach to categorisation was used in Canada's previous BR, in Canada's *6th National Communication* and in *Canada's GHG Emissions Reference Case* (December 2016), a publication which provided projections of GHG emissions to the year 2030. It is also presented in Canada's NIR along with GHG emissions categorised under the IPCC reporting requirements by activity sectors.

Figure 5.2 shows the distribution of 2015 emissions on an IPCC activity basis versus an economic sector basis. Some adjustments that are made to the IPCC categories to calculate economic sector emissions include:

- Reallocating off-road transportation emissions related to farming (primarily farm tractors and other mobile machinery) to the agriculture sector instead of transportation.
- Reallocating off-road transportation emissions related to mining operations from transportation to the oil and gas sector and the heavy industry[b] sector.
- Reallocating emissions related to pipeline operations to the oil and gas sector.
- Reallocating some of the industrial process emissions to the buildings sector.

In addition, stationary combustion emissions under the IPCC categorisation are allocated across economic sectors, as appropriate. Almost all industrial process and fugitive emissions under these processes are aligned with the economic sector that generates them (primarily in the heavy industry and oil and gas sectors). In addition, emissions from landfills are included in the waste and others sector. For a more detailed description of the reconciliation of between economic and IPCC sector categories, please see Chapter 3: Canada's Greenhouse Gas Inventory.

---

[b] Heavy industry subsectors include mining activities, smelting and refining, and the production and processing of industrial goods such as chemicals, fertilizers, pulp and paper, aluminum, iron and steel and cement.

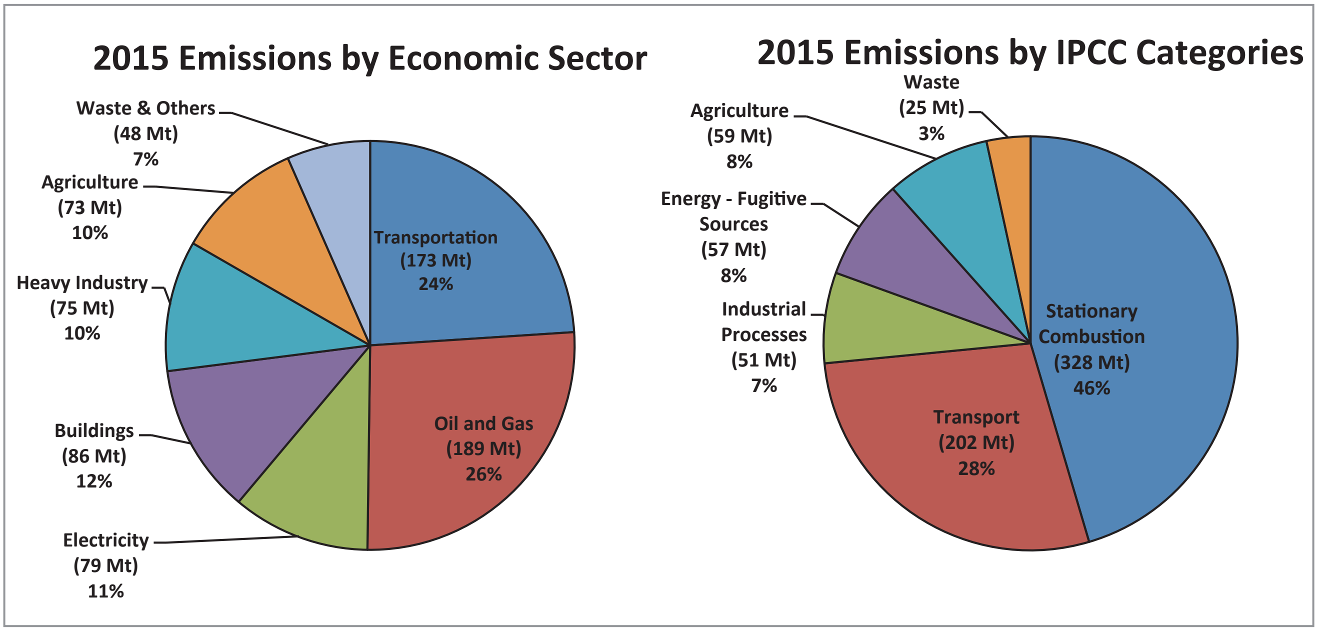


Figure 5.2: Total Canadian 2015 GHG emissions (722 Mt CO_2 eq)–Methods of Categorisation

5.2 Historical Emissions Trends

Although historical emissions have been described in detail in Chapter 3: Canada's GHG Inventory, a brief summary of historical trends by economic sector is provided here.[c] Changes to historical data since Canada's previous National Communication are discussed in Chapter 3: Canada's Greenhouse Gas Inventory.

As shown in Table 5.1, from 1990 to 2005, total emissions grew from 611 Mt to 738 Mt. The majority of this increase occurred in the oil and gas, transportation and electricity[d] sectors. As production increased and Canada's oil sands industry developed, emissions in the oil and gas sector increased 50 Mt. In the transportation sector, population and economic growth were primary drivers of a 41 Mt increase in emissions over this period. The electricity sector contributed to a further 23 Mt of the increase in total emissions as more fossil fueled power generation came online to meet rising demand.

Canadian GHG emissions fell by 16 Mt from 2005 to 2015, driven mostly by reductions in the electricity and heavy industry sectors, while emissions growth came mostly from the oil and gas and transportation sectors. Emissions in most other sectors were stable over the period. The decline in emissions from the electricity sector is primarily the result of Ontario's coal-fired electricity generation phase-out. Compositional changes within the sectors, energy efficiency improvements, and changes to energy prices have all helped contribute to relatively stable emissions in the other sectors.

Emissions are intrinsically linked to economic activity, although in Canada this link has weakened over the past two decades due to technological and structural changes such as increases in energy efficiency and the growth of lower-emissions and service-based industries. Emissions intensity, defined as GHG emissions per dollar of GDP, measures the relationship between economic activity and

---

[c] Canada's NIR 2017 provides historical emissions by IPCC sector and by economic sector.

[d] For purposes of modeling emissions projections, ECCC defines the electricity sector as consisting of electricity production from power plants whose primary purpose is to sell electricity to the grid (i.e., to the public. This is as per the North American Industry Classification System code that begins with "22"). This definition does not necessarily include all electricity production in Canada (e.g., does not include industrial electricity generation that is not sold to the grid).

emissions generation. In Canada, emissions intensity has declined at an average annual rate of 1.6% between 1990 and 2015, or a cumulative 33.4% over the entire period (Figure 5.3).

Table 5.1: GHG Emissions by Economic Sector (kt CO_2 eq) from 1990 to 2015

SECTOR	HISTORICAL					
	1990	1995	2000	2005	2010	2015
Oil and Gas	108,000	133,000	159,000	158,000	160,000	189,000
Electricity	94,000	98,000	127,000	117,000	96,000	79,000
Transportation	122,000	127,000	147,000	163,000	171,000	173,000
Heavy Industry	97,000	99,000	93,000	86,000	73,000	75,000
Buildings	73,000	79,000	85,000	85,000	81,000	86,000
Agriculture	60,000	70,000	72,000	74,000	70,000	73,000
Waste & Others	57,000	56,000	55,000	54,000	50,000	48,000
Total	**611,000**	**661,000**	**738,000**	**738,000**	**701,000**	**722,000**

Note: Numbers may not sum to the total due to rounding.

5.3 Greenhouse Gas Emissions Projections by Economic Sector and Gas under the "With Measures" Scenario

5.3.1 National Emissions Projections

Environment and Climate Change Canada (ECCC) updates Canada's GHG emissions annually, reflecting the latest historical data and up-to-date future economic and energy market assumptions. As such, projections fluctuate over time as a result of changes in these key drivers assumptions.

In this chapter, emissions are projected to 2030 with comparisons made to 2005, Canada's base year for its GHG emissions reduction targets.[e] Projections are based on policies and measures in place as of September 2017 and assume no further government action. Where applicable, historical emissions for 2010 and 2015 (the most recent year for which historical emissions are available) are also shown. Projections are based on the Energy, Environment and Economy Model for Canada (E3MC), which is internationally recognized and incorporates external data from consistent sources (for more information on E3MC, please see Annex 4 of this chapter).

ECCC consults extensively with other government officials, selected experts and provinces and territories on emissions projections. Forecast assumptions such as population growth, industry growth rates, electricity supply plans, and major projects are shared with provinces and territories prior to the development of the projections in order to insure their accuracy. Current modelled provincial policies are clarified and updated based on consultation feedback, and detailed information is obtained on any new provincial/territorial policies so that they can be modelled and incorporated into the forecast. Preliminary projections are prepared midway through their development and shared for consultation to identify any errors or concerns. Adjustments are made as additional information and clarification is being provided about

---

[e] Under the 2009 Copenhagen Accord, Canada committed to reduce its emissions by 17% below 2005 levels by 2020, or 126 Mt. This target covers all sectors and GHGs.
In May 2015, Canada submitted its Intended Nationally Determined Contribution to the UNFCCC. The submission included an economy-wide target to reduce GHG emissions by 30% below 2005 levels by 2030, or 222 Mt. This submission was updated in 2017 following the release of the Pan-Canadian Framework on Clean Growth and Climate Change, Canada's plan to address climate change and grow the economy. As outlined in the Paris Agreement and accompanying decisions adopted in December 2015, Parties are invited to submit final targets as part of ratifying the new agreement and will be obligated to submit revised nationally determined contributions every five years.

1004

economic assumptions, policies, electricity supply plans, etc. Provincial and territorial details of the final projections are then shared with each jurisdiction prior to publication.

5.3.2 Comparison of Current and Previous "With Measures" Emissions Projections

In 2030, the GHG emissions in the "with measures" scenario in Canada are projected at 722 Mt, 92 Mt below what was presented in Canada's BR2, a decline greater than 2015 emissions from Canada's entire building sector. This reflects the future impacts of a number of federal and provincial policies that were put in place over the last two years, such as:

- Alberta's Carbon levy, 2030 phase-out of coal-fired electricity, and 100 Mt cap on oil sand emissions;
- Domestic reductions from Ontario joining Québec and California in the Western Climate Initiative (WCI) cap-and-trade regime in 2017;
- Québec's regulation for new commercial, institutional and residential high-rise buildings;
- Federal measures to increase efficiency of residential and commercial equipment and appliances;
- Federal regulations to reduce releases of methane in the upstream oil and gas sector;
- Federal regulations phasing-out the use of hydrofluorocarbons;
- Federal GHG emissions standards for heavy-duty vehicles and trailers of model years 2021 to 2027;
- Increasing carbon tax in British Columbia to $50/t by 2022 and onwards; and
- Other provincial and federal policies. (A full list of policies and measures is provided in Annex 1 of this chapter.)

In addition to the new policies, the lower emissions projections for the "with measures" scenario are also driven by a lower GDP growth forecast and lower light oil, oil sands, and natural gas production estimates compared to the BR2. Changes to historical data since Canada's previous National Communication are discussed in Chapter 3: Canada's Greenhouse Gas Inventory.

Table 5.2: Revisions to Canada's "With Measures" GHG Emissions (Mt CO_2 eq) since Canada's 2nd Biennial Report

	2005	2010	2015	2020	2030
2nd Biennial Report	749	707	736	768	815
7th National Communication	738	701	722	728	722
Difference	**-11**	**-6**	**-14**	**-40**	**-92**

Note: Numbers may not sum to the total due to rounding.

5.3.3 Emissions Intensity

The link between growth in GDP and GHG emissions continues to weaken. There has been an average annual decline in Canadian emissions intensity (emissions per unit of GDP) of approximately 1.6% from 1990 to 2015. Emissions intensity is expected to continue to decrease through 2030 (Figure 5.3).

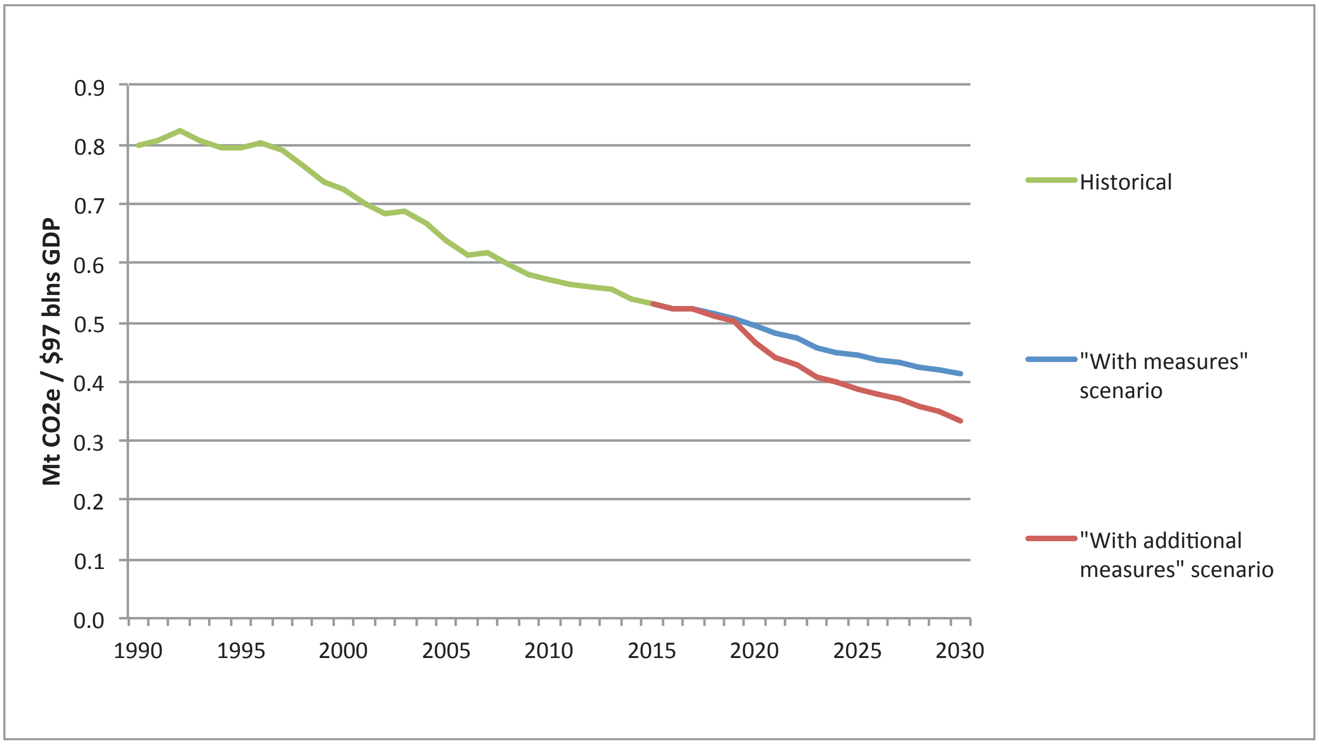


Figure 5.3: Canadian Emissions Intensity (1990 to 2030)

Decomposition of Projected Change in Canada's "With Measures" GHG Emissions Projection

The following explores how different factors contribute to trends in projected emissions through a decomposition analysis of Canada's projected GHG emissions under the "with measures" scenario (Figure 5.4).

- The **Activity Effect** measures the impact of economic growth (estimated to be 53% over the 2005–2030 period). On its own, this growth would have been expected to lead to 327 Mt of additional GHG emissions in 2030 (or 13 Mt per year).
- The **Carbon Intensity Effect** measures changes in the carbon emission coefficient of energy. The shift to cleaner fuels such as the replacement of coal-fired electricity with cleaner sources, as well as measures to reduce fugitive and process emissions, are projected to have a significant impact, reducing emissions by 111 Mt in 2030 (or 4.4 Mt per year).
- The **Energy Efficiency Effect** measures changes in energy efficiency at the subsector level. The projections indicate that the uptake of energy efficient technologies–induced by policies, consumer responses to energy prices, and stock turnover– reduces emissions by 232 Mt in 2030 (or 9.2 Mt per year).

The decomposition shows that over the period 2005–2030, there is a decoupling of economic growth on projected combustion emissions: upward pressure on GHG emission projections arising from GDP growth are slightly more than offset by the switch to cleaner and more efficient energy use.

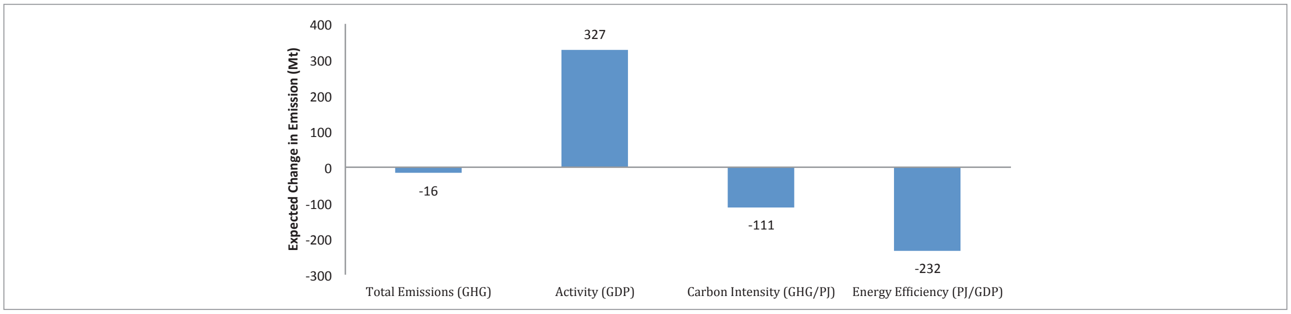


Figure 5.4: Decomposition of Emissions Growth 2005–2030 (excluding Land Use, Land-Use Change and Forestry)

5.3.4 Per Capita Emissions

Canadian per capital GHG emissions have been decreasing significantly since 2005 when they were 22.9 tonnes carbon dioxide equivalent (CO_2 eq) per person. In 2015, emissions per capita were 20.1 tonnes CO_2 eq per person, the lowest level recorded since records began in 1990.

Projections show per capita emissions to continue to decrease through 2030 and are expected to fall to 17.2 tonnes per person in 2030 (Table 5.3). This reflects a projected increase in Canada's population of 17% between 2015 and 2030, while emissions are projected to be at the same level in 2030 as in 2015.

Table 5.3: Canadian GHG Emissions Per Capita

PER CAPITA	2005	2010	2015	2020	2030
Tonnes CO_2 eq	22.9	20.6	20.1	19.2	17.2

5.3.5 Emissions by Gas

Total Canadian GHG emissions over the projection period are presented by gas in Table 5.4 and Table 5.5 in CO_2 eq and in their native gaseous forms respectively. Section 5.3.7 provides additional details by economic sector.

CO_2 emissions decreased by 1% between 2005 and 2015, and are projected to rise by about 3% between 2015 and 2030. On a CO_2 eq basis, CO_2 represented 78% of total Canadian GHG emissions in 2005. By 2030 this share is expected to increase slightly to 81%.

Between 2005 and 2015, CO_2 emissions increased in the agriculture, heavy industry, oil and gas, and transportation sectors. Emissions are projected to continue to increase in these sectors between 2015 and 2030, with the exception of transportation where emissions are projected to decrease. Agriculture CO_2 emissions increase mostly before 2015 and then decline slightly until 2030. In the case of heavy industry, emissions declined by 10% between 2005 and 2015, and are expected to increase between 2020 and 2030.

Total methane (CH_4) emissions have increased in Canada since 1990. Between 1990 and 2005, emissions increased by 21% due to increasing activity in the agriculture and oil and gas sectors. Between 2005 and 2015, this trend reversed, with emissions decreasing by 10%, mostly due to declines in emissions from the agriculture and waste and others sectors. Between 2015 and 2030, CH_4 emissions are projected to continue decreasing, reflecting a projected decrease of 41% in the oil and gas sector. Fugitive CH_4 emissions from conventional oil production are expected to decline as a result of proposed government regulations to reduce emissions in the oil and gas sector. The upstream oil and gas sector remains the largest industrial source of methane in Canada.

Nitrous oxide (N_2O) emissions, which decreased slightly between 1990 and 2005, also declined between 2005 and 2015 and are projected to remain constant between 2015 and 2030. N_2O emissions arise primarily from the agriculture sector.

Hydrofluorocarbons (HFCs) have been increasingly used in the last decade in refrigeration and air conditioning systems as an alternative to ozone damaging hydrochlorofluorocarbons (HCFCs). HCFCs are being phased out under the Montréal Protocol and an amendment to that agreement in 2016 added the phase down of the use and production of HFCs. As a result, emissions of HFCs are projected to peak in 2020 at 14.8 Mt of CO_2 eq before declining to 12.5 Mt of CO_2 eq in 2030.

Perfluorocarbons (PFCs), sulphur-hexafluoride (SF_6), and nitrogen trifluoride (NF_3) are projected to decrease substantially over the projection period. The main releases of these gases into the environment occur during the manufacture of semi-conductors, refrigeration equipment and the production of aluminium as well as other industrial processes such as in the magnesium industry. Reductions are anticipated from voluntary measures in the aluminum industry and other sectors.

Table 5.4 converts the above information into CO_2 eq with global warming potential values from the *Fourth Assessment Report* of the IPCC and provides emissions totals excluding Land Use, Land-Use Change and Forestry (LULUCF) emissions.

Table 5.4: Total Canadian Emissions Projections by Gas in CO_2 eq, Excluding LULUCF Emissions (Mt CO_2 eq) from 2005 to 2030

	HISTORICAL			PROJECTED		CHANGE 2005 TO 2030
GAS	2005	2010	2015	2020	2030	
CO_2	574	554	568	579	584	11
CH_4	110	100	100	96	86	-24
N_2O	41	37	39	38	39	-2
HFC	5	8	11	15	12	7
PFC	4	2	1	<1	<1	-4
SF_6	1	<1	<1	<1	<1	-1
NF_3	<1	<1	<1	<1	<1	<1
Total	**738**	**701**	**722**	**728**	**722**	**-16**

Note: Numbers may not sum to the total due to rounding.

Table 5.5: Total Canadian Emissions Projections by Gas, Excluding LULUCF Emissions (kilotonne (Kt)–natural form) from 1990 to 2030

	HISTORICAL						PROJECTED	
GAS	1990	1995	2000	2005	2010	2015	2020	2030
CO_2	463,000	496,000	570,000	574,000	554,000	568,000	579,000	584,000
CH_4	3,700	4,400	4,700	4,500	4,000	4,100	3,800	3,500
N_2O	140	150	130	140	130	130	130	130
HFC	1	0	2	4	5	8	10	9
PFC	1	1	1	1	<1	<1	<1	<1
SF_6	<1	<1	<1	<1	<1	<1	<1	<1
NF_3	<1	<1	<1	<1	<1	<1	<1	<1

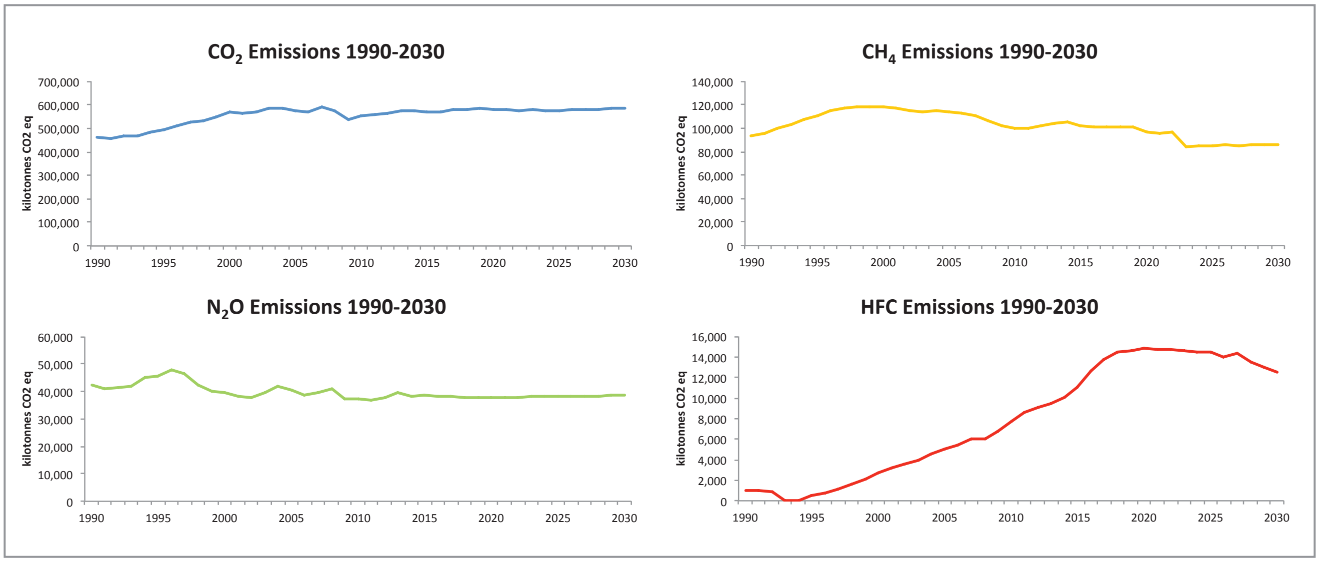


Figure 5.5: Total Canadian Emissions by Gas, 1990–2030: CO_2, CH_4, N_2O, HFC

5.3.6 Emissions Projections by Economic Sector

Table 5.6 illustrates how the projected trends in GHG emissions vary by economic sector. This is a result of the expected evolution of the key drivers of emissions in each sector, as well as various government and other initiatives. For example, in the transportation sector, growing economic activity in Canada affects the number of freight trucks on the road, thus emissions from the freight transportation subsector are projected to rise. However, offsetting this trend are the Government of Canada's Light-duty vehicles (LDV) GHG emissions standards for the LDV model years 2011 to 2025 which are causing the average emissions intensity for all on-road passenger vehicles to decline through the projection period. For the electricity sector, emissions are expected to fall, largely due to the combined impact of various government measures to create a cleaner electricity system, predominately by replacing coal-fired generation with lower-emitting natural gas and non-emitting sources.

Table 5.6: GHG emissions by Economic Sector (Mt CO_2 eq) from 2005 to 2030

SECTOR	HISTORICAL			PROJECTED		CHANGE 2005 TO 2030
	2005	2010	2015	2020	2030	
Oil and Gas	158	160	189	197	215	57
Electricity	117	96	79	71	46	-70
Transportation	163	171	173	168	155	-8
Heavy Industry	86	73	75	83	97	11
Buildings	85	81	86	88	83	-2
Agriculture	74	70	73	71	72	-3
Waste & Others	54	50	48	50	53	-2
Total	**738**	**701**	**722**	**728**	**722**	**-16**

Note: Numbers may not sum to the total due to rounding.

Table 5.7 provides a breakdown of projected trends in GHG emissions by IPCC sector.

Table 5.7: GHG emissions by IPCC Sector (Mt CO_2 eq) from 2005 to 2030

SECTOR	HISTORICAL			PROJECTED		CHANGE 2005 TO 2030
	2005	**2010**	**2015**	**2020**	**2030**	
Stationary Combustion and Fugitive Sources	400	372	385	388	382	-18
Transport	195	199	202	199	190	-5
Industrial Processes	54	48	51	57	64	10
Agriculture	61	56	59	57	58	-3
Waste	28	25	25	27	28	1
Total	**738**	**701**	**722**	**728**	**722**	**-16**

Note: Numbers may not sum to the total due to rounding.

5.3.6.1 Oil and Gas

Emissions in the oil and gas sector are related to the production, transmission, processing, refining and distribution of oil and gas products. In 2015, the oil and gas sector produced the largest share of GHG emissions in Canada (26%). Emissions increased by 50 Mt CO_2 eq over the 1990 to 2005 time period, primarily as a result of the development of the unconventional oil and gas industry.

Since 2005, GHG emissions from the oil and gas sector have increased as a result of growth in production due to higher oil prices and evolving technologies in oil sands operations, from 158 Mt in 2005 to 189 Mt in 2015—a

20% increase. Increased emissions from unconventional oil sands activity have been offset by the gradual depletion of conventional oil and natural gas resources in Canada and limited expansion of the refining sector. Government actions, such as recently published regulations on methane emissions in the upstream oil and gas sector, will also constrain increases in emissions over the projection period.

Table 5.8: Oil and Gas Sector Emissions (Mt CO_2 eq) from 2005 to 2030

	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
Natural Gas Production and Processing	57	49	56	50	45	-12
Conventional Oil Production	30	27	31	26	23	-8
Light Oil Production	12	11	14	9	10	-1
Heavy Oil Production	17	14	15	15	11	-6
Frontier Oil Production	2	2	2	2	2	0
Oil Sands[f]	35	53	71	89	115	80
Bitumen In Situ	11	20	34	42	65	54
Bitumen Mining	10	14	18	25	26	17
Bitumen Upgrading	14	19	19	21	23	10
Oil and Natural Gas Transmission	12	7	10	9	9	-3
Petroleum Products	22	22	21	22	22	-1
Natural Gas Distribution	1	1	1	1	1	0
Total	**158**	**160**	**189**	**197**	**215**	**57**

Note: Numbers may not sum to the total due to rounding.

Upstream Oil and Gas Production

Upstream oil and gas includes the extraction, production and processing of both conventional and unconventional oil and gas. This subsector represents approximately 85% of the oil and gas sector emissions in 2015 and this share is expected to increase to almost 90% by 2030 as oil sands extraction continues to grow.

Table 5.9: Upstream Oil and Natural Gas Production: Emissions and Drivers

	2005	2010	2015	2020	2030
Conventional Oil Production					
Emissions (Mt CO_2 eq)	30	27	31	26	23
Production (1,000 barrels/day)	1,360	1,227	1,264	1,207	1,400
Natural Gas Production and Processing					
Emissions (Mt CO_2 eq)	57	49	56	50	45
Production (1,000 barrels/day)	7,221	6,247	6,320	6,323	6,614
Oil Sands[g]					
Emissions (Mt CO_2 eq)	35	53	71	89	115
Production (1,000 barrels/day)	1,065	1,612	2,526	3,361	4,236

---

[f] Based on the Alberta Government's announcement, Alberta's 100 Mt cap on oil sands emissions excludes emissions from cogeneration of electricity and new upgrading. When taking these into account, total emissions from oil sands is 99 Mt in 2030 under the "with measures" scenario, below the 100 Mt cap.

[g] Based on the Alberta Government's announcement, Alberta's 100 Mt cap on oil sands emissions excludes emissions from cogeneration of electricity and new upgrading. When taking these into account, total emissions from oil sands is 99 Mt in 2030 under the "with measures" scenario, below the 100 Mt cap.

In general, extracting oil from oil sands via an *in situ* method (e.g., using in-ground techniques to separate the oil from the sand) is more emissions-intensive than oil sands mining. In the historical period within the oil sands sector, the overall emissions intensity has been decreasing over time, with increasingly energy efficient *in situ* operations and flat energy intensity in oil sands mining operations.

In the forecast, several factors could lead to increasing emissions intensity in the oil sands subsector, such as declining reservoir quality, aging of existing facilities, and shifts from mining operations to more emissions-intensive *in situ* extraction processes. On the other hand, clean technology deployment could lead to significant emissions intensity reductions in the subsector. Considering the uncertainties associated with these counterbalancing trends in oil sands emissions intensities, the projections keep the emissions intensities of new oil sands productions at the level of existing technologies.

Emission projections in the oil and gas sector are driven by the National Energy Board's (NEB) projections of oil and natural gas prices as well as the NEB's corresponding estimates of production.[h] Emissions from upstream oil and gas production are estimated to grow from 158 Mt CO_2 eq in 2015 to 183 Mt CO_2 eq in 2030. This increase is driven by the growth in bitumen production from the oil sands, where emissions are expected to increase from 71 Mt CO_2 eq in 2015 to 115 Mt by 2030.[i] Specifically, emissions from oil sands mining are projected to increase by 8 Mt CO_2 eq and *in situ* production are expected to increase by 31 Mt.

As part of the Pan-Canadian Framework, the Government of Canada reaffirmed its commitment to reduce methane emissions from the oil and gas sector by 40 to 45% from 2012 levels by 2025, building on provincial actions and targets. To achieve this goal, the Canadian government has published regulations which articulate control measures for methane emissions in the oil and gas sector. The regulations are expected to achieve 22 Mt CO_2 eq of reductions in 2030.

Emissions from conventional crude oil production are expected to fall from 31 Mt in 2015 to 23 Mt in 2030. Emissions from natural gas production and processing are also expected to decline from 56 Mt in 2015 to 45 Mt in 2030.

Consistent with the most recent NEB projections, this report does not include the construction of any liquefied natural gas production projects nor emissions from that sector over the projection period.

Transportation and Distribution of Oil and Gas

Emissions from the pipeline transportation of oil and gas and the local distribution of natural gas are expected to remain relatively flat throughout the projection period.

Petroleum Refining and Upgrading

Table 5.10 displays emissions associated with petroleum refining and upgrading from 2005 to 2030. Emissions from traditional petroleum refining are expected to remain relatively unchanged throughout the projection period. Emissions associated with the upgrading of oil sands bitumen are expected to slightly increase from 19 Mt CO_2 eq in 2015 to 23 Mt by 2030, largely driven by additional capacity in Western Canada.[j]

---

[h] Oil and gas production projections used in preparation of this report are slightly different from the ones published in NEB Energy Future 2017. These projections have been also developed by NEB, but assumption about Canada-wide carbon price of $50 has been removed from the "with measures" scenario, thus leading to slightly higher production numbers than the ones that were published in NEB Energy Futures 2017.

[i] Based on the Alberta Government's announcement, Alberta's 100 Mt cap on oil sands emissions excludes emissions from cogeneration of electricity and new upgrading. When taking these into account, total emissions from oil sands is 99 Mt in 2030 under the "with measures" scenario, below the 100 Mt cap.

[j] The increase in refining sector's emissions between 2015 and 2020 is associated with the new Sturgeon facility in Edmonton, Alberta. This facility is reported under the refining sector as it will be producing refined petroleum products, even though it will be processing bitumen. The facility is expected to be equipped with a carbon capture technology.

Table 5.10: Petroleum Refining and Upgrading Sector Emissions and Drivers

	2005	2010	2015	2020	2030
Traditional Refineries					
Emissions (Mt CO_2 eq)	22	22	21	22	22
Refined Petroleum Processed (1,000 barrels/day)	2,021	1,984	1,861	1,911	1,911
Upgraders					
Emissions (Mt CO_2 eq)	14	19	19	21	23
Refined Petroleum Processed (1,000 barrels/day)	611	849	1,058	1,298	1,415

5.3.6.2 Transportation

In 2015, transportation (including passenger, freight, and residential and commercial off-road emissions) was the largest contributor to Canada's GHG emissions, representing 24% of overall GHGs.

Between 1990 and 2005, emissions in the transportation sector increased 34%, from 122 Mt CO_2 eq in 1990 to 163 Mt in 2005. This was driven by a strong period of economic growth and low oil prices from 1990 to 1999 that influenced the fleet composition and its use (e.g., from cars to light-duty trucks).

Since 2005, transportation emissions have continued rising, representing 173 Mt in 2015. The increasing fuel efficiency of light-duty vehicles has offset the effects of an increased population putting more vehicles on the road and resulting in more kilometres (km) driven. For example, between 2005 and 2015, the sales-weighted on-road fuel efficiency for new gasoline cars improved from 9.2 litres (L) per 100 km to 8.1 L/100 km, while the sales-weighted on-road fuel efficiency for new gasoline light trucks improved from 13.2 L/100 km to 11.1 L/100 km.

Total transportation emissions increased from 163 Mt CO_2 eq in 2005 to 173 Mt by 2015, but are projected to drop to 155 Mt in 2030, a marked decline of emissions in the sector due to the projected increased fuel-efficiency of on-road vehicles. This change from historical trends is being driven by the federal LDV regulations, despite projected increases in population and number of vehicles. Emissions are projected to decrease by 13 Mt between 2020 and 2030 as the stock of existing vehicles is gradually overturned with more efficient gasoline and diesel vehicles as well as the increasing share of zero emission vehicles (ZEV). The federal heavy-duty vehicles (HDV) GHG emissions standards parts 1 and 2 will also contribute to increased fuel-efficiency of on road freight vehicles, though emissions will continue to rise in that sub sector driven by an expanding economy.

In October 2010, the Government of Canada released the Light-duty vehicles (LDV-1) GHG emissions standards, which prescribe progressively more stringent annual emission standards for new vehicles of model years 2011 to 2016. In September 2014, the Government released the Light-duty vehicles 2 (LDV-2) GHG emissions standards for model years 2017 to 2025.

These regulations will achieve significant and sustained GHG reductions and fuel-savings benefits. By 2020, it is estimated that Canadian regulations for model years 2011 to 2016 will lead to annual reductions of between 9 and 10 Mt. For model years 2017 to 2025, the regulations will reduce GHG emissions by an additional 3 Mt in 2020, increasing to 24 Mt by 2030, as these new efficient vehicles replace the existing stock.

Under both phases of LDV regulations spanning model years 2011 to 2025, the fuel efficiency of new cars will increase by 41%, as compared to model year 2010 (and 50% compared to the 2008 model year), and the fuel efficiency of new passenger light trucks will increase by 37%. The sales-weighted fuel efficiency of new cars is projected to improve from 8.6 L/100 km in 2010 to 6.4 L/100 km in 2020, and to 5.1 L/100 km by 2025.

The sales-weighted fuel efficiency of new passenger light trucks are projected to improve from 12.0 L/100 km in 2010 to 9.1 L/100 km in 2020, and to 7.6 L/100 km by 2025. In addition, the LDV regulations are driving the shift away from the use of HFCs in mobile air conditioners, resulting in a significant decrease in emissions of this gas with high global warming potential. See Table 5.24 for trends in HFC emissions.

As depicted in Table 5.11, the transportation sector comprises several distinct subsectors: passenger, freight, air and others (e.g., rail and marine). Each subsector exhibits different trends during the projection period. For example, emissions from passenger transportation are projected to decrease by 24 Mt CO_2 eq between 2005 and 2030, while those for ground freight, off-road and other vehicles are projected to grow by 18 Mt over the same time period. Note that although absolute emissions are projected to grow in the freight subsector, emissions are expected to decrease relative to business-as-usual levels as a result of various federal, provincial and territorial programs.

Table 5.11: Transportation: Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
Passenger Transport	93	92	91	84	69	-24
Cars, Trucks and Motorcycles	85	85	83	76	61	-25
Bus, Rail and Domestic Aviation	7	7	7	8	8	1
Freight Transport	64	73	76	78	79	15
Heavy Duty Trucks, Rail	56	65	71	72	74	18
Domestic Aviation and Marine	8	8	5	5	5	-3
Other: Recreational, Commercial and Residential	7	7	6	7	8	1
Total	**163**	**171**	**173**	**168**	**155**	**-8**

Note: Numbers may not sum to the total due to rounding.

5.3.6.3 Electricity Generation

As about 80% of the utility electricity supply in Canada is generated from non-GHG emitting sources, the electricity sector comprised only 11% of total Canadian GHG emissions in 2015. Since 2005, electricity sector emissions have fallen an average of 4% per year, the fastest of any sector in Canada. The mix of sources of energy used to generate power vary considerably across the country, depending on regional features such as the availability of natural resources such as hydropower, transmission interconnections to other provinces and the United States, and access to natural gas. Several provinces rely almost exclusively on hydropower at present due to abundant hydro resources, while other jurisdictions have highly diversified mixes of power that combine non-emitting power from renewables and nuclear with fossil fuel generation. A few rely primarily on fossil fuels such as refined petroleum products, natural gas, and coal.

Over the 1990 to 2005 period demand for electricity rose considerably, and this increase in demand was met with varying sources of power. Emissions from the electricity sector increased over this time period as some provinces expanded their capacity by building fossil fuel-fired power plants or by increasing the utilization rate of existing coal units in place of nuclear plants, as was done in the province of Ontario. In addition, other provinces increased their natural gas and refined petroleum product-fired generation to meet growing demand.

Post-2005, emissions in this sector fell significantly as coal-fired units were closed and more lower and non-emitting sources were brought online to replace coal. Provinces continued to replace some higher-emitting coal and diesel generation with lower-emitting natural gas generation, but also a significant increase in non-hydro renewable generation was observed over the same time period. Wind generation increased from

0.3% of total generation in 2005 to 4.7% by 2015, an average growth rate of over 30% per year, while solar generation has increased nearly 60% per year during the same period. Together, wind, solar, and biomass sources of generation accounted for 5.7% of utility electricity generation in 2015, up from 0.9% in 2005. In particular, Ontario's coal-fired generation phase-out was completed in 2014, with replacement generation coming primarily from non-GHG-emitting sources such as wind, nuclear, solar, and biomass.

Several Canadian provinces have achieved nearly 100% non-emitting grids by 2015, and their electricity supply is expected to remain non-emitting throughout the forecast. Québec, Manitoba and British Columbia generate 97 to 100% of electricity from hydro and other renewables and are expected to continue to develop new renewable resources in the future, maintaining emitting resources only for remote or back-up needs. Prince Edward Island has reduced thermal generation to near zero, with 98% of on-island generation coming from its ample wind resources. The Yukon has also substantially reduced its reliance on diesel and now generates 94% of electricity from renewable sources.

Finally, growing use of on-site cogeneration to meet industrial electricity and steam demands, particularly in the Alberta oil and gas sector, reduced utility demands and further reduced electricity sector emissions. Cogeneration is the simultaneous generation of electricity and heat or steam that can be then used in industrial processes such as *in situ* oil sands extraction. As a result of increasing use of cogeneration, emissions for electricity production are shifted from the utility electricity sector to the oil and gas sector. However, the combined production of power and heat is more efficient than their separate production due to the capturing of waste heat and steam from combustion for useful work that would otherwise need to be produced separately. As a result, the economy-wide impact of shifting from utility natural gas-fired electricity generation (or other fossil fuel sources) to industrial cogeneration using natural gas in general results in a reduction in GHG emissions. In the particular context of Alberta's coal-based electricity grid, these reductions can be substantial.

The recent downward trend in emissions from the electricity sector is expected to continue over the next decade as a result of various federal and provincial governmental initiatives. Emissions in the electricity sector fell by 38 Mt CO_2 eq from 2005 to 2015 and are projected to further decrease 32 Mt by 2030, for a total decrease of 70 Mt over the period while total generation increased. Table 5.12 outlines the decline in projected emissions alongside the expected increase in electricity generation from 2005 through 2030.

Table 5.12: Utility Electricity Sector: Emissions and Drivers

SECTOR	2005	2010	2015	2020	2030
Emissions (Mt CO_2 eq)	117	96	79	71	46
Generation (Terawatt Hours)	551	539	580	588	587

Continued use of on-site industrial cogeneration and an overall decrease in net electricity exports as major exporting provinces use increasingly more electricity domestically are projected to keep utility electricity generation growth low even as electricity demand grows. Furthermore, while population and the economy continue to grow in the forecast, residential and commercial electricity demands remain flat or decline due to improvements in energy efficiency; the majority of increased demand for electricity in the forecast is from industrial and manufacturing sectors. The modest increase in electricity generation expected through 2030 will be supplied by various fuel sources. Although coal usage for electricity generation is declining, the proportion of power generation from fossil fuels is expected to vary by province and territory depending on the availability of electricity from hydro, nuclear power, and non-hydro renewable energy sources such as wind.[k]

The proportion of utility electricity generation coming from renewable sources is projected to increase between 2005 and 2030. Hydropower generation is expected to increase in most Canadian provinces and territories, both through large dam construction and small hydro projects, bringing hydropower from 59% to 63% of utility electricity generated in Canada. Non-hydro renewables such as wind, solar, biomass and waste generation are expected to continue to grow at about 4% per year between 2015 and 2030 and are projected to account for nearly 10% of total generation by 2030. Nuclear power, however, is expected to decline by 23% over the same time frame, as Ontario reduces its nuclear capacity between 2020 and 2030 with the retirement of several ageing units.

Coal generation is expected to fall by 60% between 2015 and 2030 as coal units continue to retire or reduce production in Alberta, Saskatchewan, and Nova Scotia. Natural gas generation is expected to increase to replace coal and nuclear generation, as well as to support increasing use of intermittent sources of generation such as wind.

Federal regulations to reduce CO_2 emissions from coal-fired electricity came into effect on July 1, 2015. The regulations apply a stringent performance standard to new coal-fired electricity generation units and those coal-fired units that have reached the end of their economic life. The regulations will facilitate a permanent transition towards lower or non-emitting types of generation such as high-efficiency natural gas and renewable energy. With this regulation, Canada became the first major coal user to ban construction of traditional coal-fired electricity generation units.

The Government of Canada announced its intention to amend these regulations to accelerate action and phase out traditional coal-fired electricity generation by December 31, 2029. Draft amendments are targeted for publication in early January 2018, with final amendments targeted for publication by December 2018. The reductions from this amendment are not included in the Reference Case but are instead reflected in the "with additional measures" scenario, given the timeline of publication for the draft amendments.

In addition, several provinces have introduced significant measures to move away from fossil fuel electricity generation and towards cleaner sources of power that contribute to the decline in emissions in the electricity sector. Nova Scotia aims to decrease emissions in its electricity sector through a declining cap on emissions and a renewable portfolio standard that will require 40% of electricity sales to come from renewable sources by 2020. Alberta will phase out traditional coal-fired generation by the end of 2030, and has introduced complementary plans to achieve 30% renewable capacity over the same time frame. Newfoundland and Labrador is constructing a new large hydro dam and an underwater transmission link between Labrador and Newfoundland Island to replace ageing, high-emitting heavy fuel oil generation on the Island with renewable power.

At a national level, emissions from coal-fired generation are projected to decline by 73 Mt over the 2005 to 2030 time period, and emissions from refined petroleum products such as diesel and fuel oils are expected to fall by 8 Mt. Emissions from natural gas are expected to increase by 11 Mt over the period in this sector, as natural gas replaces coal in some provinces, helps meet growing electricity demand, and supports the integration of higher levels of intermittent renewables.

---

[k] See Annex Table 5A.7 Electricity Supply and Demand.

Table 5.13: Utility Electricity Sector Emissions by Fuel Type (Mt CO_2 eq) from 2005 to 2030

FUEL	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
Coal	95	78	61	52	22	-73
Refined Petroleum Products[a]	11	5	5	5	3	-8
Natural Gas	10	14	13	14	21	11
Biomass	<1	<1	<1	<1	<1	0
Total	**117**	**96**	**79**	**71**	**46**	**-70**

Note: Numbers may not sum to the total due to rounding.

[a] These estimates do not include the Government's recent announcement on its intent to amend the existing federal regulations to accelerate action and phase out traditional coal-fired electricity generation by December 31, 2029. The reductions from this amendment are instead reflected in the "with additional measures" scenario.

5.3.6.4 Heavy Industry

The heavy industry sector includes metal and non-metal mining activities, smelting and refining, and the production and processing of industrial goods such as chemicals, fertilizers, aluminum, pulp and paper, iron and steel and cement.

Emissions from the heavy industry sector were responsible for 16% of total Canadian emissions in 1990, and fell to 12% in 2005. The decline (11 Mt CO_2 eq) reflects technological changes such as improved emission control technologies for perfluorocarbons (PFCs) within the aluminum industry, and the closure of the adipic acid plant in Ontario. Energy efficiency measures, replacement of raw materials with recycled materials, and use of fuels such as biomass and waste in production processes were also responsible for the GHG reductions over time.

Emissions from the heavy industry sector decreased by 11 Mt between 2005 and 2015, but are projected to increase by 22 Mt between 2015 and 2030 due to increased production in some subsectors. Emissions are estimated to have been at their lowest point in 2009 following a decline in pulp and paper, iron and steel, and smelting and refining output, but then recovered somewhat with increased chemical and fertilizer production.

Table 5.14: Heavy Industry: Emissions and Drivers

MT CO_2 EQUIVALENT	2005	2010	2015	2020	2030
Emissions (Mt CO_2 eq)	86	73	75	83	97
Gross Output of Heavy Industry (1997 $billions)	3,251	3,543	4,073	4,582	5,815

On average, emissions generated by heavy industry subsectors are projected to be 4% less than 2005 levels by 2020, owing to modest production growth in the recovery years of the economic downturn, and continued reduction of emissions intensities. Exceptions include decreased emissions in pulp and paper, and increasing emissions from mining, chemicals and fertilizers as several new plants are expected to be built.

Over the 2020 to 2030 timeframe a number of subsectors are projected to increase. For example, emissions from the iron and steel subsector are projected to rise by 27%. Cement emissions are projected to increase by 27% over the period, while emissions from mining increase by 22%.This reflects expected increases in production while the energy efficiency of the subsectors increase more slowly.

Table 5.15: Heavy Industries' Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

SECTOR	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
Mining	7	8	8	9	11	5
Smelting and Refining (Non-ferrous metals)	14	11	10	11	12	-2
Pulp and Paper	9	7	6	6	5	-4
Iron and Steel	16	14	14	15	19	2
Cement	13	10	10	11	14	1
Lime and Gypsum	3	3	2	3	3	0
Chemicals and Fertilizers	23	21	25	28	33	9
Total	**86**	**73**	**75**	**83**	**97**	**11**

Note: Numbers may not sum to the total due to rounding.

5.3.6.5 Buildings

Emissions in Canada's commercial and residential buildings increased by 12 Mt CO_2 eq between 1990 and 2005, and then remained relatively stable around the 2005 levels through to 2015. From 1990 to 2015, buildings have accounted for about 12% of Canada's GHG emissions in any given year. Despite a growing population and increased housing stock and commercial/institutional building stock, projected energy efficiency improvements help to keep emissions stable post-2015.

Emissions from commercial and residential buildings are projected to decline by 2% over the 2015 to 2030 time frame (excluding indirect emissions from electricity).

Residential

As shown in Table 5.16, GHG emissions from the residential buildings (e.g., houses, apartments and other dwellings) declined by 1 Mt CO_2 eq between 2005 and 2015, and are projected to decline by a further 3 Mt (or 5%) between 2015 and 2030. This is despite an expected 19% increase (or 2.6 million) of the number of Canadian households (a key driver of residential emissions growth) between 2015 and 2030. This highlights the decreasing emissions intensities in the average dwelling due to increasing energy costs being managed with better technologies and practices. In addition, federal and provincial measures aimed at increasing the energy efficiency of residential buildings, such as building code regulations, rebates for energy efficiency improvements and voluntary housing energy efficiency standards are helping to improve efficiencies in this subsector over time.

Table 5.16: Residential Subsector: Emissions and Drivers

	2005	2010	2015	2020	2030
Emissions (Mt CO_2 eq)	46	43	45	44	42
Households (millions)	12.1	13.0	13.9	14.9	16.5
Tonnes per household	3.79	3.32	3.19	2.96	2.55

Commercial

GHG emissions from Canada's commercial buildings increased by 1 Mt between 2005 and 2015, and are expected to be at that level in 2030 (Table 5.17). Emissions in the commercial subsector remained stable between 2005 and 2015 while floor space continued to increase due, in part, to strengthening of building energy codes, an increased commitment to benchmark energy use and undertaking of energy-related retrofits. Emissions are expected to decline despite an expansion of commercial floor space (the principal driver of emissions from this subsector) as the economy continues to grow. This is a result of continued efficiency improvements and the phase down of and bulk import ban on HFCs used in refrigeration and air conditioning. As HFCs have an average global warming potential that is up to 1900 times more potent than CO_2, decreasing HFC consumption has a significant impact on emissions. Between 2015 and 2030, emissions are projected to stay constant, while floor space increases by 15%.

Table 5.17: Commercial Subsector: Emissions and Drivers

	2005	2010	2015	2020	2030
Emissions (Mt CO_2 eq)	40	38	41	43	41
Floor space (millions m^2)	654	714	749	776	863

5.3.6.6 Agriculture

GHG emissions from primary agriculture in Canada consist mainly of methane and nitrous oxide from livestock and crop production systems as well as emissions from on-farm fuel use. Emissions have remained stable over the 2005 to 2015 period at approximately 73 Mt, following an increase of 14 Mt from 1990 to 2005. Since 1990, emissions from the sector have remained stable at about 10% of Canada's total emissions. Emissions and removals (sequestration) of carbon from land management and land-use change associated with agricultural lands would be accounted for separately in the LULUCF sector.

While emissions remain stable over the 2005 to 2030 period, there are a number of compositional trends in the sector. Between 2005 and 2015, increases in crop production were offset by decreases in animal production. In the projection, however, emissions from both crop production and livestock are expected to remain stable. Agriculture emissions are projected to be 72 Mt in 2030, 1 Mt less than the 2015 levels.

Table 5.18: Agriculture Sector Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

SECTOR	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
On-Farm Fuel Use	14	14	14	14	14	0
Crop Production	16	19	22	21	21	5
Animal Production	45	37	37	36	37	-8
Total	**74**	**70**	**73**	**71**	**72**	**-3**

Note: Numbers may not sum to the total due to rounding.

5.3.6.7 Waste and Others

Emissions from waste management and other non-emissions-intensive industrial sectors such as electric and transport equipment manufacturing, remained relatively stable between 1990 and 2005. From 2005 to 2015, GHG emissions from municipal solid waste landfills declined, with the help of provincial government measures aimed at capturing landfill gas as well as solid waste diversion. Between 2015 and 2030, emissions are expected to grow, driven by projected population growth.

Non-emissions-intensive industrial subsectors included in the waste and others sector represent a wide variety of operations, and include light manufacturing (e.g., food and beverage, and electronics), construction and the forestry and logging service industry. Emissions from these various subsectors are projected to increase slightly over the 2015 to 2030 timeframe driven by projected growth in these economic activities, but will remain lower than 2005 levels.

Table 5.19: Waste and Others Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

SECTOR	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
Waste	28	25	25	27	28	1
Coal Production	2	3	2	2	2	-1
Light Manufacturing, Construction & Forest Resources	24	22	21	22	23	-2
Total	**54**	**50**	**48**	**50**	**53**	**-2**

Note: Numbers may not sum to the total due to rounding.

5.3.6.8 Land Use, Land-use Change and Forestry

A unique challenge in both projecting and accounting for emissions and removals in Canada's managed forest is the fact that natural disturbances result in significant variations in annual forest emission and removal estimates. As well, natural disturbances generally cannot be predicted. Canada's Nationally Determined Contribution, released in May 2017, notes that Canada is examining its approach to accounting in the LULUCF sector towards its 2030 emission reduction target. It also indicates that Canada will exclude the impacts of natural disturbances and use the IPCC production approach to account for harvested wood products. This applies to Canada's 2020 emission reduction target as well.

The historical estimates for LULUCF from 1990–2015 found in Canada's 2017 *National Inventory Report* (NIR) exclude for the first time the impacts of significant natural disturbances in the managed forest that occurred in the historical period (see Chapter 6 of the NIR). As noted in the 2017 NIR, work continues to refine LULUCF estimates that focus on anthropogenic emissions and removals as a basis for improved reporting and accounting for LULUCF. As this work is still underway, Canada has not shown LULUCF projections and accounting contributions.

5.3.6.9 Foreign Passenger and Foreign Freight

Emissions from Foreign Passenger and Foreign Freight sectors are not included in the national total consistent with UNFCCC reporting guidelines.

Emissions from the Foreign Passenger and Foreign Freight sectors comprise total Canadian fuel sold to foreign registered watercraft and aircraft. Emissions declined by 1 Mt between 2005 and 2015, and are expected to increase 14% between 2015 and 2030 as the number of foreign transportation vehicles and number of kilometers traveled increases.

Table 5.20: Fuel Sold to Ships Emissions by Subsector (Mt CO_2 eq) from 2005 to 2030

SECTOR	2005	2010	2015	2020	2030
Foreign Freight	5	4	2	2	2
Foreign Passenger	8	8	10	11	12

5.3.7 Detailed Emissions Projections by Gas and by Economic Sector

The following tables summarize total GHG projections by sector and by gas under the "with current measures scenario" and illustrate how the projected trends vary by gas and by economic sector.

Table 5.21: CO_2 Emissions Projections by Economic Sector (kt CO_2 eq)

	HISTORICAL						PROJECTED	
SECTOR	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2030**
Oil and Gas	70,000	83,000	102,000	109,000	117,000	143,000	157,000	187,000
Electricity	92,000	96,000	125,000	115,000	95,000	78,000	70,000	46,000
Transportation	115,000	119,000	137,000	154,000	163,000	165,000	161,000	151,000
Heavy Industry	79,000	83,000	87,000	80,000	71,000	72,000	80,000	95,000
Buildings	67,000	72,000	77,000	78,000	72,000	74,000	73,000	69,000
Agriculture	12,000	15,000	15,000	14,000	14,000	15,000	15,000	15,000
Waste & Others	29,000	28,000	27,000	24,000	23,000	21,000	22,000	23,000
Total	**463,000**	**496,000**	**570,000**	**574,000**	**554,000**	**568,000**	**579,000**	**584,000**

Note: Numbers may not sum to the total due to rounding.

Table 5.22: CH_4 Emissions Projections by Economic Sector (kt CO_2 eq)

	HISTORICAL						PROJECTED	
SECTOR	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2030**
Oil and Gas	36,000	49,000	55,000	47,000	42,000	45,000	39,000	27,000
Electricity	0	100	100	100	100	200	100	200
Transportation	600	600	500	400	400	400	400	400
Heavy Industry	200	200	200	100	100	100	100	200
Buildings	4,600	4,500	4,000	3,000	3,200	3,200	3,000	2,800
Agriculture	26,000	31,000	32,000	36,000	30,000	29,000	28,000	29,000
Waste & Others	25,000	25,000	26,000	27,000	25,000	24,000	26,000	27,000
Total	**94,000**	**111,000**	**118,000**	**114,000**	**100,000**	**102,000**	**96,000**	**86,000**

Note: Numbers may not sum to the total due to rounding.

Table 5.23: N_2O Emissions Projections by Economic Sector (kt CO_2 eq)

	HISTORICAL						PROJECTED	
SECTOR	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2030**
Oil and Gas	500	600	800	800	1,000	1,100	1,300	1,500
Electricity	500	600	700	700	600	500	500	400
Transportation	4,500	5,600	6,500	6,300	4,700	3,600	3,700	3,700
Heavy Industry	12,000	12,100	2,900	4,500	1,800	1,900	1,300	1,600
Buildings	1,100	1,200	1,400	1,200	1,100	1,100	1,100	1,100
Agriculture	22,000	24,000	25,000	25,000	26,000	29,000	28,000	28,000
Waste & Others	1 900	2,000	2,100	2,100	2,100	2,100	2,200	2 ,400
Total	**42,000**	**46,000**	**40,000**	**41,000**	**37,000**	**39,000**	**38,000**	**39,000**

Note: Numbers may not sum to the total due to rounding.

Table 5.24: HFC Emissions Projections by Economic Sector (kt CO_2 eq)

	HISTORICAL						PROJECTED	
SECTOR	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2030**
Oil and Gas	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0
Transportation	0	100	1,100	1,900	2,600	3,200	2,900	700
Heavy Industry	1,000	0	0	0	500	600	600	400
Buildings	0	300	1,500	2,800	4,400	6,800	10,900	11,100
Agriculture	0	0	0	0	0	0	0	0
Waste & Others	0	0	100	400	300	400	400	300
Total	**1,000**	**500**	**2,800**	**5,100**	**7,800**	**11,000**	**14,800**	**12,500**

Note: Numbers may not sum to the total due to rounding.

Table 5.25: PFC Emissions Projections by Economic Sector (kt CO_2 eq)

	HISTORICAL						PROJECTED	
SECTOR	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2030**
Oil and Gas	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0	0
Heavy Industry	0	0	0	0	0	900	300	300
Buildings	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0
Waste & Others	7,600	6,300	5,000	3,800	1,900	100	20	20
Total	**7,600**	**6,300**	**5,000**	**3,800**	**1,900**	**1,000**	**300**	**300**

Note: Numbers may not sum to the total due to rounding.

Table 5.26: SF_6 Emissions Projections by Economic Sector (kt CO_2 eq)

	HISTORICAL						PROJECTED	
SECTOR	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2030**
Oil and Gas	0	0	0	0	0	0	0	0
Electricity	200	200	200	200	200	200	100	100
Transportation	0	0	0	0	0	0	0	0
Heavy Industry	3,000	2,100	2,700	1,200	200	200	10	10
Buildings	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0
Waste & Others	0	0	0	0	0	0	0	0
Total	**3,200**	**2,300**	**2,900**	**1,400**	**400**	**400**	**100**	**100**

Note: Numbers may not sum to the total due to rounding.

---

[m] While reported at the Provincial/Territorial level in Canada's GHG Emissions Reference Case, emissions associated with ammonia production as well as with the consumption of PFCs and SF_6 (except for electric utilities) are only reported at the national level in Canada's NIR. As such differences in emissions totals may occur, if these totals are calculated by summing up provincial values.

[n] Although provincial and territorial governments have announced a diverse range of measures, only measures that could be readily modeled or have an announced regulatory or budgetary dimension were modeled. Aspirational goals and targets that were not supported by measurable, real and verifiable actions were not included in the projections. The policies and measures modeled in this section are listed in Table 5A.9 in Annex 1 of this chapter and several are described in more detail in Chapter 4: Policies and Measures.

5.4 Emissions by Province[m]

Emissions vary considerably by province, driven by diversity in population size, economic activities and resource base, among other factors. For example, provinces where the economy is oriented more toward resource extraction will tend to have higher emissions levels whereas more manufacturing or service-based economies tend to have lower emissions levels. Electricity generation sources also vary, with provinces that rely on fossil fuels for their electricity generation having higher emissions than provinces that rely more on hydroelectricity. Table 5.27 displays projected provincial and territorial GHG emissions from 2005 to 2030. The projected emissions reflect a diversity of economic factors and government measures to reduce GHG emissions. These include energy efficiency and renewable electricity programs, carbon taxes or levies (i.e., British Columbia, Alberta, Ontario, and Québec), regulatory measures, and legislated renewable electricity targets.[n]

Table 5.27: Provincial and Territorial GHG Emissions (Mt CO_2 eq) from 2005 to 2030

AREA	2005	2010	2015	2020	2030	CHANGE 2005 TO 2030
Newfoundland	10	10	10	12	10	-1
Prince Edward Island	2	2	2	2	2	0
Nova Scotia	23	20	16	15	13	-11
New Brunswick	20	19	14	14	14	-7
Québec	89	82	80	81	79	-10
Ontario	204	175	166	167	165	-39
Manitoba	21	20	21	21	21	0
Saskatchewan	70	70	75	74	70	0
Alberta	233	241	274	278	287	54
British Columbia	64	59	61	59	58	-6
Territories	3	2	2	4	4	2
Canada	738	701	722	728	722	-16

Note: Numbers may not sum to the total due to rounding.

Accounting for Purchasing of International Credits under the WCI Cap-and-Trade Program

The values in Table 5.27 represent domestic emissions. As such, they do not include potential allowances purchased internationally under the Western Climate Initiative (WCI) cap-and-trade program. Ontario and Québec have legislated GHG emissions targets for 2020 and 2030. Both provinces have regulated emissions caps to achieve their 2020 targets, Ontario's target being 15% below 1990 levels and Québec being 20% (representing, as of the 2015 Canadian inventory, 154 Mt and 71 Mt, respectively). In addition, both provinces have 2030 targets, Ontario's being 37% below 1990 levels and Québec's being 37.5% (representing 114 Mt and 56 Mt respectively). The provinces will use a combination of new domestic policies and international allowances acquired from California (also part of the WCI) to meet their legislated targets. The impact of Ontario and Québec's acquisition of international allowances will be additional to reductions shown in Table 5.27, and have been included in the additional measures described in Section 5.5 and in Table 5.28.

5.5 Assessment of Aggregate Effect of Policies and Measures

5.5.1 With Measures and With Additional Measures Scenarios

Under the Paris Agreement, Canada has formally committed to achieving an economy-wide target to reduce GHG emissions by 30% below 2005 levels by 2030, and under the Copenhagen Accord Canada committed to reducing GHG emissions by 17% below 2005 levels by 2020. The federal, provincial and territorial governments established the Pan-Canadian Framework to take action on climate change.

Since the submission of Canada's BR2 a number of policies and measures have been implemented, which have resulted in significantly lower emissions projections under the “with measures” scenario. Whereas in the BR2 emissions were projected to increase to 815 Mt by 2030 (or 9% above 2005 levels), they are now projected to decline to 722 Mt (or 2% below 2005 levels) under this scenario.

Under the Pan-Canadian Framework a large number of policies and measures have been announced, some of which are already reflected in the “with measures” scenario, while some policies are still under development. When taking into consideration all climate change policies and measures that have been announced in Canada and for which enough information is available, Canada’s emissions are projected to be 583 Mt in 2030, a 232 Mt decline from projections included in the BR2.

This decline, equivalent to approximately a third of Canada’s emissions in 2015, encompasses all economic sectors, consistent with the Pan-Canadian Framework.

Three of the major policies included in the “with additional measures” scenario are described below.

Pricing Carbon Pollution

The Government of Canada has outlined a benchmark for pricing carbon pollution that will build on existing provincial systems and require a minimum price of $10 per tonne is in place across Canada by 2018, rising to $50 per tonne by 2022. Provinces and territories will continue to have the flexibility to implement either an explicit price on carbon (e.g., through a carbon tax) or a cap-and-trade system and will retain all revenue generated by carbon pricing.

A number of provinces have already implemented carbon pricing policies and these are reflected in the “with measures” scenario; over 80% of Canadians currently live in a jurisdiction with a carbon price. Ontario and Québec have joined California in the Western Climate Initiative, and have implemented cap and trade regulations. British Columbia has recently announced an increase in its carbon tax from $30/t to $50/t by 2021 (increasing in $5 increments each year), and Alberta is transitioning from the Specified Gas Emitters Regulation to a carbon levy ($30/t) and output based allocation system.

The additional measures scenario assumes that federal backstop carbon pricing policy is implemented in provinces other than Ontario, Québec, British Columbia and Alberta, and an increase in carbon price to $40/t in 2021 and $50/t by 2022 in Alberta.

Reducing CO_2 emissions from coal-fired generation of electricity

Projections for the “with measures” scenario include the regulation to phase out coal-fired electricity at the end of the economic life of the facilities, with a number of coal-fired facilities continuing to operate in the post-2030 period. With the adoption of the Pan-Canadian Framework, Canada is moving forward to accelerate the phase-out of traditional coal units across the country by 2030.

Clean Fuel Standard

The Clean Fuel Standard will be a modern, flexible, performance-based approach that will encourage the use of a broad range of lower carbon fuels, alternative energy sources and technologies, such as electricity, hydrogen, and renewable fuels, including renewable natural gas. It would address a broad suite of fuels, including gaseous, solid and liquid fuels, and would go beyond transportation fuels to include those used in industry, homes and buildings. The objective of the Clean Fuel Standard is to achieve 30 Mt of annual reductions in GHG emissions by 2030.

Other Complementary Measures Included

Other complementary measures included in the “with additional measures” scenario include actions across all sectors:

- retrofit building codes for existing buildings, net-zero ready building codes for new buildings, as well as more stringent standards for equipment and appliances in the buildings sector;

- measures in the transportation sector targeting off-road vehicles, zero emissions vehicles strategy and further extension of the light duty vehicle standards for the vehicles of the post-2025 model years;
- a policy in the industrial sector to accelerate the adoption of the industrial energy management systems;
- improving electricity transmission system by building strategic interconnections, making investments into emerging renewables and smart grid, and reducing reliance on diesel in northern, remote and indigenous communities;
- and other policies.

A complete list of modeled measures included in the scenario is provided in Annex 1. Also reflected in the "with additional measures" scenario are the purchases of international allowances by Ontario and Québec under the WCI that will allow them to achieve their respective 2030 legislated targets.

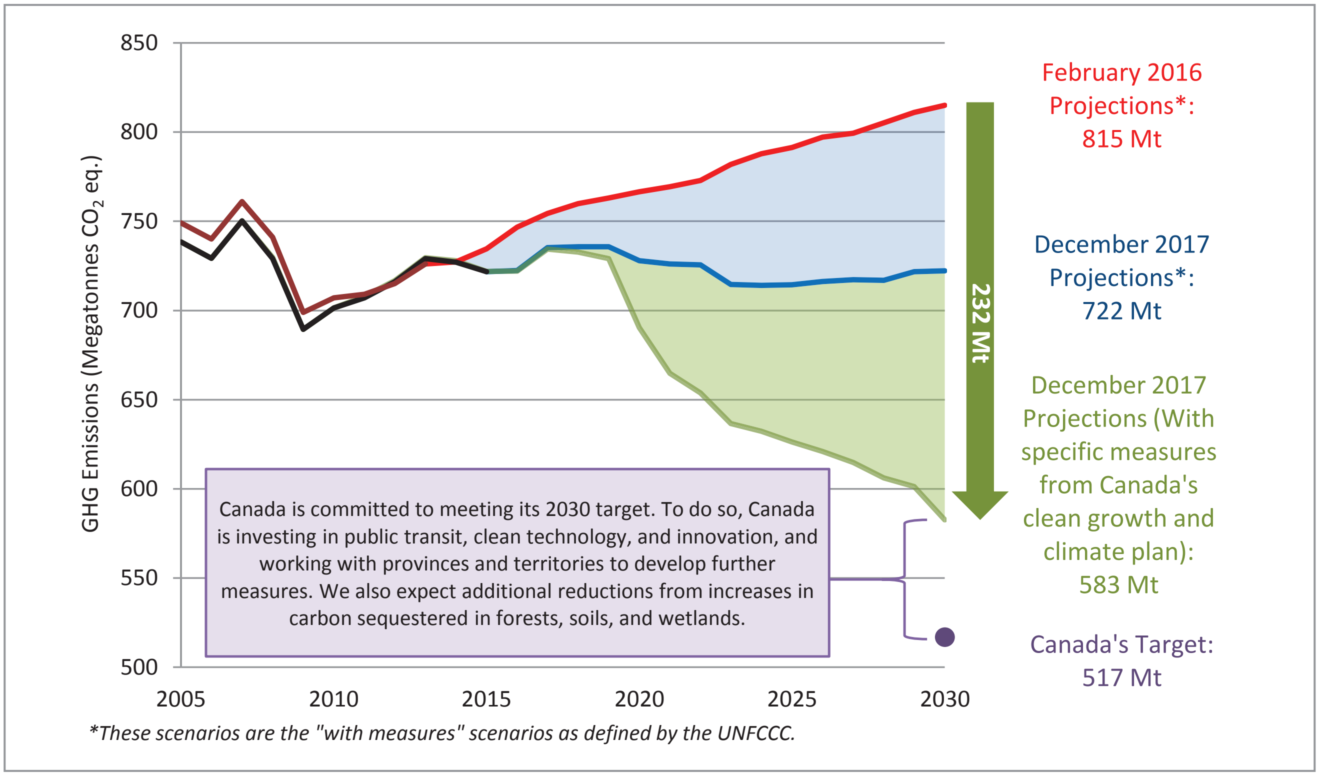
The Government of Canada has allocated significant resources under the Pan-Canadian Framework through a number of funds such as the Low Carbon Economy Fund. These resources will be used to fund some of the measures included in the additional measures scenario (e.g., in the building or electricity sectors) and will support the implementation of proposed standards by lowering the costs for consumers and industry.

Figure 5.6 shows the "with measures" and "with additional measures" projections as well as the projections presented in Canada's BR2.

Taken together, these policies have and will continue to influence GHG emissions reductions, from projected levels in 2020 and beyond. Most importantly, they encourage further action by demonstrating that government policies are having a quantifiable impact on GHG emissions.

It is expected that GHG estimates will continue to decline in the near to medium term, especially as current estimates do not include the full reductions from investment in public transit, clean technology and innovation. In addition, possible increases in stored carbon (carbon sequestration) in forests, soils and wetlands will also contribute to reductions, which could also play an important role in achieving Canada's 2030 target.

Furthermore, these projected emissions reductions do not take into consideration the additional mitigation measures that could be implemented by the provinces and territories between now and 2030. Emissions reductions from additional future actions will be assessed as new measures are implemented.



Canada is committed to meeting its 2030 target. To do so, Canada is investing in public transit, clean technology, and innovation, and working with provinces and territories to develop further measures. We also expect additional reductions from increases in carbon sequestered in forests, soils, and wetlands.

**These scenarios are the "with measures" scenarios as defined by the UNFCCC.*

Figure 5.6: Scenarios of Canadian Emissions to 2020 and 2030 (Mt CO_2 eq) (Excluding Land Use, Land-Use Change and Forestry)

Table 5.28 shows the breakdown of emissions by economic sectors for the different scenarios in 2030. Overall, emissions are projected to decrease by 232 Mt compared to the estimates in the BR2 with the biggest reductions happening in the electricity and buildings sectors, followed by oil and gas and transportation sectors.

Table 5.28: Canadian 2030 GHG Emissions Forecast (Mt CO_2 eq) Under Different Scenarios

SECTOR	2ND BIENNIAL REPORT (BR2)	7TH NATIONAL COMMUNICATION (NC7)	7TH NATIONAL COMMUNICATION–ADDITIONAL MEASURES (NC7AM)	DIFFERENCE BETWEEN NC7 AND BR2	DIFFERENCE BETWEEN NC7AM AND BR2
Agriculture	76	72	71	-5	-5
Buildings	109	83	71	-26	-38
Electricity	58	46	21	-12	-37
Heavy Industry	107	97	93	-10	-14
Oil and Gas	242	215	192	-27	-50
Transportation	164	155	143	-9	-21
Waste & Others	59	53	51	-6	-8
Purchases of international allowances under the Western Climate Initiative			-59		-59
Total	**815**	**722**	**583**	**-93**	**-232**

Note: Numbers may not sum to the total due to rounding.

5.6. Alternate Emissions Scenarios

5.6.1. Sensitivity Analysis

Projections are updated annually and reflect the latest historical data and up-to-date future economic and energy market assumptions. However, given the uncertainty regarding the key drivers of GHG emissions, the scenario presented in the previous section should be seen as one estimate within a set of possible emissions outcomes in the projection period, as events that will shape future emissions and energy markets cannot be fully anticipated. In addition, future developments in technologies, demographics and resources cannot be foreseen with certainty. The variation in these complex variables implies that modelling results are most appropriately viewed as a range of plausible outcomes.

Uncertainty is addressed via modelling and analysis of alternate cases that focus on variability in two key factors: future economic growth and population projections and the evolution of oil and natural gas prices and production as per the National Energy Board's high and low scenarios. These assumptions are presented in Table 5.29 and Table 5.30, and the overall range of emissions is presented in Figure 5.7.[o]

Table 5.29: Economic Growth and Population from 2015 to 2030

	2015 TO 2030		
	LOW	WITH MEASURES	HIGH
Annual GDP Growth Rate	1.0%	1.7%	2.5%
Annual Population Growth Rate	0.7%	1.0%	1.3%

Table 5.30: Oil and Gas Prices and Production in 2020 and 2030

		2020			2030		
FUEL	UNITS	LOW	WITH MEASURES	HIGH	LOW	WITH MEASURES	HIGH
Crude Oil Price (WTI)	Real 2014 US$/bbl	39	66	81	37	77	116
Heavy Oil (WCS)	Real 2014 US$/bbl	20	43	56	21	56	90
Crude Oil	1000 bbl/day	4,404	4,560	4,907	4,047	5,619	7,567
Natural Gas (Henry Hub)	Real 2014 US$/GJ	2.65	3.13	3.55	2.86	3.77	4.67
Natural Gas	Billion cubic feet	6471	6,789	7084	4828	7101	9570

Table 5.31: Sensitivity of GHG Emissions to Changes in GDP and Prices (excluding LULUCF) in Mt CO_2 eq

SCENARIOS	2020	2030	2030 PROJECTIONS–2005 EMISSIONS
Slow GDP, Low World Oil and Gas Prices	709	651	-87
Fast GDP, High World Oil and Gas Prices	742	793	55
"With Measures" Scenario	728	722	-16
Sensitivity Range	709 to 742	651 to 793	-87 to 55

---

[o] The High and Low alternate emissions scenarios from Section 5.7 are equivalent to the Fast GDP–High World Oil Prices and Slow GDP–Low World Oil Prices scenarios respectively in Annex 3 of this chapter.

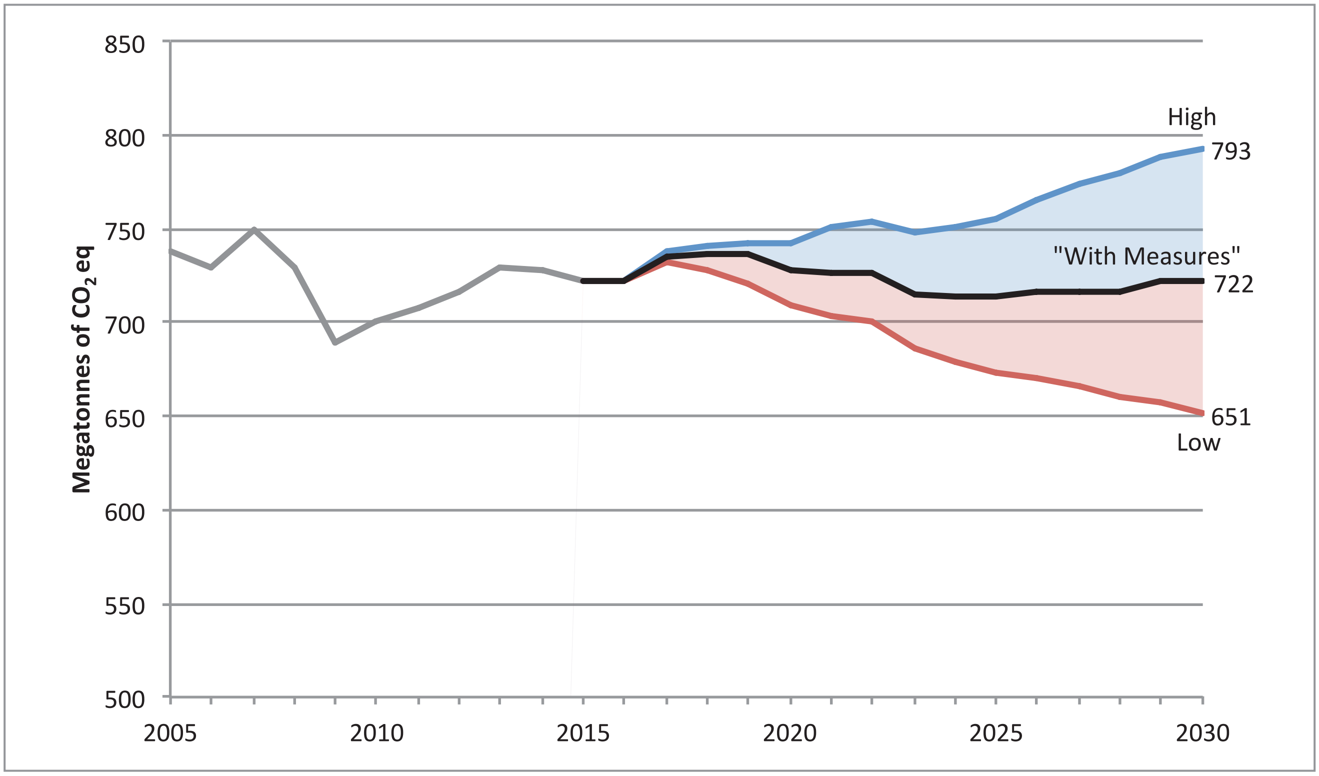


Figure 5.7: Canada's Domestic Emissions Projections (Mt CO_2 eq): low, "with measures" and high scenarios

5.6.2 Main Sources of Uncertainty for Canada's GHG Projections

Canada develops its scenarios of emissions projections using a detailed, proven Energy, Emissions and Economy model. Each year, the model is re-calibrated using the most recent data available (see Annex 4) to provide a robust, well-grounded in empirical evidence forecast. Nevertheless, uncertainty is inherent in the projections of any model that looks decades into the future.

To address this issue, this chapter presents alternative scenarios showing the sensitivity of GHG emission projections to projected energy prices and economic growth. That said, other sources of uncertainty exist, including relating to the decision-making of agents under given assumptions and the pace of clean technology development and adoption. For instance, the observed consumer adoption of emerging technologies may diverge from model predictions due to the influence of behavioral decision-making processes not captured in the model. For example, the diffusion of electric vehicles depends not only on relative vehicle prices, but also consumer awareness of electric vehicles, and the availability of recharging infrastructure both of which will evolve over time and are therefore hard to predict when looking at historical behaviour. This source of projection uncertainty is present across all economic sectors with the rapid emergence of new and cleaner technologies.

Some sources of uncertainty are also specific to sectors, several of which are listed below.

- **Oil and Gas:** As mentioned in the Canada's *National Energy Board 2017 Energy Futures* report, Canadian oil and gas production projections vary significantly depending on wold price assumptions. The global price itself is determined by supply and demand for oil, driven by factors like economic growth, technological developments, and geopolitics and is set in international markets.

- **Electricity:** From the demand side, key factors of uncertainty other than economic and population growth include electricity demand changes arising from the electrification of vehicles or industrial processes. From the supply side, emissions are affected by changes to the supply mix, for example, assumptions for new generating capacity as coal units are being phased out, future costs of renewables, the degree of localized small-scale generation by renewable energy sources, and construction of new transmission linkages.
- **Transportation:** Over the short term, vehicle-kilometers travelled is the key driver of emissions, influenced by assumptions regarding factors such as population, fuel prices and optimization of freight trucks (increased tonnage per km) and freight transportation volume resulting from changes in economic activity. Over the medium to long term, the changing characteristics of the fleet will be important and will be influenced by government policies, different types of vehicles' respective production costs, technological development and consumer choices.
- **Heavy Industry:** Emissions are primarily driven by expected economic growth in each subsector. Future technological developments that would affect the costs of electrification and carbon capture and storage technologies, as well as of other energy efficiency improvements would also have an impact on emissions.
- **Buildings:** Emission projections in this sector will be affected by consumer response to emerging technologies and government policies. Future relative fuel prices and technology costs will also have an impact.
- **Agriculture:** Emissions from agriculture production are affected by production costs such as fertilizer prices, and international prices that affect the crop composition and livestock size.

Annexes

Annex 1: Baseline Data and Assumptions

Key Economic Drivers and Assumptions

Table 5A.1: Summary of Key Price-Related Assumptions Used in Projection Analysis from 1990 to 2030

	HISTORICAL						PROJECTED	
KEY UNDERLYING ASSUMPTIONS	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2030**
Oil Price ($2015 US/bbl)	$38	$26	$39	$64	$85	$49	$66	$77
Natural Gas Price ($2015 US/mmbtu)	$2.55	$2.34	$5.50	$9.82	$4.63	$2.62	$3.31	$3.98
Consumer Price Index (1992=100)	93	104	114	127	139	151	165	202

Table 5A.2: Summary of Key Economic and Demographic Assumptions Used in Projection Analysis from 1990 to 2030

	HISTORICAL					PROJECTED		
KEY UNDERLYING ASSUMPTIONS	**1990–1995**	**1995–2000**	**2000–2005**	**2005–2010**	**2010–2015**	**2015–2020**	**2020–2025**	**2025–2030**
Real GDP Chain-Weighted ($1997)*	1.7%	4.1%	2.6%	1.2%	2.0%	1.7%	1.7%	1.6%
Population*	1.1%	0.9%	1.0%	1.1%	1.1%	1.2%	1.0%	0.9%
Population of driving age (18–75)*	1.4%	1.2%	1.4%	1.4%	1.3%	1.0%	0.9%	0.9%
Labour Force*	0.6%	1.5%	1.8%	1.3%	0.9%	0.9%	0.8%	0.7%

*Average annual growth rate

Baseline Data and Assumptions

Many factors influence the future trends of Canada's GHG emissions. These key factors include economic growth, population and household formation, energy prices (e.g., world oil price and the price of refined petroleum products, regional natural gas prices, and electricity prices), technological change, and policy decisions. Varying any of these assumptions could have a material impact on the emissions outlook.

In constructing the emissions projections, alternate pathways of key drivers of emissions were modelled to explore a range of plausible emissions growth trajectories. The baseline emissions projections scenario represents the mid-range of these variations, but remains conditional on the future path of the economy, world energy markets and government policy. The assumptions and key drivers are listed in this section. Alternative cases are explored in the sensitivity analysis in Annex 3.

The emissions projections baseline scenario is designed to incorporate the best available information about economic growth as well as energy demand and supply into the future. The projections capture the impacts of future production of goods and services in Canada on GHG emissions.

Historical data on GDP and disposable personal income are provided from Statistics Canada. Consumer price index and population demographics are also produced by Statistics Canada while historical emissions data are provided by the *National Inventory Report*, 2017 (NIR 2017). Economic projections (including GDP, exchange rates and inflation) to 2021 are calibrated to Finance Canada's March 2017 Budget Fiscal Outlook and economic projections between 2022 and 2030 are based on Finance Canada's long term projections.

Forecasts of oil and natural gas price and production are taken from the National Energy Board's *Canada's Energy Future 2016: Update—Energy Supply and Demand Projections to 2040*—October 2016. The NEB is an independent federal agency that regulates international and interprovincial aspects of the oil, gas and electric utility industries. The U.S. Energy Information Administration's outlook on key parameters is also taken into account in the development of energy and emissions trends.

Economic Growth

The Canadian economy grew by 1.6% per year over 2005 through 2015, a period that includes the 2009 global recession. Real GDP growth is expected to average 1.7% per year from 2015 to 2030.

Growth in the labour force and changes in labour productivity influence Canada's real GDP. Labour productivity is expected to increase by an average of 1.1% annually between 2015 and 2020, an improvement over the 0.6% average annual growth during the period between 2005 and 2015. The increase in productivity is attributed to an expected rise in capital formation, and contributes to the growth in real disposable personal income, which is expected to increase by an average of 2.3% per year between 2015 and 2020 and 1.7% between 2020 and 2030.

Population Dynamics and Demographics

The population size and its characteristics (e.g., age, sex, education, household formation, among others) have important impacts on energy demand. Canada's overall population is projected to grow on average at an annual rate of 1.2% between 2015 and 2020, slowing to 1.0% per year between 2020 and 2030.

Table 5A.3: Macroeconomic Assumptions, 1990–2030 Average Annual Growth Rates

	2005–2015	2015–2020	2020–2030
Gross Domestic Product	1.6%	1.7%	1.7%
Consumer Price Index	1.8%	1.9%	2.0%

Major demographic factors that can have measurable impacts on energy consumption are summarized below:

- **Household formation:** This is the main determinant of energy use in the residential sector. The number of households is expected to increase on average by 1.4% per year between 2015 and 2020 and by an average of 1.0% per year between 2020 and 2030.
- **Labour force:** This is expected to have a decelerating growth rate, reflecting the aging population. Its annual average growth rate was 1.1% per year between 2005 and 2015, and is projected to slow to 0.9% per year between 2015 and 2020 and then further slow to 0.7% between 2020 and 2030.

World Crude Oil Price

A major factor in projected GHG emissions is the assumption about future world oil prices since this drives the level of production of oil. Canada is a price taker in crude oil markets as its share of world oil production and consumption are not large enough (4% and 2%, respectively) to significantly influence international oil prices. West Texas Intermediate (WTI) crude oil is used as an oil price benchmark. North American crude oil prices are determined by international market forces and are most directly related to the WTI crude oil price at Cushing, which is the underlying physical commodity market for light crude oil contracts for the New York Mercantile Exchange. The increase in North American supply and the resulting transportation bottleneck at Cushing have created a divergence between the WTI price of crude oil and the Brent price of crude oil. As such, the North American oil market is currently being priced differently from the rest of the world.

The emissions outlook's "with measures" scenario is anchored by the world oil price assumptions developed by the NEB. According to the NEB, the world crude oil price for WTI is projected to rise from about 62 Canadian dollars (C$) per barrel of oil (bbl) in 2015 to about C$81/bbl in 2020 and C$89/bbl in 2030. Higher and lower price scenarios are used for the sensitivity analysis in Annex 3 of this Chapter.

Figure 5A.1 shows crude oil prices for light crude oil (WTI) and heavy oil. Historically the price of heavy oil/bitumen (Alberta Heavy) has followed the light crude oil price (WTI) at a discount of 50% to 60%. However, in 2008 and 2009 the differentials between the prices of light and heavy crude oils ("bitumen/light-medium differential") narrowed significantly owing to a global shortage of heavier crude oil supply.

The Canadian NEB expects the bitumen/light-medium differential to average 34% in 2020 and decline slightly to 27% in 2030.

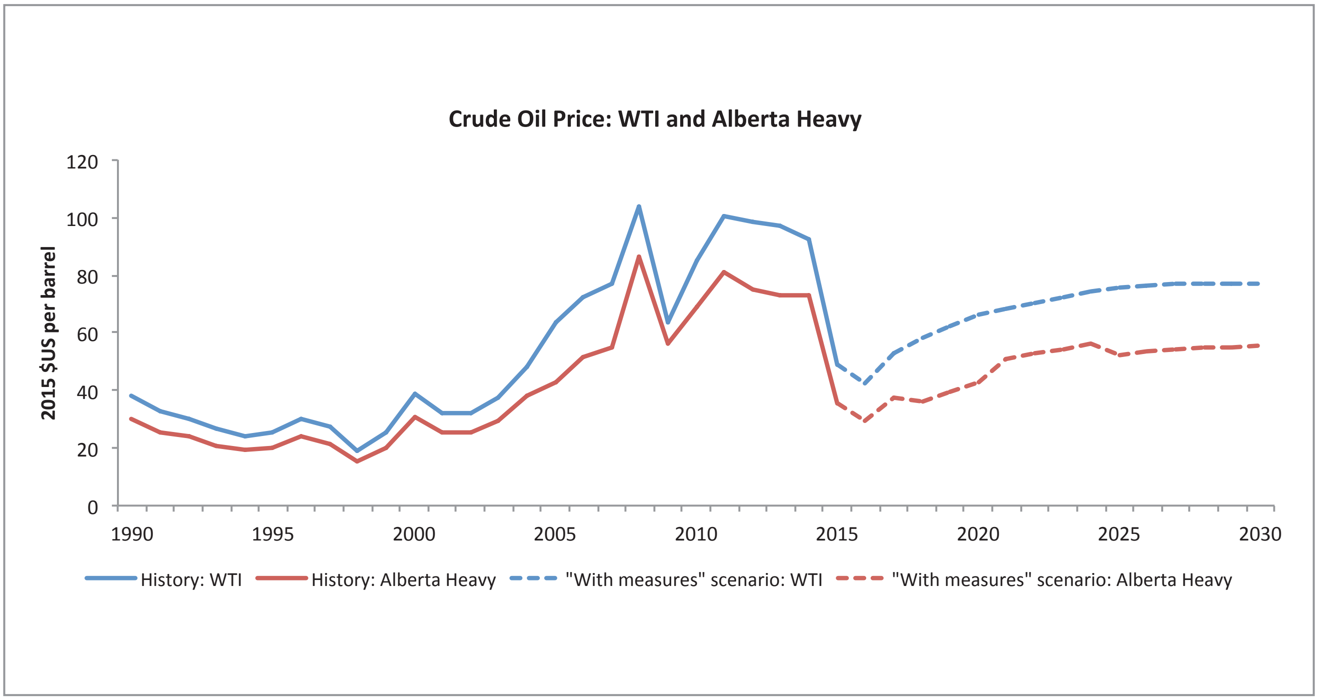


Figure 5A.1: Crude Oil Price: WTI and Alberta Heavy (US$ 2015/bbl)
Source: National Energy Board, *Canada's Energy Future 2017.*

As shown in Figure 5A.2, the Henry Hub price for natural gas in Alberta (the benchmark for Canadian prices) declined in 2015 to about three Canadian dollars per million British thermal units (MMBtu). In the projection, it begins to recover to reach about C$4.14 per MMBtu by 2020 and then C$4.70 per MMBtu by 2030.

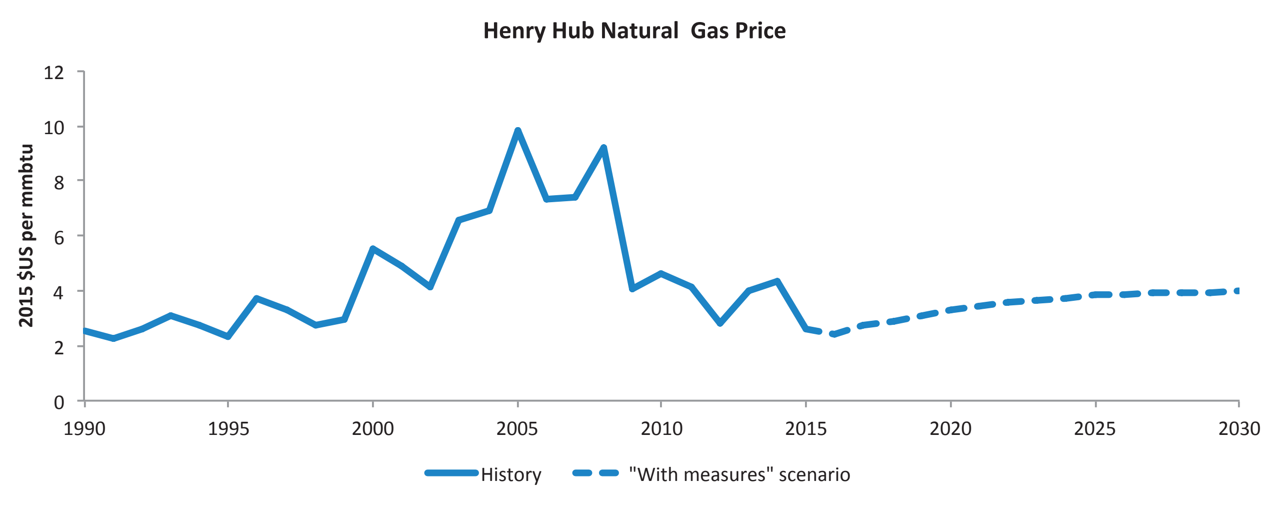


Figure 5A.2: Henry Hub Natural Gas Price ($US 2015/MMbtu)
Source: National Energy Board, *Canada's Energy Future 2017.*

Table 5A.4: Crude Oil Production (thousand barrels per day)

	2005	2010	2015	2020	2030
Crude and Condensates	**1,533**	**1,376**	**1,492**	**1,445**	**1,687**
Conventional Heavy	526	424	430	465	561
Conventional Light	511	512	654	464	640
C5 and Condensates	173	148	228	238	287
Frontier Light (offshore + northern)	323	291	181	278	199
Oil Sands	**1,065**	**1,612**	**2,526**	**3,361**	**4,236**
Oil Sands: Primary	151	194	258	302	379
Oil Sands: In Situ	288	562	1,107	1,426	2,193
Steam-assisted Gravity Drainage	83	318	843	1,100	1,752
Cyclic Steam Stimulation	205	244	263	327	441
Oil Sands Mining	627	857	1,162	1,633	1,663
Total Production (gross)	**2,598**	**2,988**	**4,019**	**4,806**	**5,923**

Note: Numbers may not sum to the total due to rounding.

Energy and Electricity Production

NEB projections show that both conventional natural gas and conventional oil production will decrease over time as a result of declining supply, although the projected increase in production from unconventional natural gas resources and oil sands operations will more than compensate for this decline. As such, under assumed prices and absent further government policy actions, it is expected that from 2015 to 2030 oil sands *in situ* production will nearly double and oil sands mining production will increase over 40% (see Table 5A.4).

There are two main products from oil sands production: synthetic crude oil (or upgraded bitumen) and non-upgraded bitumen, which is sold as heavy oil. Table 5A.5 illustrates historical and projected oil sands disposition. Synthetic crude oil production is projected to slowly increase from about 1.1 million barrels per day (bbl p/d) in 2015 to about 1.3 million bbl p/d by 2020 and then to about 1.4 million bbl p/d by 2030. Non-upgraded bitumen will increase from 1.4 bbl p/d in 2015 to 1.9 million bbl p/d by 2020 and then to 2.7 million bbl p/d by 2030. This non-upgraded bitumen is either sold as heavy oil to Canadian refineries or transported to U.S. refineries for upgrading to refined petroleum products.

Table 5A.5: Oil Sands Disposition (thousand barrels per day)

	2005	2010	2015	2020	2030
Oil Sands (gross)	**1,066**	**1,613**	**2,527**	**3,363**	**4,238**
Oil Sands (net)	980	1,502	2,412	3,223	4,089
Synthetic Crude Oil	611	849	1,058	1,298	1,415
Non-Upgraded Bitumen	369	653	1,354	1,925	2,674
Own Use	86	111	115	140	148

Note: Numbers may not sum to the total due to rounding.

Projections show gross natural gas production will remain steady at about 6.8 trillion cubic feet (TCF) in 2020, as new production and non-conventional sources such as shale gas and coal-bed methane come to market[p] and offset the continued decline in conventional gas production. These new sources of natural gas production increase output to 7.1 TCF by 2030.

Table 5A.6: Natural Gas Production (billion cubic feet)

	2005	2010	2015	2020	2030
Marketable Gas	**6,264**	**5,314**	**5,453**	**5,410**	**5,717**
Natural Gas Production (Gross)	7,753	6,707	6 785	6,789	7,101
Unconventional Gas Production	2,252	2,939	3,828	4,322	5,134
Conventional Gas Production	5,501	3,767	2,958	2,467	1,967
Own Use	-1,489	-1,393	-1,332	-1,379	-1,384

Note: Numbers may not sum to the total due to rounding.

The electricity forecast is determined by the interaction between electricity demand from end-use sectors, which changes for each sector depending on fuel and electricity prices, technology choices, efficiency changes, policy impacts, and economic driver growth, and source of electricity supplied, which depends on the historical state of each province and territory's existing supply mix as well as scheduled refurbishments and retirements, planned and modelled additions to capacity, growing industrial generation, interprovincial and international flows. Government actions further constrain supply choices in the forecast, such as the expected retirement of coal units due to the 2012 federal coal-fired electricity regulations, and renewable portfolio standards in provinces such as Nova Scotia and Alberta that mandate the addition of new renewable generation.

Gross electricity demand is projected to grow 11% from 2015 to 2030 as economic growth and fuel-switching outpace electrical efficiency improvements. However,

---

[p] For the purposes of this document, shale gas development has been included under natural gas production. As more data and information on likely shale gas production trends become available, consideration will be given to modeling shale gas separately.

utility electricity generation is only expected to increase by 1% over the same period. This is due to two significant supply-side changes in the forecast period. First, net exports of electricity to the U.S. fall by over half from near-historic highs in 2015 to 2030 as major exporting provinces use increasingly more electricity domestically. Second, industrial generation is projected to increase by over 40%, partly offsetting the need for utility generation to meet growing industrial electricity demands. Industrial generation includes both on-site hydropower generation, common in the aluminum industry in Québec, and cogeneration which produces electricity alongside heat and steam used for industrial processes, such as biomass combustion in the pulp and paper sector and own-use gas-fired cogeneration in the oil and gas sector. Emissions associated with industrial generation are allocated to the specific industrial sector, rather than to the electricity sector which captures only utility-generated emissions.

While total utility generation is expected to grow very slowly, the mix changes significantly between 2015 and 2030, with generation from coal, refined petroleum products such as fuel oil and diesel, and nuclear power being replaced by increasing renewables and natural gas generation. While the reduction of nuclear generation in Ontario results in some new, higher-emitting natural gas, Ontario generally replaces nuclear with non-emitting generation or imports, and most of this new natural gas goes to replacing coal in other provinces as it is phased out, reducing the emissions intensity of electricity generation in most provinces in the forecast.

Table 5A.7: Electricity Supply and Demand (Terawatt hours)

	2005	2010	2015	2020	2030
Electricity Required	**604**	**592**	**649**	**668**	**683**
Total Gross Demand	550	538	565	576	625
Purchased from Grid	502	489	504	505	546
Own Use	47	49	61	71	79
Net Exports	24	26	52	60	24
Exports	44	44	61	73	40
Imports	20	19	9	13	15
Losses	31	28	31	32	34
Electricity Produced	**604**	**592**	**649**	**668**	**683**
Utility Generation	551	539	580	588	587
Coal and Petroleum Coke	99	82	68	58	27
Refined Petroleum Products	12	4	4	4	2
Natural Gas	22	30	33	39	55
Nuclear	87	86	96	85	74
Hydro	327	321	346	355	370
Other Renewables	5	16	33	47	58
Industrial Generation	53	53	69	80	97
Refined Petroleum Products	1	<1	1	1	1
Natural Gas	17	21	33	41	54
Hydro	31	27	28	31	34
Other Renewables	4	4	7	8	8

Note: Numbers may not sum to the total due to rounding.

Emissions Factors

Table 5A.8 provides a rough estimate of carbon dioxide equivalent emissions emitted per unit of energy consumed by fossil fuel type for combustion and industrial processes. These numbers are estimates based on latest available data based on IPCC methodology. Specific emission factors can vary slightly by year, sector, and province.

Table 5A.8: Mass of CO_2 eq Emissions Emitted per Quantity of Energy for Various Fuels

FUEL	CO_2 EQ. EMITTED [GRAMS PER MEGA JOULE (G/MJ)]
Aviation Gasoline	74.25
Biodiesel	7.31
Biomass	5.47
Coal	90.79
Coke	110.10
Coke Oven Gas	36.25
Diesel	74.23
Ethanol	2.31
Gasoline	68.71
Heavy Fuel Oil	75.22
Jet Fuel	69.38
Kerosene	68.15
Landfill Gases/Waste	35.10
Light Fuel Oil	71.17
LPG	44.60
Lubricants	36.34
Naphtha Specialties	17.77
Natural Gas	46.80
Natural Gas Raw	57.20
Other Non-Energy Products	36.41
Petrochemical Feedstocks	14.22
Petroleum Coke	84.58
Still Gas	51.49

Federal, Provincial and Territorial Measures

Table 5A.9 identifies the major federal, provincial and territorial measures that are included when modeling the “with measures” scenario. This includes federal measures that have been implemented or announced in detail as of September 2017. Where program funding is set to end, the projections assume that the impacts of these programs, other than those embodied in consumer behaviour, cease when the approved funding terminates. The analysis also includes existing provincial and territorial measures. The Government of Canada involves provinces and territories in extensive consultations to ensure their initiatives are accounted for in analysis and modeling of emissions trends.

The “with measures” scenario does not take into account the impact of broader strategies or future measures within existing plans where significant details are still under development.

Under the Pan-Canadian Framework a number of policies and measures have been announced. As the policy development process is not yet finished, the majority of these policies were not included in the “with measures” scenario, but they were included in a “with additional measures” scenario. They are also included in Table 5A.9.

Note also that the modeled polices and measures in Table 5A.9 will not match the full list of measures included in Chapter 4: Policies and Measures of this report. This is because the economic modeling will only account for measures that have been fully funded, legislated or where sufficiently detailed data exists that make them possible to add to the modeling platform.

Table 5A.9: GHG Measures Reflected in “With Measures” and “With Additional Measures” Scenarios

PROVINCIAL/TERRITORIAL MEASURES	FEDERAL MEASURES
“WITH MEASURES” SCENARIO	
Adoption of the National Energy Code for Buildings of Canada (2010–2012) by all provinces and territories	• Reduction of carbon dioxide emissions from coal-fired generation of electricity regulations announced in 2012 • Federal Budget 2016: Supporting Energy Efficiency and Renewable Energy Development. Increase efficiency of residential and commercial devices (including refrigeration, freezers, ranges, dryers) through regulations and ENERGY STAR certification (Amendment 14) • Equipment Standards (Amendment 13) • Voluntary emission reductions for planes and trains • Light-duty vehicles 1 (LDV-1) GHG emissions standards for the light-duty vehicle model years 2011 to 2016 • Light-duty vehicles 2 (LDV-2) GHG emissions standards increases stringency for model years 2017 to 2025 • Heavy-duty vehicles 1 (HDV) GHG emissions standards for heavy-duty vehicle model years 2014 to 2018 • Heavy-duty vehicles 2 (HDV) GHG emissions standards for heavy-duty vehicle model years 2021 to 2027 and trailers • Regulations Amending the Ozone-depleting Substances and Halocarbon Alternatives Regulations • Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas sector)
Renewable Fuel Content across all provinces and territories (except for Newfoundland and Labrador, Yukon, the Northwest Territories and Nunavut)	
Newfoundland • Muskrat Falls hydro project	
Nova Scotia • Cap on GHG emissions from the electricity sector • Renewable portfolio standard for electricity generation • Electricity demand-side management policies • Solid Waste-Resource Management Regulations	
New Brunswick • Renewable Portfolio Standard	
Québec • Western Climate Initiative cap-and-trade regime • 5% ethanol objective in gasoline distributors fuel sales • Drive electric program • Landfill gas regulation • Eco-performance program for industry • Program to support energy efficiency improvements in marine, air and rail transport (PETMAF) • Program to reduce/avoid GHG emissions by using intermodal transportation (PREGTI) • Program Écocamionnage	
Ontario • Western Climate Initiative cap-and-trade regime • Residential electricity peak savings (time-of-use pricing) • Feed-in tariff program • Landfill gas regulation (O. Reg. 216/08 and 217/08) • Strategy for a Waste-free Ontario • Independent Electricity System Operator contracted electricity supply • Nuclear refurbishment • Energy Storage Contract with Québec • Ontario Natural Gas 2015–2020 Conservation Framework • Ontario Electricity 2015–2020 Conservation Framework • Ontario Electric Vehicle Chargers Ontario, Electric Vehicles Incentive Program (EVIP) and Electric and Hydrogen Vehicles Advancement Partnership (EHVAP)	
Manitoba • Emissions tax on coal • Manitoba Building Code Section 9.36 (for housing) • Manitoba Composts program	
Saskatchewan • Boundary Dam 3 Carbon Capture Project • Uniform Building and Accessibility Standards Regulations (2013)	

PROVINCIAL/TERRITORIAL MEASURES	FEDERAL MEASURES
Alberta • Specified Gas Emitters Regulations transitioning to the Emissions Performance Standards in 2018 • Carbon levy • Coal Phase-Out by end of 2030 • 100 Mt cap for oil sands • Renewable Electricity Program • Quest carbon capture and storage project • Carbon Trunk Line Project–CO_2 capture and use for enhanced oil recovery • Energy efficiency requirements for housing and small buildings, section 9.36 of the 2014 Alberta Building Code edition • Municipal Waste Annual Disposal Targets	
British Columbia • Carbon tax increasing to $35 in 2018, $40 in 2019, $45 by 2020 and $50 in 2021 • British Columbia Cement Low Carbon Fuel Program • Renewable and Low Carbon Fuel Requirements Regulation (10% reduction in CI by 2020) • Landfill gas management regulation • British Columbia Clean Energy Act: Clean or renewable electricity requirement–100% of electricity from clean or renewable sources by 2025 • Revisions for energy efficiency of large residential and commercial buildings (Part 3) (reg # 167/2013) • Revisions for energy efficiency of housing and small buildings (Part 9) (reg # 173/2013) • City of Vancouver Building Codes • Clean Energy Vehicles Program (Phase 1, 2, Phase 3 and Beyond) and support for zero emissions vehicle charging stations in buildings • Step Code: Increased Energy Efficiency Requirements in the Building Code • Municipal Waste disposal target and organic waste disposal restriction	
Northwest Territories • Biomass Strategy	
“WITH ADDITIONAL MEASURES” SCENARIO	

PROVINCIAL/TERRITORIAL MEASURES	FEDERAL MEASURES
Ontario and Québec • WCI credits (Assumes Ontario and Québec meet their legislated emissions targets through purchases of WCI allowances.) Saskatchewan • SaskPower Renewable Electricity Target British Columbia • BC's electrification of natural gas sector • Increasing the Low Carbon Fuel Standard (15% reduction in carbon intensity by 2030) • New Energy Efficiency Standards for Gas Fired Boilers	• Federal Backstop Carbon Pricing • Clean Fuel Standard • Accelerated Coal Phase Out by 2030 • Accelerating Industrial Energy Efficiency Management • Low-Carbon Economy Fund • Performance standards for natural gas electricity generation • Strategic Interconnections in electricity • Emerging renewables and smart grids • Off-diesel energy systems in remote communities • Net-zero energy ready building codes (for new commercial and residential buildings) by 2030 • Labelling and codes for existing buildings (retrofits) • More stringent Energy Efficiency Standards for appliances and equipment • Regulations for off-road industrial, commercial, residential and recreational vehicles • Post-2025 LDV regulations and ZEV Strategy • Increased use of wood in buildings construction

Canadian provinces and territories have committed to taking action on climate change through various programs and regulations. In the “with measures” scenario, provincial and territorial targets are not modelled. Instead, individual policies that are brought forward as methods to attain the provincial targets may be included in the modeling platform if they meet the criteria discussed above. Table 5A.10 lists the emissions reductions targets announced by each province or territory.

Table 5A.10: Announced GHG Reduction Targets of Provincial/Territorial Governments

PROVINCE/TERRITORY	TARGET IN 2020	TARGET IN 2030	TARGET IN 2050
Newfoundland	10% below 1990	35% to 45% below 1990	
Prince Edward Island	10% below 1990	35% to 45% below 1990	75% to 85% below 1990 levels in the long term
Nova Scotia	10% below 1990	35% to 45% below 1990	
New Brunswick	10% below 1990	35% to 45% below 1990	
Québec	20% below 1990	37.5% below 1990	
Ontario	15% below 1990	37% below 1990	80% below 1990
Manitoba	15% below 2005	30% below 2005	50% to 80% below 2005
Saskatchewan	20% below 2006		
Alberta	50 Mt below BAU		200 Mt below BAU
British Columbia	33% below 2007		80% below 2007
Nunavut	No Territorial target announced		
Yukon	Carbon neutral		
Northwest Territories	No Territorial target announced		

Annex 2: Modeling and Methodological

Modeling and Methodological Differences from Canada's 2nd Biennial Report

- A new methodology to model solid waste disposal emissions was developed to better capture the effects of population growth, waste diversion, and landfill gas capture on projected emissions.
- Improvements to the alignment between different measures of GDP increased the growth rates of sectors driven by regional GDP, such as freight transportation.
- Electricity transmission and distribution line losses were revised to reflect real historical transmission and distribution losses by province and territory rather than utilizing a Canadian average.
- A new module was developed to simulate the emissions from the production of liquid biofuels—ethanol and biodiesel—used primarily for transportation.
- The historical calibration procedure was changed for the buildings sector so that historical process efficiency improvements were captured in the process efficiency variable rather than non-price factors. The overall efficiency trends in the U.S. National Energy Modeling System (NEMS) were also applied to building sector device efficiencies.
- In the previous forecast, all HFCs were driven at the same growth rate; now, transportation-related HFC emissions are split out and grown at a separate growth rate. This new, lower growth rate captures the shift away from using HFCs in automobile air conditioning, which helps manufacturers comply with the LDV regulations. As a result, transportation HFCs are lower and buildings HFCs are higher; although the HFC regulation reduces HFC emissions in all scenarios.
- The current forecast includes new assumptions related to ZEV sales up to 2030 in all provinces and territories based on regional preferences and existing incentives. The modeling approach has also been improved, and now captures with more precision the expected uptake in ZEV sales in all provinces and territories.
- In the previous forecast, LDV regulations were modelled as an efficiency standard for gasoline and diesel vehicles only. For 2017, the impact of increased ZEV uptake has been incorporated and this change increases GHG emissions in the current forecast. The phase-out of HFCs in passenger vehicle air conditioners was also incorporated as a compliance mechanism for LDV2. Vehicle manufacturers get credits that can be applied to meeting the LDV2 efficiency standard. This was modelled as a small decrease in gasoline and diesel vehicle efficiencies. There is no net change in GHG emissions as a result of this change, though HFC emissions are down and combustion emissions are higher.
- Fuel demands associated with industrial and commercial cogeneration in the history were split between electricity production and steam/heat production rather than assigned to only electricity generation, allowing for more accurate representation of the relative efficiency of cogeneration in the model.
- Previous modelling of growth of industrial generation in the forecast was limited to particular sectors and generation technologies. A more holistic approach now adds industrial generation proportionate to growth in energy demands and relative to the utility price of electricity in all sectors with self-generation in the historical data.
- The Western Climate Initiative (WCI) has been remodeled. Until now, the cap-and-trade was modeled as a carbon tax in line with the expectations of the price of allowances. This year, the WCI has been remodeled as a proper cap-and-trade system with all the available compliance mechanisms, including offsets, and all participating jurisdictions, including not only Québec and Ontario but also California. This allows us to more properly capture the dynamics of the cap-and-trade, including the reductions occurring from the system and the trading of allowances. As well, the price assumptions of the cap-and-trade

allowances have been revised in line with the latest expectations based on analysis by California Carbon. These improvements are all driving further reductions compared to the previous forecast.

- The modeling of the building codes has been improved and now better reflects the stringency of the different building codes implemented by the provinces. The model was improved to facilitate the addition of geothermal heat pumps and solar photovoltaics.
- Historical building-related device efficiencies were revised and updated, subject to availability.
- Natural gas pipeline drivers were changed to specifically reflect the best-correlated driver for each province and territory.

Annex 3: Alternate Emissions Scenarios

Given the uncertainty regarding the key drivers of GHG emissions, the emissions projections for the "with measures" scenario presented in Figure 5.1 should be seen as one estimate within a range of plausible outcomes. Future developments in technologies and the rate of resource extraction cannot be foreseen with certainty. Typically, these key uncertainties are addressed through examining alternative cases. The sensitivity analysis presented here focuses on two key uncertainties: future economic growth and the evolution of world oil prices and their impact on macroeconomic growth and energy consumption.

In Table 5A.11, the emissions outcomes of these alternative cases are presented independently and in various combinations. These alternative cases explore the interaction of energy markets and economic growth, and their impact on emissions, under a range of assumptions.

Table 5A.11: Sensitivity Analysis

SCENARIO	GHG EMISSIONS IN 2030	DIFFERENCE BETWEEN 2005 AND 2030
Fast GDP–High World Oil Prices	793	44
High World Oil Prices	777	28
Fast GDP	746	-2
With Measures	722	-27
Slow GDP	691	-58
Low World Oil Prices	685	-64
Slow GDP–Low World Oil Prices	651	-98
Range	651 to 793	-98 to 44

In our scenario with slow GDP, slow population growth and low world oil prices, GHG emissions could be as low as 651 Mt CO_2 eq by 2030 on the low end and 793 Mt CO_2 eq on the high end. This represents a range of 142 Mt CO_2 eq.

The oil and gas price and production assumptions come from the NEB's 2017 high and low scenarios. The fast and slow GDP assumptions were derived from the 2017 *Annual Energy Outlook* by the U.S. Energy Information Agency. As for the population growth assumptions, they were derived by applying the relative differences between Statistics Canada's 2013 high, M1 and low scenarios to the population growth from our "with measures" scenario.

Figure 5A.3 illustrates how differing price and GDP growth assumptions in various combinations might impact Canadian GHG emissions through 2030.

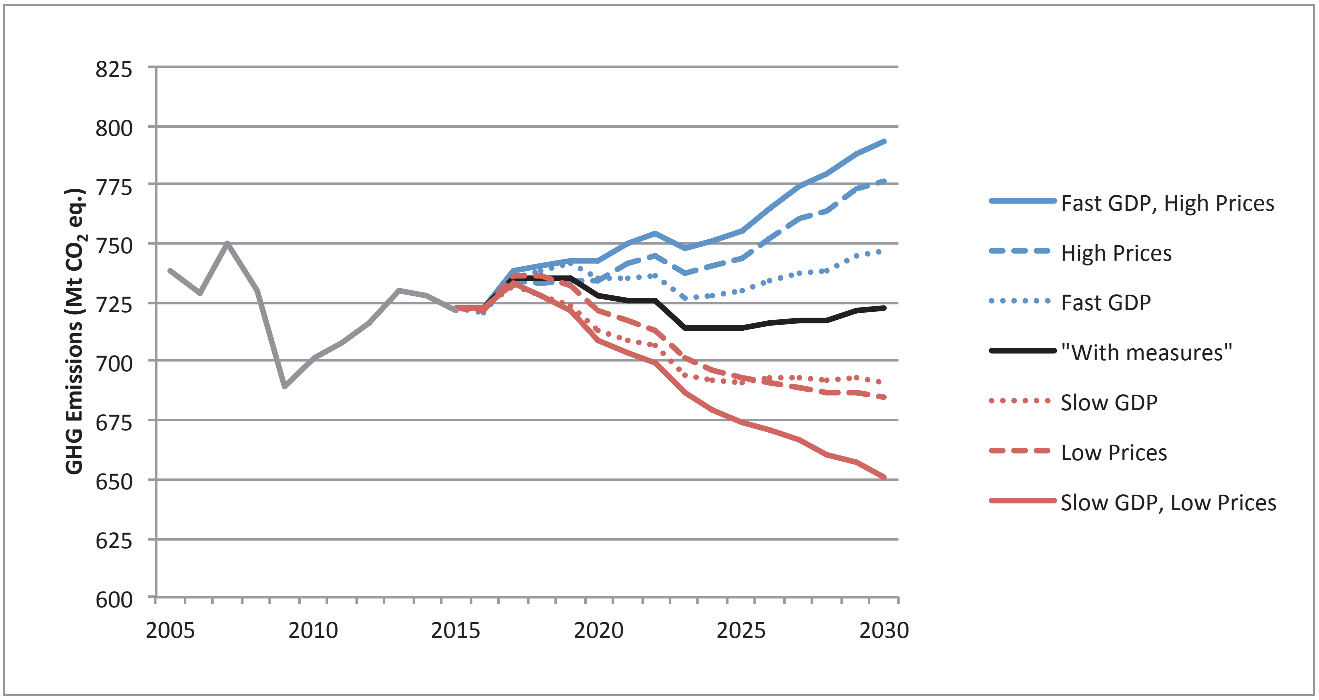


Figure 5A.3: Projected GHG Emissions under Full Range of Alternative Economic Assumptions (excluding LULUCF)

In all of these scenarios, 2015 is the last year of historical data. In 2017, the different scenarios already start to diverge. By 2020, there is already a 33 Mt CO_2 eq range in emissions which stretches out to 142 Mt CO_2 eq in 2030. In 2023, there is a noticeable drop in emissions in all seven of the scenarios, due to the federal methane regulation.

Note that the high and fast scenarios cross around 2020 and the slow and low scenarios cross around 2025. For the low and slow scenarios, this crossing can be explained by the lag between the effect of slow GDP growth on heavy industry and the effect of low world oil price on oil and gas. Since growth of our heavy industry sector is closely tied to that of GDP, the slow GDP growth scenario has much lower emissions in the heavy industry sector compared to the “with measures” scenario. When world oil prices are low, Canada’s oil and gas production suffers, but its heavy industry sector grows a bit due to lower fuel costs. The opposite is true for the fast growth and high price scenarios.

Table 5A.12 contains a sectoral breakdown of the 2030 emissions levels in the various alternate emission scenarios.

Table 5A.12: Projected Difference in GHG Emissions Between the “With Measures” Scenario and the Alternate Emission Scenarios by Sector (excluding LULUCF) in Mt CO_2 eq in 2030

SECTOR	FAST GDP–HIGH WORLD OIL PRICE	HIGH WORLD OIL PRICES	FAST GDP	SLOW GDP	LOW WORLD OIL PRICES	SLOW GDP–LOW WORLD OIL PRICES
Oil and Gas	60	60	0	0	-49	-49
Electricity and Steam	7	5	3	-4	-2	-6
Transportation	4	0	8	-8	1	-7
Heavy Industry	-2	-11	10	-16	9	-9
Buildings	1	0	1	-1	1	0
Agriculture	0	0	0	0	0	0
Waste and Others	1	0	2	-2	2	-1
Grand Total	**71**	**55**	**24**	**-31**	**-37**	**-72**

Note: Numbers may not sum to the total due to rounding.

The range of oil and gas emissions between scenarios is 109 Mt of CO_2 eq. This represents about 75% of the total range of emissions in the alternate emissions scenarios, reflecting the sector’s overall contribution to Canadian emissions and its sensitivity to the highly uncertain driver of world oil and gas prices.

Annex 4: Methodology for Development of Emissions Scenarios

The scenarios developed to support Canada’s GHG emissions projections derive from a series of plausible assumptions regarding, among others, population and economic growth, prices, demand and supply of energy, and the evolution of energy efficiency technologies. With the exception of the “with additional measures” scenario, the projections also assume no further government actions to address GHG emissions beyond those already in place as of September 2017.

The emissions projections presented in this report cannot be viewed as a forecast or prediction of emissions at a future date. Rather, this report presents a simple projection of the current structure and policy context into the future, without attempting to account for the inevitable but as yet unknown changes that will occur in government policy, energy supply, demand and technology, or domestic and international economic and political events.

The emissions projections have been developed in line with generally recognized best practices. They incorporate IPCC standards for estimating GHG emissions across different fuels and processes, rely on outside expert views and the most up-to-date data available for key drivers such as economic growth, energy prices, and energy demand and supply, and apply an internationally recognized energy and macroeconomic modeling framework in the estimation of emissions and economic interactions. Finally, the methodology used to develop the projections and underlying assumptions has been subject to peer review by leading external experts on economic modeling and GHG emissions projections, as well as vetted with key stakeholders.

The approach to developing Canada’s GHG emissions projections involves two main features:

- Using the most up-to-date statistics on GHG emissions and energy use, and sourcing key assumptions from the best available public and private expert sources.
- Developing scenarios of emissions projections using a detailed, proven Energy, Emissions and Economy Model for Canada (E3MC).

Up-to-date Data and Key Assumptions

Each year, ECCC updates its models using the most recent data available from Statistics Canada’s *Report* *on Energy Supply and Demand in Canada* and Canada's NIR. Historical emissions are aligned to the latest NIR. For these projections, the most recent historical data available were for 2015.

In addition to the most recent historical information, the projections are based on expert-derived expectations of key drivers (e.g., world oil price). Projections are based on the latest energy and economic data, with key modeling assumptions aligned with Government of Canada views:

- NEB views on energy prices and large-scale energy projects.
- Economic projections (including GDP, exchange rates and inflation) to 2021 are calibrated to Finance Canada's March 2017 Budget Fiscal Outlook. Economic projections between 2022 and 2030 are based on Finance Canada's long term projections.
- Statistics Canada's population growth projections.[q]

Even with the benefit of external expert assumptions, there is considerable uncertainty surrounding energy price and economic growth assumptions, particularly over the medium- to long-term. As such, a range of emissions is presented representing a series of sensitivity analyses. These cases were based on high and low GDP growth as well as high and low oil prices and production levels.

Energy, Emissions and Economy Model for Canada

The projections presented in this chapter were generated from ECCC's E3MC model. E3MC has two components: Energy 2020, which incorporates Canada's energy supply and demand structure; and the in-house macroeconomic model of the Canadian economy.

Energy 2020 is an integrated, multi-region, multisector North American model that simulates the supply of, price of, and demand for all fuels. The model can determine energy output and prices for each sector, both in regulated and unregulated markets. It simulates how such factors as energy prices and government measures affect the choices that consumers and businesses make when they buy and use energy. The model's outputs include changes in energy use, energy prices, GHG emissions, investment costs, and possible cost savings from measures, in order to identify the direct effects stemming from GHG reduction measures. The resulting savings and investments from Energy 2020 are then used as inputs into the macroeconomic model.

The in-house macroeconomic model is used to examine consumption, investment, production, and trade decisions in the whole economy. It captures the interaction among industries, as well as the implications for changes in producer prices, relative final prices, and income. It also factors in government fiscal balances, monetary flows, and interest and exchange rates. More specifically, the macroeconomic model incorporates 133 industries at a provincial and territorial level. It also has an international component to account for exports and imports, covering about 100 commodities. The macroeconomic model projects the direct impacts on the economy's final demand, output, employment, price formation, and sectoral income that result from various policy choices. These, in turn, permit an estimation of the effect of climate change policy and related impacts on the national economy.

E3MC develops projections using a market-based approach to energy analysis. For each fuel and consuming sector, the model balances energy supply and demand, accounting for economic competition among the various energy sources. This ensures consistent results among the sectors and regions. The model can be operated in a forecasting mode or an analytical mode. In forecasting mode, the model generates an annual energy and emissions outlook to 2050. In analytical mode,

---

[q] Population forecasts are based on Statistics Canada projections, the M1 median growth scenario released in May 2015, and based on the 2011 census. These projections have been updated and adjusted based on provincial consultations.

it assesses broad policy options, specific programs or regulations, new technologies, or other assumptions.

The model's primary outputs are tables showing energy consumption, production and prices by fuel type, year and region. The model also identifies many of the key macroeconomic indicators (e.g., GDP or unemployment) and produces a coherent set of all GHG emissions (such as CO_2, CH_4 and N_2O) by sector and by province.

Figure 5A.4 shows the general structure of E3MC. The component modules of E3MC represent the individual supply, demand, and conversion sectors of domestic energy markets, and also include the macroeconomic module. In general, the modules interact through values representing the prices of the energy delivered to the consuming sectors and the quantities of end-use energy consumption.

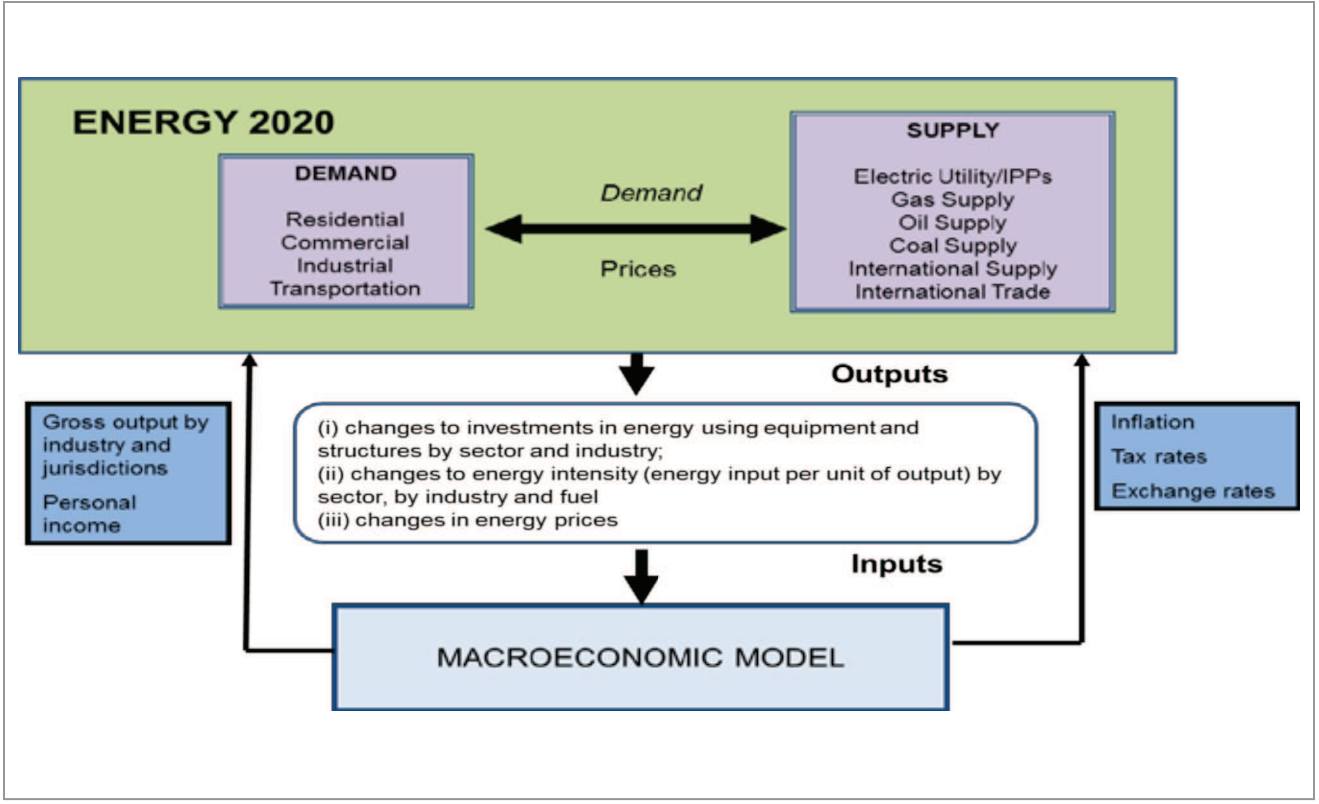


Figure 5A.4: Energy, Emissions and Economy Model for Canada

To develop this projection of energy use and related emissions, it was necessary to provide a view of the Canadian economy to 2030. The level and composition of energy supply and demand, and the resulting GHG emissions, are determined based on many assumptions that influence the overall size and growth rate of the economy.

Treatment of Interaction Effects

Estimates of the net impact of government measures incorporated into the modeling scenarios need to take into account major interaction and behavioural affects. The analytical approach permitted by E3MC addresses these key modeling challenges.

Additionality

This issue relates to the question of what would have happened without the initiative in question. Problems of additionality arise when the stated emissions reductions do not reflect the difference in emissions between equivalent scenarios with and without the initiative in question. This will be the case if stated emissions reductions from an initiative have already been included in the "with measures" scenario: emissions reductions will effectively be double-counted in the absence of appropriate adjustments. The E3MC model controls for additionality by basing its structure on incremental or marginal decision-making. The E3MC model assumes a specific energy efficiency or emission intensity profile at the sector and end-use point (e.g., space heating, lighting, or auxiliary power). Under the E3MC modeling philosophy, if the initiative in question were to increase the efficiency of a furnace, for example, only the efficiency of a new furnace would be changed. The efficiency of older furnaces would not change unless those furnaces are retired and replaced with higher-efficiency ones. As such, any change in the model is incremental to what is reflected in the business-as-usual assumptions.

Free ridership

A related problem, free ridership, arises when stated reductions include the results of behaviour that would occur regardless of the policy. This can occur when subsidies are paid to all purchasers of an item (e.g., a high-efficiency furnace), regardless of whether they purchased the item because of the subsidy. Those who would have purchased the product regardless are termed free riders. In the E3MC model, the behaviour of free riders has already been accounted for in the "with measures" scenario. Thus, their emissions are not counted toward the impact of the policy. Instead, the E3MC model counts only the incremental take-up of the emissions-reducing technology.

The Rebound Effect

This describes the increased use of a more efficient product resulting from the implied decrease in the price of its use. For example, a more efficient car is cheaper to drive and so people may drive more. Emissions reductions will generally be overestimated by between 5% and 20% unless estimates account for increased consumption because of the rebound effect. Within the model, we have mechanisms for fuel choice, process efficiency, device efficiency, short-term budget constraints, and cogeneration, which all react to changes in energy and emissions costs in different time frames.[r] All of these structures work to simulate the rebound effect. In the example above, the impact of extra kilometres that may be driven as a result of improved fuel efficiency is automatically netted out of the associated emissions-reduction estimates.

Policy Interaction Effects

This describes impacts on the overall effectiveness of Canada's emissions-reduction measures when they interact with each other. A policy package containing more than one measure or policy would ideally take into account these impacts in order to understand the true contribution that the policy package is making (in this case, to emission reductions).

E3MC is a comprehensive and integrated model focusing on the interactions between sectors and policies. In the demand sectors, the fuel choice, process efficiency, device efficiency, and level of self-generation are all integrally combined in a consistent manner. The model includes detailed equations to ensure that all the interactions between these structures are simulated with no loss of energy or efficiency. For example, the electric generation sector responds to the demand for electricity from the energy demand sectors, meaning that any policy to reduce electricity demand in the consumer sectors will impact the electricity generation

---

[r] A shift in energy prices will cause: cogeneration to shift in the short to medium term, device efficiency to adjust over the short to midterm, process efficiency to adjust in the midterm, and fuel choice to react in the mid- to long-term. The actual adjustment times depend on the particular sector.

sector. The model accounts for emissions in the electricity generation sector as well as for emissions in the consumer demand sectors. As the electricity sector reduces its emissions intensity, policies designed to reduce electricity demand in the consumer sectors will cause less of an emissions reduction. The natural gas and oil supply sectors similarly respond to the demands from the consumer sectors, including the demands for refined petroleum products for transportation. The model also simulates the export of products by supply sectors.

Taken as a whole, the E3MC model provides a detailed representation of technologies that produce goods and services throughout the economy, and can simulate, in a realistic way, capital stock turnover and choices among technologies. The model also includes a representation of equilibrium feedbacks, such that supply and demand for goods and services adjust to reflect policy. Given its comprehensiveness, E3MC covers all the GHG emissions sources, including those unrelated to energy use.

Simulation of Capital Stock Turnover and Endogenous Technological Change

As a technology vintage model, E3MC tracks the evolution of capital stocks over time through retirements, retrofits, and new purchases, in which consumers and businesses make sequential acquisitions with limited 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 traveled. In each period, capital stocks are retired according to an age-dependent function (although the retrofitting of unretired stocks is possible, if warranted by changing economic conditions). Demand for new stocks grows or declines depending on the initial exogenous forecast of economic output (i.e., a forecast that is external to the model and not explained by it) and the subsequent interplay of energy supply–demand with the macroeconomic module. A model simulation iterates between energy supply–demand and the macroeconomic module until there is a convergence. The global convergence criterion is set at 0.1% between iterations. This convergence procedure is repeated for each year over the simulation period.

The E3MC model simulates the competition of technologies at each energy service node in the economy, based on a comparison of their cost and some technology-specific controls, such as a maximum market share limit in cases where a technology is constrained by physical, technical or regulatory means from capturing all of a market. The technology choice simulation reflects the financial costs as well as the consumer and business preferences, revealed by real-world technology acquisition behaviour.

Model Limitations

While E3MC is a sophisticated analytical tool, no model can fully capture the complicated interactions associated with given policy measures between and within markets or between firms and consumers. Unlike computable general equilibrium models, however, the E3MC model does not fully equilibrate government budgets and the markets for employment and investment. That is, the modeling results reflect rigidities such as unemployment and government surpluses and deficits. Furthermore, the model, as used by ECCC, does not generate changes in nominal interest rates and exchange rates, as would occur under a monetary policy response to a major economic event.

Annex 5: Further Sources

Canada produces three products that report on GHG emissions:

1. *National Inventory Report*

The NIR provides Canada's historical emissions starting in 1990. The Report fulfills Canada's obligations as a signatory to the UNFCCC, to prepare and submit an annual national GHG inventory covering anthropogenic emissions by sources and removals by sinks. The Report is prepared with input from numerous experts and scientists across Canada.

2. *Facility GHG Emissions Reporting*

The GHG Emissions Reporting Program (GHGRP) is Canada's legislated, publicly accessible inventory of facility-reported GHG (GHG) data and information. Unlike the NIR, which compiles GHG data at a national level and is developed from national and provincial statistics, the GHG Reporting Program applies only to the largest GHG emitters in Canada (industrial and other types of facilities). Through the GHG Reporting Program, all facilities that emit the equivalent of 50 kt CO_2 eq or more of GHGs per year are required to submit a report to ECCC.

3. *Canada's GHG Emissions Reference Case*

Canada's GHG Emissions Reference Case is a projection of GHG emissions to the year 2030, at the national, provincial and sector level. The report is used to for a variety of purposes, including supporting climate change policy development. The projections are generated by an in-house integrated energy, economy and environment modeling platform, peer-reviewed by external experts.

The NEB's *Canada's Energy Future* forms the basis for the oil and gas sector modeling. This report contains comprehensive energy supply and demand expectations to 2030 and includes scenarios for all energy commodities including oil, natural gas, natural gas liquids and electricity. Further, the NEB provides data on energy prices, factors affecting prices and the deliverability of natural gas. Data and projections from the NEB are incorporated into the exogenous oil and gas module in E3MC.

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1,* SC 2018, c. 12

Court of Appeal File No.: C65807

COURT OF APPEAL FOR ONTARIO
Proceedings commenced at Toronto

AFFIDAVIT OF WARREN GOODLET AFFIRMED JANUARY 29, 2019 FILED ON BEHALF OF THE ATTORNEY GENERAL OF CANADA

ATTORNEY GENERAL OF CANADA
Department of Justice Canada
Prairie Region Office (Winnipeg)
301 – 310 Broadway
Winnipeg, MB R3C 0S6

Per: Sharlene Telles-Langdon, Brooke Sittler,
Mary Matthews, Neil Goodridge, and Ned Djordjevic

Phone: 204-983-0862
Fax: 204-984-8495
E-mail: sharlene.telles-langdon@justice.gc.ca

Counsel for the Attorney General of Canada

Fax to: (416) 326-4015
E-mail to: joshua.hunter@ontario.ca
padraic.ryan@ontario.ca
thomas.lipton@ontario.ca

Court of Appeal File No.: C65807

COURT OF APPEAL FOR ONTARIO

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1*, SC 2018, c. 12

AFFIDAVIT OF ANDRÉ FRANÇOIS GIROUX
AFFIRMED ON JANUARY 11, 2019
FILED ON BEHALF OF THE ATTORNEY GENERAL OF CANADA

ATTORNEY GENERAL OF CANADA
Department of Justice Canada
Prairie Region Office (Winnipeg)
301 – 310 Broadway
Winnipeg, MB R3C 0S6

Per: Sharlene Telles-Langdon,
Brooke Sittler, Mary Matthews,
Neil Goodridge, and Ned Djordjevic

Phone: 204-983-0862
Fax: 204-984-8495
E-mail: sharlene.telles-langdon@justice.gc.ca

Counsel for the Attorney General of Canada

Docket: C65807

COURT OF APPEAL FOR ONTARIO

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1,* SC 2018, c. 12

AFFIDAVIT OF ANDRÉ FRANÇOIS GIROUX, AFFIRMED ON JANUARY 11, 2019 FILED ON BEHALF OF THE ATTORNEY GENERAL OF CANADA

AFFIDAVIT OF ANDRÉ FRANÇOIS GIROUX

I, ANDRÉ FRANCOIS GIROUX, of the Municipality of Ottawa, in the province of Ontario, MAKE OATH AND SAY THAT:

1. I am the Secretary and Director, Free Trade Agreements and NAFTA, Secretariat at Global Affairs Canada. I have held this position since September 2017. As part of my current responsibilities, I serve as Canada's Contact Point for the Canada-European Union Comprehensive Economic and Trade Agreement ("CETA"). According to Article 26.5 of CETA, each Party is required to appoint an individual who serves as the CETA contact point. In this capacity, I am the Government of Canada official responsible for the administration and oversight of CETA. By virtue of this position I have contact with many of the representatives of the EU and Member States. More specifically, I am entrusted by the CETA treaty to:

(a) monitor the work of all institutional bodies established under this Agreement, including communications relating to successors to those bodies;

(b) coordinate preparations for committee meetings;

(c) follow up on any decisions made by the CETA Joint Committee, as appropriate;

(d) except as otherwise provided in CETA, receive all notifications and information provided pursuant to CETA and, as necessary, facilitate communications between the Parties on any matter covered by CETA;

(e) respond to any information requests pursuant to Article 27.2 (Provision of Information) of CETA; and

(f) consider any other matter that may affect the operation of CETA as mandated by the CETA Joint Committee.

2. I am also the Canadian co-chair of the CETA Trade and Sustainable Development Committee ("TSD Committee"). Among other things, the TSD Committee worked to develop a joint Canada-EU Recommendation on trade, climate change and the *Paris Agreement* that was signed on September 26, 2018 by Canada's Minister for International Trade Diversification and the EU Commissioner for Trade. The TSD Committee is also responsible for the initiation of joint cooperative TSD initiatives between Canada and the European Union ("EU"), the establishment of CETA TSD Domestic Advisory Groups (made up of domestic stakeholders and civil society), the planning of the TSD Civil Society Forum, and the review of the Trade and Sustainable Development Chapter of CETA.

3. As a result of these two responsibilities (CETA Contact Point and TSD Committee co-Chair), I am privy to issues and concerns of the Parties that are relevant to their engagement with CETA in general, and on environment and labour issues more particularly.

4. I obtained a Bachelor of Laws from the University of Montréal in 1992, a Master of Laws from McGill University in 1994, a Master of European Community Law from the College of Europe in Belgium in 1995, as well as a Master of Business Administration from HEC Montréal in 2001. I have been a member of the Barreau du Québec since 1995.

5. I joined the Department of Foreign Affairs and International Trade in 1995. Since then, I have served Canada abroad in various capacities. From 1996 to 1999, I served abroad as Third and Second Secretary at the Permanent Mission of Canada to the United Nations in New York, in part during Canada's term on the Security Council. From 2004 to 2008, I served as counselor at the Embassy of Canada to France. My most recent service abroad was 2012 to 2016, as the Ambassador of Canada to the Kingdom of Denmark.

6. Within Canada, I have had assignments in the Trade Law Bureau (1999-2000) and in the International Economic Relations and Summits Division (2001-2004), where I held the position of Deputy Director – G7/G8 Summits. From 2008 to 2010, I was Director of the Non-Proliferation and Disarmament Division, and from 2010 to 2012, I was Director of the Office of the Deputy Minister of Foreign Affairs. Prior to my current position, I was Deputy Chief of Protocol of Canada & Director Official Visits from 2016 to 2017.

Trade Agreements

7. International trade agreements are the product of negotiations between two or more States that dictate the terms of the acceptable exchange of goods and services between the parties. Canada's participation in international trade agreements is important to the country's prosperity as a whole. Canada has an abundance of production in natural resources, manufactured goods, and the provision of services, but has a relatively small domestic market. This means it is critical for Canada to gain access to foreign markets and attract foreign investments and to secure and enhance that access through enforceable rules. The benefits of international trade agreements include a clear and stable framework within which to conduct business, as well as secure and improved access to markets.

8. International trade agreements, such as CETA, can provide many economic benefits to the citizens of a nation. They can, for example, serve to lower the price of imports so consumers pay less for products, and allow domestic businesses and industries to find new markets abroad for their own tariff-free or tariff-reduced products. International trade agreements create a level playing field for companies to compete in international markets. They offer predictable, fair, and transparent conditions for businesses operating abroad. This is of critical importance to a trading nation such as Canada, where exports accounted for 31.5% of GDP in 2015 (or 36% of GDP before the global recession began in 2008), up from 25% before Canada signed a series of international trade agreements starting in 1988. In 2011, these exports directly and indirectly accounted for 2,942,400 jobs in Canada according to Statistics Canada, or 16.7% of all employment.

9. Financial advantage is not the only factor that is taken into consideration by many States when deciding whether to embark upon negotiating or ratifying an international trade agreement. Other non-economic factors, such as a State's human rights record, its labour practices, and increasingly, its record on environmental protection, can play key roles in determining whether a State is an acceptable partner with which to enter into negotiations or ratify a trade agreement. The number of international trade agreements that include environmental provisions is on the rise and often an entire chapter is devoted to environmental protection. In the Canadian context, the public is generally very supportive of the diversification of markets, but they also expect Canada to enter into trade relationships with States that share Canada's values in areas such as labour standards and environmental protection. For example, Canada has sought enforceable environment and labour chapters in its recent trade negotiations, including in the recently signed US-Mexico-Canada Agreement ("USMCA"). Many other States seek similar provisions on environment and labour, including the EU and many of its Member States.

CETA and Environmental Protection

10. CETA is a significant international trade agreement for Canada. The agreement gives Canadian exporters preferential access to the largest market in the world, constituting approximately 510 million people.

11. CETA covers virtually all sectors and aspects of Canada-EU trade in order to eliminate or reduce barriers to markets. It addresses everything from tariffs to product standards, investment, professional certification, and many other areas of activity. The agreement's broad scope—including improved access to EU markets for goods and services; greater certainty, transparency, and protection for investments; and new opportunities in EU procurement markets—translates into real benefits for Canadians and contributes to Canada's long-term prosperity. CETA upholds and promotes values that Canada shares with the EU, including sustainable development, labour standards, and environment protection. The agreement was signed on October 30, 2016 and almost all of it has been provisionally applied since September 21, 2017. CETA has only been ratified by 11 of the 28 Member

States, and remains to be ratified by States such as France, Italy, and Germany. This process of ratification will take a minimum of four to five years.

12. CETA contains a number of environment-related provisions, including provisions set out in chapters titled "Trade and Environment" and "Trade and Sustainable Development." The chapters reflect several environmental principles such as the precautionary principle (whereby the absence of scientific certainty must not be a reason to delay adopting environmental measures) and the polluter pays principle (whereby the costs of pollution must be assumed by the polluter rather than by society as a whole). CETA also expressly refers to climate change. It requires Parties to pay special attention to trade in environmental goods and services related to renewable energy sources, and to cooperate in their climate change adaptation and mitigation policies.

13. Negotiations of the CETA were concluded before the adoption of the *Paris Agreement.* I have been informed by counsel for Canada that the *Paris Agreement* will be attached as an Exhibit to the Affidavit of Mr. John Moffet. A number of the Member States placed great importance on a commitment of the Parties to environmental protection, including the implementation of the *Paris Agreement*. This was acknowledged in a Joint Interpretative Instrument on CETA between Canada, the EU, and its Member States ("Joint Interpretive Instrument") that was concluded at the time of signature of the CETA.

14. The Joint Interpretive Instrument provides a clear and unambiguous statement of what the Parties agreed to in a number of CETA provisions that have been the object of public debate and concern, and provides an agreed interpretation thereof. This includes, in particular, the impact of CETA on the ability of governments to regulate in the public interest, the provisions on investment protection and dispute resolution, and on sustainable development, labour rights, and environmental protection. Article 9 of the Joint Interpretive Instrument states the following:

> 9. Environmental Protection

> a) CETA commits the European Union and its Member States and Canada to provide for and encourage high levels of environmental protection, as well as to strive to continue to improve such laws and policies and their underlying levels of protection.
>
> b) CETA explicitly recognises the right of Canada and of the European Union and its Member States, to set their own environmental priorities, to establish their own levels of environmental protection and to adopt or modify their relevant laws and policies accordingly, mindful of their international obligations, including those set by multilateral environmental agreements. At the same time in CETA the European Union and its Member States and Canada have agreed not to lower levels of environmental protection in order to encourage trade or investment and, in case of any violation of this commitment, governments can remedy such violations regardless of whether these negatively affect an investment or investor's expectations of profit.
>
> c) CETA includes commitments towards the sustainable management of forests, fisheries and aquaculture. It also includes commitments to cooperate on trade-related environmental issues of common interest such as climate change where the implementation of the *Paris Agreement* will be an important shared responsibility for the European Union and its Member States and Canada.

15. On September 26, 2018, the CETA Joint Committee, established under Article 26.1 of the CETA, held its first meeting which I attended in Montréal, Canada. The Joint Committee adopted three recommendations at that time which set the stage for further work under CETA, one of which concerned climate change and the *Paris Agreement*. The Canadian Minister for International Trade Diversification, James Carr, and the European Commissioner for Trade, Cecilia Malmström, adopted a joint Canada-EU Recommendation on Trade, Climate Change and the *Paris Agreement*, reaffirming their commitment to effectively implement the *Paris Agreement*. The objectives of the Recommendation were reiterated in the joint communiqué issued by Minister Carr and Commissioner Malmström following the conclusion of the CETA Joint Committee meeting. This Recommendation is attached as Exhibit "A" to my affidavit.

Canada's efforts towards meeting Paris Agreement *and their effect on CETA*

16. It is of critical importance that the Member States who have not yet ratified CETA see that Canada is following through with its environmental responsibilities, including its ability to meet Canada's *Paris Agreement* emissions reduction target of reducing greenhouse gas emissions across all sectors of the economy by 30% below 2005 levels by 2030. Canada's commitment to mitigating climate change and to the *Paris Agreement* was, and continues to be, a key factor in achieving ratification of CETA.

17. Irrespective of the reason, should it become clear that Canada is not on track to meet its *Paris Agreement* emissions reduction target, many of the Member States that have still not ratified CETA will have difficulty proceeding with that ratification. The European Commission and a number of key Member States are watching the developments in Canada closely with respect to Saskatchewan and Ontario's rejection of a national carbon pricing regime. They are observing these developments with great concern in relation to their impact on Canada's ability to meet its greenhouse gas emissions reduction target under the *Paris Agreement*. France in particular has expressed reservations with regards to its ratification of CETA due to the agreement's lack of commitment on climate action, and to the implementation of the *Paris Agreement*.

18. In October, 2017, as a response to domestic public and political pressures vis-à-vis CETA and other international trade agreements, the French government presented an action plan on CETA implementation where it outlined a substantive list of proposals, including one on climate action. The joint Canada –EU Recommendation on Trade, Climate Change and the *Paris Agreement*, signed by the CETA Joint Committee on September 26, 2018, specifically addressed some of these sensitivities to encourage France (and other EU Member States) to ratify the Agreement by linking Canada's shared commitment to the *Paris Agreement* to CETA.

19. France, like Germany (where similar concerns have also been raised), is a key player within the EU and its refusal to ratify CETA would serve as an incentive for other EU Member States to oppose the Agreement as well. Moreover, France has since expressed

concern over making trade deals with States that do not abide by climate conventions. French President Emmanuel Macron declared on September 25, 2018 before the U.N. General Assembly in New York that France would no longer accept "commercial agreements" with countries that do not respect the *Paris Agreement*. The transcript of President Macron's speech is attached as Exhibit "B" to my affidavit.

20. Ultimately, CETA's ratification by all the Member States and the EU will be placed in jeopardy if Canada is not on a path to meet its *Paris Agreement* emissions reduction target. Canada's ability to meet environmental targets in multilateral environmental agreements, such as the *Paris Agreement*, is not only important under CETA and to ensure further ratifications of CETA by EU Member States, it will also play an increasingly important role in Canada's ability to negotiate future international trade agreements.

AFFIRMED BEFORE ME in the City of Ottawa, in the Province of Ontario, on January 11, 2019. I certify that Mr. Giroux has satisfied me that he is a person entitled to affirm. Commissioner for Taking Affidavits	André François Giroux

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1*, SC 2018, c. 12

Court of Appeal File No.: C65807

COURT OF APPEAL FOR ONTARIO

Proceedings commenced at Toronto

AFFIDAVIT OF ANDRÉ FRANÇOIS GIROUX, AFFIRMED ON JANUARY 10, 2019 FILED ON BEHALF OF THE ATTORNEY GENERAL OF CANADA

ATTORNEY GENERAL OF CANADA
Department of Justice Canada
Prairie Region Office (Winnipeg)
301 – 310 Broadway
Winnipeg, MB R3C 0S6

Per: Sharlene Telles-Langdon,
Brooke Sittler, Mary Matthews,
Neil Goodridge, and Ned Djordjevic

Phone: 204-983-0862
Fax: 204-984-8495
E-mail: sharlene.telles-langdon@justice.gc.ca

Counsel for the Attorney General of Canada

Fax to: (416) 326-4015
E-mail to: joshua.hunter@ontario.ca
padraic.ryan@ontario.ca
thomas.lipton@ontario.ca

This is **Exhibit A** referred to in the
affidavit of **André François Giroux**
affirmed before me on January 11, **2019**

Commissioner for Taking Affidavits

Canada and the European Union hold the inaugural meeting of the CETA Joint Committee

Canada and the EU held the first meeting of the Comprehensive Economic and Trade Agreement (CETA) Joint Committee today in Montreal

Joint Communique

September 26, 2018

Today, the Joint Committee established under the Canada-European Union (EU) Comprehensive Economic and Trade Agreement (CETA) held its first meeting in Montreal, Canada, co-chaired by the Canadian Minister for International Trade Diversification, James Carr, and the European Commissioner for Trade, Cecilia Malmström.

Minister Carr and Commissioner Malmström reviewed the progress achieved since the start of provisional application on September 21, 2017, took stock of the status of the implementation of the Agreement, and discussed how CETA is creating new opportunities for people on both sides of the Atlantic.

Three recommendations were adopted setting the stage for further work under CETA, specifically on trade and small and medium-sized enterprises (SMEs), climate change and the Paris Agreement, and trade and gender.

To increase trade and investment opportunities for small and medium-sized enterprises (SMEs), contact points and a dedicated website for such companies will be set up, to take into account the needs of SMEs in the implementation of CETA.

Minister Carr and Commissioner Malmström discussed how the Agreement can further support efforts to address the urgent threat of climate change. By adopting a joint Canada-EU Recommendation on Climate Change and the Paris Agreement, they affirmed their commitment to effectively implement the Paris Agreement. Intensifying existing collaboration in the climate field, the adopted document states that the two sides will "*cooperate, work together and take joint actions*" to contribute to the goals of the Paris Agreement and the transition to low greenhouse-gas emissions.

On the topic of trade and gender, the agreed document recognises the importance of making trade policies more gender-responsive in order to ensure that the benefits of trade liberalisation reach everyone. It also stresses the need to better understand the impact of trade on gender equality and women's participation in the economy. Canada and the EU will cooperate and share information to that end.

Minister Carr and Commissioner Malmström, recalling the October 2016 Joint Interpretative Instrument, and the commitment to initiating an early review of the Trade and Sustainable Development Chapters, including their enforcement mechanisms, agreed to intensify efforts to that end. They welcomed progress in the implementation of these chapters so far – Canada and the EU have already identified some preliminary joint priorities for this work, such as labour issues in the global supply chains in third countries; collective bargaining in the context of the changing world of work, in particular in the web-based economy; understanding better the dynamic between trade and gender equality; and promoting responsible business conduct. Commissioner Malmström and Minister Carr invited the CETA Trade and Sustainable Development Committee to swiftly follow-up with concrete actions in these areas and potentially others. The two also agreed to propose solutions and outcomes at the second CETA Joint Committee meeting next year.

Carr and Malmström welcomed the establishment of the Civil Society Forum, composed of representatives of civil society that will conduct a dialogue with the CETA Trade and Sustainable Development Committee throughout its work. They also encouraged civil society to engage in future exchanges on regulatory cooperation in the Regulatory Cooperation Forum.

Carr and Malmström welcomed progress and reiterated their commitment to reduce duplicative testing requirements under CETA's Protocol on Conformity Assessment, with a view to cut down on certification costs.

Today's meeting also allowed Minister Carr and Commissioner Malmström to reiterate their commitment to the success of CETA. The agreement serves as a signal to the rest of the world of the determination of Canada and the EU to continue to stand up for inclusive free trade, at a time when the global rules-based trading system faces serious challenges. For this reason, both sides took the opportunity to discuss initiatives to reform the World Trade Organisation (WTO).

Finally, the meeting was an occasion to celebrate the one-year anniversary of the provisional application of CETA. Since September 2017 Canada and the EU have benefitted from increased trade in many sectors.

Minister Carr and Commissioner Malmström agreed to hold the second meeting of the CETA Joint Committee next year in Europe to review further progress, and to ensure that the agreement continues to deliver tangible benefits on both sides of the Atlantic.

This is **Exhibit B** referred to in the
affidavit of **André François Giroux**
affirmed before me on January 11, **2019**

Commissioner for Taking Affidavits

Seventy-third United Nations General Assembly – Speech by M. Emmanuel Macron, President of the Republic

New York, 25 September 2018

Mr President of the United Nations General Assembly,

Mr Secretary-General,

Heads of state and government,

Ladies and gentlemen,

UN ROLE

All of us here have inherited a tremendous hope, that of saving future generations from the scourge of war, of building a world order based on law and on keeping promises, of helping humanity move forward towards economic, social and moral progress, with freedom that is increasingly guaranteed.

And we have made progress: human rights have spread, trade and prosperity have been expanded, poverty has been reduced. This is what we have achieved over the last few decades.

However, we must examine the period we are going through with a clear head. We are currently experiencing a deep crisis of the Westphalian liberal world order that we have known. Firstly, because it has failed in part to regulate itself. Its economic, financial, environmental and climate-related failings have not yet been satisfactorily resolved.

Secondly, because our collective capacity to respond to crises is still all too often hampered by divisions in the Security Council. Our organization is all too often limited to deploring the violations of rights that it had sworn to guarantee. Seventy years after the adoption of the Declaration of Human Rights by this Assembly in Paris, cultural, historical, and religious relativism is now calling into question the foundations of their universality.

Born out of hope, the UN may become, like the League of Nations that preceded it, a symbol of powerlessness. And there is no need to look for those responsible for this disintegration: they are here, in this Assembly. They are speaking today. It's we, the leaders, who are responsible.

Based on this observation, we essentially have three main paths forward. The first involves seeing this as a moment, an interlude in history before things return to normal. I do not believe this. I do not believe this because we are currently experiencing a crisis of the effectiveness and principles of our contemporary world order which will not be able to get back on track or return to how it functioned before. The period we are going through is not an interlude: it reflects our own past deficiencies.

The second path forward would be based on a survival-of-the-fittest approach, the temptation for everyone to follow their own laws. What I am saying is that this path of unilateralism leads us directly to withdrawal and conflict, to widespread confrontation between everyone, to the detriment of all - even, eventually, of those who believe they are the

VI

strongest. We have a joint responsibility for peace: it cannot be delegated, cannot be refused, cannot be pre-empted. A survival-of-the-fittest approach does not protect any group of people against any kind of threat, whether chemical or nuclear.

IRAN

What will make it possible to truly resolve the situation in Iran and what has already started to help stabilize it? A survival-of-the-fittest approach, pressure from a single stakeholder? No! We know that Iran was on the path towards military nuclear capability, but what stopped it? The agreement brokered in Vienna in 2015. As I said a year ago, we should not exacerbate regional tensions, but rather propose a broader agenda that will make it possible to address all nuclear, ballistic and regional concerns caused by Iranian policies, through dialogue and multilateralism. Without being naïve or complacent, but without any posturing, which will certainly be pointless in the end.

TRADE

What will resolve the problem of trade imbalances and all of their consequences on our societies? Common rules adapted to today's reality that will make it possible to establish the conditions for equal and fair competition, and not, under any circumstances, the bilateral treatment of all our trade disputes or a new form of protectionism.

MIDDLE EAST CONFLICT

What will make it possible to resolve the crisis between Israel and Palestine? Not unilateral initiatives, or ignoring the legitimate rights of the Palestinians to achieve sustainable peace, or underestimating the legitimate right of Israelis to their security. There is no other credible alternative to the solution of two states living side by side in peace and security, with Jerusalem as their capital. Israel knows that France is a true friend and it is in the name of this friendship that I call on it to swiftly put an end to the fait accompli policy which threatens the very possibility of achieving a peace deal. To continue along this path would be a mistake.

"NEW WORLD BALANCE"

On this issue, I am ready, and we must be ready, to abandon the dogmas, the long-standing positions, to take new initiatives, provided that this leads to positive changes on the ground. A survival-of-the-fittest approach will only serve to increase frustrations and violence.

As you will have understood, in the face of the current imbalances, I do not believe in a survival-of-the-fittest approach even if it were disguised as some form of legitimacy, when in reality it has lost any kind of legality.

I believe in a third way forward for us, undoubtedly the most difficult, undoubtedly the most challenging, requiring us to forge together a new model, to find together a new world balance. Because after a form of superpower model, we have been experiencing for several years now a new form of global instability, marked by the return of multiple powers.

The new equilibrium that we must create must be based on new forms of regional and international cooperation and will, I believe, be based on three principles: firstly, respect for sovereignty, which is at the very foundation of our charter; secondly, the strengthening of our regional cooperation; and thirdly, the provision of more robust international guarantees. And it

VI

is through this method, based on these three principles, that we must ensure we can resolve the current crisis situations.

SYRIA

Therefore, in Syria, we are continuing the fight against Islamist terrorism. The military engagement of certain countries has allowed the regime to re-establish itself, resulting in crimes for which the perpetrators will one day be held accountable. The Syrian people have tragically paid the price, and there can be no victors in a Syria in ruins. What we have to do now is restore peace under UN auspices. It is not up to us to decide for the Syrian people, but to develop the ways and means to implement this method that I have just described and therefore to develop a solution that is backed, not just by the guarantor states in the Astana process, but by other states in the region and the international community through the Small Group, under the coordination of the United Nations and the special representative of the Secretary-General, in order to resolve the humanitarian crisis on the one hand and, on the other hand, to build an inclusive, lasting political solution through constitutional reform and the holding of free elections.

This is what truly respecting Syrian sovereignty means! It does not mean deciding on behalf of the Syrian people who should be their leader or agreeing to cover up all of the crimes by allowing this leader to remain until the end of time, on the basis that we no longer have any principles, or, basically, any rights.

LIBYA

And again in Libya, this new method should make it possible to bring about a lasting solution. The current status quo enables the militias, the traffickers to gain ground, destabilizing the entire region. We will not give the Libyan people the means to resolve the situation if we remain divided, if Libya becomes the battleground, as it still too often is, for confrontation between foreign influences.

In Paris, the Libyans pledged to swiftly hold elections, which will make it possible to reunify state institutions. These commitments must be fulfilled under the auspices of the United Nations, with close cooperation from the African Union.

Yesterday an important step was taken, one that I would like to applaud. It is in the Libyan people's interest and in that of their neighbours, the Europeans and the international community, which must unite around these goals in order to move forward.

SAHEL

All together we are strong in the face of terrorism when states can count on their own forces to guarantee their security, and also when that security is based on regional and international solutions, according to the principle I have just elucidated.

That is the decision taken by the Sahel nations, which are working together within the G5 Force. That is the point of the process launched by the African Union to better shoulder its responsibilities through African peace operations. That is the point of the initiatives being taken in the Lake Chad region, which are also being shepherded by Nigeria, Chad and Cameroon and supported by the African Union.

VI

That is why we must support this African Union initiative and push for better coordination between the African Union and the United Nations. I hope that by the end of the year a resolution can be adopted to that effect.

We are strong in the face of terrorism when together we assume our responsibilities for combating all its methods of financing; when – as we are doing in the Sahel Alliance – we are capable of working together to foster development, agriculture and education, to eradicate the roots of the despair that has allowed terrorists to capture people's souls.

S7.5 billion has now been allocated to 500 projects that were jointly defined with all the relevant nations and the partners in the Sahel Alliance. It is these initial results that we must consolidate.

You can see that in each of these crises, the answer was not to leave states on their own, not to take their place or to tell them from here what the law or solution is, but rather to conscientiously articulate the principle of the sovereignty of peoples, of regional cooperation and of a true commitment by the international community. These things form a triptych on which contemporary solutions are built.

Only collective action makes it possible to preserve the sovereignty and equality of the people who have given us a mandate. It is this same imperative we must champion in the face of the demographic, climate and digital challenges awaiting us, which none of us can confront alone.

MIGRATION

Faced with the great challenge of migration, I do not believe in talk of unconditional openness – it only produces worry and heightens intolerance. Nor do I believe the lies of those who claim, for example, that in Europe and elsewhere they will be stronger if they take shelter behind closed borders. That is not true.

The only effective way to manage the migratory flows affecting all of our continents in an orderly, controlled fashion is to create the conditions for a type of international mobility that is freely chosen, not imposed; to work together, whether we are countries of origin, of transit or of destination, to tackle the deep causes of such migration, especially when it is imposed; to dismantle networks of traffickers, which are the worst scourge in this situation; and to protect our borders in a respectful way while ensuring compliance with international law, and in particular the unconditional protection of those who have the right to asylum. That is what we decided to do together in the UN compact that will be adopted in Marrakesh this December, and which I support.

CLIMATE/DIGITAL WORLD

When it comes to climate disruption, there are no free-riders or easy solutions either. Even those who dispute the reality suffer the consequences like everybody else. Extreme weather is now a daily occurrence. Those who undermine collective action are only exposing themselves to a greater degree.

When it comes to the great digital transformation, here too it is our duty to stand together to establish contemporary rules that will make it possible to reconcile the

\/\

development of artificial intelligence with our ethical rules, to guide the digital transformation of our societies.

MULTILATERALISM

You see, my dear friends, I believe deeply in the sovereignty of peoples, which today is strong and present, and demanded by all of our people on the international stage. But at the same time I believe in a strengthened cooperation taking multiple forms and in the renewed legitimacy of international engagement in this context. The great battle of our forerunners was the fight for peace, which is still incumbent upon us. We will only win that battle in the 21st century by restoring a strong multilateral system capable of resolving conflicts in a pragmatic manner, but also and more broadly by tackling the causes of these disturbances.

To be honest, I don't believe in one great globalized people. Not at all – it is utopian, there is no such thing. But I do believe in universal values, and on this point we must not back down, it is not the same thing! I believe in the non-negotiable defence of our values, human rights, the dignity of individuals, gender equality. I believe in our ability to establish equilibriums that are respectful of people and cultures, with no haggling about their universality – they are the reality! And in no way will I yield the principle of the sovereignty of peoples to nationalists or to those in the international community who advocate retreating inwards, who want to use the sovereignty of peoples to attack the universality of our values - their strength is what keeps us all here in this room!

INEQUALITIES

All of us here, even those who make a point of criticizing it, benefit from the structuring of the international order that went hand in hand with globalization. Now we must tackle the deep causes of our imbalances, we must look together at the weaknesses of our international order and – beyond the crises I've just mentioned – look at the deep inequalities that have set in.

For me, this is the crux of our problem today: what is rekindling nationalism and doubts about our Assembly? What is generating crises everywhere? These deep inequalities that we have been unable to resolve.

Ten years ago, when the financial crisis broke out, we took emergency measures but we did not solve the deepest problem, we did not curb the trend towards the hyper-concentration of wealth on our planet and we did not really provide an answer to all those who were left behind by globalization. All those who were marginalized and frustrated by the humiliations they had suffered harboured a despair whose price we are collectively paying today.

We owe all these fellow citizens an answer. We owe an answer, my friends, to the 265 million children, more than half of whom live in sub-Saharan Africa, who have no access to schooling; to the girls who enjoy fair access to education in less than 40 percent of all countries.

We owe an answer to the 700 million children who live in the regions most exposed to the effects of climate change, who are the victims of floods, drought, rising waters, diminishing resources.

We owe an answer to the 200 million women who don't have access to contraception, to the billion-plus who are not protected by the law if they suffer violence in their home. To all the women whose pay gap with men averages 23% worldwide and up to 40% in rural areas. We owe an answer to the 783 million people who live below the poverty line, who suffer from hunger or chronic malnutrition, to those who don't have access to basic care.

We owe an answer when it comes to the aspirations of the largest number of young people in history, our young people, i.e. nearly two billion people between 10 and 24 years old today, 90% of whom live in developing countries.

We owe an answer to all those who look to us because their fate depends on what we can or can't do here together, in this Assembly. And those people who forget that we owe them all an answer are wrong because they're preparing for crises tomorrow, the day after, because they'll leave their successors, because we'll leave our children in a much worse situation than the one we're in right now.

2030 AGENDA FOR SUSTAINABLE DEVELOPMENT

We have made progress on reducing inequalities between our countries, and we have given ourselves the framework for this with the 2030 Agenda for [Sustainable] Development; but the battle is not behind us, it is far from over. Per capita wealth is 50 times greater in OECD countries than it is in low-income countries. Do we believe we can build stability, balance, over the long term, given such a situation? No, we must act!

That's why – as I announced here last year – I decided to increase France's official development assistance by €1 billion from 2019. Our humanitarian funding will go up 40%.

FRENCH G7 PRESIDENCY

But this is also why the fight against inequalities will be the priority of France's G7 summit presidency in 2019. Indeed, after Canada – whose leadership I want to pay tribute to here –, France will hold the next presidency of the G7, whose format I would like to thoroughly revise to involve more effectively several other powers, and work at new forms of coordination.

It's at the United Nations first that I want to say this inequalities agenda will be central to the next G7. I am also pledging to you to report back on the results of the Biarritz G7 next September, because the time when a club of rich countries could alone define the world's inequalities is long gone, because the fate of every country belonging to it is inseparable from that of every member of this Assembly.

Yes, we must tackle present-day inequalities today because they're at the root of the evil I was denouncing at the beginning of my speech. We must tackle inequalities of destiny. It's a moral aberration as much as a reality which is untenable. It is unacceptable not to enjoy the same opportunities depending on the country you are born in, not to be able to go to school in some countries because you are a woman, not to have access to certain basic care.

EDUCATION

We've honoured the pledge the President of Senegal and I made right here last year; the Global Partnership for Education's Financing Conference in Dakar in February raised $2.5

billion to develop access to education in the world. It's a historic sum. France increased its contribution tenfold. The active efforts the G7 has already begun to make under Canada's presidency will have to allow further progress.

We are at a watershed on this issue, during which we'll be able to grasp the full extent of the challenge facing us, or not. Six hundred and twenty million more children in the world need to be provided with schooling between now and 2030, including 444 million Africans. Are we going to give ourselves the resources for this? Are we going to give them all the resources for a solid grounding, enabling them to take control of their lives, fraternal lives in tomorrow's world? If we don't, what kind of world are we setting up for ourselves?

This is why I have committed France to this battle to such an extent, it's why I place so much emphasis on teacher training, vocational education and educational equality between boys and girls. This is why I call on you all to become part of this global drive for education. Education and health won't just be the pillars of our societies in the 21st century; they will be the basic components of our economies too.

GENDER

We must also fight passionately against gender-linked inequalities. I have made gender parity in France the great cause of my five-year term, and I issue an appeal here to make this a great global cause with you. Women and girls are the first to be affected by poverty, conflict, the consequences of global warming; they are the first victims of sexist and sexual violence, which too often prevents them from moving around freely, working or choosing what happens to their bodies.

Our responsibility in the 21st century is to end these kinds of violence, from harassment on the street to femicide. It's time our world stopped making women victims and at last gave them their rightful place – the one where they are leaders too! We must guarantee them access everywhere to education, healthcare, jobs, and to taking economic and political decisions, and fight every kind of violence they are subjected to.

So France will propose to governments wishing to move forward with us the creation of a coalition for adopting new laws for gender equality. Fifty percent of our development aid will be devoted to projects to reduce gender inequalities.

HEALTH

We must also relaunch efforts to fight health inequalities at international level. We are hosting the Replenishment Conference of the Global Fund to Fight AIDS, Tuberculosis and Malaria in Lyon in 2019. We will retake the initiative on the fight against fake drugs and step up our action to tackle major pandemics. I call on everyone here to mobilize.

CLIMATE

Finally, we must fight – with a passionate sense of urgency – against environmental inequalities. It is unacceptable for 45% of greenhouse gas emissions to be produced by 10% of the planet's richest inhabitants. It is inefficient – as is the case with solar power – for countries with the largest potential and greatest needs to be those with the least access to the appropriate technology.

V1

It is indefensible that 100 million more people will be doomed to extreme poverty by 2030 if we don't succeed in honouring our commitments to fight global warming. Here too, it is a battle which must bring us together.

Some countries here are suffering more than others and we owe them solidarity. But we will all have to provide an explanation to our peoples and our own children for this growing number of disasters.

PARIS CLIMATE AGREEMENT

The heralded breakdown of the Paris Agreement has been averted, because we've managed to remain united, despite the American decision to withdraw from it. This strength must continue to carry us along and dispel all fatalistic approaches.

We're told that solutions exist but that funding isn't up to the mark. Then let's go and find it; let's innovate. That is what we did in Paris on 12 December last year, with many of you, at the One Planet Summit, with concrete commitments and initial results. It is what we did at the beginning of the year in Delhi with the International Solar Alliance. It is what we'll do again in New York tomorrow, with the second One Planet Summit.

We're told that it is already too late, that we won't meet the targets. Then let's speed up, let's adopt together the Paris Agreement's rules of implementation at COP24 in December. Let's implement the protocol against HFC gases, which could enable us to reduce the planet's average temperature by 1°C by 2050. Let's set ourselves the goal of concluding in 2020 a plan for an ambitious global pact for the environment, and making the Beijing COP on biodiversity and the IUCN World Conservation Congress in France in 2020 decisive steps.

Let's commit ourselves clearly and let's all be equally clear, concrete and coherent. It is an emergency. So let's comply with the commitments we've made. Let's sign no more trade agreements with powers that don't respect the Paris Agreement. Let's ensure our trade commitments include our environmental and social obligations. Let's more heavily mobilize sovereign funds, which finance this low-carbon policy strategy.

France will continue to exercise global leadership in this battle, along with everyone who so wishes. We will work at the G7 to ensure that the commitments made at COP21 are revised upwards, and if one of the members doesn't want to move forward, we will move forward even so, going to seek new coalitions, new formats, because the G7's remit is to remain a united group of countries committed to democracy. But today it must also help create new coalitions enabling the global collective system to be furthered and rebuilt.

So let's build new forms of cooperation so as to move forward and take decisions on these fundamental issues.

INEQUALITIES

Only together can we effectively combat all these inequalities, which have each fractured our societies. Mistrust in our societies and the temptation of self-absorption are fuelled by this. They are fuelled by all these inequalities we have allowed to emerge and by our collective inability to address them effectively.

V\

But none of us, acting alone, can effectively combat these inequalities I've just denounced. Otherwise there will ultimately be only two solutions. The first would be to always choose the lowest common denominator and follow the standards we know: this is what we have done for decades. There is a trade war, so let's reduce workers' rights, let's reduce taxes even more, let's fuel inequalities in order to try to tackle our trade difficulties. What does this lead to? To deeper inequalities in our societies and to this fracture we are currently experiencing.

The other response would be to say it is the rules that don't work. So let's withdraw into ourselves. Isolationism, protectionism. But this leads to only one thing: an increase in tensions. It in no way addresses deep inequalities.

I propose, on the contrary, that we establish a collective mechanism for working together on what we're doing, in each of our countries, to reduce inequalities.

To assess our actions but also make them more consistent and spread good practice. So I propose that the international institutions – the United Nations but also, of course, the OECD – support us in establishing this mechanism, for which the G7 will have to be the driving force.

WTO REFORM

In order to defeat inequalities, we must change approach and scale. First of all, revise both our trading and social rules; rather than pursuing protectionism, we must all work together to radically revise the WTO rules. We must restore the WTO's ability to resolve conflicts, enact rules to deal with unfair trade practices, non-respect for intellectual property and forced technology transfers, which no longer allow for a fair fight.

This year, the G20 in Argentina must give us a credible road map for radically reforming the WTO.

This is also what we'll have to do at social level, next year, during the centenary of the International Labour Organization.

Secondly, we'll also have to develop the practical details of our action, bring into our field of collective action the major absentees from this hall and from our General Assembly, the major non-state actors who help change the world but who don't play a sufficient role in reducing the inequalities these transformations bring about. I'm referring to the major digital players, in terms of both taxation and responsibility in the battle against the manipulation of information.

On all our major challenges, our collective action must also work differently and include dialogue with these new private players and these Internet giants.

AFRICA

Thirdly, we must give Africa its full role, to ensure its role is central to the recomposition of the international system. It is not just on that continent that we will collectively win or lose our great battle against inequalities. It is with that continent.

V1

Because it is indeed today in Africa that we find the most fervent champions of multilateralism and regional integration, because our African partners have clearly understood that together we will be in a position to tackle our common challenges. And the French G7 presidency will also set to work on this new alliance with Africa.

As you see, I believe very strongly that in the face of these rifts, these challenges in the contemporary world order, we can build a new language of action and we must, at the same time, attack the underlying causes that contemporary inequalities represent.

And it's the responsibility of France and all its European partners, the European Union, to be at the forefront of this battle, to build this new contemporary humanism which must not yield an inch to temptations of self-absorption or to naivety, and at the same time build, as mediating powers, these new rules of the international order.

MULTILATERALISM

Ladies and gentlemen, at a time when our collective system is breaking up, I must say we have never needed it so much.

We will therefore support the agencies working for a project of peace and humanity: UNESCO – the very conscience of the United Nations –, the Human Rights Council, the International Criminal Court, and UNRWA, for which we will increase our contribution because, I remind you here, it is simply about enabling hundreds of thousands of children to go to school. Nothing more, nothing less.

We will support the enlargement of the Security Council in its members' two categories so that its composition reflects contemporary balances and it is strengthened as a place of consultation and not obstruction.

We will ensure that by the end of the year at this General Assembly, two-thirds of its members can support the suspension of the right of veto in the event of mass atrocities.

We will defend international humanitarian law by supporting staff who take every risk to help civilians on the ground, by negotiating, one by one, humanitarian access in every theatre.

On the 70th anniversary of the 1948 Declaration, we will recall that human rights are not a cultural phenomenon, revocable values or options, but a body of law sanctified by international treaties to which the members of this Assembly freely consented. We will recall that their universality is not contrary to the sovereignty of peoples but that it is the only possible condition for protecting and exercising their rights.

France will be there to ensure the world does not forget that the din of nationalism always leads to the abyss, that democracies are weak if they lack courage in defending their principles, and that accumulated resentment, combined with a fragile international system, can lead twice in the space of a human life to a global unleashing of violence. I am talking here from our own experience.

In a few weeks' time, on 11 November 1918, the Paris Peace Forum will provide an opportunity for a surge in intelligence and courage in order to regain what keeps us here together. It must provide an opportunity, united by the tragedies of the 20th century, to renew

VI

and revitalize our solemn promise to protect future generations from the scourge of war. I want us and our counterparts together to shoulder new responsibilities, in order to mark out a path at the Forum for specific actions to promote peace.

I know, my dear friends, that many people may be tired of multilateralism. I know that in a world where information clashes, where we have entered a world of showbiz, in a sense, freed of inhibitions, and where saying the worst things means being in fashion, making the news; I know that denouncing consequences whose causes one has cherished can be a crowd-pleaser; I know that championing cooperation and multilateralism may no longer be in fashion.

Then let's not be in fashion any more, because we owe it to those who have enabled us to be seated here, because never forget that the genocides that led to your being here today were fuelled by the language we are growing accustomed to, because they were fuelled by the demagoguery we applaud, because we are currently seeing this international law and all forms of cooperation crumbling, as if it were business as usual – out of fear, out of complicity, because it looks good!

No, I can't agree to that, because I come from a country which promoted the declarations that brought us here, because I come from a country which stands up, which has made a lot of mistakes and done a lot of bad things but has, throughout its history and international history, had something universal about it! It's today, it's now!

So don't grow accustomed, let's not accept all these forms of unilateralism! I can't get used to these pages being torn every day, these betrayals of our history!

So I say to you very clearly: the century which has begun is watching us, and our children are waiting for us! Let's resolve the crises! Let's work together to combat all these inequalities, but let's do so in a human way and with the stringency of our principles, our history, passionately driven by our universalism!

In any case, this will be my commitment to you, and I am counting on you for it./.

√\

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1,* SC 2018, c. 12

Court of Appeal File No.: C65807

COURT OF APPEAL FOR ONTARIO
Proceedings commenced at Toronto

AFFIDAVIT OF ANDRÉ FRANÇOIS GIROUX AFFIRMED JANUARY 11, 2019 FILED ON BEHALF OF THE ATTORNEY GENERAL OF CANADA

ATTORNEY GENERAL OF CANADA
Department of Justice Canada
Prairie Region Office (Winnipeg)
301 – 310 Broadway
Winnipeg, MB R3C 0S6

Per: Sharlene Telles-Langdon, Brooke Sittler,
Mary Matthews, Neil Goodridge, and Ned Djordjevic

Phone: 204-983-0862
Fax: 204-984-8495
E-mail: sharlene.telles-langdon@justice.gc.ca

Counsel for the Attorney General of Canada

Fax to: (416) 326-4015
E-mail to: joshua.hunter@ontario.ca
padraic.ryan@ontario.ca
thomas.lipton@ontario.ca

Court of Appeal File No.: C65807

COURT OF APPEAL FOR ONTARIO

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1*, SC 2018, c. 12

AFFIDAVIT OF DR NICHOLAS RIVERS
AFFIRMED ON JANUARY 25, 2019
FILED ON BEHALF OF THE ATTORNEY GENERAL OF CANADA

ATTORNEY GENERAL OF CANADA
Department of Justice Canada
Prairie Region Office (Winnipeg)
301 – 310 Broadway
Winnipeg, MB R3C 0S6

Per: Sharlene Telles-Langdon,
Brooke Sittler, Mary Matthews,
Neil Goodridge, and Ned Djordjevic

Phone: 204-983-0862
Fax: 204-984-8495
E-mail: sharlene.telles-langdon@justice.gc.ca

Counsel for the Attorney General of Canada

Docket: C65807

COURT OF APPEAL FOR ONTARIO

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1,* SC 2018, c. 12

AFFIDAVIT OF DR. NICHOLAS RIVERS

I, Nicholas Rivers, of the City of Ottawa, in the Province of Ontario, SOLEMNLY AFFIRM AND DECLARE THAT:

1. I am an Associate Professor in Graduate School of Public and International Affairs at the University of Ottawa. I hold the Canada Research Chair in Climate and Energy Policy.

2. I earned a Bachelor of Engineering degree in mechanical engineering from the Memorial University of Newfoundland in 2000, and a Master degree in Resource and Environmental Management from Simon Fraser University in 2003. From 2003 to 2007, I worked as a consultant with MK Jaccard & Associates on issues relating to sustainable energy policy. I earned my Doctorate in Resource and Environmental Management from the Simon Fraser University in 2011.

3. From 2007 to 2012, I sat as an advisory board member for BC Hydro on the subjects of long-term electricity rates and conservation strategy. I began working as an Assistant Professor at the University of Ottawa in 2011, and became an Associate Professor in 2016. From 2017 to 2018, I was a Visiting Senior Economist at the Organization for Economic Cooperation and Development in Paris, France, where I worked on air pollution, energy efficiency, and carbon pricing research. I have been the Co-Editor of the *Journal of Environmental Economics and Management* since 2017. In 2018, I was appointed a Research Fellow at the School of Public Policy of the University of Calgary. I regularly write papers and present on the economic aspects of climate change policy and economic tools for implementing those policies.

4. My work has focused on economic evaluation of environmental policies, particularly through the application of computational and quantitative methods to study the effectiveness of energy and climate change mitigation policies. Much of my published work involves the examination of market incentives including carbon pricing. I was one of the experts consulted by the Working Group on Carbon Pricing Mechanisms. I am also one of the experts being consulted in the ongoing emissions-intensive and trade-exposed industries review of the *Pan-Canadian Framework on Clean Growth and Climate Change*. A copy of my current curriculum vitae is attached as Exhibit "A".

5. I have been retained and instructed by the Attorney General of Canada to provide three opinions. The first opinion I was asked to provide is an opinion on the efficacy of carbon pricing in reducing greenhouse gas emissions. My opinion on this question, based on my review of existing literature and on my own primary research, is contained in my report, titled "Empirical Evidence on the Impact of Carbon Pricing on the Environment", which is attached as Exhibit "B". I note that, of the forty-eight academic articles to which I refer in my report, I was an author on three of these articles. Despite my authorship on these articles, in my report I refer to myself in the third person. This is consistent with academic convention and the manner in which the authors of all of the cited articles are referenced.

6. The conclusions that I reach based on my review of the existing literature and evidence on this question are bolded in my report. As set out in my report, I have reached the following conclusions with respect to the effectiveness of carbon pricing in reducing greenhouse gas emissions:

   a. Virtually all the available literature finds that consumers reduce fuel consumption in response to increases in fuel price:

      i. The available evidence strongly suggests that fuel retailers will pass through carbon prices to fuel consumers in the form of higher energy prices;

      ii. There is very strong evidence, from a large number of studies, that increases in fuel prices lead to reductions in fuel consumption:

        1. Gasoline demand is reduced when gasoline price is increased, with a larger reduction in the long-run than in the short-run; and
        2. The available evidence finds that increases in the price of natural gas, possibly via a carbon price, would serve to reduce demand for natural gas and reduce carbon dioxide emissions.

b. The existing literature is highly convergent in finding that carbon prices that have been implemented around the world have been successful in reducing greenhouse gas emissions:

    i. there is strong evidence – from the European Union, the United Kingdom, the United States, Sweden, and Canada – that previously implemented carbon prices have successfully reduced greenhouse gas emissions; and

    ii. analysis of greenhouse gas emissions data from before and after policy implementation show that jurisdictions with a carbon price reduced emissions more substantially than comparable jurisdictions without a carbon price.

c. While the body of empirical evidence on low-carbon innovations is small, it shows that carbon prices are likely to cause firms to invest in low-carbon innovations that will help to reduce the cost of tackling climate change.

    i. Existing studies show that when energy prices are high, firms invest in innovation aimed to reduce fuel consumption.

    ii. Existing studies show that firms exposed to a carbon price increase innovations in low-carbon technologies.

7. The basis on which I reach those conclusions is set out in detail in my report.

8. The second opinion I was instructed to provide is an opinion on whether and how distributing proceeds raised from a carbon price back to households using a "climate action incentive rebate" changes the incentives for households to reduce greenhouse gas emissions. My opinion on this question, based principally on my application of microeconomic theory, is contained in my report, titled "Do Climate Action Rebates Affect Household Incentives to Reduce Greenhouse Gas Emissions?", which is attached as Exhibit "C".

9. The conclusion that I reach based principally on standard microeconomic theory is bolded in my report. As set out in my report, I reached the following conclusion: microeconomic theory is conclusive on this point: for an average household, there is no reason to believe that receiving a climate action incentive rebate will undermine incentives to reduce emissions. The basis on which I reach this conclusion is set out in detail in my report. Although the microeconomic theory is not complicated, the style of analysis used in this report may not be familiar to those without training in economics. As a result the report begins with a simple example that serves to illustrate the basic insight of the theoretical model in an informal setting.

10. Finally, I was instructed to provide a third opinion: a brief review on the elements of the Ontario environment plan related to climate change mitigation, which was recently released for consultation. There are few details on any of the proposed measures, and so a complete assessment of the plan is not possible. This review focuses on a high-level assessment of the key measures proposed in the plan. My comments are contained in my report, titled "Comments on 'Preserving and protecting our environment for future generations: A made-in-Ontario environment plan'", which is attached as Exhibit "D".

11. As set out in my report, I have reached the following conclusions upon reviewing the Ontario environment plan related to climate change mitigation:

a. Ontario's proposed measures confuse emissions reductions under their plan with reductions attributable to the federal climate plan, or which would have occurred anyway;

b. Ontario's plan appears to propose emissions performance standards for large emitters which are similar to the output-based pricing system under the *Greenhouse Gas Pollution Pricing Act*, but does not give enough detail to allow me to assess those standards, and permits "across-the-board" exemptions by industrial sectors; and

c. Ontario's plan proposes to use Carbon Trust and reverse auction mechanisms which, based on both theory and prior experience with similar programs, are costly and unlikely to substantially reduce greenhouse gas emissions.

12. Counsel for the Attorney General of Canada has advised me as to my obligations to the Court as an expert witness providing opinion evidence, as set out in rule 4.1.01 of the *Rules of Civil Procedure*. My acknowledgment of expert's duty form is attached as Exhibit "E".

AFFIRMED BEFORE ME in the)
City of Ottawa, in the Province of)
Ontario, on January 25, 2019.)
I certify that Dr. Rivers has satisfied)
me that he is a person entitled to)
affirm.)
)
)
)
Commissioner for Taking Affidavits) Dr. Nicholas Rivers
LSO# P13919
RHEIAN SHANNON

This is **Exhibit A** referred to in the

affidavit of **Nicholas Rivers**

affirmed before me on **January 25, 2019**

Commissioner for Taking Affidavits

Office #6023, 120 University, Social Science Building
K1N 6N5 Ottawa
☎ *(613) 562 5800 ext.4676*
✉ *nrivers@uottawa.ca*

Nicholas Rivers

Last updated: September, 2018

Current Employment

2016– **Associate Professor and Canada Research Chair**, *University of Ottawa.*
Graduate School of Public and International Affairs and Institute of the Environment

Work Experience and Appointments

2018– **Research Fellow**, *School of Public Policy, University of Calgary.*
Calgary, Alberta

2017-2018 **Visiting Senior Economist**, *Organization for Economic Cooperation and Development (OECD), Paris, France.*
Environment Directorate, Environment and Economy Integration Division

2017– **Co-editor**, *Journal of Environmental Economics and Management.*
Elsevier

2011–2016 **Assistant Professor**, *University of Ottawa.*
Graduate School of Public and International Affairs and Institute of the Environment

2003–2007 **Consultant**, *MK Jaccard and Associates.*

Education

2007–2011 **Ph.D.**, *Simon Fraser University.*
Resource and Environmental Management

2001–2003 **M.R.M.**, *Simon Fraser University.*
Resource and Environmental Management

1994–2000 **B.Eng.**, *Memorial University of Newfoundland.*
Mechanical Engineering

Awards

2016–2021 **Canada Research Chair, (Tier II)**, *$500,000.*
2011–2016 **Canada Research Chair, (Tier II)**, *$500,000.*
2008–2011 **Trudeau Foundation Doctoral Scholarship**, *$200,000.*
2007–2009 **NSERC Canada Graduate Scholarship**, *$70,000.*
2001-2003 **NSERC Postgraduate Scholarhip**, *$30,000.*
2000 **Association of Professional Engineers Silver Medal**.

Grants

2017–2018	**Productivity Research Network**, *$10,000*, McMaster University. With Philippe Kabore
2017-2021	**Social Sciences and Humanities Research Council**, *$75,000*, Insight Grant, Competitiveness and climate policy.
2016-2017	**Government of Ontario**, *$20,000*, Leakage from domestic climate policy.
2012-2015	**Carbon Management Canada, NSERC Network Centre of Excellence**, *$400,000*, With Randy Wigle, Canadian environment-economy model.
2012	**SSHRC**, *$20,000*, With Anthony Heyes, Innovative Environmental Policy Workshop.
2012	**Sustainable Prosperity**, *$8,000*, With Robb Barnes, Land value taxation and urban form.
2012	**Sustainable Prosperity**, *$8,000*, With Randy Wigle, Learning by doing and renewable energy.
2012	**Pacific Institute for Climate Solutions**, *$10,000*, With Brandon Schaufele, Impact of the BC carbon tax on the agricultural sector.

Books

[1] J. Simpson, M. Jaccard, and N. Rivers. *Hot air: Meeting Canada's climate change challenge*. McClelland and Stewart, Douglas Gibson Books, 2007.

Journal Articles

[2] Anthony Heyes, Brandon Nicholas Schaufele, and Nicholas Rivers. Politicians, pollution and performance in the workplace: the effect of pm on mps. *Land Economics*, accepted, 2018.

[3] Nicholas Rivers and Bora Plumptre. The effectiveness of public transit subsidies on commuting behaviour and the environment: Evidence from Canada. *Case Studies on Transport Policy*, accepted, 2018.

[4] Marisa Beck, Nicholas Rivers, and Randall Wigle. How do learning externalities influence the evaluation of Ontario's renewables support policies? *Energy Policy*, 117:86–99, 2018.

[5] Maureen L Cropper, Richard D Morgenstern, and Nicholas Rivers. Facilitating retrospective analysis of environmental regulations. *Review of Environmental Economics and Policy*, 12:359–370, 2018.

[6] Brett Dolter and Nicholas Rivers. The cost of decarbonizing the Canadian electricity system. *Energy Policy*, 113:135–148, 2018.

[7] Steve Martin and Nicholas Rivers. Information provision, market incentives, and household electricity consumption: Evidence from a large-scale field deployment. *Journal of the Association of Environmental and Resource Economists*, 5(1):207–231, 2018.

[8] Nicholas Rivers. Does daylight savings time save energy? evidence from Ontario. *Environmental and Resource Economics*, 70(2):517–543, 2018.

[9] Soodeh Saberian, Anthony Heyes, and Nicholas Rivers. Alerts work! air quality warnings and cycling. *Resource and Energy Economics*, 2017.

[10] Nicholas Rivers and Brandon Schaufele. New vehicle feebates. *Canadian Journal of Economics/Revue canadienne d'économique*, 50(1):201–232, 2017.

[11] Nicholas Rivers and Brandon Schaufele. Gasoline price and new vehicle fuel efficiency: Evidence from Canada. *Energy Economics*, 68:454–465, 2017.

[12] Nicholas Rivers, Sarah Shenstone-Harris, and Nathan Young. Using nudges to reduce waste? the case of Toronto's plastic bag levy. *Journal of Environmental Management*, 188:153–162, 2017.

[13] Jared C Carbone and Nicholas Rivers. The impacts of unilateral climate policy on competitiveness: Evidence from computable general equilibrium models. *Review of Environmental Economics and Policy*, 11(1):24–42, 2017.

[14] Marisa Beck, Nicholas Rivers, and Hidemichi Yonezawa. A rural myth? sources and implications of the perceived unfairness of carbon taxes in rural communities. *Ecological Economics*, 124:124–134, 2016.

[15] Christoph Böhringer, Nicholas Rivers, and Hidemichi Yonezawa. Vertical fiscal externalities and the environment. *Journal of Environmental Economics and Management*, 77:51–74, 2016.

[16] Nicholas Rivers and Leslie Shiell. Free-riding on energy efficiency subsidies: The case of natural gas furnaces in Canada. *The Energy Journal*, 2016.

[17] Marisa Beck, Nicholas Rivers, Randall Wigle, and Hidemichi Yonezawa. Carbon tax and revenue recycling: Impacts on households in British Columbia. *Resource and Energy Economics*, 41:40–69, 2015.

[18] Brian Murray and Nicholas Rivers. British Columbia's revenue-neutral carbon tax: A review of the latest "grand experiment" in environmental policy. *Energy Policy*, 86:674–683, 2015.

[19] Nicholas Rivers and Brandon Schaufele. Salience of carbon taxes in the gasoline market. *Journal of Environmental Economics and Management*, 74:23–36, 2015.

[20] Nicholas Rivers and Brandon Schaufele. The effect of carbon taxes on agricultural trade. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, 63(2):235–257, 2015. Best paper award: Honourable mention.

[21] Christoph Böhringer, Nicholas Rivers, Thomas Rutherford, and Randall Wigle. Sharing the burden for climate change mitigation in the Canadian federation. *Canadian Journal of Economics/Revue canadienne d'économique*, 48(4):1350–1380, 2015.

[22] Nigel Bankes, Anatole Boute, Steve Charnovitz, Shi-Ling Hsu, Sarah McCalla, Nicholas Rivers, and Liz Whitsett. International trade and investment law and carbon management technologies. *Natural Resources Journal*, 53(2):285–324, 2013.

[23] Nicholas Rivers and Steven Groves. The welfare impact of self-supplied water pricing in Canada: a computable general equilibrium assessment. *Environmental and Resource Economics*, 55(3):419–445, 2013.

[24] Anthony Heyes, Dylan Morgan, and Nicholas Rivers. The use of a social cost of carbon in Canadian cost-benefit analysis. *Canadian Public Policy*, 39(Supplement 2):S67–S79, 2013.

[25] Nicholas Rivers. Renewable energy and unemployment: A general equilibrium analysis. *Resource and Energy Economics*, 35(4):467–485, 2013.

[26] Christoph Bohringer, Nicholas Rivers, Randall Wigle, and Thomas Rutherford. Green jobs and renewable electricity policies: Employment impacts of Ontario's feed-in tariff. *B.E. Journal of Economic Analysis and Policy (Contributions)*, pages 1–40, 2012.

[27] Nicholas Rivers. The distributional impacts of a carbon tax in Canada. *Canadian Tax Journal*, 60(2):899–916, 2012.

[28] N. Rivers and M. Jaccard. Electric utility demand side management in Canada. *The Energy Journal*, 32(4), 2011.

[29] N. Rivers. Impacts of climate policy on the competitiveness of Canadian industry: How big and how to mitigate? *Energy Economics*, 32(5):1092–1104, 2010.

[30] N. Rivers and M. Jaccard. Intensity-based climate change policies in Canada. *Canadian Public Policy*, 36(4):409–428, 2010.

[31] C. Bataille, N. Rivers, P. Mau, C. Joseph, and J.J. Tu. How malleable are the greenhouse gas emission intensities of the G7 nations? *The Energy Journal*, 28(1):145–170, 2007.

[32] M. Jaccard and N. Rivers. Heterogeneous capital stocks and the optimal timing for CO2 abatement. *Resource and energy economics*, 29(1):1–16, 2007.

[33] R. Murphy, N. Rivers, and M. Jaccard. Hybrid modeling of industrial energy consumption and greenhouse gas emissions with an application to Canada. *Energy Economics*, 29(4):826–846, 2007.

[34] C. Bataille, M. Jaccard, J. Nyboer, and N. Rivers. Towards general equilibrium in a technology-rich model with empirically estimated behavioral parameters. *The Energy Journal*, (Special Issue# 2):93–112, 2006.

[35] N. Rivers and M. Jaccard. Choice of environmental policy in the presence of learning by doing. *Energy Economics*, 28(2):223–242, 2006.

[36] N. Rivers and M. Jaccard. Useful models for simulating policies to induce technological change. *Energy Policy*, 34(15):2038–2047, 2006.

[37] N. Rivers and M. Jaccard. Canada's efforts towards greenhouse gas emission reduction: a case study on the limits of voluntary action and subsidies. *International journal of global energy issues*, 23(4):307–323, 2005.

[38] N. Rivers and M. Jaccard. Combining top-down and bottom-up approaches to energy-economy modeling using discrete choice methods. *The Energy Journal*, 26(1):83–106, 2005.

[39] M. Jaccard, R. Murphy, and N. Rivers. Energy-environment policy modeling of endogenous technological change with personal vehicles: combining top-down and bottom-up methods. *Ecological Economics*, 51(1-2):31–46, 2004.

Other articles

[40] Nicholas Rivers. Leveraging the smart grid: The effect of real-time information on consumer decisions. Technical report, OECD Publishing, 2018.

[41] Nicholas Rivers and Randall Wigle. Reducing greenhouse gas emissions in transport: All in one basket? Technical report, Calgary School of Public Policy, 2018.

[42] Nicholas Rivers, Randall Wigle, et al. An evaluation of policy options for reducing greenhouse gas emissions in the transport sector: The cost-effectiveness of regulations versus emissions pricing. Technical report, Laurier Centre for Economic Research and Policy Analysis, 2018.

[43] Nicholas Rivers. *The Case for a Carbon Tax in Canada*. Canada 2020, 2014.

[44] C. Bataille, B. Dachis, and N. Rivers. Pricing greenhouse gas emissions: The impact on Canada's competitiveness. Commentary 280, CD Howe Institute, 2009.

[45] 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. Commentary 234, CD Howe Institute, 2009.

[46] R. Murphy, M. Jaccard, N. Rivers, and C. Bataille. The case for a carbon management standard. In A. Khare and J. Nodelman, editors, *Energy Management and the Environment: Challenges and the Future*, page 189. Fachbuch Verlag Winkler, 2009.

[47] N. Rivers and M. Jaccard. Talking without walking: Canada's ineffective climate effort. In B. Eberlein and B. Doern, editors, *Governing the Energy Challenge: Canada and Germany in a Multilevel Regional and Global Context*, pages 285–313. University of Toronto Press, Toronto, 2009.

[48] M. Jaccard and N. Rivers. Canadian policies for deep greenhouse gas reductions. In J. Leonard, C. Ragan, and F. St-Hillaire, editors, *A Canadian priorities agenda: policy choices to improve economic and social well-being*, page 77. McGill-Queen's University Press, 2007.

[49] M. Jaccard and N. Rivers. Estimating the effect of the Canadian government's 2006-2007 greenhouse gas policies. Working paper, CD Howe Institute, 2007.

[50] M. Jaccard, N. Rivers, and M. Horne. The morning after optimal greenhouse gas policies for Canada's Kyoto obligations and beyond. Commentary 197, CD Howe Institute, 2004.

Working papers and work in progress

[51] Jared C Carbone, Nicholas Rivers, Akio Yamazaki, Hidemichi Yonezawa, et al. Comparing applied general equilibrium and econometric estimates of the effect of an environmental policy shock. 2018.

[52] Christoph Boehringer and Nicholas Rivers. The energy efficiency rebound effect in general equilibrium. *Oldenburg Discussion Papers in Economics*, 2018.

[53] Nicholas Rivers and Blake Shaffer. Stretching the duck's neck: The effect of climate change on future electricity demand. 2018.

[54] Nicholas Rivers, Brandon Schaufele, and Soodeh Saberian. Public transit and air pollution. 2017.

Professional service

2017-	**Co-Editor**, *Journal of Environmental Economics and Management.*
2012	**Guest Editor**, *Canadian Public Policy.*
2012–	**Organizing committee**, *Ontario Network for Sustainable Energy Policy.*
2012–2014	**Organizer**, *Joint Carleton-Ottawa environmental policy seminar series.*
ongoing	**Referee**, Climate Policy, Journal of Environmental Economics and Management, The Energy Journal, Energy Economics, Energy Policy, Canadian Public Policy, Ecological Economics, Journal of Regulatory Economics, Economics of Energy and Environmental Policy.
2010–	**Sustainable Prosperity**, *Research Network co-chair.*
2012–	**Canadian Association of Energy Economics**, *Executive Committee.*
2007–2012	**BC Hydro**, *Advisory board member for long-term electricity rates and long-term conservation strategy.*
2005–	**Op-eds**, *Occasional contributions to* The Globe and Mail, The Ottawa Citizen, The National Post, The Vancouver Sun, *and* The Mark.

Selected recent presentations

2018

Paris, France	The economic impact of air pollution, Ecole des Mines Economics Seminar
Paris, France	Information provision and electricity consumption, International Energy Agency
Bonn, Germany	The economic impact of air pollution, Institute for the Study of Labor (IZA)
Paris, France	Carbon pricing and competitiveness, OECD
Paris, France	Information provision and electricity consumption, OECD greentalks webinar
Paris, France	The economic impact of air pollution, OECD internal seminar

Oldenburg, Germany	The economic impact of air pollution, Oldenburg Economics Seminar
Paris, France	The economic impact of air pollution, University Paris Dauphine Economics seminar
Gotenburg, Sweden	General equilibrium rebound, WCERE
Gotenburg, Sweden	Carbon pricing and competitiveness, WCERE
Gran Canaria, Spain	General equilibrium models for energy and environment, World Energy Modeling Workshop

2017

Montreal, QC	Carbon pricing in the agriculture sector, Canadian Agricultural Economics Society Conference
Antigonish, NS	Gasoline price and fuel efficiency, Canadian Economics Association Conference
Ottawa, ON	Mitigating greenhouse gases, Conference Board of Canada
Ottawa, ON	Taxing externalities, Department of Finance seminar
Paris, France	Information provision and electricity consumption, OECD seminar
Picton, ON	Daylight savings and electricity consumption, Ontario Network for Sustainable Energy Policy
Paris, France	Canadian climate policies, International Energy Agency
Zurich, Switzerland	Economics seminar, ETH Zurich
Canada	Carbon pricing in the agricultural sector, Farm Credit Canada

2016

Ottawa, ON	Information provision and electricity consumption, Canadian Economics Association Conference
Waterloo, ON	Climate policy choices conference
Banff, AB	Validating a CGE model, Canadian Resource and Environmental Economics Conference
Montreal, QC	Decarbonizing electricity generation, Montreal Environment and Resources seminar
Picton, ON	Information and electricity consumption, Ontario Network for Sustainable Energy Policy
Ottawa, ON	Integration of carbon pricing and fiscal reform, North American climate policy conference
Waterloo, ON	Information and electricity consumption, Balsillie School of International Affairs seminar

2015

Ottawa, ON	Transport policy and GHG emissions, Conference Board of Canada
Montreal, QC	Information provision and electricity consumption, McGill Montreal Environment and Resources seminar

Picton, ON	GHG emissions from Energy East, Ontario Network for Sustainable Energy Policy webinar
Sherbrooke, QC	Information provision and electricity consumption, Canadian Resource and Environmental Economics Association
Toronto, ON	Comparing CGE and quasi-experimental evaluations of an environmental policy, Canadian Economics Association
Ottawa, ON	What can we learn from Ontario's renewable energy experience?, Carleton University
Edmonton, AB	Lessons from BCs carbon tax, Alberta Climate summit
Ottawa, ON	Provincial and Federal climate policies, Centre for International Policy Studies panel
Golden, CO	Vertical fiscal externalities and the environment, Colorado School of Mines seminar
Picton, ON	Oil transport infrastructure and greenhouse gas emissions, Ontario Network for Sustainable Energy Policy
Toronto, ON	Cap and trade or carbon tax, Climate Action Network panel
Ottawa, ON	Ontario carbon policies, Climate Action Network panel
Toronto, ON	Quasi-experiments in environmental policy, Research Matters conference
Ottawa, ON	Air pollution and cognition, Institute of the Environment seminar

2014

Ottawa, ON	Discussant, Environment Canada Research Network
Saskatoon, SK	Vertical fiscal externalities and the environment, Canadian Resource and Environmental Economics Workshop
Ottawa, ON	Agricultural trade and the BC carbon tax, Environment Canada Departmental Seminar
Picton, ON	Free-riding on energy efficiency subsidies, Ontario Network for Sustainable Energy Policy
Vancouver, BC	Vertical fiscal externalities and the environment, Canadian Economics Association
Vancouver, BC	Climate policy and competitiveness, Canadian Economics Association
Ottawa, ON	Climate policy, Discussant, The Ottawa Forum

2013

Ottawa, ON	Climate policy and competitiveness, Environment Canada Research Network
Banff, AB	Vehicle feebates in theory and practice, Association of Environmental and Resource Economics
Montreal, QC	Vehicle feebates in theory and practice, Canadian Economics Association
Nottawasaga, ON	Ontario's vehicle feebate, Ontario Network for Sustainable Energy Policy

2012

Ottawa, ON	Overlap between federal and provincial climate change policies, Environment Canada, Departmental Seminar

Ottawa, ON	The social cost of carbon in Canada, Environment Canada, Departmental Seminar
Victoria, BC	Overlap between federal and provincial climate change policies, BC Climate Action Secretariat, Departmental Seminar
Vancouver, BC	Impact of the BC carbon tax, Global Conference on Environmental Taxation
Vancouver, BC	Overlap between federal and provincial climate change policies, Global Conference on Environmental Taxation
Vancouver, BC	Impact of the BC carbon tax, SFU School of Public Policy
Ottawa, ON	The social cost of carbon in Canada, Innovative Environmental Policies Workshop
Ottawa, ON	The impact of climate change and climate policy on the Canadian economy: discussant, Innovative Environmental Policies Workshop
Ottawa, ON	Mitigating objections to carbon pricing, Carbon Management Canada Annual Conference
Niagara on the lake, ON	Economic and employment effects of Ontario's feed-in tariff program, Ontario Network for Sustainable Energy Policy
Ottawa, ON	Canadian climate policy and the challenges of federalism, Joint Ottawa-Carleton seminar
Ottawa, ON	Climate change policy and the Canadian federation, University of Ottawa FEDLAB
Kingston, ON	Overlap between federal and provincial climate change policies, Queen's Institute for Intergovernmental Affairs
	2011
Toronto, ON	Economic and employment effects of Ontario's feed-in tariff program, Ontario Ministry of Environment
Ottawa, ON	How should behavioural economics influence energy and environmental policies?, University of Ottawa Behavioural Economics Workshop
Waterloo, ON	Domestic content requirements in renewable energy support policies, Southern Ontario Resource and Environmental Economics
Stockholm, SE	Domestic content requirements in renewable energy support policies, International Association for Energy Economics
London, ON	Pricing industrial water use: Results from a general equilibrium model, National Roundtable on the Environment and the Economy

This is **Exhibit B** referred to in the
affidavit of **Nicholas Rivers**
affirmed before me on **January 25, 2019**

Commissioner for Taking Affidavits

EMPIRICAL EVIDENCE ON THE IMPACT OF CARBON PRICING ON THE ENVIRONMENT

PREPARED FOR: DEPARTMENT OF JUSTICE CANADA

PREPARED BY: NICHOLAS RIVERS

SEPTEMBER 13, 2018

UPDATED JANUARY 4, 2019

INTRODUCTION

The objective in this report is to provide evidence on the likely response by emitters of greenhouse gas to the imposition of a price on greenhouse gas emissions (carbon price). Specifically, the paper focuses on the question of whether there is evidence that imposing a carbon price would result in a reduction in emissions of carbon dioxide and other greenhouse gases. The report provides evidence based on two different approaches. Both approaches demonstrate that the imposition of a carbon price would reduce greenhouse gas emissions.

First, the report provides indirect evidence on how a carbon price would impact greenhouse gas emissions by drawing from the large literature on how consumers have responded to past changes in energy prices (Figure 1). This part of the report first shows that a carbon price is likely to be passed through to consumers in the form of higher energy prices. Following this, the report reviews econometric evidence on consumer responses to changes in energy prices. There are a wide variety of empirical estimates of the consumer responsiveness to energy price changes, depending on the region, sector, and timeframe covered and the methodological approach used to estimate these responses. However, **virtually all the available literature finds that consumers reduce fuel consumption in response to increases in fuel price.** Because fuel consumption releases greenhouse gas emissions, these findings demonstrate that carbon prices are likely to reduce energy demand and consequently to reduce greenhouse gas emissions.

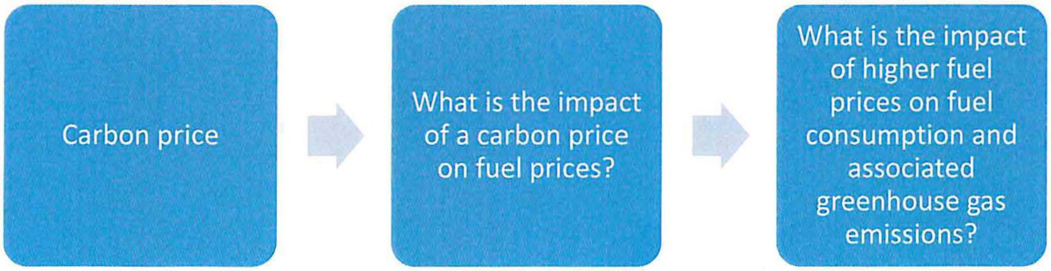


Figure 1: Indirect evidence on the impact of a carbon price on greenhouse gas emissions

Second, the report reviews evidence from regions that have implemented carbon prices in the past (Figure 2). In some cases, carbon prices have been implemented for a decade or more, which provides an opportunity for understanding how these have affected greenhouse gas emissions in both the industrial sectors and for final consumers of energy. Again, the available evidence shows that carbon prices have been successful in reducing greenhouse gas emissions. While there is heterogeneity across regions and sectors, as well as inevitable uncertainty in attribution of the effect of specific policies, **the existing literature is highly convergent in finding that carbon prices that have been implemented around the world have been successful in reducing greenhouse gas emissions**.

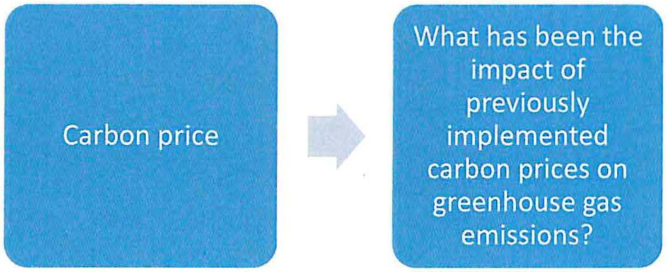


Figure 2: Direct evidence on the impact of a carbon price on greenhouse gas emissions

The final section of the report focuses on how carbon prices affect innovation of low-carbon technologies (such as solar panels or electric vehicles). Innovations in low-carbon technologies help to reduce the cost of mitigating climate change and promoting innovation in these technologies is considered important in enabling a transition to a low-carbon future. As above, the report considers two sources of evidence on the impact of carbon pricing on low-carbon innovation. Indirect evidence shows that higher energy prices in the past have caused innovations in energy-saving technologies. Direct evidence shows that carbon pricing schemes have caused firms to invest in low-carbon technologies. **While the body of empirical evidence on low-carbon innovations is small, it shows that carbon prices are likely to cause firms to invest in low-carbon innovations that will help to reduce the cost of tackling climate change.**

INDIRECT EVIDENCE ON THE IMPACT OF A CARBON PRICE ON GREENHOUSE GAS EMISSIONS

The impact of a carbon price on energy prices

The primary way in which a carbon price can reduce greenhouse gas emissions is through its effect on energy prices.[1] Consequently, it is important to assess the degree to which a carbon price is likely to affect energy prices before considering any behavioural impact of higher energy prices. This section reviews the literature on the degree to which carbon prices influence energy prices. **The available evidence strongly suggests that fuel retailers will pass through carbon prices to fuel consumers in the form of higher energy prices.**

Carbon prices are for the most part based on the carbon that is released or expected to be released when a unit of fossil fuel is combusted.[2] Since the chemical composition of fuels is well established, the levy on the use of fuel can be calculated in a straightforward manner (from the carbon content of fuel per unit of volume). Table 1 provides calculated levies on several fossil fuels corresponding to a \$50/tCO$_2$e carbon price.

Table 1: Example fossil fuel levies corresponding to a \$50/tCO$_2$e carbon price for selected fuels

Fuel	**Levy at \$50/t CO$_2$e**
Gasoline	11.63 c/L
Natural gas	9.79 c/m^3
Coal	\$88.62 – 112.58/tonne

Source: Technical Paper on the Federal Carbon Pricing Backstop. Environment and Climate Change Canada. 2017.

---

[1] Carbon prices are mostly based on greenhouse gases that are released or expected to be released when fossil fuels are combusted. However, carbon prices can also be levied on non-energy related greenhouse gases. These non-energy greenhouse gases represent a relatively small portion of total greenhouse gas emissions and there is little available empirical evidence on how emissions of these gases respond to carbon pricing. As a result, this report will not further consider the impact of carbon pricing on non-energy greenhouse gas emissions.

[2] See footnote 1.

However, while it is a mechanical exercise to determine the levy corresponding to a particular carbon price for a particular fuel, it is less straightforward to determine the *economic incidence* of the levy. The economic incidence refers to the impact of the levy on equilibrium prices of fuels as well as on other goods. An example helps to illustrate the concept. Suppose a carbon price is introduced that requires gasoline retailers to remit a levy corresponding to the carbon content of gasoline, such as in Table 1. In theory, a gasoline retailer has several options available to respond to the lost revenue associated with the new levy: (a) increasing gasoline prices; (b) reducing wages; (c) reducing prices paid for other inputs; (d) reducing profits drawn from the retail establishment. If the retailer responds to the levy by increasing gasoline prices, then the levy provides an incentive for consumers to reduce their gasoline consumption. Conversely, if the retailer responds, for example, by reducing wages but maintaining gasoline prices constant, then the levy provides little incentive for gasoline consumers to reduce their consumption. It is thus important to understand the economic incidence of the levy.

It is well-known that the actual outcome depends on a number of factors, including elasticities of supply and demand facing the retail establishment, as well as the degree of competition in the market (Fullerton and Metcalf, 2002). For a gasoline retailer, wages and other inputs are sourced in competitive markets in which gasoline retailers represent only a small share of demand; it is thus difficult to pass the levy backward onto inputs. Likewise, many gasoline retailers are owned by corporations that can shift investments to maximize return, making it difficult to pass the levy back to owners of capital. In contrast, gasoline demand by consumers is supplied entirely by gasoline retailers, meaning that gasoline consumers cannot easily avoid price increases by retailers. It is therefore likely that gasoline retailers will be able to "pass-through" the gasoline levy to final consumers in the form of higher energy prices. This predicted response is supported by the evidence.

An example of gasoline price pass-through is given in Figure 3, which shows the difference between regular retail gasoline prices in Vancouver and Calgary. The graph spans the introduction of the carbon levy of \$20/tCO_2e in Alberta on January 1, 2017. Based on Table 1, this carbon price corresponds to a 4.5c/L levy on gasoline. If the levy were entirely passed through to consumers, we would therefore expect an increase in gasoline prices in Alberta of 4.5c/L on January 1, 2017. The figure suggests that this is roughly what occurred when the carbon price was introduced in Alberta. Vancouver gasoline prices in December of 2016 averaged 26c/L higher than Calgary prices, while in January of 2017, they were 21.9c/L higher, implying a drop in the differential of 4.2c/L (numbers do not add up due to rounding). This is suggestive evidence that the pass-through of gasoline levies such as a carbon price to final consumers is nearly complete. It is important, however, to note that many other factors were changing at the same time, and so it is not possible to draw a strong conclusion from a single case study like this. Instead of relying only on case studies such as this one, economists typically turn to aggregate evidence from a large number of changes in levies to understand pass-through.

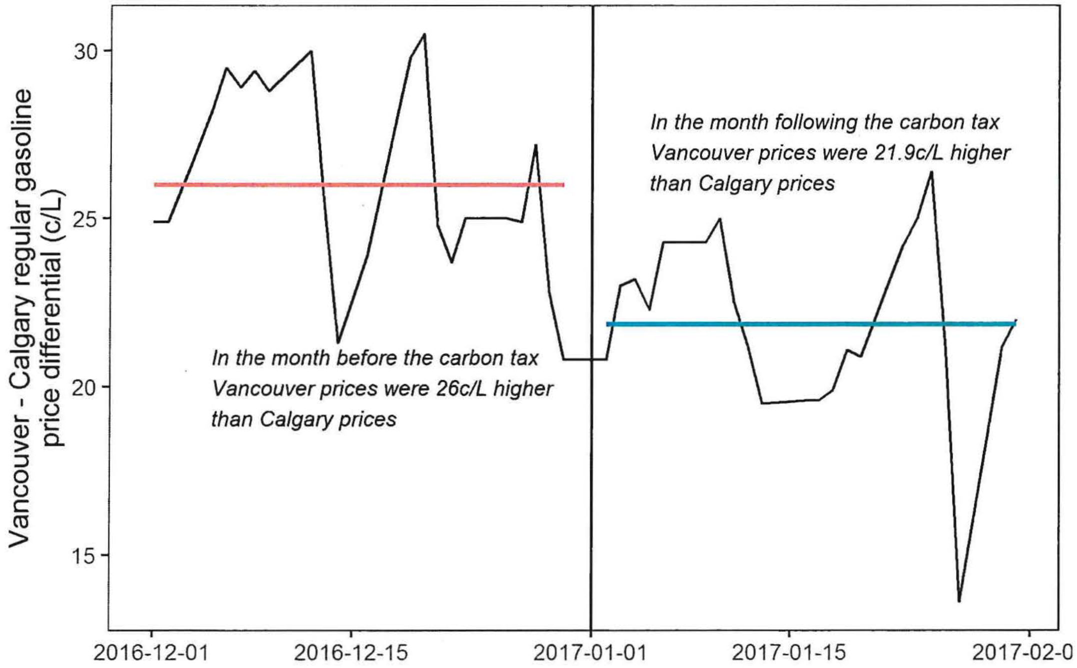


Figure 3: Differential in regular retail gasoline prices in Vancouver compared to Calgary from December 2016 to January 2017.

Source: Author calculations. Data from the Kent Group Ltd. Daily Pump Price Survey.

Notes: The figure shows the retail price for regular gasoline in Vancouver minus the price in Calgary for the last month of 2016 and first month of 2017. Alberta introduced a $\$20/\text{tCO}_2\text{e}$ levy on January 1, 2017. The red line is the average differential in gasoline prices in the last month of 2016 (26c/L), and the blue line corresponds to the first month of 2017 (21.9c/L). The difference between the blue and red lines is 4.2c/L.

There exists a body of evidence on the economic incidence of excise taxes for gasoline. This literature follows a similar approach in spirit as the analysis contained in Figure 3, except that it aggregates over a much larger number of excise tax changes across a larger number of regions, and typically attempts to control for other factors that can affect gasoline prices. The broad conclusion of the literature is that fuel levies are typically completely passed through to final consumers, in line with the stylized analysis above. For example, Chouinard and Perloff (2004) find that state-level excise taxes on gasoline in the US are passed through entirely to consumers,[3] Alm et al. (2009) similarly find that state-level excise taxes on gasoline in the US are completely passed through to final consumers (although in states with less competition, there is slightly less than full pass-through, an empirical result consistent with a Cournot-Nash model of gasoline retailer competition), and Marion and Muehlegger (2011) find full pass-through of both state and federal gasoline and diesel taxes under normal supply conditions.[4] In Canada, Sen (2003) finds that changes in wholesale gasoline prices are completely passed through to retail prices within a month.

Overall, the evidence strongly suggests that a carbon price would be translated completely or almost completely onto fuel prices, and thus potentially impact behaviour related to fuel consumption. I review evidence related to this point in the following section.

---

[3] They find that federal excise taxes on gasoline is not passed through entirely to consumers (only about 50%). This is a result of the significant share of United States in the world crude oil market market. Gasoline demand in Canada is an order of magnitude smaller than in the US, so the same reasoning would not apply in Canada.

[4] Under supply disruptions, such as an unexpected refinery shutdown, they find that pass-through is likely to be lower than 100%.

The impact of higher fuel prices on fuel consumption and associated greenhouse gas emissions

Introduction

As shown in the prior section, carbon prices increase the prices of carbon-containing fuels. As a result, one way to predict the likely impact of a carbon price is to review evidence on how consumers have responded in the past to changes in fuel prices. This section reviews that evidence and shows that while there is uncertainty in the magnitude of the likely response, **there is very strong evidence, from a large number of studies, that increases in fuel prices lead to reductions in fuel consumption**. Since greenhouse gas emissions are produced during fuel consumption, this evidence suggests that the imposition of a carbon price would lead to a reduction in greenhouse gas emissions. Similarly, the evidence suggests that higher carbon prices would lead to larger reductions in greenhouse gas emissions than lower carbon prices.

There is a large body of evidence on the consumer response to changes in fuel prices, originating with the first energy price shocks of the 1970s. In this section, I review two types of evidence: (1) meta-analyses of prior estimates of fuel price elasticities, (2) recent studies on consumer responses to changes in fuel prices that are of particularly high quality. I divide the evidence according to fuel type. In each case, most of the evidence on consumer responsiveness to price changes is presented as an *elasticity*. The price elasticity of energy demand is defined as the percentage change in consumer demand caused by a 1% change in energy price. Thus a price elasticity of demand of -0.5 implies that a 1% increase in energy prices causes a 0.5% decrease in energy demand. Short-run elasticities correspond to the period during which fuel-using equipment (and other capital stocks) is fixed; long-run elasticities correspond to the period over which the consumer is able to choose new equipment in response to the changed energy price. Long-run elasticities are typically found to be larger than short-run elasticities, because consumers have more flexibility over a longer period. For example, in the case of gasoline consumption, in the short-run, the response to higher fuel prices is limited to changing travel modes, reducing overall travel demand, increasing vehicle occupancy rates, or (for multi-vehicle households) changing the relative intensity of use of different vehicles. In the long-run, households can also adapt by changing their vehicle portfolio or changing locations of home or work. Moreover, vehicle manufacturers may respond by changing the characteristics of the vehicles offered for sale.

Gasoline

The demand for gasoline has received the most scrutiny of all fuel types, resulting in a very large volume of research on the price elasticity of gasoline demand. These studies show that **gasoline demand is reduced when gasoline price is increased, with a larger reduction in the long-run than in the short-run**.

There exist a number of surveys of the literature. These meta-analyses compile the results of individual studies together to synthesize the literature on gasoline demand. The number of individual results compiled varies by study, but the most recent (Dahl, 2012) incorporates over 1,000 individual estimates of the price elasticity of gasoline demand. Table 2 summarizes mean estimates of short- and long-run gasoline price elasticities from five meta-analyses.[5]

Results are relatively consistent from one meta-analysis to another. First, all meta-analytic estimates of the price elasticity of gasoline demand are negative, providing clear evidence that increases in the price of gasoline reduce gasoline demand. Second, estimates of short-run elasticities are smaller than long-run elasticities. Third, the available evidence suggests that gasoline demand falls less than proportionately with respect to price (i.e., a 1% increase in price causes a less than 1% reduction in demand). In terms of magnitudes, empirical estimates of the short-run price elasticity are concentrated around -0.2 to -0.3, while estimates of the long-run price elasticity are concentrated around -0.6 to -0.9.

---

[5] It is important to note that these meta-analyses are not completely independent from one another, since they draw upon many of the same sources in the literature.

Table 2: Meta-analyses of the mean price elasticity of gasoline demand reported in meta-analyses

Study	Long-run gasoline demand elasticity	Short-run gasoline demand elasticity
Dahl and Sterner (1991)	-0.8 to -0.92	-0.22 to -0.31
Espey (1996)	-0.53	
Espey (1998)	-0.58	-0.26
Brons et al. (2008)	-0.84	-0.34
Dahl (2012)	-0.34	

It is possible to use these elasticities along with the evidence on the near-complete pass-through of excise taxes to consumer gasoline prices reviewed in the prior section to provide an estimate of the greenhouse gas reductions that could result from a given carbon price. For example, a \$50/t CO_2e carbon price would be expected to increase retail gasoline prices by about 11.6c/L (Table 1). Assuming a starting price of \$1.00/L, this reflects an increase of 11.6%. Based on evidence in Table 2, we might expect a reduction in gasoline demand of about 3% in the short-run and about 6% in the long-run. Since combustion greenhouse gas emissions are proportional to fuel consumption, we would expect a proportional reduction in greenhouse gas emissions associated with gasoline consumption.

In addition to these meta-analyses of gasoline demand elasticities, I also highlight the results of two recent high-quality studies on gasoline demand. This is useful for a number of reasons. First, much of the literature surveyed in the meta-analyses is rather dated, so it is useful to compile results from some more recent literature. Second, the two studies highlighted here use very large administrative data sets and a clear strategy to estimate the causal impact of changes in gasoline price, so the inferences they draw are potentially more relevant than the literature above. Importantly, the conclusions reached are broadly supportive of the conclusions from the broader evidence from the meta-analyses.

Levin et al. (2017) obtain data on all VISA credit and debit card transactions in 243 US metropolitan areas at a daily aggregation between 2006-09. They combine this expenditure information with daily average gasoline price data, to produce a highly geographically and temporally disaggregate data set with which to estimate the elasticity of gasoline demand. They estimate that the short-run price elasticity of gasoline demand is between about -0.3 and -0.4. They suggest that this is likely an under-estimate of the true gasoline demand elasticity, because it does not account for the likely effect of consumers switching from cash to debit/credit card payment as gasoline prices increase. They argue that many prior studies have under-estimated gasoline demand elasticity because they use data that is too aggregated (i.e., gasoline demand is actually more responsive to prices than most studies recognize).

Gelman et al. (2017) obtain data from a financial aggregation and bill-paying computer and smartphone application, which allows users to link financial accounts, credit card accounts, utility bills, and other financial information to a central app. They are thus able to measure individual gasoline purchases at a very high geographic and temporal resolution, using data from 2013-16. They estimate that the short-run price elasticity of gasoline demand is about -0.2 to -0.25. Moreover, their estimates suggest that the long-run elasticity is likely larger than this, because as the time horizon in their analysis expands, they obtain larger price elasticities. Because they use a single estimate of gasoline prices at the national level, it is likely that this is an underestimate of the true gasoline price elasticity.[6]

While there is substantial variation in prior estimates of gasoline price elasticity, in all cases, the available evidence from both meta-analyses as well as more recent "big data" analyses strongly suggests that increases in gasoline prices caused by the imposition of carbon prices would cause reductions in the quantity of gasoline demanded.

---

[6] The underestimation (sometimes called "attenuation bias") results from measurement error in the dependent variable in a regression, and is a well understood phenomemon (e.g., Greene, 2003, pp. 84-85).

Natural gas

There exist far fewer estimates of natural gas demand elasticities relative to gasoline, and those that exist are somewhat dated. **The available evidence finds that increases in the price of natural gas, possibly via a carbon price, would serve to reduce demand for natural gas and reduce greenhouse gas emissions**.

Taylor (1977) surveys 11 studies on natural gas demand, finding that long-run demand for natural gas is *elastic* on average (i.e., larger than -1 in absolute value) in most studies and for most sectors, but with substantial variation between individual studies. Bohi (1981) surveys 16 studies of natural gas demand, again finding substantial heterogeneity between studies. Based on the studies, Bohi (1981) suggests that residential natural gas demand is likely *inelastic* (less than -1 in absolute value). Dahl (1993) surveys several more recent studies on natural gas demand. Averaging across studies, she reports a short-run residential natural gas price elasticity of -0.13, increasing to -0.68 in the long-run. Again, there are substantial differences across studies.

There are two more recent studies on natural gas demand that are useful to highlight as supplements to the existing literature. Davis and Muehlegger (2010) estimate the elasticity of demand for natural gas for different customer classes, using state by month data from across the United States. They use an instrumental variables approach in an effort to obtain causal estimates of key elasticities. They find price elasticities of natural gas demand of -0.41, -0.22, and -0.71 for the residential, commercial, and industrial sectors, respectively. They interpret these elasticities as short-run values, and assume (although do not empirically verify) that long-run demand elasticities are likely larger in absolute value.

Auffhammer and Rubin (2018) obtain a large data set covering about 300 million monthly natural gas bills for residential consumers across California. They use this high-resolution data to estimate the elasticity of natural gas demand. Their research design is based on spatial discontinuities in pricing across natural gas utility service areas (i.e., different natural gas distributors charge different prices to households that are otherwise similar to one another and located close to one another), and this is combined with an instrumental variables approach based on the pass-through of Henry Hub natural gas prices to utility retail gas prices. They obtain precise estimates of the residential natural gas elasticity in this context: -0.23. They find that the elasticity varies considerably by seasons, and by customer type. In particular, consumers respond much more to prices in the winter (heating) season compared to the summer, and low-income consumers are more price responsive than high-income consumers. Canada, which has both lower incomes and lower temperatures on average than California, would also likely have more elastic natural gas demand, based on these results.

These studies on natural gas are highly heterogeneous in terms of methodological approach, attention to institutional details of the natural gas sector, region studied, and consequently, in terms of results. However, while it is difficult to pin down a particular elasticity of natural gas demand that applies universally, it is clear from these studies that natural gas consumers do respond to price --- all of the studies surveyed above provide evidence that the price elasticity of natural gas demand is negative. Again, the available evidence suggests that increases in the price of natural gas, possibly via a carbon price, would serve to reduce demand for natural gas and reduce greenhouse gas emissions.

Some back-of-the-envelope calculations can be used to estimate the rough magnitude of reductions in natural gas consumption and associated greenhouse gas emissions that might accompany the introduction of a carbon price. Statistics Canada reports that the residential natural gas price in 2015 averaged 36.2 c/m^3 and the industrial price averaged 13.7 c/m^3.[7] Based on Table 1, a \$50/t CO_2e price would increase residential prices by about 27% and industrial prices by about 71% relative to 2015. Assuming a residential demand elasticity of -0.3 and an industrial demand elasticity of -0.6 suggests reductions in natural gas consumption and associated greenhouse gas emissions of approximately 7% in the residential sector and 38% in the industrial sector.

---

[7] Statistics Canada table 25-10-0033-01. The values are the unweighted monthly average of 2015 prices.

Coal

Coal is primarily used by electricity generators and some large industrial facilities. In many cases, the facilities are located close to the coal source, and in some cases, the mine and generator are operated by the same firm. Coal is also heterogeneous in terms of quality, and much is sold on long-term contracts, making the spot price less relevant. These characteristics make it less straightforward to estimate demand elasticities for coal, and there are consequently many fewer existing estimates of elasticities for this fuel. Dahl (1993) reviews several existing studies and concludes that long-run coal demand is likely *inelastic* (i.e., less than -1 in absolute value), but notes that there is substantial uncertainty in the precise magnitude.

Because much coal demand is in the electricity sector, where dispatch is conventionally based on cost-minimization, simulation/optimization models can provide insight into price responsiveness in this sector. Dolter and Rivers (2018) construct such model for the electricity sector in Canada and use it to estimate the impact of carbon prices on electricity generation in Canada. They project that at a carbon price of about \$80/tCO$_2$e, utilities across Canada would retire existing coal-based generators, in favour of natural gas and renewable electricity generators. The National Energy Board likewise finds that a carbon price would reduce coal (and natural gas) generation and associated greenhouse gas emissions.[8] Brown and Eckert (2018) construct a detailed model of the Alberta electricity sector and use it to simulate the impact of implementing a \$30/tCO$_2$e carbon price along with output-based rebates. They find a reduction in emissions from that sector of 14-21% associated with the policy in the electricity sector, depending on assumptions made regarding the exercise of market power by electricity generating firms. Again, both the available econometric and simulation model evidence suggests that coal demand is likely to respond to changes in prices that would be induced by a carbon price.

---

[8] National Energy Board, 2017. Canada's Energy Future 2017.

DIRECT EVIDENCE FROM EXISTING CARBON PRICES

Introduction

Since the early 1990s, jurisdictions around the world have begun using carbon pricing as a policy instrument designed to reduce carbon dioxide and other greenhouse gas emissions. Carbon pricing since has expanded beyond initial applications in Northern Europe to jurisdictions around the world (see Figure 4). Currently, carbon prices cover around 14% of worldwide greenhouse gas emissions (see Figure 5), with that proportion expected to rise to almost 20% in the near future as China's emission trading system enters into force. These prior experiences with carbon pricing provide a basis for understanding the impact of previously implemented carbon prices on greenhouse gas emissions. This section provides a review of the literature on the effect of these international carbon pricing regimes on environmental performance. In line with the findings of the prior section, **this section provides strong evidence that previously implemented carbon prices have reduced greenhouse gas emissions.**

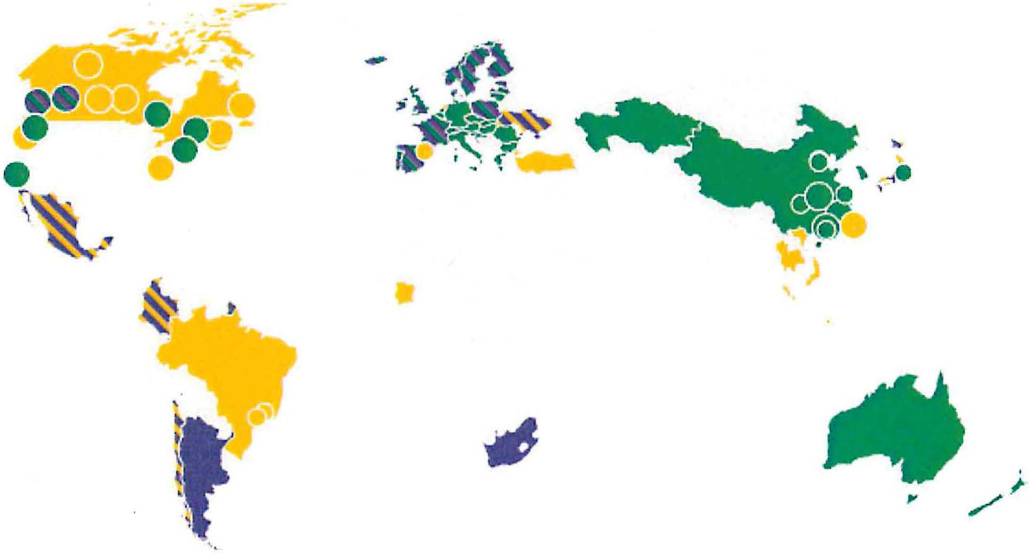


Figure 4: Carbon prices implemented or scheduled for implementation worldwide. Source: World Bank Carbon Pricing Dashboard (https://carbonpricingdashboard.worldbank.org/)

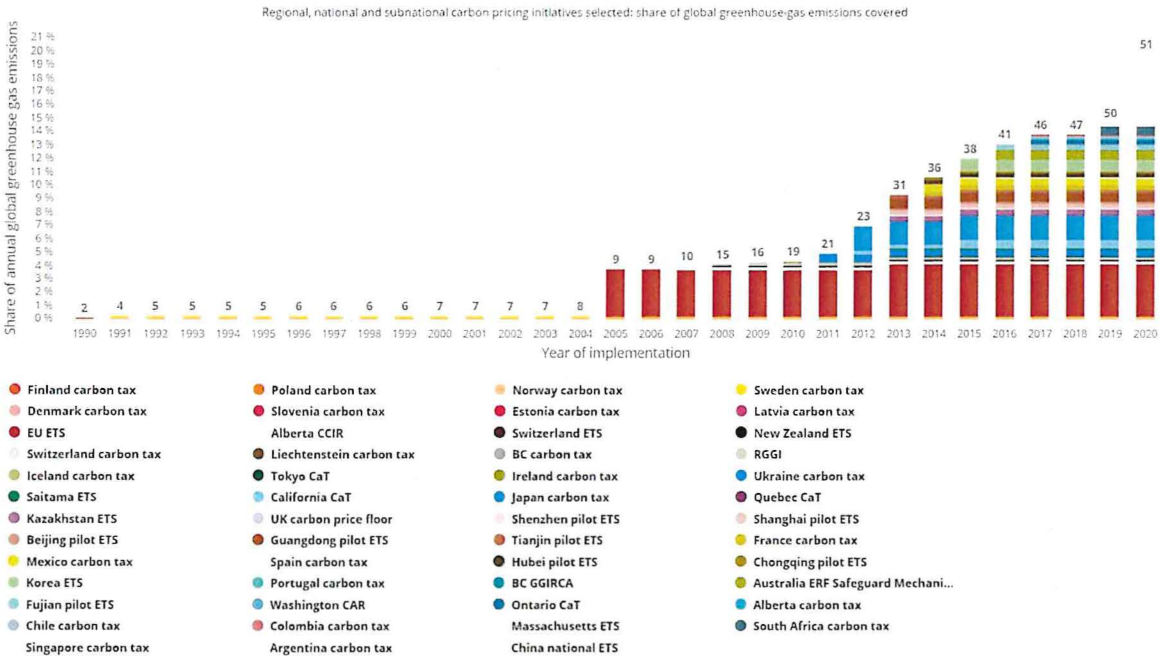


Figure 5: Proportion of total worldwide greenhouse gas emissions covered by carbon prices worldwide. Source: World Bank Carbon Pricing Dashboard (https://carbonpricingdashboard.worldbank.org/)

Evidence from the European Emission Trading System

The European Emissions Trading System (EU-ETS) was initiated in phases starting in 2005 and remains the largest carbon pricing policy implemented worldwide (measured by emission coverage or by permit value).[9] It requires large industrial emitters and power generators to hold allowances equivalent to their level of greenhouse gas emissions. As of 2014, about 13,500 of these entities were directly regulated (i.e., required to remit allowances to cover their emissions) under the EU-ETS (Ellerman et al., 2016). The EU-ETS does not impose a carbon price directly on smaller emitters, such as the personal transport, residential, or commercial sectors. The EU-ETS was implemented in phases, with Phase 1, a pilot, running from 2005-2007, Phase 2 running from 2008-2012, and Phase 3 starting in 2013. Allowance prices were generally low in Phase 1 because the emission cap was non-binding. Moreover, allowances could not be saved from Phase 1 to be used in Phase 2. Allowance prices at the start of Phase 2 were higher (15 to 30 euros per tonne) but fell

---

[9] Ellerman et al. (2016) provide an overview of the structure and implementation of the EU-ETS.

towards the end of Phase 2 as evidence emerged that there was an excess of Phase 2 allowances in the market. Allowance prices at the start of Phase 3 have been relatively low (0 to 10 euros per tonne) although prices have recently increased as regulators have sought to remove excess permits from the market. As a result of these price dynamics, the largest impact of the EU-ETS on emissions is likely to have occurred during the start of Phase 2 of the program. The evidence below supports this presumption, finding that regulated installations cut emissions substantially in response to carbon prices in Phase 2 of the EU-ETS.

A number of studies have attempted to measure the impact of the EU-ETS on emissions abatement by regulated installations. There are many challenges confronting this research, as there are a large number of factors that affect firm or plant behaviour, and it is not straightforward to distinguish between changes in behaviour caused by the EU-ETS and changes caused by other factors. Existing studies compare plants or firms regulated under the EU-ETS with comparison plants or firms that are not directly regulated by the EU-ETS, controlling where possible for other drivers of emissions. There are two underlying assumptions required for this to be a meaningful comparison (Martin et al., 2016). First, the control firms or plants must be chosen such that their realized outcomes represent a good counterfactual for the outcomes of regulated plants, had the latter not been regulated. This assumption cannot be tested, but researchers have made efforts to carefully match regulated plants with good control groups from the pool of unregulated plants, as described below. Second, for the control group to be a suitable control, it must not be itself affected by the EU-ETS. This assumption is likely violated in the case of the EU-ETS, which, because it covers electric power generators, likely causes impacts on electricity prices which affect both regulated and unregulated entities. Studies of the EU-ETS therefore estimate the *direct* impact of the EU-ETS on emissions, rather than the *indirect* effect, which includes its effect on emissions via its effect on electricity prices. As a result, any estimated effects of the EU-ETS on energy consumption or emissions are likely to reflect a lower bound of its actual total effect.

Petrick and Wagner (2014) use microdata on all German manufacturing plants with more than 20 employees (approximately 50,000 plants). They follow the plants from 1995 until 2010, which covers the period prior to EU-ETS implementation as well as the first and (a portion of the) second phases of the EU-ETS. There are about 1,900 EU-ETS installations in Germany, and so Petrick and Wagner (2014) use their data to follow the emissions of these plants in comparison to a group of matched plants that they select for their comparability to the EU-ETS plants from the full microdata.[10] Their main analysis, which uses a difference-in-difference regression with the matched control group, finds that the EU-ETS had little impact on regulated manufacturing plant emissions during the Phase 1 pilot from 2005-2007, but had a substantial impact on regulated plant emissions during Phase 2, when permit prices were higher. In particular, Petrick and Wagner (2014) find that regulated plants reduced greenhouse gas emissions by 25 to 28 percentage points relative to similar non-regulated manufacturing plants during Phase 2 of the EU-ETS. Moreover, they find that the impact on regulated manufacturing plants results from a change in carbon intensity (i.e., emissions per unit of output) rather than from an effect on plant output. Their statistical results appear robust across different specifications, and are precisely estimated due to the high quality data and careful matching approach. In additional statistical analysis, Petrick and Wagner (2014) report that the large reduction in emissions is due substantially to switching from fossil fuels to electricity by regulated firms. To further probe reasons for the large impact on emission reductions, Petrick and Wagner (2014) conduct "double-blind" interviews with plant managers, and report that EU-ETS plants report upgrading machinery and optimizing process heat, along with other measures, in response to the EU-ETS.

In a similar study, Wagner et al. (2014) evaluate the impact of the EU-ETS on emissions from French manufacturing plants. Their sample includes substantial plant-level data on 384 plants regulated under the EU-ETS as well as about 5,600 comparison plants that are unregulated under the EU-ETS. Like Petrick and Wagner (2014), Wagner et al. (2014) employ non-parameteric matching techniques to select from the pool of control plants those that provide the best counterfactual for the regulated plants. They estimate a small and imprecise impact of the EU-ETS on greenhouse gas emissions during Phase 1, but a substantial 14 to 20 percentage point reduction in emissions in regulated plants relative to unregulated plants in Phase 2. As with Petrick and

---

[10] Petrick and Wagner (2014) use a propensity score approach to choosing the plants to include in the control group, in which the "weight" assigned to each control plant is based on how close a match it is for a treatment plant. Not all regulated plants are included in the analysis, because in some cases, a close match cannot be found.

Wagner (2014), Wagner et al. (2014) report that the reduction in greenhouse gas emissions derives primarily from a reduction in greenhouse gas intensity (and not from reductions in plant output).

Two other studies undertake a similar approach, using data from Norwegian and Lituanian manufacturing plants. Jaraite and Di Maria (2016) evaluate the impact of the EU-ETS on Lituanian manufacturing plants using a non-parameteric matching approach very similar to the above studies. They find that in Phase 1 of the EU-ETS, there was no evidence of emissions reductions by regulated Lituanian plants. They note that permit prices in Phase 1 were very low, and that Lituanian installations were granted more allowances than required for compliance, so they view these results as unsurprising. They do report some evidence that the CO_2e intensity of regulated manufacuting plants falls faster than for non-regulated plants. Unfortunately, they do not have data on Phase 2 of the EU-ETS, when allowance prices were higher, so are not able to determine how manufacturing plants reacted to this more stringent policy environment. Klemetsen et al. (2016) study how the EU-ETS affected emissions in Norwegian plants, again using a matching strategy to compare regulated plants to a suitable control group of non-regulated plants. They find that greenhouse gas emissions in plants regulated under the EU-ETS fell by 33 to 36 percent relative to non regulated plants during Phase 2 of the EU-ETS, and by 13 to 15 percent during Phase 3 of the EU-ETS. As with prior studies, Klemestern et al. (2016) report that the change in emissions derives from changes in emissions intensity, rather than from changes in plant output. Unfortunately, due to the relatively small data set, the estimates are imprecise.

Dechezlepretre et al. (2018) use plant-level emissions data from France, the Netherlands, Norway, and the United Kingdom to evaluate the extent to which the EU-ETS has impacted plant-level carbon emissions. They use a restrictive matching approach, by comparing regulated plants with other plants in the same sector and country that are just slightly too small to have been included in the EU-ETS. They report an average reduction by regulated plants over Phases 1 and 2 of 10 to 14%, with the impact larger in Phase 2 of the EU-ETS than in Phase 1. By 2012, they report that EU-ETS plants have emissions that are about 25% lower than otherwise comparable unregulated plants.

The prior results point towards a robust finding across countries that the EU-ETS had little impact on plant level emissions in Phase 1, but appears to have had a substantial impact on emissions in Phase 2. The outcome for Phase 1 is unsurprising, since allowance prices in that Phase were low because of over-allocation by governments and because there was no ability to bank allowances for later use (which would have given the allowances more value). At the beginning of Phase 2, allowances prices were relatively high, and the evidence from the studies above is that these prices were enough to encourage a substantial amount of emission reduction---on the order of 10 to 30 percent, depending on the study---by covered plants. Where evidence is available, it shows that these reductions in greenhouse gas emissions result from improvements in greenhouse gas intensity rather than from reductions in plant output.

Figure 6 summarizes empirical estimates from the studies described above on the impact of the EU-ETS on the emissions of regulated manufacturing plants. Each study produced more than one estimate of the impact of the EU-ETS, with estimates varying depending on which plants are included in the sample, which controls are used, and other variables. Individual estimates are shown in the figure, grouped by study. From the figure it is clear that while there is uncertainty about the exact magnitude of greenhouse gas reductions attributable to the EU-ETS, all the available evidence points towards the finding that the EU-ETS (in Phase 2) was successful in reducing emissions from regulated plants.

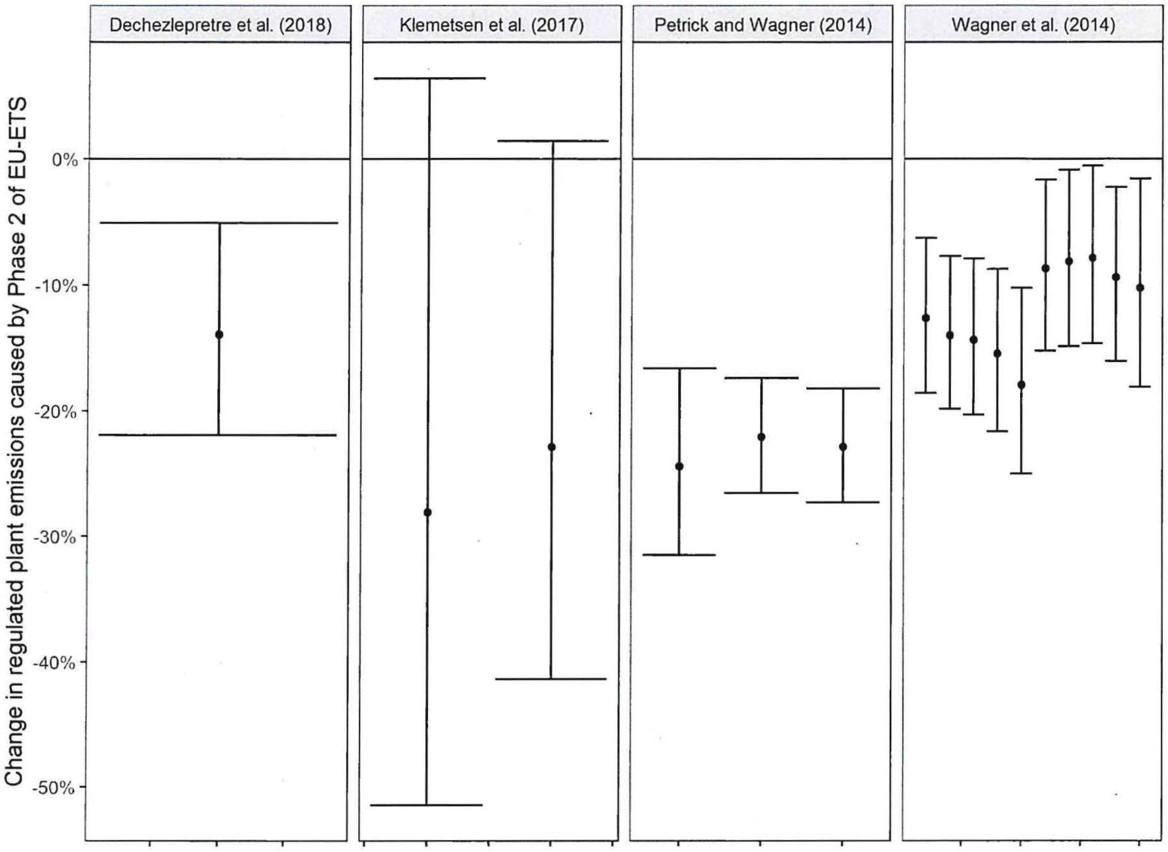


Figure 6: Empirical estimates of the impact of the European Union Emission Trading System on plant- or firm-level CO_2 or greenhouse gas emissions

Notes: Each point (along the x-axis) reflects an estimate of the effect of the EU-ETS on carbon dioxide or total greenhouse gas emissions emitted by manufacturing plants or by manufacturing firms, based on estimated parameters from models in each of the papers. In each case, I restrict the estimates to those reflecting Phase II of the EU-ETS, when the permit price was between about 10-30 euros/tCO_2. The error bars around each point reflect the 95% confidence intervals. Note that the confidence interval for Dechelepretre et al. (2018) estimates is estimated from a graphical summary.

Evidence from other carbon levies

In addition to the EU-ETS, there exist a number of instances where carbon prices have been used with the aim of reducing greenhouse gas emissions. In cases where ex post evaluations of these policies have been conducted, they can also help to inform the likely behavioural response to future carbon price implementation.

Although there are relatively few ex post analyses of market-based carbon prices outside of the EU-ETS, those that do exist provide additional evidence about the likely impact of carbon prices on emissions. In each of the cases reviewed below, **analysis of greenhouse gas emissions data from before and after policy implementation show that jurisdictions with a carbon price reduced emissions more substantially than comparable jurisdictions without a carbon price**.

UK Climate Change Levy

The UK Climate Change Levy is a levy on greenhouse gas emissions emitted by manufacturing plants. Unusually, the rate varied by fuel type, and was set at between £16-32/tCO_2e depending on the type of fuel (these levies add about 15% to a typical plant energy costs). It was implemented in conjunction with a set of voluntary agreements (called climate change agreements or CCAs) under which plants set targets for future energy consumption or carbon dioxide emissions in exchange for obtaining substantial reductions in the climate change levy. Martin et al. (2014) use these features of the policy in order to conduct an empirical evaluation of the policy's impact on the environmental and economic performance of plants. Their basic approach is a difference-in-difference comparison between plants that obtain a CCA (and thus face a reduced levy rate) and plants that do not. Importantly, they recognize the potential for plants to self-select into CCAs, and use an appropriate strategy (instrumental variables) to address this potential source of bias. Martin et al. (2014) use longitudinal micro-data on manufacturing plant output and performance to conduct their empirical investigation. They find that the Climate Change Levy caused a reduction in energy intensity of around 18-20% and a reduction in carbon dioxide emissions from regulated plants by 8.4-22.6%.

US Regional Greenhouse Gas Initiative

The US Regional Greenhouse Gas Initiative (RGGI) was introduced in 2009 by a consortium of 10 Northeastern US states. It aims to reduce greenhouse gas emissions from the electricity generation sector through the imposition of a cap and trade system. Emissions from the power sector in RGGI states have indeed fallen substantially since 2009, both in absolute terms and relative to other US states. However, attributing the change to the RGGI program is complicated, since many factors have impacted electricity generation choices in the US over this period, including the "great" recession and substantial reductions in natural gas prices. Murray and Maniloff (2015) use a statistical approach to determine the degree to which the RGGI program contributed to reductions in greenhouse gas emissions from RGGI states. They compare greenhouse gas emissions in RGGI states to those in other states, before and after the RGGI program was put in place, using annual state-level data. They control for fuel prices, weather, employment, and population, as well as state fixed effects and time effects. They find that the RGGI program reduced greenhouse gas emissions by about 0.6 tCO_2e/person (they note that for one state in their sample, this was about a 16% reduction in emissions).

Sweden carbon tax

Sweden was one of the first countries in the world to implement a carbon tax in 1991. When introduced, it was set at a level of US\$32/tCO_2, and the tax level has been since increased over time to US\$132/tCO_2. Andersson (2017) conducts an empirical investigation of the impact of the tax on CO_2 emissions from the Swedish transport sector, using both a difference-in-difference approach as well as a synthetic control approach. In each case, the empirical analysis is conducted by comparing CO_2 emissions from the Swedish transport sector to emissions from the transport sectors of other comparable countries, both before and after the imposition of the Swedish emissions tax. The empirical estimates suggest that the CO_2 tax caused a reduction in CO_2 emissions between 8.1-10.9% on average. Importantly, Andersson (2017) reports that the impact of the carbon tax on emissions is much larger (about three times larger) than would be expected based on the price change of fuels alone. This effect is consistent with other literature (e.g., Rivers and Schaufele, 2015; Antweiler and Gulati, 2016).

Evidence from British Columbia's carbon tax

In 2008, British Columbia became one of the first jurisdictions in North America to implement a broad-based levy on carbon dioxide emissions at a substantial level (Murray and Rivers, 2015). The British Columbia carbon tax was set at \$10/tCO_2e in July 2008, and increased in \$5/tCO_2e increments to \$30/tCO_2e by July 2012. In April 2018, it was again increased by \$5/tCO_2e, and is scheduled to increase to \$50/tCO_2e by 2021. The British Columbia carbon tax was originally implemented in a revenue-netural manner, with revenue from the tax being rebated via personal and corporate income tax cuts as well as direct rebates to households.

Murray and Rivers (2015) review the impact of the British Columbia policy on a number of key outcomes, including greenhouse gas emissions, economic output and competitiveness, public support for the policy, and household distributional incidence. Although they do not conduct primary research on the impact of the tax on greenhouse gas emisions, they synthesize findings from prior literature (some of which is reviewed separately below) and report that the British Columbia carbon tax reduced greenhouse gas emissions in British Columbia by between 5 and 15 percent relative to a no-tax counterfactual.

Several ex post studies have been conducted to assess the degree to which the implemented carbon tax has affected fuel consumption, purchasing behaviours, and greenhouse gas emissions. Elgie and McClay (2013) examine trends in petroleum fuel consumption in British Columbia following the introduction of the tax. They compare changes in fuel consumption in British Columbia after the tax is in place compared to a base year immediately prior to the tax's introduction, and also compare to the rest of Canada. They find that fuel consumption per capita in British Columbia declined by 17.4% between 2008 and 2012, while consumption in the rest of Canada increased by 1.5%. They also show that British Columbia and the rest of Canada followed similar trends in fuel consumption prior to the introduction of the carbon tax, suggesting a causal impact. Finally, they compare trends in the consumption of fuels covered by the carbon tax with those not covered by the carbon tax (aviation fuels), and show that while British Columbia experienced a much more rapid decline in per capita consumption for fuels covered by the carbon tax, the pattern does not hold for fuels not covered by the carbon tax (aviation fuel consumption, which is not affected by the tax, followed similar trends in British Columbia and the rest of Canada) again suggesting a causal impact of the tax on fuel consumption.

Rivers and Schaufele (2015) estimate the impact of the British Columbia carbon tax on gasoline consumption. They use monthly panel data from all provinces in Canada, spanning the period before and after the introduction of the carbon tax in British Columbia. They statistically control for a number of other factors that could impact gasoline consumption, including gasoline prices, income, employment, and other business-cycle variables. They find that the carbon tax caused a significant reduction in gasoline consumption in British Columbia. In their preferred specification, they find that a 1c/L increase in gasoline price due to the carbon tax causes a 1.2% reduction in gasoline consumption. The \$30/tCO$_2$ carbon tax, which results in a 6.7c/L increase in gasoline prices, is therefore estimated to reduce gasoline consumption by 8.1%. Notably, Rivers and Schaufele (2015) find that British Columbia's carbon tax causes a much larger (three times as large) impact on gasoline consumption than an equivalent change in gasoline prices for other reasons (for example, due to changes in the price of crude oil). They hypothesize that the large response to the British Columbia carbon tax is due to the *salience* of the tax: it was widely reported in the media such that there was consumer awareness of the price change, unlike for other gasoline price changes.

Antweiler and Gulati (2016), Lawley and Thivierge (2018), and Erutku and Hildebrandt (2018) also examine the impact of the British Columbia carbon tax on gasoline consumption. Like Rivers and Schaufele (2015), Antweiler and Gulati (2016) use monthly-level data on gasoline sales from all Canadian provinces to estimate the impact of the tax on gasoline demand. They extend the data set using more recent data, and also account for the potential impact of the BC carbon tax on cross-border gasoline shopping. Like Rivers and Schaufele (2015), they find that the carbon tax had a substantial impact on gasoline demand; in their preferred model, they find that a 1% increase in gasoline prices due to a carbon (or other) tax causes a 1.3% reduction in gasoline consumption. They use this estimated coefficient to simulate the impact of a \$30/tCO$_2$e tax, and find that this level of tax would be expected to reduce gasoline consumption by 7.1%. They hypothesize that the large impact of the tax relative to other price changes is due to its permanence: consumers may be more willing to undertake long-term changes in behaviour or make investments in response to the tax than a usual gasoline price change, which may quickly be reversed. In addition to studying the impact on gasoline sales, Antweiler and Gulati (2016) empirically estimate the impact of the carbon tax on vehicle fleet fuel economy, by exploiting detailed vehicle sales data from BC and other provinces. They find that the BC carbon tax caused an increase in market share for fuel efficient vehicles and a decline in less fuel efficient vehicles, corresponding to an overall improvement in fleet fuel efficiency of between 0.1-0.4L/100km (about 4% improvement in new vehicle fuel economy, in their preferred specification).

Lawley and Thivierge (2018) use household-level data from multiple waves of a large household expenditure survey (the Canadian Survey of Household Spending, SHS) to determine the impact of the carbon tax on household gasoline consumption. Because they use an extremely detailed household survey, they are able to control for a large number of household-level variables that could confound the estimate of the carbon tax on gasoline consumption. They use the data to compare household expenditures on gasoline in British Columbia before and after the tax, and in British

Columbia compared to other provinces. Their empirical estimates suggest that the $30/tCO$_2$e tax caused a 10.6% reduction in gasoline consumption. Similar to Rivers and Schaufele (2015) and Antweiler and Gulati (2016), they find that the carbon tax caused a much more substantial (about three times as large) reduction in gasoline consumption as would be expected from a change in gasoline prices from another source. Using the detailed household data, Lawley and Thivierge (2018) are able to examine heterogeneous impacts of the carbon tax across different regions in the province. They find that the tax caused the largest reduction in gasoline consumption in Vancouver, followed by other smaller cities in British Columbia. They find that the tax had little measurable impact on gasoline consumption in rural areas of the province. Lawley and Thivierge (2018) also conduct an analysis to determine how potential cross-border shopping for gasoline could impact these estimates. This analysis suggests that some of the impact of the carbon tax may have been to induce additional cross-border shopping, but the overall conclusions of the analysis are essentially unchanged when allowing for cross-border shopping (i.e., the effect of cross-border shopping on British Columbia gasoline sales is small). A similar conclusion on this point was reached by Antweiler and Gulati (2016).

Erutku and Hildebrand (2018) revisit the analysis of Rivers and Schaufele (2015) by using more recent data, as well as by introducing an additional control in the Rivers and Schaufele (2015) analysis to address potentially divergent patterns in gasoline consumption between British Columbia and the rest of Canada prior to the implementation of the carbon tax. Their analysis yields similar outcomes as the Rivers and Schaufele (2015) analysis. However, in the estimation with the extended data, the estimate of the effect of the carbon tax is less precise (although it remains very close to the estimate from the studies listed above). Their preferred specification suggests that the $30/tCO$_2$e tax caused a 7.9% reduction in gasoline consumption. The other estimates presented suggest a larger impact. Again, this study suggests a more substantial response to carbon taxes than other components of gasoline price.

Figure 7 summarizes empirical estimates of the impact of the British Columbia carbon tax on gasoline consumption from the key studies outlined above. The figure contains multiple estimates of the impact of a carbon tax on gasoline consumption derived from each study. The multiple estimates relate to differences in econometric methodology, differences in the data selected for inclusion, and differences in statistical controls employed. In each study, I highlight in black the preferred estimate (in cases where the authors do not explicitly state their preferred estimate, I pick the estimate that appears to be the preferred estimate based on the text). Each empirical estimate also contains a 95% confidence interval. Although there are some differences between the estimates between and within papers, the preferred estimates conform closely to one another, and suggest that the BC carbon tax caused roughly an 8-10% reduction in gasoline consumption within the province. Because greenhouse gas emissions are released when gasoline is burned, these results also suggest a commensurate reduction in greenhouse gas emissions associated with gasoline combustion.

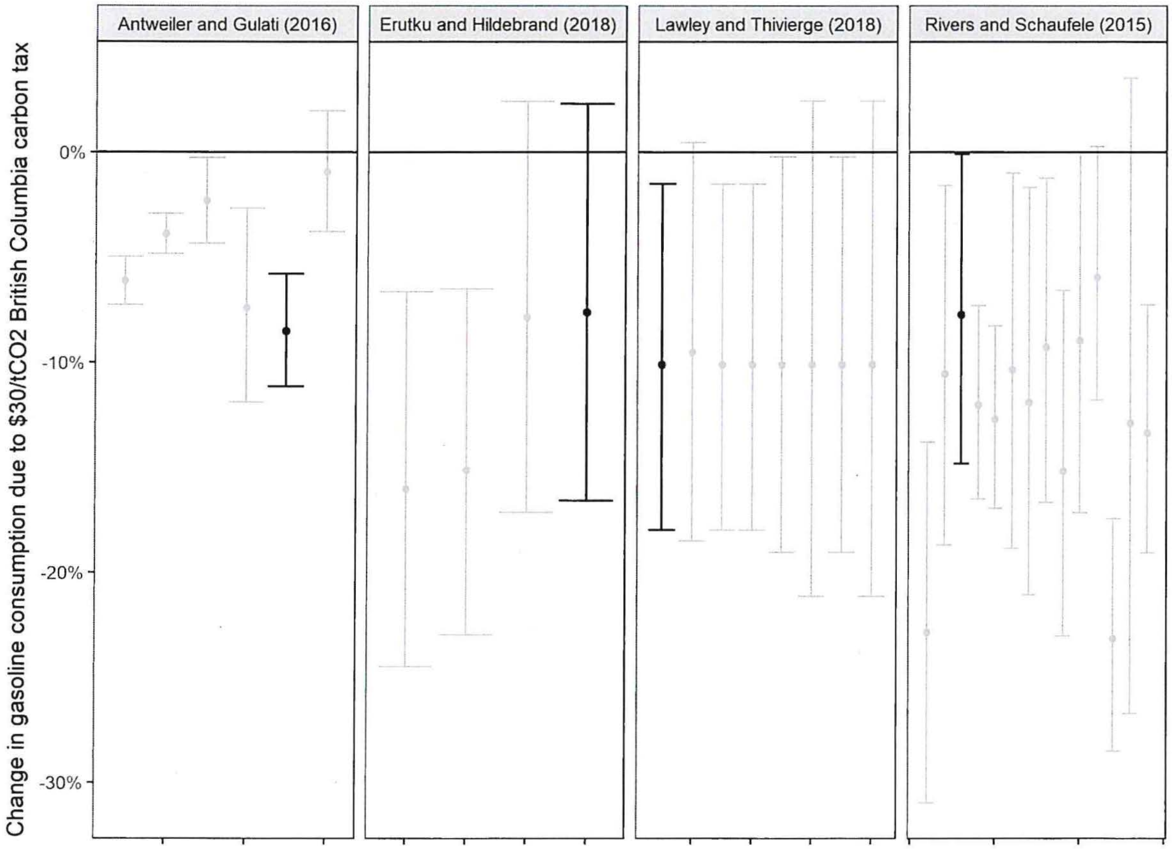


Figure 7: Empirical estimates of the impact of the British Columbia carbon tax on gasoline consumption

Notes: Each point (on the x-axis) reflects an estimate of the effect of a \$30/tCO$_2$e carbon tax on gasoline consumption, calculated based on estimated parameters from models in each of the papers. Preferred models (indicated by authors of each paper) are indicated by black points and lines. In each case a \$30/tCO$_2$e carbon tax is assumed to increase gasoline price by 6.67c/L. Where necessary, the net gasoline price (exclusive of carbon tax) is assumed to be \$1.00/L. The error bars around each point reflect the 95% confidence intervals.

While the above studies focused on gasoline consumption, there are a few studies focused on the impact of the British Columbia carbon tax on other fuels. Bernard and Kichian (2017) estimate the impact of the British Columbia tax on diesel sales. They use a time-series approach, and estimate an error correction model as well as a dynamic ordinary least squares model. They find that the long-run price elasticity of diesel demand in the province is -0.52. Using the error correction model, they find that the carbon tax causes an additional short-run impact on diesel consumption, in addition to the long-run impact. Combining these two components, they estimate that the British Columbia carbon tax caused a short-run reduction in diesel demand (and associated greenhouse gas emissions) of about 7%, and a long-run reduction of about 3.5%.

Finally, Xiang and Lawley (2018) examine the impact of the carbon tax on residential natural gas consumption. Using both a synthetic control approach as well as a difference-in-difference approach combined with monthly state- and province-level panel data, Xiang and Lawley (2018) find that the carbon tax in British Columbia caused households to reduce natural gas consumption by between 6.9 and 10.1 percent. Their panel data approach is able to control for weather as well as a number of other potential determinants of natural gas demand, and both traditional panel data as well as synthetic control approaches deliver similar estimates of the effect of the carbon tax on natural gas demand. As is the case for studies of gasoline demand described above, Xiang and Lawley (2018) find that consumers reduced natural gas consumption much more in response to the carbon tax compared to their response to an equivalent increase in natural gas price for other reasons.

IMPACTS OF CARBON PRICING ON INNOVATION

In addition to the more immediate impact of a carbon price on behavior of individuals and plants, it is also important to consider the potential impact of a carbon price on the development and diffusion of new technologies. Because the availability and cost of greenhouse gas mitigation technologies is so critical in influencing the degree of emission reduction that will be pursued, economists consider that the effects of environmental policies on innovation of new technologies may, in the long run, be one of the most important determinants of the effect of environmental policies (Jaffe, Newell, and Stavins, 2003).

This section briefly reviews the empirical evidence on the effects of carbon pricing on innovations in energy saving and low-carbon technology. As in the prior section, both indirect and direct evidence is relevant. Indirect evidence shows that in the past, when energy prices have increased, firms have responded by producing more energy-saving innovations such as fuel efficient cars and heat pumps, as well as producing more alternative energy technology innovations.[11] Direct evidence based on existing carbon prices shows that firms regulated by a carbon price produce more low-carbon innovations than similar unregulated firms. **While the empirical evidence is relatively thin, the combined evidence offers strong support that increases in energy prices, possibly resulting from a carbon price, increase innovation in low-carbon and energy efficient technologies.**

Economic theory provides support for the notion that carbon pricing is likely to drive innovation in clean energy technologies. The "induced innovation hypothesis" reflects the idea that profit-seeking firms will respond to changes in relative prices by investing in innovation to economize on costly inputs (Hicks, 1932). According to this theory, carbon pricing, which increases the cost of emitting greenhouse gases, should be expected to provide incentives for firms to innovate to find

---

[11] While most evidence in the prior section focused on manufacturing *plants*, evidence in this section focuses in particular on *firms* (which may own no, one, or multiple plants). This difference exists because emissions are tracked at the plant level, whereas innovations (and patenting of innovations) occurs at the firm level.

technologies that reduce these emissions (Popp, Newell, and Jaffe, 2010; Milliman and Prince, 1989).

While the theory on induced innovation provides clear predictions, empirical tests of the induced innovation theory in the context of carbon pricing are fairly limited. For one, this is a result of limited data with which to test the theory. Measuring innovation – unlike, for example, measuring energy consumption – is not straightforward. Recent empirical work in this area typically uses patent counts as a proxy for innovation. Patents, however, can vary substantially in quality, such that the value of an additional patent is not always clear. Moreover, the link between patents and their application in reducing greenhouse gas emissions is likewise not always clear. Another reason that empirical studies lag behind the theory is because of conceptual difficulties in extending the theory to real-world practice. For example, while theory suggests that higher energy prices will increase innovation in energy efficient technologies, it is not always clear which energy prices are relevant (expected future prices? Contemporaneous prices? Recent historical prices?). Moreover, innovators can work in one region (and register patents there) in response to energy prices in another region, expecting to market their new technology there. This makes finding suitable "control units" for empirically testing the induced innovation theory challenging.

Despite these difficulties, there have been empirical advances in testing the induced innovation theory in the context of energy and carbon pricing. Newell, Jaffe, and Stavins (1999) examined innovation in household appliances (air conditioners and gas heaters) in response to changes in energy prices. They show that innovation occurs autonomously (that is, with the passage of time) as well as due to energy efficiency regulations, but significant amounts of innovation are also due to changes in energy prices. They show that if energy prices had remained at their (low) 1973 levels rather than following their historical path, the energy efficiency of air conditioners and gas heaters offered for sale in the US would have been one quarter to one half lower than it actually was. This paper was one of the first that provided clear empirical evidence that policies such as a carbon price would likely result in increases in innovation in energy efficient technologies.

Popp (2002) takes a similar approach to testing whether higher energy prices encourage innovation in energy-saving technologies. Popp measures innovation using patent counts, and weights patent counts by the number of citations they receive as a measure of patent quality. He focuses on 11 different patent technology groups, encompassing both energy supply patents (for example, patents for solar energy production) as well as energy demand patents (for example, electric heat pump patents). Using this approach, Popp finds that higher energy prices cause more patenting activity in this group of energy technologies. Specifically, a ten percent increase in energy prices is determined to increase energy-related patents by 3.5% over the long run. Again, this study provides indirect evidence that a carbon price, which increases energy prices, is likely to result in clean energy innovations.

Aghion et al. (2016) follow this line of research and test the effect of energy prices on innovation in the automobile industry. They leverage the fact that different automobile manufacturers are exposed to different automobile markets in differing degrees. For example, General Motors sells a large share of its vehicles in the US market, while Toyota sells a large share of its vehicles in the Japanese market. General Motors would therefore be expected to respond especially strongly to an increase in US gasoline prices, whereas Toyota would respond most to a change in Japanese fuel prices. Following this logic, Aghion et al. (2016) construct a weighted fuel price associated with each automobile manufacturing firm, based on their exposure to all vehicle markets worldwide. They then relate this measure to the patenting activity by each firm, focusing on energy-conserving patents. They find that increases in the fuel prices faced by a firm cause an increase in energy efficient patenting activity, by a roughly proportional amount – that is, a 10% increase in fuel prices faced by a firm causes a roughly 10% increase in "green" patents obtained by the firm. They use the results of their empirical analysis to consider what level of fuel price increase would be required for "green" vehicles (electric, fuel cell, and hybrid vehicles, for example) to overtake standard vehicles. They find that any fuel price increase would increase the knowledge stock for clean vehicles, but that for clean vehicles to overtake standard vehicles would require a substantial and sustained increase in energy prices. For example, they find that a 30% increase in fuel prices would cause clean vehicles to overtake standard vehicles over a period of roughly 18 years.

All of the above studies provide *indirect* evidence on the impact of a carbon price on innovation, by estimating the relationship between past changes in energy prices and a measure of innovation. In contrast, Calel and Dechezlepretre (2016) stands out because it provides *direct* evidence on how an existing carbon pricing regime affects innovation. This study evaluates how the EU-ETS has affected low-carbon innovation in regulated firms. The EU-ETS uses a size threshold to determine whether particular installations are regulated (and thus face a carbon price). Calel and Dechezlepretre (2016) compare a group of firms with installations just above the inclusion threshold with similar firms that own installations just below the inclusion threshold to determine how the EU-ETS impacts firm-level innovation. They compare patenting activity in the two sets of firms, focusing both on overall patenting activity, as well as low-carbon patents. They find that the EU-ETS led to roughly a 36% increase in low-carbon patenting activity in regulated firms. In a similar study, Calel (2018) compares low-carbon patenting by UK firms with at least one installation covered by the EU-ETS with similar firms without any such coverage, and finds the EU-ETS caused roughly a 25% increase in low-carbon patenting activity among regulated firms.

Overall, while the empirical research on the impact of energy and carbon prices on low-carbon innovation is relatively small, the findings in the literature strongly point towards the conclusion that firms respond to increases in energy and carbon prices with innovations in low-carbon and energy savings technologies. These innovations constitute an important long-run impact of carbon prices on the environment.

CONCLUSION

The objective of this report is to provide evidence on the likely impact of a carbon price on greenhouse gas emissions. To do this, I provide indirect evidence, based on how consumers have responded in the past to changes in fuel prices, and also provide direct evidence, based on how greenhouse gas emitters have responded in the past to the imposition of carbon prices. In both cases, the evidence suggests that the imposition of a carbon price would lead to reductions in greenhouse gas emissions. Moreover, the evidence that tests the induced innovation hypothesis finds that high carbon prices help to drive low-carbon innovation. While there is uncertainty in the results of any given scientific study, the strong convergence of evidence from multiple contexts, methodological approaches, and regions provides clear evidence that imposing a carbon price would cause reductions in greenhouse gas emissions and increases in low-carbon innovation.

References

Aghion, Philippe, Antoine Dechezleprêtre, David Hemous, Ralf Martin, and John Van Reenen. "Carbon taxes, path dependency, and directed technical change: Evidence from the auto industry." *Journal of Political Economy* 124, no. 1 (2016): 1-51.

Alm, James, Edward Sennoga, and Mark Skidmore. "Perfect competition, urbanization, and tax incidence in the retail gasoline market." *Economic Inquiry* 47.1 (2009): 118-134.

Andersson, Julius. "Cars, carbon taxes and CO_2 emissions." *London: Grantham Research Institute on Climate Change and the Environment* (2015).

Antweiler, Werner, and Sumeet Gulati. "Frugal cars or frugal drivers? How carbon and fuel taxes influence the choice and use of cars." (2016).

Auffhammer, Maximilian, and Edward Rubin. "Natural Gas Price Elasticities and Optimal Cost Recovery Under Consumer Heterogeneity: Evidence from 300 million natural gas bills." No. w24295. National Bureau of Economic Research, 2018.

Bernard, Jean-Thomas, and Maral Kichian. "Carbon Tax Saliency: The Case of BC Diesel Demand." (2017).

Bohi, Douglas R. *Analyzing demand behavior: a study of energy elasticities*. RFF Press, 2013.

Brons, Martijn, Peter Nijkamp, Eric Pels, and Piet Rietveld. "A meta-analysis of the price elasticity of gasoline demand. A SUR approach." *Energy Economics* 30.5 (2008): 2105-2122.

Brown, David P., Andrew Eckert, and Heather Eckert. "Carbon pricing with an output subsidy under imperfect competition: The case of Alberta's restructured electricity market." *Resource and Energy Economics* 52 (2018): 102-123.

Calel, Raphael. "Adopt or Innovate: Understanding Technological Responses to Cap-and-Trade." (2018).

Calel, R. and Dechezlepretre, A., 2016. Environmental policy and directed technological change: evidence from the European carbon market. *Review of economics and statistics*, *98*(1), pp.173-191.

Chouinard, Hayley, and Jeffrey M. Perloff. "Incidence of federal and state gasoline taxes." *Economics Letters* 83.1 (2004): 55-60.

Dahl, Carol, and Thomas Sterner. "Analysing gasoline demand elasticities: a survey." *Energy economics* 13.3 (1991): 203-210.

Dahl, Carol "Measuring global gasoline and diesel price and income elasticities." *Energy Policy* 41 (2012): 2-13.

Dahl, Carol "A survey of energy demand elasticities in support of the development of the NEMS", Colorado School of Mines (1993). Prepared for US Department of Energy.

Dechezlepretre, Antoine, Daniel Nachtigall, and Frank Venmas. "The joint impact of the European Emissions Trading System on carbon emissions and economic performance". (2018) *OECD Environment Working Paper*. ENV/EPOC/WPIEEP(2018)7/REV2.

Davis, Lucas W., and Erich Muehlegger. "Do Americans consume too little natural gas? An empirical test of marginal cost pricing." *The RAND Journal of Economics* 41.4 (2010): 791-810.

Dolter, Brett, and Nicholas Rivers. "The cost of decarbonizing the Canadian electricity system." *Energy Policy* 113 (2018): 135-148.

Elgie, Stewart, and Jessica McClay. "Policy Commentary/Commentaire BC's carbon tax shift is working well after four years (attention Ottawa)." *Canadian Public Policy* 39.Supplement 2 (2013): S1-S10.

Ellerman, A. Denny, Claudio Marcantonini, and Aleksandar Zaklan. "The European Union Emissions Trading System: ten years and counting." *Review of Environmental Economics and Policy* 10.1 (2016): 89-107.

Erutku, Can, and Vincent Hildebrand. "Carbon Tax at the Pump in British Columbia and Quebec." *Canadian Public Policy* 44.2 (2018): 126-133.

Espey, Molly. "Explaining the variation in elasticity estimates of gasoline demand in the United States: a meta-analysis." *The Energy Journal* (1996): 49-60.

Espey, Molly. "Gasoline demand revisited: an international meta-analysis of elasticities." *Energy Economics* 20.3 (1998): 273-295.

Fullerton, Don, and Gilbert E. Metcalf. "Tax incidence." *Handbook of Public Economics* 4 (2002): 1787-1872.

Gelman, Michael, Yuriy Gorodnichenko, Shachar Kariv, Dmitri Koustas, Matthew D. Shapiro, Dan Silverman, and Steven Tadelis. *The response of consumer spending to changes in gasoline prices*. No. w22969. National Bureau of Economic Research, 2016.

Greene, William H. "Econometric analysis." (2003). Prentice Hall.

Hicks, John. *The theory of wages*. Springer, 1932.

Jaffe, Adam B., Richard G. Newell, and Robert N. Stavins. "Technological change and the environment." *Handbook of environmental economics*. Vol. 1. Elsevier, 2003. 461-516.

Jaraite-Kažukauske, Jurate, and Corrado Di Maria. "Did the EU ETS Make a Difference? An Empirical Assessment Using Lithuanian Firm-Level Data." *The Energy Journal* 37.1 (2016).

Klemetsen, Marit E., Knut Einar Rosendahl, and Anja Lund Jakobsen. "The impacts of the EU ETS on Norwegian plants' environmental and economic performance." *Discussion Papers* 833 (2016).

Lawley, C., and V. Thivierge. "Refining the Evidence: British Columbia's Carbon Tax and Household Gasoline Consumption." *Energy Journal* 39.2 (2018): 147-171.

Levin, Laurence, Matthew S. Lewis, and Frank A. Wolak. "High frequency evidence on the demand for gasoline." *American Economic Journal: Economic Policy* 9.3 (2017): 314-47.

Marion, Justin, and Erich Muehlegger. "Fuel tax incidence and supply conditions." *Journal of public economics* 95.9-10 (2011): 1202-1212.

Martin, Ralf, Laure B. De Preux, and Ulrich J. Wagner. "The impact of a carbon tax on manufacturing: Evidence from microdata." *Journal of Public Economics* 117 (2014): 1-14.

Martin, Ralf, Mirabelle Muûls, and Ulrich J. Wagner. "The impact of the European Union Emissions Trading Scheme on regulated firms: What is the evidence after ten years?." *Review of environmental economics and policy* 10.1 (2016): 129-148.

Milliman, Scott R., and Raymond Prince. "Firm incentives to promote technological change in pollution control." *Journal of Environmental economics and Management* 17.3 (1989): 247-265.

Murray, Brian C., and Peter T. Maniloff. "Why have greenhouse emissions in RGGI states declined? An econometric attribution to economic, energy market, and policy factors." *Energy Economics* 51 (2015): 581-589.

Murray, Brian, and Nicholas Rivers. "British Columbia's revenue-neutral carbon tax: A review of the latest "grand experiment" in environmental policy." *Energy Policy* 86 (2015): 674-683.

Newell, Richard G., Adam B. Jaffe, and Robert N. Stavins. "The induced innovation hypothesis and energy-saving technological change." *The Quarterly Journal of Economics* 114.3 (1999): 941-975.

Petrick, Sebastian, and Ulrich Wagner. "The impact of carbon trading on industry: Evidence from German manufacturing firms." (2014).

Popp, David, Richard G. Newell, and Adam B. Jaffe. "Energy, the environment, and technological change." *Handbook of the Economics of Innovation*. Vol. 2. North-Holland, 2010. 873-937.

Popp, David. "Induced innovation and energy prices." *American economic review* 92.1 (2002): 160-180.

Rivers, Nicholas, and Brandon Schaufele. "Salience of carbon taxes in the gasoline market." *Journal of Environmental Economics and Management* 74 (2015): 23-36.

Sen, Anindya. "Higher prices at Canadian gas pumps: international crude oil prices or local market concentration? An empirical investigation." *Energy Economics* 25.3 (2003): 269-288.

Taylor, Lester D. "The demand for energy: a survey of price and income elasticities." *International Studies of the Demand for Energy* (1977): 3-43.

Wagner, Ulrich, Mirabelle Muûls, Ralf Martin, and Jonathan Colmer. "The Causal Effects of the European Union Emissions Trading Scheme: Evidence from French Manufacturing Plants." (2014).

Xiang, Di and Lawley. "The impact of British Columbia's carbon tax on residential natural gas consumption." (2018). *Energy Economics*, Accepted manuscript.

This is **Exhibit C** referred to in the

affidavit of **Nicholas Rivers**

affirmed before me on **January 25, 2019**

Commissioner for Taking Affidavits

DO CLIMATE ACTION REBATES AFFECT HOUSEHOLD INCENTIVES TO REDUCE GREENHOUSE GAS EMISSIONS?

PREPARED FOR: DEPARTMENT OF JUSTICE CANADA

PREPARED BY: NICHOLAS RIVERS

DECEMBER 31, 2018

Introduction

The objective of this report is to explain whether and how distributing proceeds raised from a carbon price back to households using a "climate action incentive rebate" changes the incentives for households to reduce greenhouse gas emissions. The adoption of this type of policy approach is relatively new, and so there does not exist a body of empirical evidence available to study exactly how households have responded in the past to a carbon price in conjunction with household carbon dividends. Instead, this report relies principally on standard microeconomic theory in order to provide insight into this question. **Microeconomic theory is conclusive on this point: for an average household, there is no reason to believe that receiving a climate action incentive rebate will undermine incentives to reduce emissions.** The report outlines the assumptions necessary for this theoretical prediction to hold, which are the standard assumptions that underlie the economic theory of consumer behaviour. In general, these assumptions are minor with respect to the case at hand. However, the report also notes which assumptions are less likely to hold, and explores the associated consequences.

Although the microeconomic theory is not complicated, the style of analysis used in this report may not be familiar to those without training in economics. As a result the report begins with a simple example that serves to illustrate the basic insight of the theoretical model in an informal setting.

Informal analysis of carbon pricing and climate action incentive rebates

Since all of us have experience as consumers, perhaps the most straightforward way to understand the impact of the carbon price and associated climate action incentive rebates is through a simple example.

The imposition of the carbon price increases the price of carbon-emitting goods, such as gasoline, natural gas, and coal.[1] This increase in price provides an incentive for consumers to reduce their consumption of these emission-producing products, since by reducing their consumption of these products, consumers can reduce the amount of carbon levy they have to pay.

The climate action incentive rebate increases the income available to the consumer. Importantly, although for a province the amount of money rebated back to consumers is directly related to the total proceeds from the carbon price, for an individual there is no relation between the two. More precisely, a family or individual cannot influence the amount of carbon rebates it receives. Because of this, carbon rebates do not directly impact the incentive to reduce emissions.

For a concrete example, consider an individual who needs to decide how to commute to work. The individual travels 10km each way, and has a vehicle that uses 10 litres of gasoline per 100 km of travel. Assuming a gasoline price of \$1.00/L and 250 work days per year, the individual expects to spend \$500 per year in gasoline for commuting (in addition to other costs associated with driving to work, such as vehicle maintenance and parking). As an alternative, the individual can choose to take transit to work. Taking transit requires purchasing a transit pass, but also possibly imposes costs related to the inconvenience of transit (additional commuting time, less flexibility, etc.).[2]

Now consider the introduction of a carbon levy, which reaches \$50/tCO$_2$ in 2022. This implies an increase in the price of gasoline of 11.6c/L by 2022, resulting in an increase in annual commuting costs by vehicle of \$58 (i.e., gasoline costs for commuting increase from \$500 to \$558).

To determine how to travel to work, the individual may tally up the costs of the various options, and pick the one with the cheapest overall cost (including the potential costs associated with non-financial characteristics, such as inconvenience). Consider three types of individuals, as illustrated in **Figure 1**. Although individuals differ in many ways, for illustrative purposes, the figure considers individuals that differ in the inconvenience of transit, perhaps because some live closer to transit stations than others.

Panel A illustrates an individual for whom the inconvenience cost of transit is high. For this individual, the overall cost of transit is larger than for commuting by vehicle, even with the proposed carbon levy in place. This individual chooses to drive to work both before and after the carbon levy is applied (i.e., the levy has no effect on this consumer's commuting behaviour). For this individual, the carbon levy imposes a cost of \$58.

Panel B illustrates an individual for whom the inconvenience cost of transit is low. For this individual, the overall cost of commuting by transit is lower than the cost of commuting by vehicle, such that the individual takes transit even without the levy. Again the levy has no impact on this individual's

---

[1] The carbon price is also likely to increase the price of other goods consumers purchase, to the extent that these goods require the use of fossil fuels in their production.

[2] For some individuals, transit may be more convenient that driving in a private vehicle, in which case the "inconvenience cost" would be negative.

commuting behaviour. For this individual, who does not directly consume gasoline for commuting, the levy has no direct cost.

Panel C illustrates an individual for whom the inconvenience cost of transit is moderate. When there is no levy on gasoline, this individual commutes by vehicle, since that mode offers the lowest overall costs. However, when the gasoline levy is in place, this individual decides to commute by transit, since with the levy in place that mode of commuting is least costly. For this individual, the carbon levy causes a reduction in gasoline consumption (and associated emissions). For this individual, the carbon levy imposes a cost, but the magnitude of the cost is less than $58.[3]

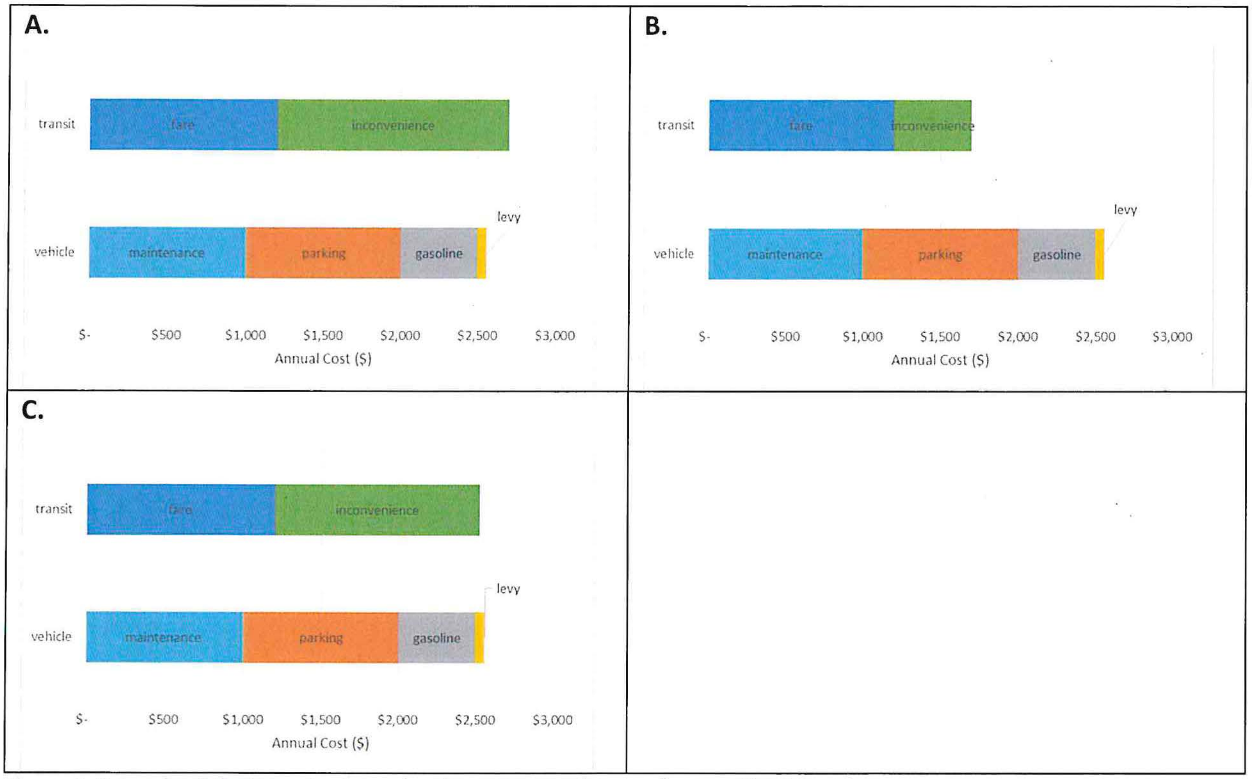


***Figure 1**: Example of the impacts of a carbon levy on annual costs of commuting to work.*

Now consider the impacts of a rebate of carbon levy revenues to all households. Each household in the example receives the same rebate, no matter how the consumer decides to travel to work. No household can influence how much rebate it receives. Because the calculus of how an individual decides to commute to work in this this illustrative example does not depend on household income, the rebate itself does not impact commuters' behaviour.[4] Specifically, for household C, who reduces greenhouse gas emissions because of the levy, the rebate does not change the relative costs of the two commuting options, and thus does not impact the consumer's decision.

---

[3] The cost must be less than $58, since the consumer has the option of continuing to commute by vehicle, a choice which would result in a cost of $58. Since the consumer switched to transit, the cost of switching to transit must be less than $58 (because it was preferred by the consumer).

[4] While large changes in income are likely to affect consumer choices, it is reasonable to assume that small changes in income, such as those associated with the climate action incentive rebate, do not substantially affect consumer choices. The following section deals more formally with consumer choices following changes in incomes.

The rebate does affect consumer incomes. Rather than some households suffering a reduction in disposable income when the carbon levy alone is applied, the rebate helps to ensure that most households are at least as well off after the levy and rebate combination as before.

While this analysis is simplified and stylized, it illustrates the main mechanisms at play. In particular, the carbon levy affects individual incentives to reduce greenhouse gas emissions, while the rebate does not substantially affect these incentives. Instead, the rebate serves to ensure that consumer disposable income is not significantly affected by the application of the carbon levy.

It is important to emphasize that the simple analysis above only focused on one consumer decision --- the decision of which transportation mode to choose in commuting to work. The carbon levy will affect other consumer and business decisions in a similar manner. For example, the carbon levy makes electric vehicles more attractive relative to gasoline vehicles, makes fuel efficient vehicles more attractive relative to fuel inefficient vehicles, makes insulating an attic roof more attractive, etc. By affecting decisions on all of these margins, the carbon levy causes both consumers and businesses to reduce emissions.

Formal microeconomic theory of carbon pricing and household rebates

The question of whether rebating carbon levy revenues to households undermines the incentives to reduce emissions is one for which microeconomic theory is useful. In this section, I use the standard microeconomic model of consumer behaviour to show clear theoretical conclusions for this case: for the average consumer a carbon rebate does not undermine the incentive to reduce emissions that results from application of a carbon price.

The standard model of consumer behaviour involves a consumer choosing between multiple goods in order to best satisfy her preferences and achieve her highest possible well-being.[5] Preferences over different combinations of goods are represented by a *utility function*. In the real world, consumers purchase hundreds of different products, and each of these contributes to consumer utility, or well-being. Here, I simplify by presenting a model of consumer choice in which the household only chooses between two products – gasoline and other goods. For simplicity, I assume that gasoline produces greenhouse gas emissions, whereas consumption of other goods does not.[6]

The utility function can be expressed mathematically as $U = U(G, X)$, where *U* is utility, *G* is gasoline consumption, and *X* represents consumption of all other goods. The utility function captures the idea that consumption of both gasoline and other goods affects household utility (mathematically, utility is a function of the consumption of both gasoline and other goods). The standard model imposes several assumptions on the consumer utility function. First, it imposes the assumption that increases in consumption of gasoline or other goods increase consumer utility (consumers would rather have more than less of each good). Second, it imposes the assumption that each additional unit of consumption of a good generates less utility than the prior unit. To consider the realism of this assumption, think for instance about consumption of lighting. For a household with no indoor lighting at all, receiving just one lightbulb (and the electricity to power it) generates a large increase in well-being: it becomes possible to read and study in the evening, for example. Obtaining a second lightbulb still improves well-being, perhaps by allowing another room to be lit in the evening, or by improving the quality of light. However, the gain in well-being from the second lightbulb is not as great as for the first. In a modern typical North American house with dozens of lightbulbs, an additional lightbulb---perhaps an outdoor light---generates only a small increase in well-being. Increasing consumption of a good becomes less and less useful as the consumption of the good increases. The standard model of consumer utility imposes this assumption, sometimes referred to as "declining marginal utility", on the consumption of all goods.

---

[5] This model of consumer behaviour is taught in all courses on microeconomic theory. For a textbook presentation at the undergraduate level, see Mankiw, G. "Principles of economics", *Harvard University* Press, 2011. At the graduate level, see Deaton, A. and Muellbauer, J., "Economics and consumer behavior". *Cambridge University Press*, 1980, and Mas-Colell, A., Whinston, M., and Green, J., "Microeconomic theory". *Oxford University Press*, 1995.

[6] It is important to note that a carbon levy would impact prices of all fossil fuels, not just gasoline, and also indirectly impact the prices of other goods (e.g., electricity generated from coal). In this report, I focus just on gasoline for simplicity and because of its familiarity.

These assumptions impose some structure on the utility function, which is visualized in **Figure 2**. Point A is depicted as the reference point---the observed consumption of gasoline and other goods over a particular period of time (e.g., a year) for a household or group of households. The black line going through point A is an "indifference curve". It is referred to this way because consumers are indifferent to all the points that lie along this curve (i.e., consumer utility is constant along the curve). For example, because point Z lies on the same indifference curve as point A, consumers are indifferent between point A and point Z. Reading the values off the figure, this suggests that a consumer would be willing to give up about 1% of other good consumption to get about 27% more gasoline consumption.

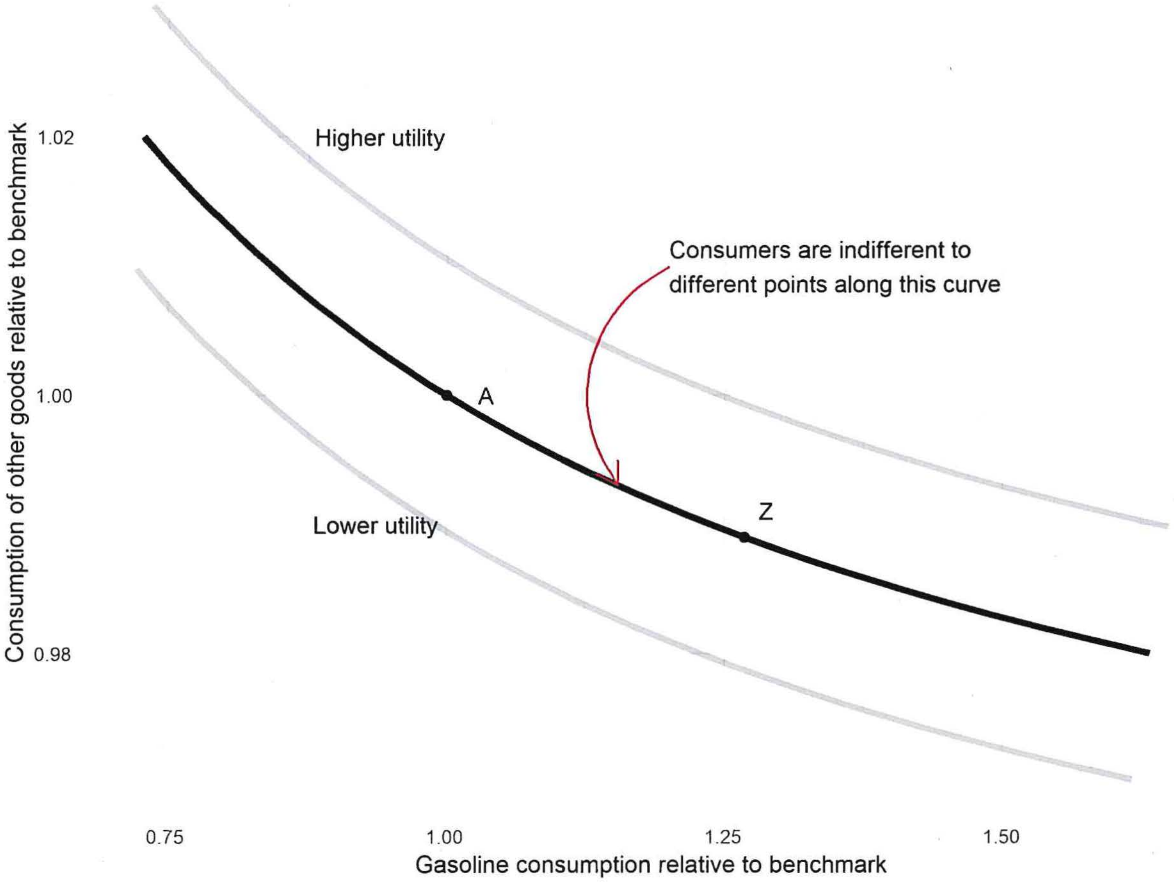


Figure 2: Consumer utility function. The original consumer consumption is represented by point A. The thick black line is referred to as an "indifference curve", since consumer utility is constant along this line (consumers are indifferent to different points along the curve). Indifference curves of higher overall utility are represented by movement towards the top-right of the figure (more consumption of both goods), and indifference curves of lower overall utility are represented by movement towards the bottom-left of the figure (less consumption of both goods).

The curvature of the indifference curve reflects the assumption of declining marginal utility. For example, the curve shows that as the consumer gasoline consumption increases, the consumer becomes less and less willing to give up consumption of other goods in order to increase consumption of gasoline. Importantly, the curvature of the indifference curve is directly related to the willingness of the consumer to substitute one good for another. A highly curved indifference curve indicates that consumers are unwilling to substitute one good for another (i.e., demand for the good is highly "inelastic"). A more linear indifference curve indicates that consumers are flexible in what they consume, and are willing to substitute between consuming gasoline and consuming other goods (i.e., demand for gasoline is more "elastic"). Alternative assumptions about the curvature of the indifference curve are visualized in **Figure 3**. In the curve labelled "high substitutability", consumers show a high willingness to shift between consuming gasoline and consuming other goods. In contrast, in the "low substitutability" case, consumers show a low willingness to substitute one good for another.

Working through an example helps to illustrate the concept. Consider a requirement that consumers reduce gasoline consumption by 25%. In order to keep the consumer as happy as before the requirement was put in place (i.e., "indifferent" to the change), the consumer requires some compensation. If the consumer preferences are reflected by the thick black line, reducing gasoline consumption by 25% while maintaining well-being constant involves a shift from point A to point X (well-being is constant, because point A and X are on the same indifference curve). Reading off the figure, to keep the consumer just as happy as in the benchmark, the consumer would require being compensated with an increase in the consumption of other goods of about 2% in order to compensate for reducing gasoline consumption. However, if consumer preferences are reflected by the "high substitutability" curve, the consumer would only require compensation equal to about 1% of other good consumption (from point A to point Y in the figure). If consumer preferences are represented by the "low substitutability" curve, there is no amount of compensation that could be provided to the consumer to compensate for reducing gasoline consumption by 25% -- for this consumer, a reduction in gasoline consumption entails a loss in utility.

The thick black line in **Figure 3** as well as the indifference curve in other subsequent figures are representative of the empirical evidence about the substitutability of gasoline and other goods for Canadian consumers.[7]

---

[7] For the graphical exposition, I use a constant elasticity of substitution function in which the elasticity of substitution between gasoline and other goods is 0.5 and the benchmark share of gasoline in total expenditures is 5%. These are both supported by the empirical evidence: see Exhibit B (Rivers, N., 2018, Empirical evidence on the impact of carbon pricing on the environment, Prepared for Department of Justice Canada); for households that consume gasoline, the share of gasoline in total expenditures is between about 3 and 5 percent on average according to the Canadian Survey of Household Spending.

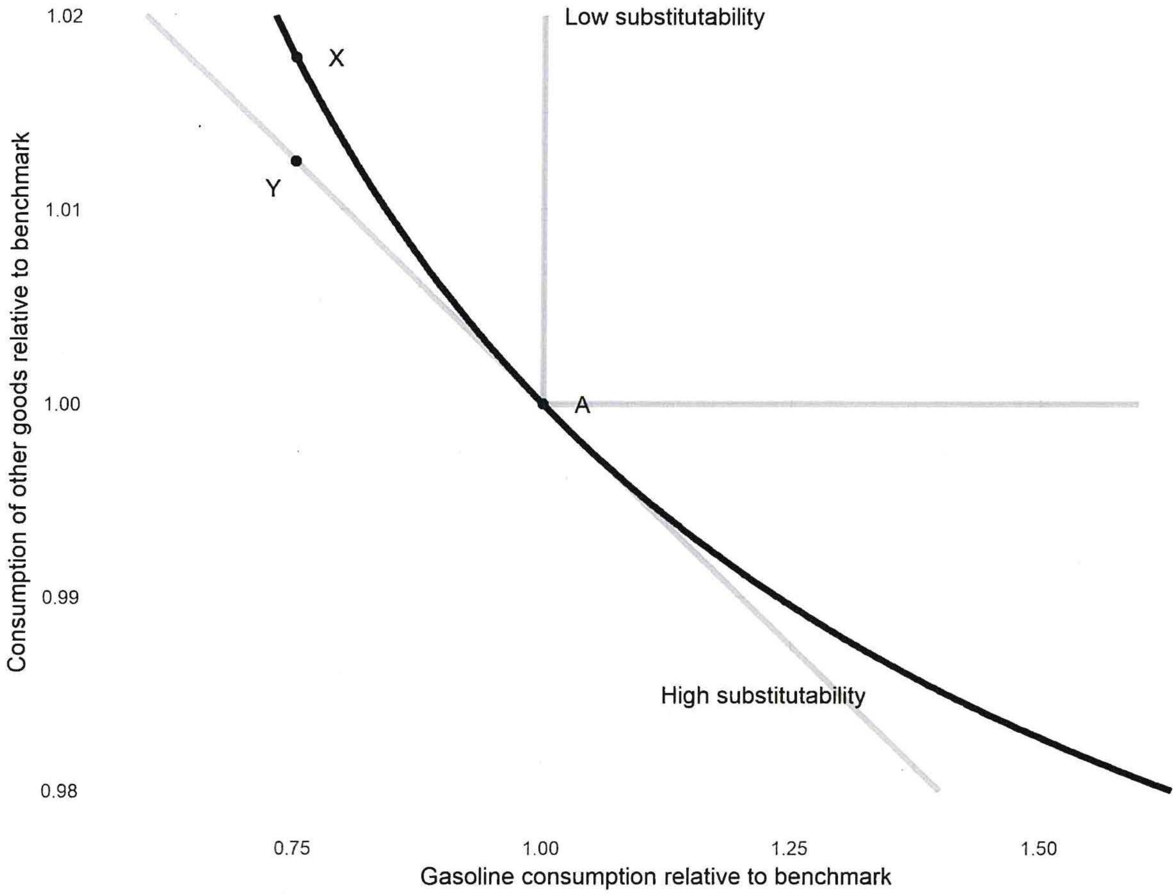


Figure 3: The curvature of the indifference curve indicates how willing consumers are to substitute one good for another.

Looking back to **Figure 2**, it also illustrates two other indifference curves---one in which utility is higher, and one in which utility is lower than at point A. Because of the assumption that additional consumption of each good is utility-enhancing, higher utility points are towards the top-right of the figure, and lower utility points are towards the bottom-left of the figure. If the consumer faced no constraints, she would choose to increase consumption of both goods.

However, the consumer does face a constraint, which is that her expenditures on G and X cannot exceed her available budget. Denoting the available budget (for example, the consumer's disposable income) by M, the budget constraint can be expressed mathematically as $p_G G + p_X X \leq M$, where p_G is the price of gasoline and p_X is the price of other goods. This expression simply states that the sum of consumer expenditures must be less than or equal to the available budget.

It is possible to visualize the consumer budget constraint, as shown in **Figure 4**. In the figure, the combinations of gasoline and other goods that are affordable to the consumer (i.e., within her budget) are shown as the shaded blue area. Within the shaded blue area, the combinations of gasoline and other goods would not fully exhaust the consumer budget. The downward sloping blue line represents combinations that completely exhaust the consumer budget (along this line, total expenditures are exactly equal to the available budget). The slope of the blue line reflects the relative price of gasoline compared to other goods. Finally, the white area on the top-right of the figure reflects combinations of consumption that are not affordable to the consumer, given her budget.

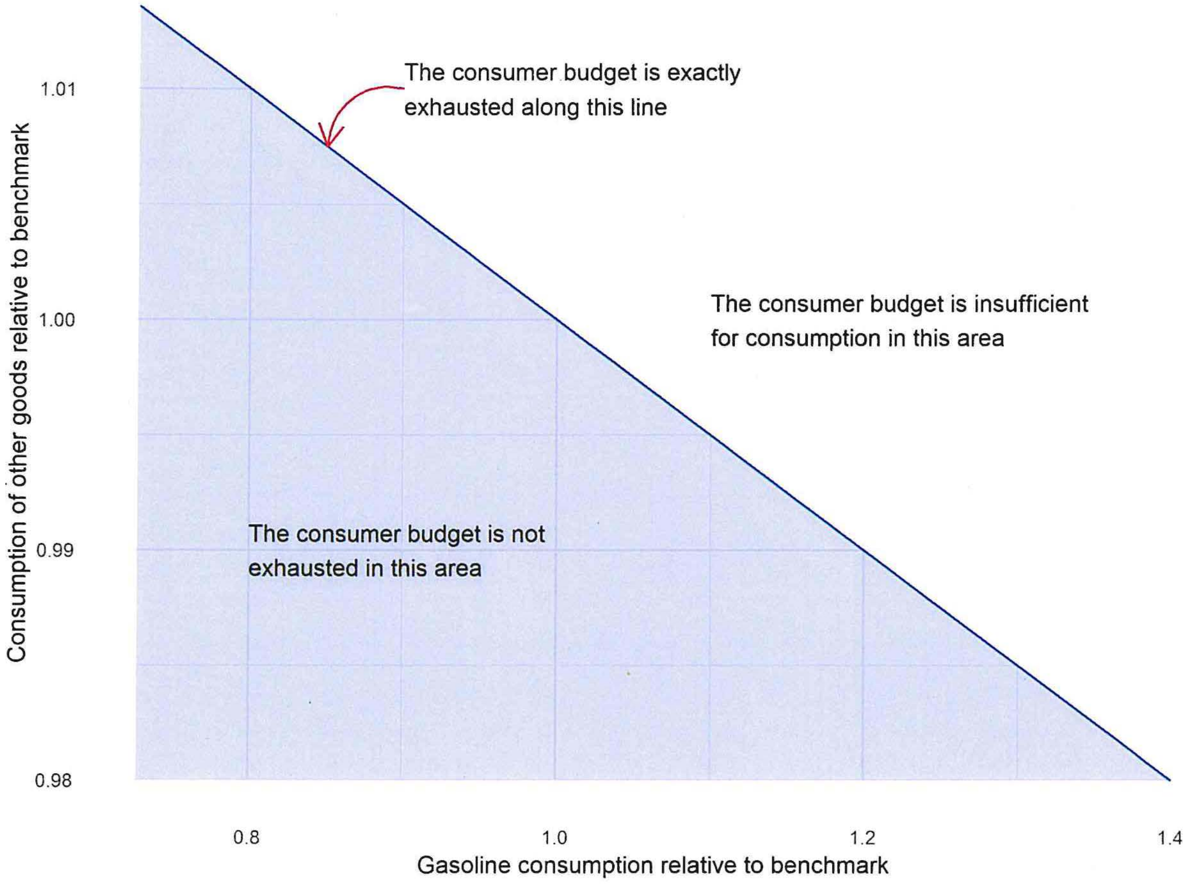


Figure 4: Consumer budget constraint.

The consumer's problem involves choosing how much gasoline and other goods to consume in order to best satisfy her preferences, while remaining within her available budget. While it is straightforward to solve this problem algebraically, it is standard to illustrate the solution to the problem graphically, as in **Figure 5**. In **Figure 5**, indifference curves are illustrated by the curved lines.[8] As above, each indifference curve illustrates combinations of the two inputs that leave the consumer indifferent; i.e., consumer utility is constant at all points along the line. Higher utility is represented by movement to the top right of the figure, and lower utility is represented by movement to the bottom left of the figure. That is, the consumer would prefer to be along the curve labelled "higher utility", which involves higher levels of consumption, rather than along the curve labelled "lower utility". The budget constraint is given by the downward sloping blue line and the shaded blue area beneath. The consumer's budget can cover any choice that falls in the blue area, with points along the blue line completely exhausting the budget. Given the budget constraint, the set of consumer preferences, and the set of prices facing the consumer, the optimal (utility-maximizing) choice for the consumer is at point A.

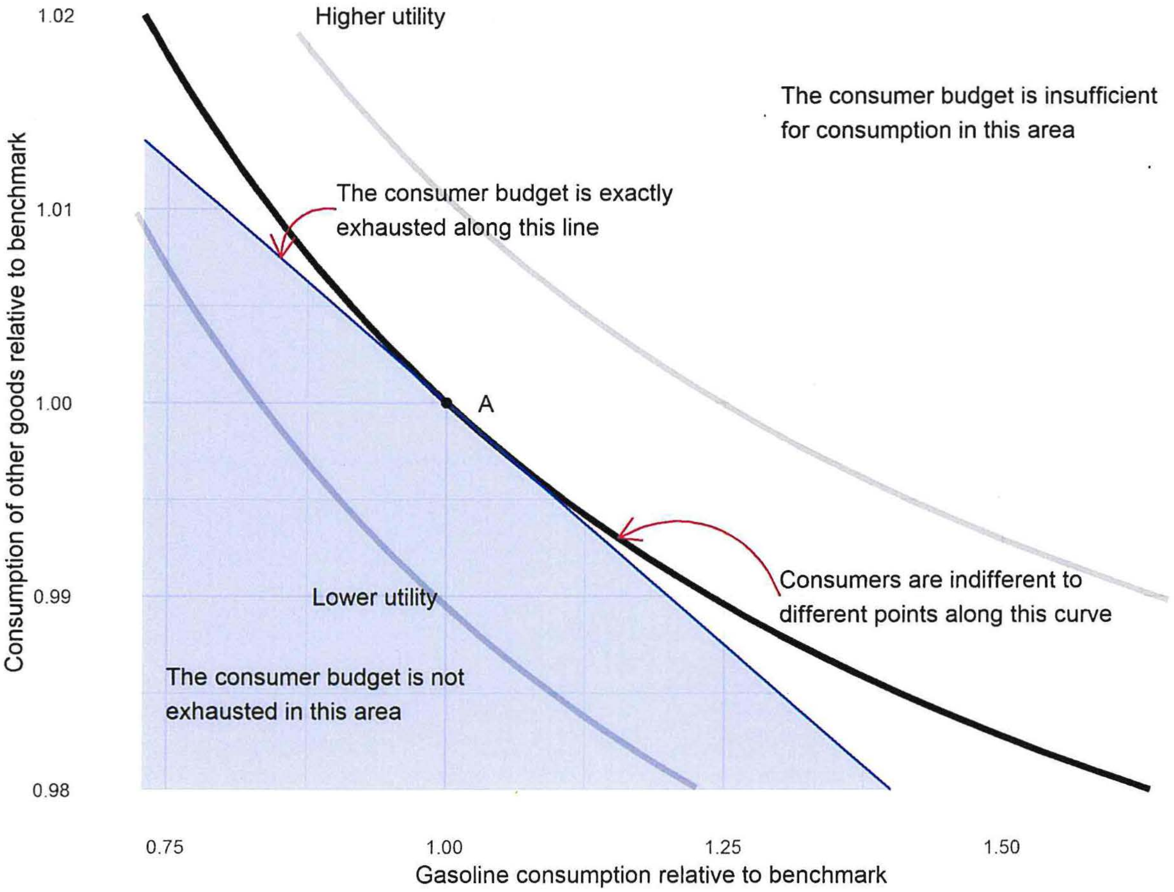


Figure 5: The consumer utility function is illustrated by the thick black line. The consumer budget constraint is depicted by the downward-sloping blue line, and the choices available within the budget are given by the shaded blue area. The optimal choice with the initial set of prices is given by the point labelled "A".

---

[8] In this example, I present the standard "interior solution" to the problem, which involves the consumer choosing positive quantities of both gasoline and other goods. I take up the issue of "corner solutions" below.

1140

With this model in hand, it is now possible to consider the impact of a carbon price and household rebates on consumer choices. **Figure 6** illustrates the impact of a change in relative prices, such as would be caused by a carbon price. **Figure 6** does not include the climate action incentive rebate. In this figure, I model the impact of a 10 percent increase in the gasoline price, which is similar in magnitude to the federal government's carbon pricing backstop, once the carbon levy reaches \$50/tCO$_2$. The increase in gasoline price impacts the consumer's budget constraint, which is illustrated as a change in the slope of the blue line in **Figure 6**. With the carbon price in place, the consumer cannot afford as much consumption, which is reflected by the inward rotation of the consumer budget constraint. Absent the climate action incentive rebate, combinations of gasoline and other goods that were affordable under the reference prices are no longer affordable to the consumer with the carbon price in place. With the new prices, the consumer alters her choices to maximize utility at point C. At this point, the consumer is consuming both less gasoline as well as less of other goods compared to the benchmark equilibrium (point A), and so she is on a lower utility indifference curve than in the reference case.

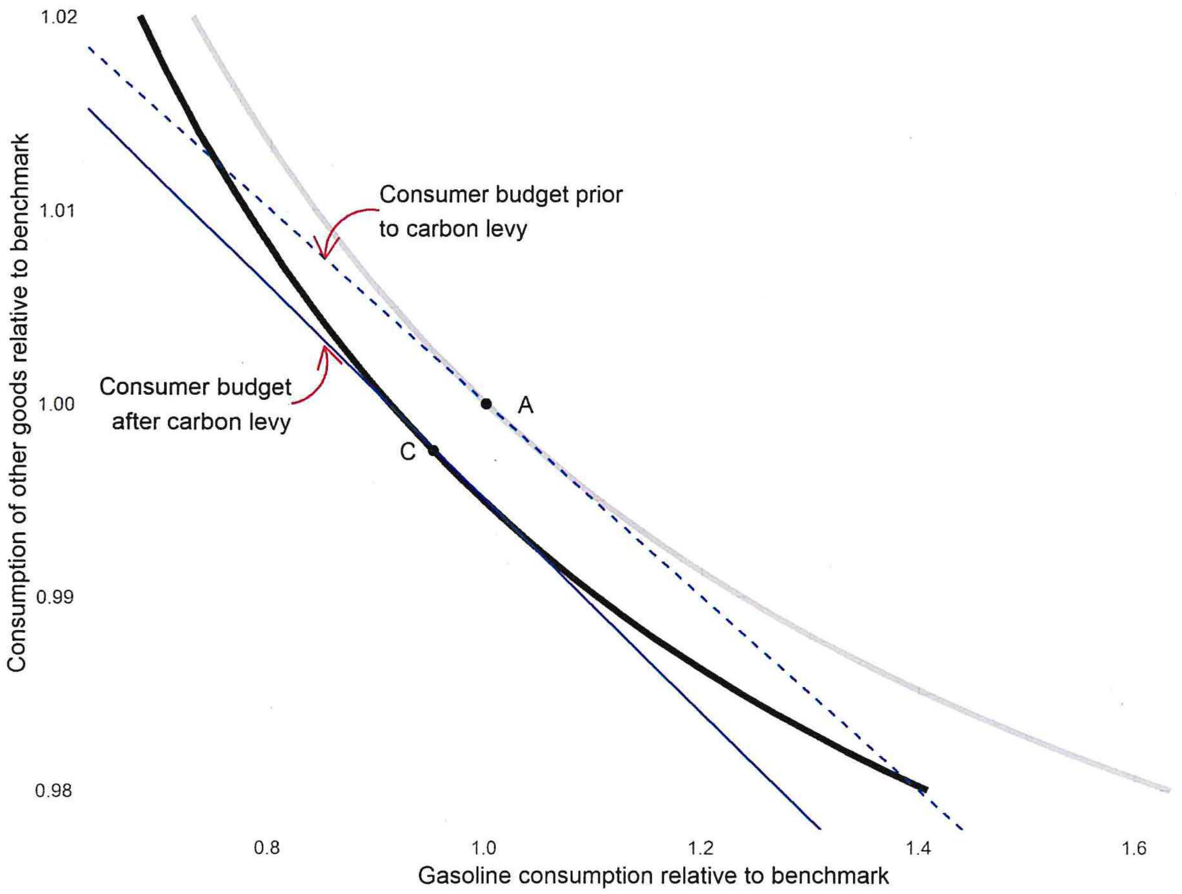


Figure 6: Consumer choices under old (A) and new (C) prices. The curved lines represent the utility function. The downward sloping blue lines represent the budget constraint. The change in the gasoline price is illustrated by a change in the slope of the budget constraint. Because of the increase in gasoline price, consumers can afford less consumption.

Economists decompose the impact of a price change into two components: an income effect and a substitution effect. These are illustrated in **Figure 7**. The substitution effect captures the substitution amongst the two inputs in response to a change in their relative prices, holding utility constant. The substitution effect is captured by the movement from point A to point B in the figure. The income effect measures the change in the total level of utility that is achievable to the consumer as a result of the change in prices. The income effect is captured by the movement from point B to point C in the figure. The total impact of a price change is the sum of the substitution effect and the income effect, and is given by the movement from point A to point C in the figure. It is important to note that while this decomposition is useful for thinking about what happens to consumer choices when prices change, it is not meant to depict the thought process of a consumer in making consumption decisions; instead it is used by economists to evaluate how changes in prices affect consumer choices and consumer well-being.

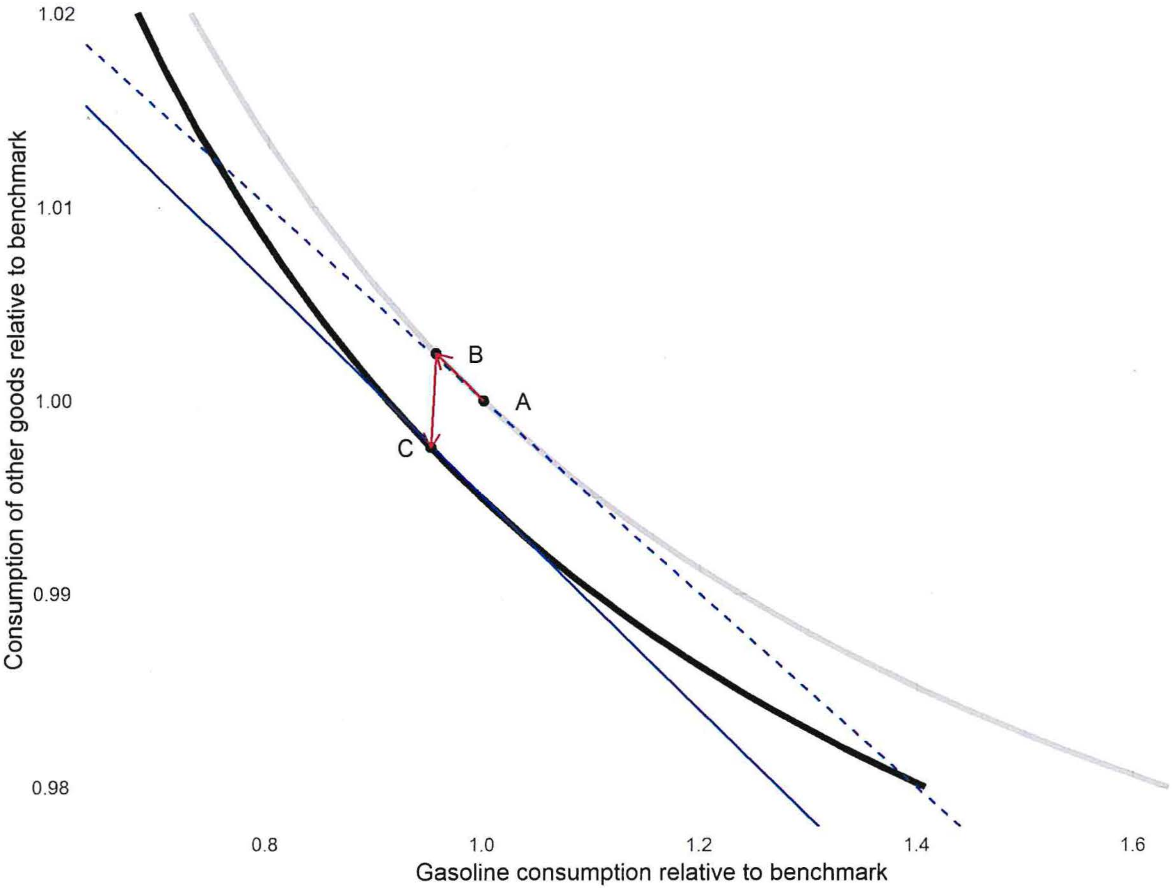


Figure 7*: Income and substitution effects of a price change. Point A is the initial equilibrium. Point C is the new equilibrium, following an increase in the gasoline price. The arrow between point A and point B reflects the "substitution effect" of the change in gasoline price, and the arrow between point B and point C reflects the "income effect."*

At this point we can ask what would be the impact of rebating the carbon levy revenue back to consumers. It is important to note that a rebate increases the consumer income, but does not affect the price of gasoline relative to the price of other goods. In contrast, as described above, the carbon levy both causes consumers to substitute between gasoline and other goods as the relative prices of gasoline and other goods changes, and also effectively lowers the consumer's real income (as a result of the price increase). **Figure 8** shows the impact of a carbon levy plus rebate on consumption of gasoline and other goods. In this figure, it is assumed that all proceeds from the carbon levy are returned back to households. Further, the results in the figure correspond to an average household, who pays the same amount in total carbon levies as it receives in carbon rebates.[9] In a later section of the paper, I take up the analysis for a household who receives more in rebates than it pays in carbon levies.

The impact of the carbon levy alone is illustrated by the arrow from A to C in Figure 8, as in the figures above. The impact of the rebate is illustrated by the move from C to D. The new equilibrium--with the carbon levy and the rebate in place--involves a lower level of gasoline consumption and a higher consumption of other goods relative to the benchmark. For an average consumer, the rebate does not undermine the incentive to reduce gasoline demand (or the demand for other carbon-intensive products).

Thinking back to the decomposition in **Figure 7**, it is evident that the rebate reverses the "income effect" associated with the carbon levy, but it does not affect the "substitution effect". That is, the rebate ensures that on average consumer income is unaffected by the imposition of the carbon levy, but the impact of the carbon levy on the relative prices of gasoline and other goods remains, even after the rebate is applied. This change in the relative prices of gasoline and other goods is what causes consumers to substitute between gasoline and other goods (the substitution effect in **Figure 7**).

---

[9] It is important to emphasize that although the average household pays about the same amount in carbon levies as it receives in carbon rebates, an individual household has no ability to manipulate the amount of carbon rebates it receives.

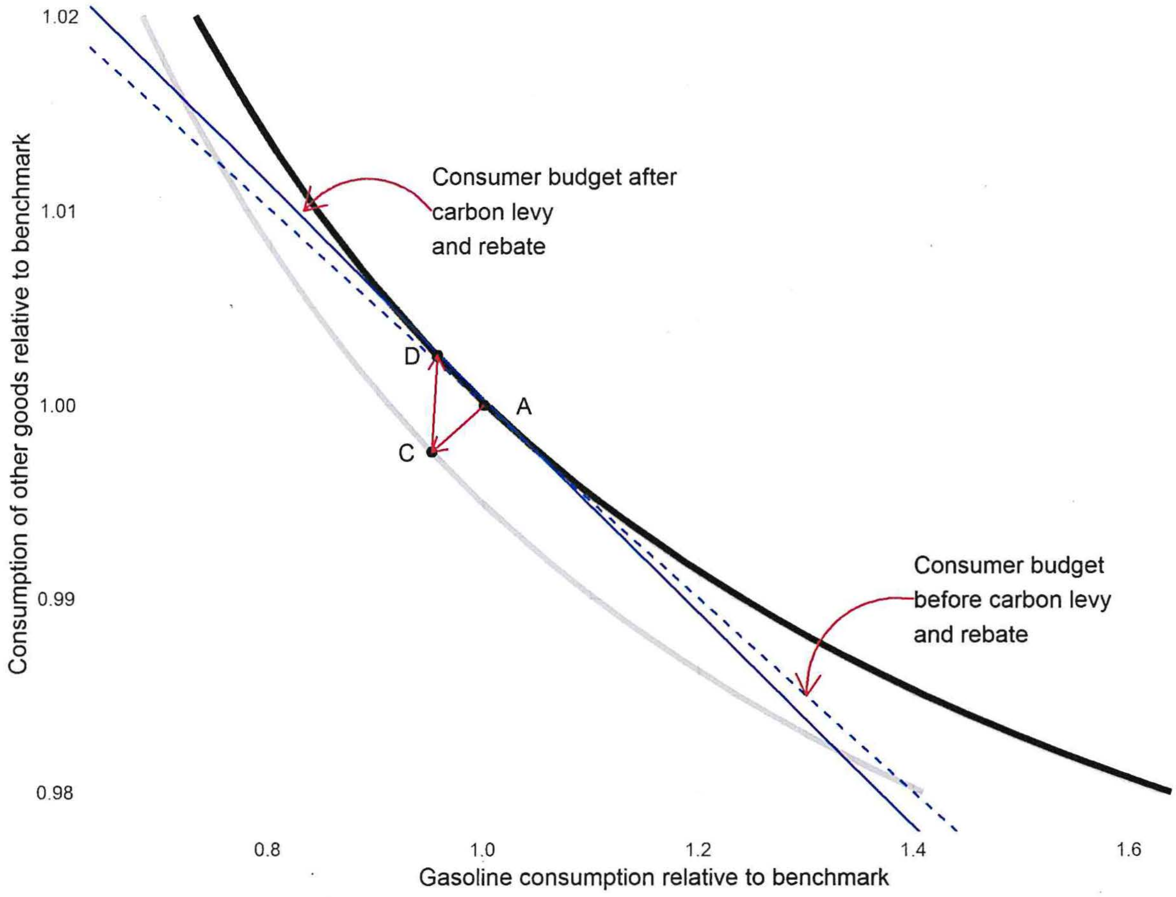


***Figure 8**: Impact of a carbon levy with rebate on consumption. The initial equilibrium is at point A. Consumer choices with a carbon levy are given by point C. Consumer choices with a carbon levy and rebate are at point D. The rebate eliminates the "income effect" but the "substitution effect" associated with the carbon levy remains.*

The predictions from the standard model are very clear. They show that a rebate would not eliminate incentives for consumers to reduce gasoline consumption that are created by the carbon levy. However, the clean predictions generated by the simple model of consumer behaviour are underlain by some assumptions, and it is important to consider the validity of these assumptions. Here, I briefly outline the main assumptions imposed by the theoretical model.[10]

1. Consumer preferences are *rational*, which means they must satisfy several conditions. First, this assumption implies that consumer preferences are *complete*, which implies that consumers can order any two possible bundles of consumption goods (i.e., they are able to choose between them). Second, it implies that consumer preferences are *transitive* (or consistent), which means that if a consumer prefers A to B and B to C, the consumer must also prefer A to C. Third, it implies that consumer preferences are *continuous*, which implies that consumer preferences cannot exhibit non-continuous "jumps" (i.e., the indifference curves in the above analysis are smooth and not discontinuous).

---

[10] See Deaton, A. and Muellbauer, J., "Economics and consumer behavior". *Cambridge University Press*, 1980, and Mas-Colell, A., Whinston, M., and Green, J., "Microeconomic theory". *Oxford University Press*, 1995.

2. Consumers are not *satiated*. This means that consumers always prefer more of a good (in our model, gasoline or other goods) to less.
3. Preferences are *convex*, which implies that consuming increasing amounts of a particular good is associated with diminishing marginal returns for a consumer.
4. Climate action incentive rebates do not over-compensate consumers for the loss of income resulting from the carbon levy.

Given these assumptions, it is clear from the above analysis that rebating carbon levy revenue back to households will not undermine the incentives for a typical household to reduce greenhouse gas emissions generated by the levy. With a carbon levy and rebate, a typical consumer will suffer no income loss, but will be motivated to reduce greenhouse gas emissions as the relative price of fossil fuels and other greenhouse gas intensive goods increases relative to non-emitting goods.

Consequences of possible violations of the model assumptions

While the microeconomic theory underlying the predictions described above is very clear, it rests on assumptions about how consumers behave when faced with changes in prices or with changes in income. In this section, I focus on two of the assumptions used in developing the standard model, and explain the consequence of violation of these assumptions.

1. Over-compensation of households with the climate action incentive rebate

The theoretical analysis above is based on a "typical consumer", for whom the effective loss in income from the carbon levy is balanced with the gain in income from the climate action incentive rebate. It is important to point out that some consumers will receive more in climate action rebates than they pay in carbon levies and so the analysis above would need to be modified to apply to them. In this section, the analysis is extended to focus on households that receive more in carbon rebates than they pay in carbon levies. In particular, this section focuses on what happens to the between 10 and 20 percent of households in Canada who do not consume any gasoline.[11] For these households, the climate action incentive rebate will exceed the carbon levy (from gasoline) and so it is possible in theory for a carbon levy with rebates to generate an increase in gasoline consumption. The logic is straightforward: for a household with zero gasoline consumption, the carbon levy itself would have no direct effect on the household. However, the household would still obtain a carbon rebate, which would increase its income. It is possible, in theory, for this increase in income to cause the consumer to begin consuming gasoline, thereby increasing greenhouse gas emissions (of course, this outcome depends on the nature of the consumer preferences and constraints, which will be unique for each consumer).

---

[11] The 10 to 20 percent figure is calculated using the Survey of Household Spending Public Use Microdata Files for 2006 to 2009. The logic in this section applies to consumers that use a below-average amount of gasoline (not just those with zero gasoline expenditures); the focus on households that consume zero gasoline is for expositional purposes.

Figure 9 shows the initial equilibrium for a household with zero gasoline consumption. In this figure, household preferences are such that at the initial price of gasoline, the household does not consume any gasoline, and spends all its budget on other goods. The impact of the carbon levy and associated climate action incentive rebate is given in **Figure 10**. Since the household consumes no gasoline, when the price of gasoline is increased as a result of the carbon levy, the household is unaffected (in **Figure 10**, the consumer remains at point A after the carbon levy is applied). In contrast, the household is eligible for the carbon rebate, which increases its income. This is illustrated by the outward shifting of the budget constraint in **Figure 10**. As a result of the increased income, the household may begin to consume some gasoline. The new equilibrium is illustrated by the point B in **Figure 10**, in which the household consumes a small amount of gasoline following the application of the levy and rebate. In other words, for this household, the combination of levy and rebate results in an increase in gasoline consumption (and associated greenhouse gas emissions).

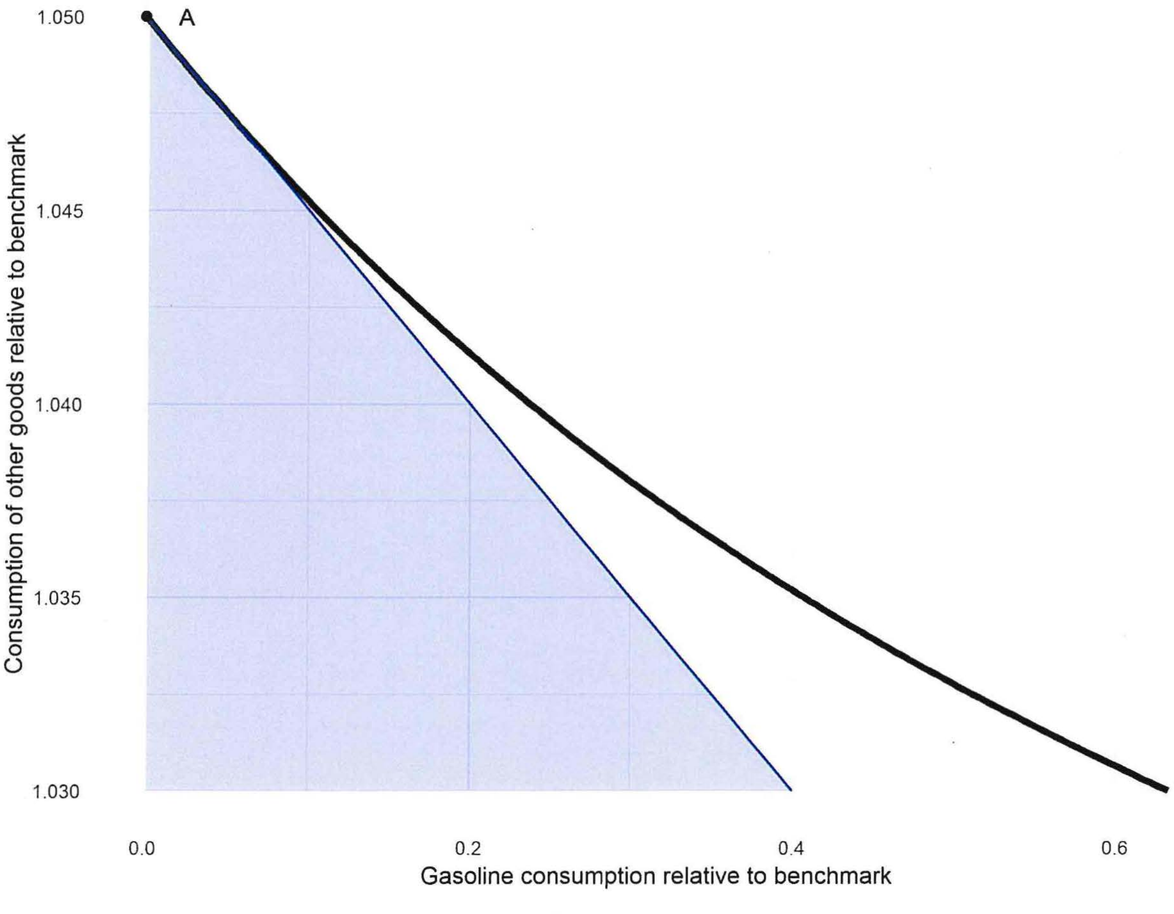


Figure 9: Initial equilibrium for a household that consumes no gasoline. This situation is sometimes referred to as a "corner solution." Point A reflects the initial equilibrium.

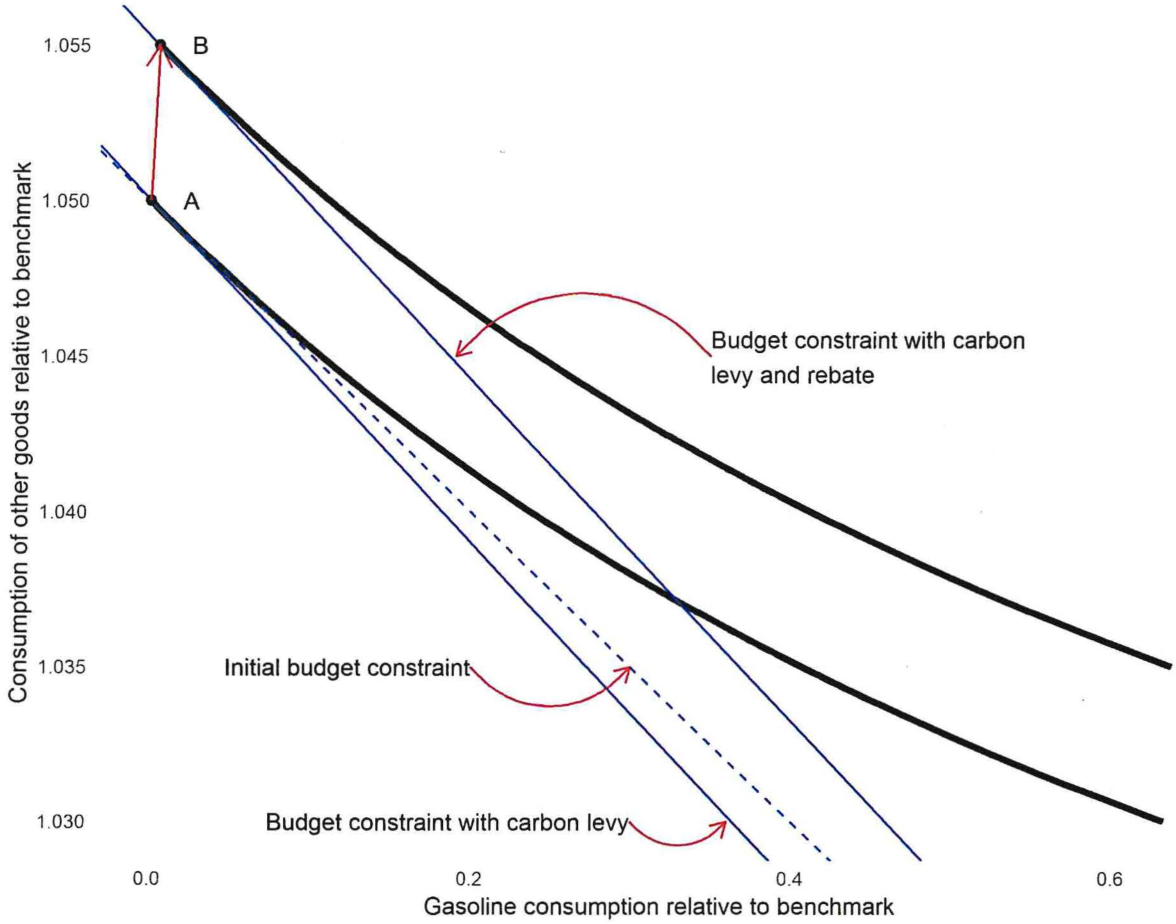


***Figure 10**: The impact of a carbon levy and associated climate action rebate on a household with zero initial gasoline consumption. The initial equilibrium is at point A, and the equilibrium after the carbon levy and climate action rebate is at point B.*

Some evidence about the potential magnitude of this impact is given in **Figure 11**, which compares the proportion of households reporting zero total annual gasoline expenditures to household income. Clearly, as household income increases, there are fewer households that report not spending any money on gasoline in a year. The figure shows that it is possible that an increase in household income could induce some households that formerly did not spend any money on gasoline to begin consuming some gasoline. For example, consider an urban household with two workers and an income of $50,000. According to the data, 11.8% of all households with an income at this level did not consume any gasoline at all. The rebate will cause an increase in the income for this group of households. Consider a rebate of $500 for these households. According to the data in **Figure 11**, this additional income may lead to the number of households reporting zero gasoline consumption to fall from 11.8% to about 11.5%.[12] This illustrates that while it is possible in theory for households who are originally consuming no gasoline to begin consuming gasoline as a result of the climate action incentive rebate, the number of such

---

[12] The figure is a simple correlation, and likely overstates the degree to which changes in income *cause* changes in gasoline consumption. Conclusions drawn from the figure should be treated as illustrative only.

households is extremely small, and the effect on overall gasoline consumption and emissions is likely to be negligible.[13]

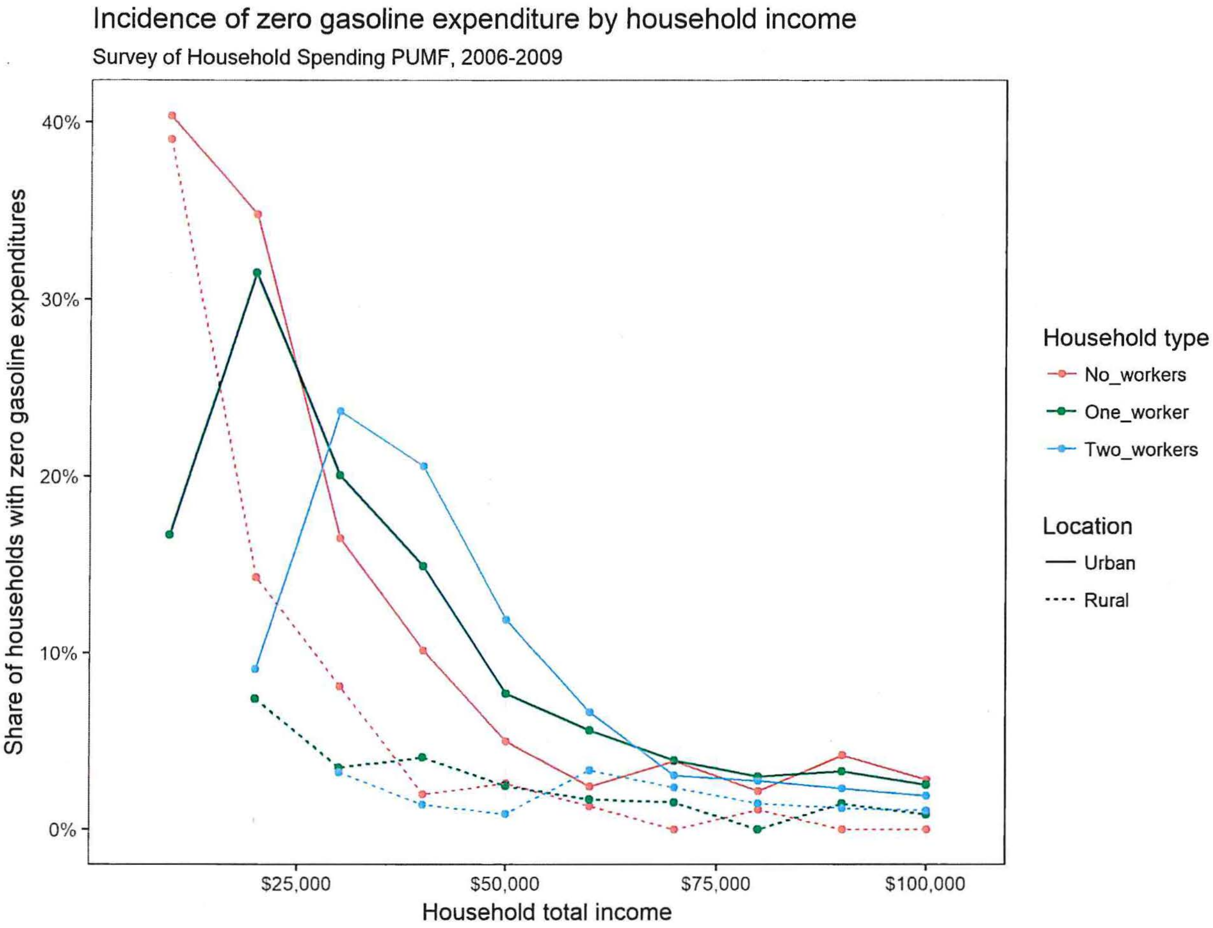


Figure 11: Incidence of zero gasoline consumption by household income. Data is from the Survey of Household Spending Public Use Microdata Files from 2006-09, and contains only households with a couple. Work status is based on whether a household works at least 40 weeks per year.

2. Behavioural anomalies

Over the last two decades, economists have uncovered a number of cases of behavioural "anomalies", in which consumer behaviour deviates from predictions made in the standard model. Unlike for the standard model, there is not (yet) a unified theory of behavioural economics, such that much behavioural economics research consists of documenting particular cases in which the standard model predictions are violated, rather than providing general predictions about how consumers may react in

---

[13] This section focused on households that do not consume any gasoline, since it is clear that these households will receive more in climate action incentive rebates than they pay in carbon levies. There are other households who do consume some gasoline, who nevertheless receive more in rebates than they pay in carbon levies, and for whom outcomes such as the one described in this section are possible. However, the analysis in this section is chosen as it reflects a "worst case" outcome in this dimension, since households who pay nothing in carbon levies will be the most over-compensated by the rebates.

particular circumstances. Nevertheless, based on past empirical study, it is possible to speculate about how consumer behaviour might deviate from the predictions made above.

A key assumption underlying the standard model of consumer behaviour outlined above is "rationality," and one key corollary of this assumption is that consumers spend their income from various sources in the same way. That is, by assumption, consumers do not reserve income from certain sources for certain expenditures. Instead, in the standard model, income is fungible, such that it can be reallocated from one expenditure category to another. This assumption could be violated if consumers do actually earmark certain types of income for certain types of expenditure. In the case at hand, the predictions of the standard model outlined above might be erroneous if consumers reserve the climate action incentive rebate for certain types of expenditures. For example, some consumers may decide to spend all of the income they receive from the climate action incentive dividend on "climate action," for example by allocating it towards weather-stripping windows or other actions that reduce greenhouse gas emissions. Other consumers may decide to allocate all of their climate action incentive rebate towards gasoline consumption, perhaps reasoning that it was raised by a levy on gasoline (and other fuels) and so should be used for expenditures on these goods. And other customers may allocate the climate action rebate towards something else entirely, such as a luxury good purchase or a restaurant meal.

While there is no evidence to show how consumers have spent climate action incentive rebates in the past, there is evidence from other public policies to show how consumers have spent other types of similar government rebates. For example, Beatty et al. (2014) study how consumers spend the UK Winter Fuel Payment, which is a cash transfer to households containing an individual that is aged 60 and above to help offset high heating costs.[14] They find that households that receive the payment spent around half of the payment on fuel. In contrast, if the payment were treated as "ordinary" cash, Beatty et al. (2014) estimate that only 3% would have been spent on fuel. They interpret this large deviation from the prediction of the standard model as a "labelling" effect. Because the winter fuel payment is labelled as such (and because it arrives at the start of the heating season), households allocate a large portion of the additional income towards winter fuel.

In another study, Hastings and Shapiro (2019) study how households spend income from the Supplemental Nutrition Assistance Program (SNAP).[15] The SNAP program provides recipient households with a monthly electronic benefit to spend on groceries. Because most households spend more on food than they receive in SNAP benefits, in the standard economic model of consumer behaviour, SNAP benefits are equivalent to cash. However, whereas low-income consumers allocate about 10 cents of each dollar of ordinary income to grocery expenditures, Hastings and Shapiro (2019) find that they allocate 50 to 60 cents out of each SNAP dollar to grocery expenditures, again in contrast to the standard model's predictions. Hastings and Shapiro (2019) attribute the difference to "mental accounting", which posits that households treat income from different sources differently (Thaler, 1999).[16]

---

[14] Beatty, Timothy KM, et al. "Cash by any other name? Evidence on labeling from the UK Winter Fuel Payment." *Journal of Public Economics* 118 (2014): 86-96.

[15] Hastings, Justine and Shapiro, Jesse. "How are SNAP benefits spent? Evidence from a retail panel." *American Economic Review. Forthcoming.*

[16] Thaler, Richard H. "Mental accounting matters." *Journal of Behavioral decision making* 12.3 (1999): 183-206.

While it is difficult to generalize from these two studies in different contexts to the climate action incentive rebate, the household transfers in these two studies share some characteristics that may help with extrapolations to other contexts. In both of these cases, the household transfer was labelled and highly salient. In the heating fuel study, the rebate was issued at the beginning of the winter heating season, and clearly labelled as a winter fuel rebate. Consequently, consumers spent a large proportion of the rebate on the targeted expenditure category. In the case of the SNAP benefits, the benefits are in the form of a monthly electronic card that can only be spent at grocery retailers. In both cases, the labelling and timing of the benefits appear to have caused consumers to spend money on the targeted category.

How does this compare to the proposed climate action incentive rebate? In terms of labelling, the rebate is labelled as a "climate action incentive". If consumers respond to the title of the rebate, it should cause additional emission reductions as consumers allocate additional income from the climate action incentive rebate to emissions-mitigation expenditures. In terms of saliency, however, if the rebate is returned at the same time as other federal benefits, rebates, and tax credits, it may be hard for consumers to distinguish the source of the rebate, which reduces its saliency. Based on these points, it appears that the rebate may cause some additional reduction of emissions, but that it is likely to be limited compared to the above studies. Overall, it is hard to be definitive about the impacts of labeling on consumer expenditures based on the existing evidence base, but based on prior literature, labeling the benefit as a climate action incentive rebate may help reduce greenhouse gas emissions.

Conclusions

Standard microeconomic analysis is based on a very well developed theoretical model that involves a consumer aiming to satisfy his or her preferences as best as possible, given prices and an available budget. This model offers clear predictions for the case at hand: it predicts that for a typical household a carbon levy will reduce household consumption of carbon-emitting goods (such as gasoline) and it predicts that a rebate will not undermine the incentives generated by the carbon levy. While the predictions of the standard model rest on a set of assumptions, it does not appear likely that the potential violations of the assumptions for the case at hand will substantially affect the results of the analysis. Overall, there is strong evidence that rebating carbon levy revenues back to households will not remove the incentives for households to cut greenhouse gas emissions.

This is **Exhibit D** referred to in the

affidavit of **Nicholas Rivers**

affirmed before me on **January 25, 2019**

Commissioner for Taking Affidavits

1153

Comments on "Preserving and protecting our environment for future generations: A made-in-Ontario environment plan"

Nic Rivers

December 18, 2018

Introduction

This note is a brief review of the recently-released Ontario environment plan. It focuses in particular on the elements of the plan related to climate change mitigation. In this dimension, key measures proposed in the plan are: (1) adoption of a new target for greenhouse gas mitigation, (2) announcement of industry performance standards for large emitters, and (3) announcement of the Ontario Carbon Trust and reverse auction. There are few details on any of the proposed measures, and so a complete assessment of the plan is not possible. This note focuses on a high-level assessment of the approach taken, and follows the outline described above.

Overall, this report notes that the greenhouse gas mitigation targets proposed in the 2018 plan are substantially less ambitious than in the prior Ontario plan, and that because of poor accounting practices, the stated target in the 2018 plan is substantially less ambitious than claimed in the plan. The report finds that there are insufficient details to assess the industry performance standards, but that the basic approach could be consistent with the federal output-based pricing system. The report also finds that the Ontario Carbon Trust and reverse auction are unlikely to substantially reduce emissions because of information asymmetry problems that will make it difficult for government to know whether projects it funds result in incremental emission reductions.

Adoption of a new target for greenhouse gas mitigation

The 2018 Ontario climate plan updates the target for greenhouse gas abatement relative to the climate plan in place in 2017.[1] The new climate plan proposes reducing emissions by 30 percent relative to 2005 levels, whereas the prior climate plan proposes reducting emissions by 37 percent relative to 1990 levels, both by 2030. A visualization of this change is provided in Figure 1. The new climate plan adopts a target of reducing emissions to 143 MtCO2e by 2030, in comparison to about 113 MTCO2e under the earlier plan. This difference is 30 MtCO2 by 2030, or about 18% of 2015 emission levels. Adoption of the new target will make it more difficult for Canada to comply with its international commitment under the Paris Agreement.

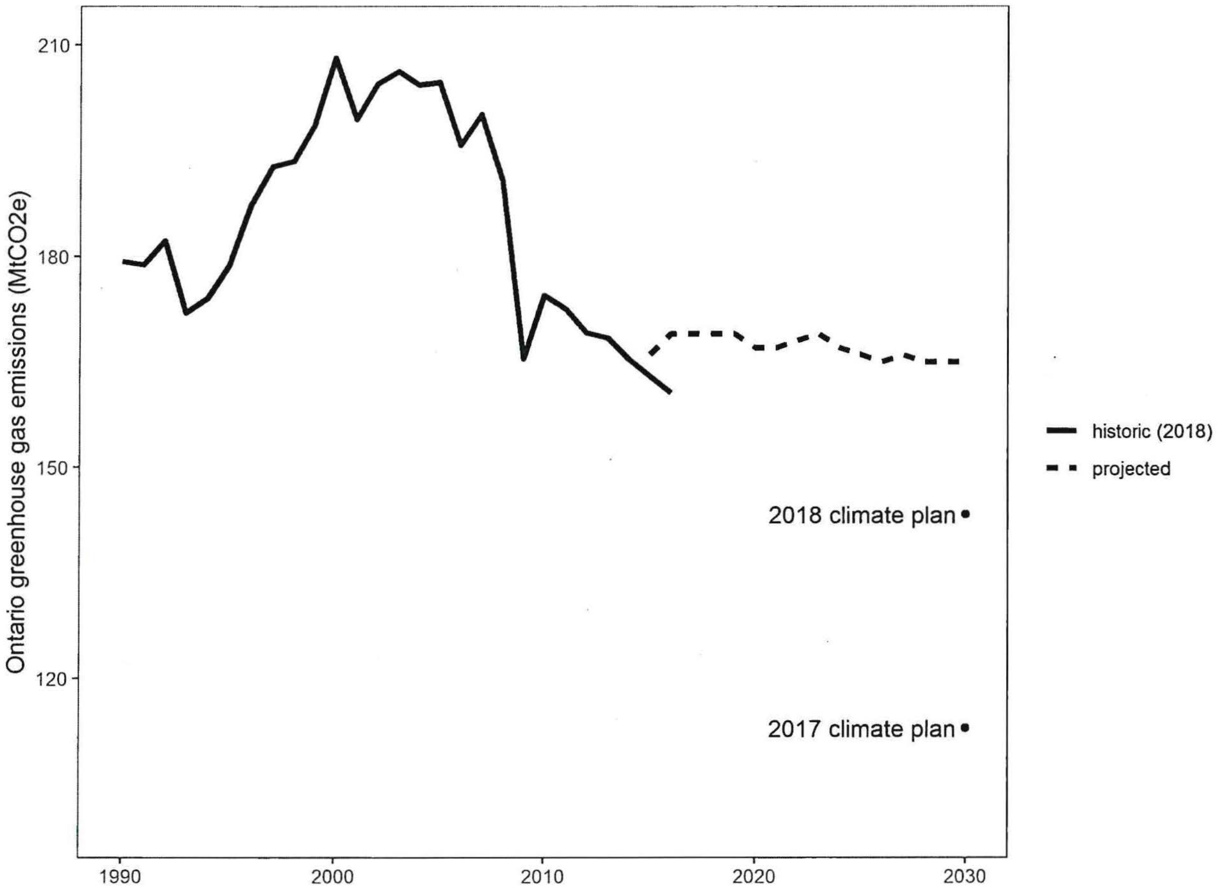


Figure 1: Historic and projected greenhouse gas emissions and proposed greenhouse gas targets (excluding LULUCF), Ontario. Source: calculations based on data from Canada's 7th National Communication and 3rd Biennial Report to the United National Framework Convention on Climate Change.

The 2018 Ontario climate plan describes how Ontario will reach the proposed 2030 target. In particular, it describes a number of measures that will be undertaken that will cause emissions in Ontario to fall below the projected "business-as-usual" forecast. However, the proposed measures confuse (1) emission reductions caused by Ontario's climate plan, (2) emission reductions caused by the federal climate plan,

---

[1] Ontario's five year climate change action plan, 2016-2020. Government of Ontario.

(3) emission reductions that would have occurred anyway. For example, the Ontario climate plan states that "innovation" will achieve 15% of required emission reductions by 2030. However, since there is no policy that promotes innovation, these emission reductions, should they materialize, should properly be accounted for in the "business-as-usual" trajectory. A similar confusion relates to "low carbon vehicles uptake." Since there is no policy promoting the uptake of these vehicles, any uptake that occurs must not be due to policy in Ontario, and should instead be reflected in the business-as-usual trajectory. A similar confusion relates to the federal policies; in particular the proposed federal clean fuel standard. Since the federal clean fuel standard is not part of the Ontario climate plan, Ontario should not account for emission reductions induced under this policy under its climate plan. Making these changes in accounting would demonstrate that the Ontario climate plan only proposes to aim for a small amount of emission reductions, beyond those that would have occurred anyway.

The rest of this report describes some of the policies that are proposed for adoption in Ontario. In some cases, it appears unlikely that the proposed policies will succeed in reducing emissions, and in others there is insufficient information to be able to tell if the proposed policies will succeed in reducing emissions.

Announcement of industry performance standards for large emitters

The 2018 Ontario climate plan announces the future implementation of emission performance standards for large emitters. An emission performance standard mandates the emission performance of a regulated facility. For example, under an emission performance standard, a steel manufacturing facility might face a performance standard that limits the amount of greenhouse gas emissions that can be released per tonne of rolled steel produced. The Ontario plan notes that the performance standards "may include compliance flexibility mechanisms such as offset credits and/or payment of an amount to achieve compliance."

Unfortunately, there are few details relating to the proposed program, and so it is not possible to offer a complete assessment. Missing from the climate plan are details relating to the timeline for regulatory development and implementation, the stringency for the regulations, how the stringency would evolve over time, precision on the use of flexibility mechanisms, and which facilities may be affected.

However, despite the plan missing most information required for assessing the program, it is notable that the proposed structure of the program is potentially quite similar to the federal output-based pricing system for large industrial emitters.[2] The federal program applies to large emitters of greenhouse gases (over 50kt CO2e annual emissions) and sets a facility performance standard that is equal to 80 to 95% of industry-average greenhouse gas intensity.[3] For a facility that does not reach the performance requirement, the federal regulation imposes the requirement to obtain credits (by purchasing from other facilities or from offset providers) or pay an emission charge. For a facility that exceeds the performance requirement, the federal regulation will grant surplus credits to the facility, which can be used in future years or traded to other facilities. As a result, the federal policy exposes regulated facilities to a carbon price. The level of the federal carbon price increases from $20/tCO2e in 2019 to $50/tCO2e in 2022.

Importantly, both the federal output-based pricing system and the proposed Ontario industry performance standards are forms of carbon pricing systems, in that facilities that are not in compliance with the regulation would be required to purchase carbon credits (this generates a "price" on carbon emissions).[4] While comparing the two systems is not possible because of the lack of accompanying details in the Ontario policy, key aspects to consider as Ontario's plan is developed include which facilities are covered, compliance mechanisms for covered facilities, and how the performance standard is set.

Figure 2 compares the Canadian output-based pricing system with the proposed Ontario emission performance standard. The Canadian system covers all facilities with annual emissions exceeding 50ktCO2e (smaller facilities may voluntarily opt in to the program). The proposed Ontario system does not specify which facilities would be included. It does note that "across-the-board" exemptions from the program may be granted to entire sectors, such as the auto sector. Providing exemptions clearly reduces the environmental effectiveness of the program, since exempted sectors would not have any incentive under the program to reduce emissions. Economists have noted that exemptions can substantially increase the cost of reducing emissions in a carbon pricing system.[5] Sector-wide exemptions would also

---

[2] See: https://www.canada.ca/en/services/environment/weather/climatechange/climate-action/pricing-carbon-pollution/compliance-options-output-based-system.html

[3] See: https://www.canada.ca/en/services/environment/weather/climatechange/climate-action/pricing-carbon-pollution/output-based-pricing-system-technical-backgrounder.html.

[4] This assessment is contingent on Ontario moving forward with its plan to use compliance flexibility mechanisms.

[5] Böhringer, Christoph, and Thomas F. Rutherford. "Carbon taxes with exemptions in an open economy: a general equilibrium analysis of the German tax initiative." Journal of Environmental Economics and Management 32.2 (1997): 189-203.

imply that the Ontario policy would not be in compliance with the federal benchmark, which requires coverage similar to British Columbia's carbon tax (which does not offer sector-wide exemptions).

The Canadian output-based pricing system sets a performance standard for individual facilities at 70 to 90% of sector greenhouse gas intensity. For example, if the steel sector produces on average 1 tonne of CO2e for each tonne of steel produced, facilities producing steel would be required to produce steel at an emission intensity of 0.9 tCO2e per tonne of steel.[6] In contrast, the Ontario emission performance standard does not describe how the performance standard would be set.

The Canadian output-based pricing system allows facilities that are not in compliance with the performance standard to achieve compliance by obtaining credits: (1) directly from government through a payment, (2) from surplus credits, (3) from offset providers, or (4) a combination. The price required to obtain a compliance credit measures the stringency of the system, and measures the incentive of regulated facilities to reduce emissions. The emission charge in the Canadian system rises from $20/tCO2e in 2019 to $50/tCO2e in 2022. In contrast, the Ontario emission performance standard does not describe which compliance mechanisms would be permitted, and what the cost of an emission permit purchased from government would be, if permitted.

The Canadian output-based pricing system will come into force on January 1, 2019. There is no stated timeline for regulatory development or coming into force for the Ontario system.

	Canada output-based pricing system	Ontario emission performance standard
Covered facilities	All facilities which report more than 50ktCO2 per year in any year since 2014; optional participation of smaller facilities.	Not stated. Potential "across-the-board" exemptions for entire sectors, such as the auto sector.
Performance standard	Between 70-90% of industry-average greenhouse gas intensity.	Not stated.
Compliance mechanisms	1. Paying an emission charge to government of Canada ($20/tCO2 in 2019; increasing to $50/tCO2 by 2022) 2. Submitting surplus credits issued by government of Canada 3. Submitting eligible offset credits 4. A combination of above	The program may include compliance flexibility mechanisms such as offset credits and/or payment of an amount to achieve compliance.
Coming into force	January 1, 2019	Not stated.

Figure 2: Comparison of Ontario and Canada large industry greenhouse gas intensity regulations

Based on this assessment, it is possible that the proposed Ontario emission performance standard will be similar to the Canadian output-based pricing system. However, at this point, insufficient details on the

---

[6] https://www.canada.ca/en/services/environment/weather/climatechange/climate-action/pricing-carbon-pollution/output-based-pricing-system-technical-backgrounder.html.

plan are available for a complete assessment, and it is impossible to know whether the proposed Ontario system will substantially reduce greenhouse gas emissions without additional details.

Announcement of the Ontario Emission Trust and reverse auction

The 2018 Ontario climate plan announces the launch of an emission reduction fund, named the Ontario Carbon Trust, as well as a reverse auction fund. The total funding for these two initiatives will be $400 million over 4 years, with $350 million allocated to the Ontario Carbon Trust and $50 million allocated to the reverse auction fund.

There are few details relating to how these funds would operate. However, in principle, the Ontario Carbon Trust would seek to reduce emissions by partnering with private organizations on certain low-carbon projects. The reverse auction would solicit bids from potential emission reduction project proponents, and award funding to projects that claim to be able to reduce emissions at a low cost.

If funds from the Ontario Carbon Trust and reverse auction are used to advance low-carbon projects that would not be feasible without government funding, it is possible in theory that the fund will cause emissions to be reduced. This is not likely to be the case in practice.

In particular, it is not clear that the Ontario Carbon Trust and reverse auction would have any way of distinguishing which projects require government funding to go ahead, and which do not. This problem of "adverse selection" is well-understood, and is the reason that analysts are typically skeptical that programs like the Ontario Carbon Trust and reverse auction are able to actually reduce emissions.[7] More precisely, potential private partners of the Ontario Carbon Trust and reverse auction will have more information about the project economics that the Ontario Government. They know, for example, how much outside funding is required to make the project profitable. The Ontario government does not have this information. When facing funding requests from a number of project proponents, the Ontario government is not able to distinguish projects that actually require outside funding to go ahead from those that do not. It is as a result not able to allocate funding in a way that actually ensures that emission reductions take place. This negative outcome is caused by the asymmetry in information availability and is referred to by economists as "adverse selection."

Why is adverse selection a problem for a project-based fund like the Ontario Carbon Trust and reverse auction, but not a problem for a carbon pricing policy? The reason is that the information requirements under the two policies are very different. For government to levy a fuel charge or other form of carbon price, it only needs to observe the level of carbon emissions for facilities subject to the charge. Clearly, it is possible to observe facility-level carbon emissions, and there are well-established protocols available for doing so, which are either based on the quantity of fuel consumed or based on measured emissions. Indeed, all facilities that are above a certain size are already required to report greenhouse gas emission levels in Ontario and Canada. In contrast, for government to provide funding for projects that reduce emissions, it needs two pieces of information: (1) the on-going emission levels of the participating facility, and (2) the emissions that would have been observed if the facility had not received external funding (the difference between the two reflects the amount that the proposed project reduces emissions). The second of these is difficult or impossible for government to observe. Even if project proponents know this information, they cannot be induced to reveal it to government, and thus there is an information asymmetry between government and the project proponent. This information asymmetry problem leads to adverse selection. To see why, consider two projects proposed by proponents that focus on retrofitting an industrial facility to improve its energy efficiency. In one project, the facility is old and requires updating

---

[7] For example, see the following article, which evaluates the Australian Emission Reduction Fund: Burke, Paul J. "Undermined by adverse selection: Australia's direct action abatement subsidies." Economic Papers: A journal of applied economics and policy 35.3 (2016): 216-229.

to improve the building layout. While doing the retrofit, it makes (financial) sense to improve the energy efficiency at the same time. As a result, the proponent will undertake the retrofits regardless of whether government funding is obtained. In the other project, the building is still serviceable, and the proponent would not undertake upgrades without government funding. Only if the proponent were able to obtain government funding would the project go ahead. The two proponents understand the specifics of the projects, but the government does not. It has no way of knowing whether the proponents require government funding in order to go ahead with their retrofits, and so it can't select the appropriate project to support. Under a reverse auction scheme, it is likely that the first project will be able to bid in at a lower cost (because it is planning on undertaking the retrofits even without government funding), and thus win the reverse auction, even though the project does not reduce emissions over and above what would have happened anyway. This information asymmetry makes it unlikely that the Ontario Carbon Trust and reverse auction will achieve substantial emission reductions.

Assessments of Australia's Emission Reduction Fund, which uses a similar mechanism as the proposed Ontario Carbon Trust and reverse auction, point to problems of adverse selection undermining the program. For example, Burke (2016) notes that most of the funding under Australia's Emission Reduction Fund has likely been awarded to projects that did not require outside funding to reduce emissions. As a result, the Emission Reduction Fund is likely to have had little impact on Australian greenhouse gas emissions.

Assessments of the international Clean Development Mechanism (CDM), which is a similar project-based fund for reducing emissions, likewise find that the fund has not been effective. For example, Victor (2009) states that "many CDM credits do not represent real reductions in emissions."[8] Wara (2007) documents that many project proponents strategically manipulate baselines in order to be granted credits, and that a large number of CDM credits are awarded for projects that would have gone ahead even without outside funding, suggesting that the CDM has not been effective in reducing emissions.[9] A particularly egregious example of baseline manipulation under the CDM relates to HFC destruction (HFCs are refrigerants and an extremely potent greenhouse gas). Wara (2007) documents a number of examples of HFC manufacturing facilities being opened just so that they could be closed and obtain associated CDM credits. Schneider and Kollmuss (2015) report that all projects that received credits for reducing HFC refrigerant emissions increased waste gas production to unprecedented levels in order to mislead fund managers about the baseline.[10] Perversely, the emission fund actually caused increases in emissions rather than reductions. This example neatly illustrates the information problems facing governments under project-based emission reduction funds.

In addition to problems with verifying the additionality of projects, project-based emission reduction funds, such as the Ontario Carbon Trust and reverse auction, the Australian Emission Reduction Fund, and the international Clean Development Mechanism all impose an extremely high administrative burden, in comparison to a carbon pricing approach. The reason for the high administrative burden is directly related to additionality – project proponents need to establish that the outside funding is instrumental to

---

[8] Victor, David. "Plan B for Copenhagen." Nature 461.7262 (2009): 342.

[9] Wara, Michael. "Measuring the clean development mechanism's performance and potential." UCLA L. Rev. 55 (2007): 1759.

[10] Schneider, Lambert, and Anja Kollmuss. "Perverse effects of carbon markets on HFC-23 and SF 6 abatement projects in Russia." Nature Climate Change 5.12 (2015): 1061.

the project success, and doing so typically requires a substantial amount of overhead. For example, in an analysis of the Australian Emission Reduction Fund, Clarke et al. (2015) note:[11]

> Under the Emission Reduction Fund (ERF), it is necessary to ensure that any abatement undertaken is true abatement beyond that which would have occurred without any abatement policy. Avoiding this problem requires a detailed determination of benchmark emissions by all firms submitting bids through the ERF. It will also be necessary to forecast these emissions into the future over the entire period of the operation of the ERF. As a result, it is likely **that the cost of writing emission reduction contracts between the government and firms bidding under the ERF will become expensive**.

The finding that project-based funds for emission reduction have high administrative burdens is not unique to the Australian Emission Reduction Fund, and there is not an easy way to avoid it. For example, the Clean Development Mechanism also has high costs of administration and verification, and these are not easy to resolve.[12]

Overall, both based on theory and prior experience, there is little reason to believe that the Ontario Carbon Trust and reverse auction will be able to instigate substantial additional reductions in greenhouse gases, over and above what would have happened anyway. In addition, because of high overhead and verification costs, any greenhouse gas reductions that do materialize will likely come at a high cost.

---

[11] Clarke, Harry, Iain Fraser, and Robert George Waschik. "How much abatement will Australia's emissions reduction fund buy?." Economic Papers: A journal of applied economics and policy 33.4 (2014): 315-326.

[12] Wara, Michael W., and David G. Victor. "A realistic policy on international carbon offsets." Program on Energy and Sustainable Development Working Paper 74 (2008): 1-24.

This is **Exhibit E** referred to in the

affidavit of **Nicholas Rivers**

affirmed before me on **January 25, 2019**

Commissioner for Taking Affidavits

FORM 53

Docket: C65807

COURT OF APPEAL FOR ONTARIO

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1,* SC 2018, c. 12

ACKNOWLEDGMENT OF EXPERT'S DUTY

1. My name is Nicholas Rivers. I live at Ottawa, in the Province of Ontario.
2. I have been engaged by the Attorney General of Canada to provide evidence in relation to the above-noted court proceeding.
3. I acknowledge that it is my duty to provide evidence in relation to this proceeding as follows:
   (a) to provide opinion evidence that is fair, objective and non-partisan;
   (b) to provide opinion evidence that is related only to matters that are within my area of expertise; and
   (c) to provide such additional assistance as the court may reasonably require, to determine a matter in issue.
4. I acknowledge that the duty referred to above prevails over any obligation which I may owe to any party by whom or on whose behalf I am engaged.

Date: 25 January, 2019

Signature

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1,* SC 2018, c. 12

Court of Appeal File No.: C65807

COURT OF APPEAL FOR ONTARIO
Proceedings commenced at Toronto

AFFIDAVIT OF DR NICHOLAS RIVERS AFFIRMED JANUARY 25, 2019 FILED ON BEHALF OF THE ATTORNEY GENERAL OF CANADA

ATTORNEY GENERAL OF CANADA
Department of Justice Canada
Prairie Region Office (Winnipeg)
301 – 310 Broadway
Winnipeg, MB R3C 0S6

Per: Sharlene Telles-Langdon, Brooke Sittler,
Mary Matthews, Neil Goodridge, and Ned Djordjevic

Phone: 204-983-0862
Fax: 204-984-8495
E-mail: sharlene.telles-langdon@justice.gc.ca

Counsel for the Attorney General of Canada

Fax to: (416) 326-4015
E-mail to: joshua.hunter@ontario.ca
padraic.ryan@ontario.ca
thomas.lipton@ontario.ca

IN THE MATTER OF A REFERENCE to the Court of Appeal pursuant to section 8 of the *Courts of Justice Act*, RSO 1990, c. C.34, by Order-in-Council 1014/2018 respecting the constitutionality of the *Greenhouse Gas Pollution Pricing Act*, Part 5 of the *Budget Implementation Act, 2018, No. 1,* SC 2018, c. 12

Court of Appeal File No.: C65807

COURT OF APPEAL FOR ONTARIO
Proceedings commenced at Toronto

RECORD OF THE ATTORNEY GENERAL OF CANADA

Volume 4 of 4

ATTORNEY GENERAL OF CANADA
Department of Justice Canada
Prairie Region Office (Winnipeg)
301 – 310 Broadway
Winnipeg, MB R3C 0S6

Per: Sharlene Telles-Langdon, Brooke Sittler,
Mary Matthews, Neil Goodridge, and Ned Djordjevic

Phone: 204-983-0862
Fax: 204-984-8495
E-mail: sharlene.telles-langdon@justice.gc.ca

Counsel for the Attorney General of Canada

Fax to: (416) 326-4015
E-mail to: joshua.hunter@ontario.ca
padraic.ryan@ontario.ca
thomas.lipton@ontario.ca