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November 27, 2012

VIA EMAIL, RESS, AND COURIER

Ms Kirsten Walli
Board Secretary
Ontario Energy Board
2300 Yonge Street
Suite 2700
Toronto, Ontario, M4P 1E4

Dear Ms Walli:

**Re: Enbridge Gas Distribution Inc. ("Enbridge")
2013 Rate Adjustment Application
Ontario Energy Board ("Board") File Number EB-2011-0354**

Attached please find Enbridge's responses to the following undertakings:

Exhibits J1.1 to J1.3 and
Exhibit J2.1.

This submission was filed through the Board's RESS and will be available on the Company's website at www.enbridgegas.com/ratecase .

Please contact the undersigned if you have any questions.

Yours truly,

[original signed by]

Lorraine Chiasson
Regulatory Coordinator

cc: Mr. F. Cass, Aird & Berlis LLP
All Interested Parties in EB-2011-0354

UNDERTAKING J1.1

UNDERTAKING

TR 1, page 82

To provide final cost of Concentric.

RESPONSE

Please see the following table which shows Concentric's costs related to the cost of capital issue.

Witness: M. Lister

EGDI Equity Thickness - Expert Support for 2013 Rate Application						
Concentric Budget (July 22, 2011 Engagement Letter) vs. Estimated Final Costs						
		Estimated	Actual			
Tasks to Filing of Direct Evidence		Labor	Labor	Expenses	Total	Explanation
1.	Peer Group Analysis					Budgeted time-frame for analysis and filing of evidence was 3 months.
2.	Financial Analysis					
3.	Regulatory Analysis					Actual time-frame for filing was 6 months, allowing for additional peer group, risk and financial analysis in support of the filing.
4.	Develop Draft Evidence and Recommendation					
5.	Review with EGD and Counsel					
6.	Finalize Evidence					
	Subtotal to Filing	**$75,000.00**	**$127,677.50**	**$359.04**	**$128,036.54**	
Post Filing Activities (Time & Materials Basis)						
7.	Next steps in the IR Plan(May and June)		$2,200.00	$8.48	$2,208.48	Labor dedicated to research, next steps in the IR plan, and review of Booth evidence.
8.	Respond to interrogatories (July)		$39,867.50	$53.20	$ 39,920.70	90% of July labor was dedicated to activities relative to responding to interrogatories.
9.	Respond to interrogatories, prepare for Technical Conference (August)		$41,236.25	$3,245.83	$ 44,482.08	90% of August labor was dedicated to activities relative to the technical conference on 9/4 - 9/6 and responding to interrogatories.
10.	Technical Conference, and response to Undertakings from the Technical Conference (September)		$32,122.50	$3,604.89	$35,727.39	60% of September labor was dedicated to activities relative to the technical conference on 9/4 - 9/6.
11.	Expert Conference & Report (Hot-tub process) (October)		$57,227.50	$5,751.55	$62,979.05	85% of October labor was dedicated to activities relative to the expert conference on 10/22 - 10/23.
12.	Hearings, assist with drafting of briefs and/or final comments to the Board (November ***estimate***)		*$71,191.25*	*$2,262.62*	*$73,453.87*	38% of November labor was dedicated to activities relative to the expert conference on 10/22 - 10/23. 60% of November labor was dedicated to activities relative to the oral hearings on 11/19 - 11/20.
	Subtotal post Filing		**$243,845.00**	**$14,926.57**	**$258,771.57**	
	Total		**$371,522.50**	**$15,285.61**	**$386,808.11**	

UNDERTAKING J1.2

UNDERTAKING

TR 1, page 98

To provide effective yield and the spread of 2011 debt and 2013 estimate of debt yield and spread.

RESPONSE

The following table summarizes the actual bond pricing for the 40-year EGD bond re-opening completed on September 1, 2011.

	2011
Amount	$100 million
Issue Price	$104.415 per $100.00 of principal amount of the Notes
30-year Government of Canada Bond Yield	3.102%
EGD Spread	1.60%
EGD 40-year Bond Yield	4.702%

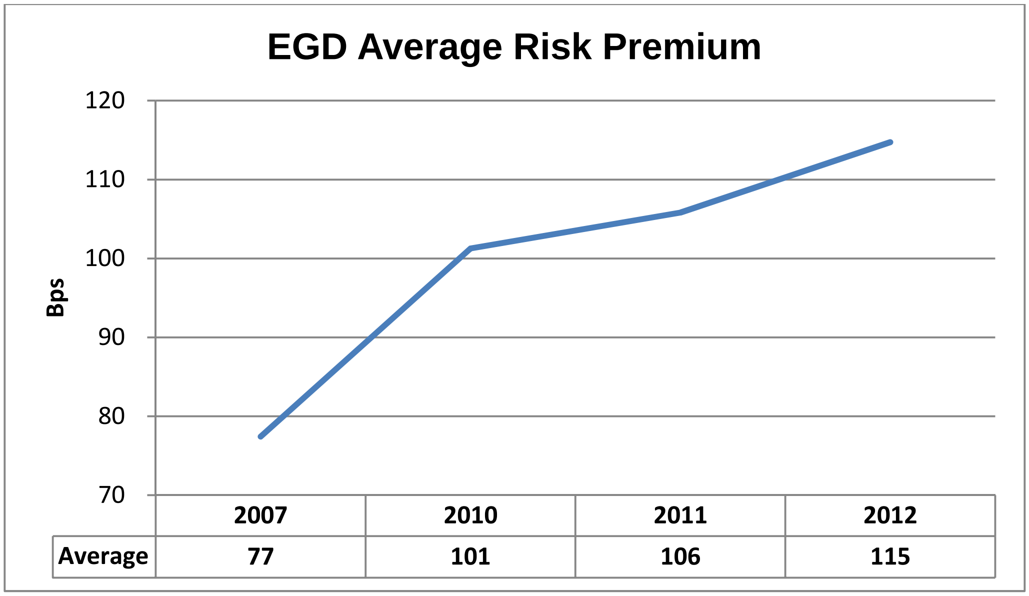
The following summarizes the estimated bond pricing for a hypothetical 10-year EGD bond issuances within 2013:

	2013
Issue Price	$100.00 per $100.00 of principal amount of Notes
Estimated 10-Year Government of Canada Bond Yield	3.00%
Estimated EGD 10-year Spread	1.10%
Estimated 10-year EGD Bond Yield	4.10%

Witness: D. Yaworsky

From 2007 to 2012, EGD experienced a 38 bps increase in its risk premium (spread over the Government of Canada bond yield) for a 10-year bond issuance. This trend indicates that the Canadian Debt Capital Markets view EGD's business risk as being 38 bps riskier in 2012 versus 2007.

The following graph and table identify risk premium trending from 2007 to 2012:



	2007	2010	2011	2012
Average	**77**	**101**	**106**	**115**

Note: The risk premium data for 2008 and 2009 was excluded given pricing distortion resulting from the global financial crisis.

The data was collected using the weekly, new issuance pricing provided by the Bank of Montreal, Canadian Imperial Bank of Canada, HSBC, National Bank, Royal Bank of Canada, Bank of Nova Scotia and Toronto Dominion Bank covering the period beginning January 1, 2007 to October 22, 2012.

Witness: D. Yaworsky

UNDERTAKING J1.3

UNDERTAKING

TR 1, page 163

With reference to the three categories of volumetric demand profile, system size and complexity and environmental and technological advancements, to advise which category each of the 24 Risks identified in JT2.14 falls into.

RESPONSE

The requested table is presented below. Please see the original interrogatory response filed at Exhibit I, Issue E2, Schedule 7.2, part c), and the Undertaking response filed at Exhibit JT2.14 for the full context.

In addition to the risks as presented in the pre-filed evidence, the Company identified changes in Regulatory Risk as also having changed over time. This assessment is provided in the interrogatory response filed at Exhibit I, Issue E3, Schedule 1.3 and the Attachment. In order to provide a complete response, EGD includes Regulatory Risk to the list of risks outlined in the pre-filed evidence in this Undertaking request.

EGD Business Risk Criteria	**Items listed in JT2.14**
System Size & Complexity	Infrastructure or Safety Issues
System Size & Complexity	Training
System Size & Complexity	Price of materials
System Size & Complexity	Interest Rates or Utility Credit Spreads
System Size & Complexity	Cost of labour
System Size & Complexity	Insurance Costs
System Size & Complexity	Cost of Litigation
System Size & Complexity	Cost of bad debts
System Size & Complexity	Ability to generate other revenues as forecast
Volumetric Profile	Economic Impacts on Volumes Generally
Volumetric Profile	Economic Impacts on Industrial Uses
System Size & Complexity	Ageing Workforce
System Size & Complexity	Technical, Safety, or Compliance Standards
System Size & Complexity	Operational Risks associated with underground facilities
System Size & Complexity	Third party damages
System Size & Complexity	Employee Health and Safety

Witnesses: K. Culbert
R. Fischer
M. Lister
D. Yaworski

System Size & Complexity	Environment and Physical risks of ruptured or leaking infrastructure
Volumetric Profile	Weather
Volumetric Profile	Demand for gas across North America
Volumetric Profile	Availability and Access to Supply
Volumetric Profile	Storage Spreads
Environment & Technology	Price of Fuel Oil or Other Energy Alternatives
Environment & Technology	Advancement of other technologies
Regulatory Risk	Regulatory or legislative impacts

In its pre-filed evidence, the Company identified other ways to categorize business risks as well (for example, "regulatory risk, sales/consumption risk, price/cost risk, and operations among others"). The business risks identified by the Company are virtually the same as those identified by the National Energy Board as well, and as such, it may be helpful for the Board to see how the business risk categories map to one another.[1] In other words, the risks categories identified by EGD in the presentation of its case, elsewhere in the pre-filed evidence, and by the NEB all seek to measure the same factors, just named or categorized in different ways. The NEB Categorizes business risks as follows:

Competition Risk – This is the risk that customers adopt alternatives for a business's product. While a risk unto itself, the NEB also notes that this risk indirectly affects business risk by affecting market and supply risk. This is consistent with the Environment & Technology Risk presented by the Company.

Market Risk – This is the risk that the demand for natural gas will fall. As the Company indicated during cross-examination, it is the consumption impact that is at risk, and not specifically the price of natural gas, although this can influence consumption. This is consistent with the Volumetric Profile and Environment & Technology Risks presented.

Supply Risk – From a pipeline's perspective, this is the risk that supply may affect utilization rates. From a distributor's perspective, this is the risk associated with the prudent management of supply sourcing and contracting upstream of the delivery network. This risk is referred to in the Regulatory Risk analysis found in the interrogatory response noted (Exhibit I, Issue E3, Schedule 1.3).

Regulatory Risk – This is the risk related to the method of regulation. As highlighted above, a regulatory risk analysis was presented in response to an interrogatory response (Exhibit I, Issue E3, Schedule 1.3).

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[1] The reference to long term business risks categories analyzed by the NEB can be found at Tab 1 of BOMA's cross-examination compendium, which was filed at Exhibit K1.4.

Witnesses: K. Culbert
R. Fischer
M. Lister
D. Yaworski

Operating Risk – This is the risk that arises from technical and operational factors. In practice, items that impact costs (for example, labour costs) or financing conditions (for example, interest rates) would fit into this category. This is consistent with System Size & Complexity (Age and Condition of Assets) Risk as presented by the Company.

Witnesses: K. Culbert
R. Fischer
M. Lister
D. Yaworski

UNDERTAKING J2.1

UNDERTAKING

TR 2, page 215

To file complete versions of 2008 report entitled "Final report: A technology roadmap to low greenhouse emissions in the Canadian economy, a sectoral and regional analysis," and the 2012 udpate

RESPONSE

Please find the “Final Report: A Technology Roadmap to Low Greenhouse Emissions in the Canadian Economy; A Sectoral and Regional Analysis” dated August 22, 2008 as Attachment 1 and “A Report by the National Round Table on the Environment and the Economy (“NRTEE”)” as Attachment 2.

Witnesses: J. Coyne
J. Lieberman
Concentric

FINAL REPORT

A Technology Roadmap to Low Greenhouse Gas Emissions in the Canadian Economy: A sectoral and regional analysis

August 22, 2008

Prepared for:
National Round Table on the Environment and the Economy

Prepared by:
J & C Nyboer and Associates, Inc.
15168 91A Ave.
Surrey, BC. V3R 6X1

Project team
Jotham Peters
Chris Bataille
Michelle Bennett
Noel Melton
Brian Rawson

Executive Summary

In 2007, the National Round Table on the Environment and the Economy (NRTEE) published *Getting to 2050: Canada's transition to a low-emissions future*, which simulated policies that could be used to attain deep reductions in greenhouse gas emissions over the medium- and long-term. The NRTEE has retained M.K. Jaccard and Associates to develop a technology roadmap derived from the *Getting to 2050* deep emissions reductions pathways that simulates a 20% reduction in Canada's GHG emissions from 2006 levels by 2020 and a 65% reduction in emissions by 2050. The purpose of a technology roadmap is to support strategic research, development, marketing, investment and policy decisions to achieve deep reductions in greenhouse gas emissions at the least cost to society. The technology roadmap identifies key technologies or their components for getting to this goal, the order in which they need to be achieved, and the required investment necessary for each step. It also shows which technologies may support the advancement of other sub-goals within the roadmap.

Besides identifying key GHG reduction technologies and their development path, the technology roadmap has the added feature of being grounded in a full scale modeling simulation of the Canadian economy. The CIMS model, a technology end-use model that integrates energy supply, demand, capital vintaging and realistic consumer and firm behavior in response to energy and climate policy, was used to simulate a sufficiently large and economy wide emissions price to achieve a deep reduction in emissions (Table ES 1). To achieve the target, firms and households must reduce about 780 Mt of greenhouse gas emissions (measured in carbon dioxide equivalent) from the reference case projection emissions of just over 1,000 Mt in 2050, non-inclusive of agriculture, halocarbons, nitric and adipic acid and land use change and forestry. The emissions price pathway modeled does not reflect a policy *per se*; instead it shows the strength of policy required to achieve a deep reduction in emissions.

Table ES 1: Greenhouse gas price simulated in this report ($2005 / tonne CO_2e)

	2011-2015	*2016-2020*	*2021-2025*	*2026-2030*	*2031-2035*	*2036-2040*	*2041-2045*	*2046-2050*
Greenhouse Gas Price	$15	$115	$215	$300	$300	$300	$300	$300

Besides identifying key technologies for deep emissions reductions, this roadmap project also estimates the environmental and economic impacts on individual sectors within the economy associated with this specific roadmap. Impacts include the emission of greenhouse gases, energy consumption, the costs of producing a good or commodity (e.g., cement), the costs of operating a sector (e.g., household), changes in output and the level of capital investment required by the sector to attain the emissions target for 2020 and 2050.

The technology roadmap described here is highly uncertain, in part because there are often multiple methods of reducing greenhouse gas emissions from a specific sector. For example, passenger vehicles, which require concentrated and storable motive energy to meet power and range requirements, could be fueled by biofuels, hydrogen, or electricity, or a hybrid of electricity and some other fuel. Our analysis, which assumes cellulosic ethanol or biodiesel will become technologically and economically feasible at sufficient supply to meet most transportation demand, projects that biofuels will be the dominant transport fuel in the deep reduction scenario. However, hydrogen or battery vehicles could play the dominant role if unforeseen technology breakthroughs make these technologies more economically competitive, or if they are perceived to be more politically favorable. Similarly, our analysis shows significant emissions reductions from carbon capture and storage in the electricity generation and oil sands upgrading sectors. If there were a breakthrough in large-scale electricity storage, a key challenge to intermittent renewables such as wind, this could change. Another possibility is that a large-scale deployment of nuclear energy could perform a similar role to carbon capture and storage, if deemed to be politically acceptable. These uncertainties are inherent in projecting technology developments decades in the future, but they should not prevent us from forming policy to guide technological development in socially and environmentally responsible directions. Put another way, this roadmap identifies the sectors that must achieve significant transformation (e.g., decarbonization of electricity production and transportation) and provides one scenario of how it may occur (e.g., use of a mix of carbon capture and storage, renewables and some nuclear in electricity, and accelerated adoption of hybrid vehicles and biofuels in transportation).

This summary report first reviews the key emission reduction technology actions in our modeling scenario. It then provides a description of the necessary capital investment by sectors, followed by a summary of key areas for technology research, development and deployment. Finally, we provide a graphic summary of the technology roadmap.

In the following discussion, we outline the key findings for each action to reduce greenhouse gas emissions:

- **Carbon capture and storage** in the upstream oil and gas industry, electricity production and industry.
- **Decarbonization of the transportation sector** through energy efficiency improvements through hybridization and fuel switching to low and zero GHG motive fuels.
- **Electrification of residential and commercial buildings and the industrial sector**, which also requires a decarbonization of the electricity sector through carbon capture and storage, more hydropower, and wide scale use of wind turbines and other renewables. Nuclear is held at its 2005 share of total electricity production by assumption.
- **Energy efficiency in the residential, commercial and industrial sectors**.
- **Controls on process greenhouse gas emissions**, such as reduction of well head venting, flaring and other fugitives in upstream oil and gas; changing of industrial processes, etc.

Carbon capture and storage (325 Mt CO_2e of reductions from reference projection in 2050)

- **Natural gas processing, ammonia production and hydrogen production are likely to be early adopters of carbon capture and storage.** In the medium-term, the first adopters of carbon capture are likely to be in the separation of formation carbon dioxide in natural gas processing, ammonia production in chemical products manufacturing and hydrogen production in oil sands upgrading. Each of these processes is uniquely suitable for carbon capture because their costs of capturing carbon dioxide are relatively low and many plants are situated close to areas with good geologic potential for carbon storage. They produce, or can be easily retrofitted to produce, relatively pure streams of carbon dioxide, and therefore avoid the significant costs of separating carbon dioxide from the other flue gases. By 2030 in the policy scenario, almost all these processes employ carbon capture and storage (see Table ES 2).

Table ES 2: Penetration of carbon capture in ammonia, formation carbon dioxide separation and hydrogen production

	2020	*2030*	*2040*	*2050*
Formation Carbon Dioxide from Natural Gas Processing	100%	100%	100%	100%
Hydrogen Production from Oil Sands Upgrading	91%	98%	100%	100%
Ammonia Production from Chemical Products Manufacturing	67%	93%	98%	99%

- **Most emissions reductions from carbon capture and storage are attained in electricity generation and the oil sands extraction and upgrading sectors.** In the long-run, carbon capture is likely to play the most significant role from combustion sources in the electricity generation and oil sands extraction and upgrading sectors, which are forecasted to emit 167 Mt CO_2e and 172 Mt CO_2e in 2050 in the absence of any mitigation policy, respectively. The adoption of carbon capture from these sources is slower than for sources with relatively pure streams of carbon dioxide for several reasons:
    - Capture from combustion sources is more costly because it requires significant capital and energy expenditures to separate the carbon dioxide from other combustion exhaust gases. Combustion can be designed to produce a relatively pure stream of carbon dioxide (i.e., through burning in a virtually pure oxygen environment with no nitrogen) but this is an expensive departure from current practices. Because the policy's stringency increases over time, some of the investments in carbon capture do not occur until later.
    - Retrofitting existing facilities can also be more costly than new construction.
    - The existing stock of electricity plants, oil sands upgraders and in-situ operators is sufficiently large that it will take many years to retrofit or retire the existing stock.
    - Many electricity plants are in locations without good potential for geological storage, and will require pipelines to transport carbon dioxide. By 2050, generation using carbon capture and storage accounts for 27% of total generation, and the remaining electric capacity is almost completely renewable or nuclear (see Table ES 3). Virtually all oil sands upgraders and most in-situ operations employ carbon capture by the end of the simulation period.

Table ES 3: Penetration of carbon capture from large combustion sources

	2020	*2030*	*2040*	*2050*
Utility Electricity Generation	7%	17%	23%	27%
Oil Sands Upgrading	58%	88%	96%	99%
In-situ	35%	54%	57%	55%

Decarbonization of transportation (235 Mt CO_2e of reductions)

- **Approximately 70% of the emissions reductions from the transportation sector are the result of biofuel consumption.** In most modes of transportation, consumers and the freight industry begin to fuel their vehicles with biodiesel or ethanol instead of refined petroleum products (i.e., gasoline and diesel). In some situations, fuel switching requires adjustments to the engine to use biofuels (e.g., a gasoline engine must be modified to run on fuels with 85% ethanol by volume). In other situations, the biofuel may be a functional substitute for a refined petroleum product (e.g., biodiesel may be manufactured so that it has similar performance to diesel). By 2050, 62% of the passenger vehicle stock and virtually the entire freight fleet are fuelled by renewable fuels (see Table ES 4).

Table ES 4: Penetration of vehicles that consume biofuels

	Renewable fuel share (% of total fuel)				*Increase due to Policy (%)*			
	2020	*2030*	*2040*	*2050*	*2020*	*2030*	*2040*	*2050*
Passenger Vehicles	7%	51%	62%	62%	7%	50%	60%	59%
Freight Trucks	20%	72%	96%	97%	20%	72%	96%	97%

- **The policy accelerates the adoption of hybrid and plug-in hybrid vehicles, which reduces the energy intensity of transportation and increases electricity consumption.** By 2050, hybrid and plug-in hybrid vehicles enjoy close to a full penetration in the market for passenger vehicles (see Table ES 5). Mode switching to public transit and purchasing smaller vehicles also contribute to the improvement in energy efficiency. Improvements in freight transportation occur as a result of the adoption of hybrid trucks as well as mode shifts to rail transport.

Table ES 5: Penetration of hybrid and plug-in hybrid vehicles

	Technology Penetration (% of total Stock)				*Increase due to Policy (%)*			
	2020	*2030*	*2040*	*2050*	*2020*	*2030*	*2040*	*2050*
Passenger Hybrid	3%	6%	11%	12%	2%	3%	-14%	-29%
Passenger Plug-in Hybrid	13%	69%	83%	83%	12%	60%	67%	65%
Freight Hybrid	3%	32%	59%	62%	2%	26%	15%	0%

- **The expansion of biofuel and electricity consumption requires increased production of biofuels and electricity.** The increases in ethanol and biodiesel consumption require a substantial increase in the production of biofuels. In order to meet the demand for biofuels, production is forecasted to expand from negligible levels in 2005 to over 2,000 PJ by 2050. The sector must also reduce its greenhouse gas intensity and produce biofuels in a manner that does not put politically unsustainable pressure on agroecosystems or food prices. In this forecast, most ethanol production is from waste and woody biomass using cellulosic ethanol processes, and carbon capture and storage is used at biofuel manufacturing plants. The expansion of the electricity sector is discussed in the following section.

Electricification of buildings and industry (75 Mt CO_2e of reductions)

- **Many sectors throughout the economy substitute away from direct use of fossil fuels and use more electricity to reduce their direct greenhouse gas emissions.** The share of electricity among total energy consumption increases as key sectors reduce emissions by switching to electricity (see Table ES 6). In the residential and commercial sectors, the policy causes an increase in the adoption of ground source heat pumps and electric baseboards for space heating; in the transportation sector, the share of plug-in hybrid vehicles among passenger vehicles expands considerably; in the manufacturing sectors, electricity can be used to produce heat, steam and hot water.

Table ES 6: Electricity share of total energy consumption

	Electricity fuel share (%)				*Increase in electricity share due to Policy (%)*			
	2020	*2030*	*2040*	*2050*	*2020*	*2030*	*2040*	*2050*
Residential	68%	87%	94%	97%	20%	35%	36%	32%
Commercial	57%	69%	77%	79%	12%	24%	33%	35%
Other Manufacturing	48%	65%	75%	78%	21%	38%	47%	50%

- **The increase in electricity demand requires a significant expansion of the electricity sector.** Similar to the biofuels, the increased demand for electricity requires a considerable expansion of electric capacity while reducing the greenhouse gas intensity of the sector. In 2050, electricity generation in the policy scenario is 1,700 TWh – 50% greater than the reference projection. Reducing the greenhouse gas intensity of the electricity sector presents unique challenges to each province. Provinces without significant hydroelectric potential – particularly Alberta and Saskatchewan – show an expansion of electricity generated using carbon capture and storage. Provinces with better hydroelectric potential employ considerable expansions of hydroelectric generation. Table ES 7 illustrates electric generation by different systems, and the increase above the reference case projection.

Table ES 7: Electric generation in the policy scenario

	Electric Generation (TWh)				*Increase due to Policy (%)*			
	2020	*2030*	*2040*	*2050*	*2020*	*2030*	*2040*	*2050*
Renewable	544	703	860	1,013	20%	36%	42%	43%
Nuclear	124	168	204	232	25%	54%	64%	57%
Coal w/o CCS	112	86	43	5	4%	-30%	-71%	-98%
Natural Gas w/o CCS	26	15	9	6	-29%	-65%	-81%	-89%
Carbon Capture & Storage	62	193	328	456	NA	NA	NA	NA

Note: There is minimal penetration of carbon capture and storage in the reference case, so we do not show an increase over the reference case.

- **The expansion of electricity generated from renewables reduces greenhouse gas emissions at the point of electricity consumption.** The analysis shows a considerable increase in electricity generated from renewable sources, but it does not show significant emissions reductions in the electricity sector from switching to renewables. Most of the new capacity to generate electricity from renewables is added in provinces where generation is already dependent on renewables, and does not have a significant impact on emissions at the point of electric generation. However, the expansion of generation from renewables in these provinces enables other sectors, such as the residential and commercial sectors, to increase electricity consumption and reduce their consumption of fossil fuels.

Energy efficiency improvements in buildings and industry (20 Mt CO_2e of reductions)

- **Most improvements to energy efficiency, outside transportation, occur in the residential and commercial sectors.** Most reductions from energy efficiency improvements in the commercial and residential sectors are from investments in ground source heat pumps. Improvements to building shells lead to modest emissions reductions.
- **The energy efficiency improvements in the industrial and energy supply sectors are mostly offset due to the adoption of carbon capture and storage.** Carbon capture requires more energy than an equivalent facility without, so most of the sectors which abate their emissions using carbon capture and storage show increases in energy intensity.

Controls on process greenhouse gas emissions (55 Mt CO_2e of reductions)

- **Capturing and flaring landfill gas is likely to be an early opportunity to reduce greenhouse gas emissions.** The cost of capturing and flaring landfill gas is relatively low and the policy is likely to induce all landfills to capture and flare landfill gas by 2020. In 2020, the waste sector reduces emissions by 25 Mt CO_2e from the reference case projection, and by 2050 the reduction reaches 30 Mt CO_2e.
- **Reduced and managed well venting and flaring, testing, and leak detection and repair programs can reduce fugitive emissions from the natural gas and crude oil extraction sectors.** By 2050, these actions account for approximately 19 Mt CO_2e of emissions reductions from the reference projection.

Capital expenditures required to meet the deep reduction target

In order to attain a 65% reduction in greenhouse gas emissions from 2006 levels by 2050, the level of capital expenditure rises by 5% – 6.4 billion per year ($2005) – from the reference case projection in the medium-term, and by 3% in the long-term (6.0 billion per year) (see Table ES 10). However, numbers mask very large sectoral differences (Table ES 10), and large differences in focused costs and diffuse benefits.

Table ES 10: Increase in annual capital expenditures caused by policy (2005$ millions)

	Medium-Term (2011-2030)	*Long-term (2031-2050)*
Demand Sectors		
Residential	41	-117
Commercial	-136	642
Transportation	-8,414	-6,892
Manufacturing Industry	-228	-322
Landfills	70	19
Supply Sectors		
Electricity	12,512	9,554
Fossil Fuel Extraction & Refining	1,054	496
Biofuel Manufacturing	1,519	2,637
Total	6,418	6,018

The effects on individual sectors are radically different, especially between the transport, electricity and other energy supply sectors. In passenger transportation, capital expenditures fall as people purchase smaller vehicles, travel less, and use public transit more. Expenditures in freight transport decline due to an increase in rail transport, and a decline in total freight transport. Expenditures by the electricity sector increase by an average of $11 billion per year ($2005) to expand generation and to finance efforts to decarbonize production. Capital expenditures in the fossil fuel extraction and biofuel sectors also increase markedly, mainly for carbon capture and storage for the former, and increased output and decarbonization for the latter.

Summary of actions to reduce greenhouse gas emissions

Table ES 8 summarizes the emissions reductions from key actions to reduce direct greenhouse gas emissions (i.e., at the point of emission). As discussed above, the expansion of biofuels and electricity production in some provinces does not significantly reduce emissions at the point of greenhouse gas emissions, but enables emissions reductions at the point of energy consumption (e.g., an increase in the production of hydroelectricity in Québec enables the residential sector to reduce natural gas consumption).

Table ES 8: Summary of direct emissions reductions by action (Mt CO_2e)

	2020	2030	2040	2050
Carbon Capture and Storage	**94**	**183**	**259**	**325**
Formation Carbon Dioxide from Natural Gas Processing	6	6	5	5
Hydrogen Production from Oil Sands Upgrading	11	13	14	15
Ammonia Production from Chemical Products Manufacturing	2	3	4	4
Utility Electricity Generation	28	75	114	154
Oil Sands Upgrading	33	53	70	76
In-situ Bitumen Extraction	8	16	22	29
Other Carbon Capture and Storage	5	17	30	41
Energy Efficiency & Carbon Capture Overlap	**11**	**20**	**29**	**37**
Decarbonization of Transportation	**60**	**156**	**208**	**235**
Biofuel Consumption for Transportation	16	88	147	175
Electricity Consumption for Transportation	2	17	23	25
Reduced Energy Consumption from Hybrid Vehicles [a]	28	41	31	29
Mode switching to Public Transit and Rail Freight Transport [a]	12	13	9	9
Decline in Petroleum Refining	6	14	17	16
Increased Biofuel and Electricity Production for Transportation	-4	-16	-19	-18
Electrification of Buildings and Industry	**3**	**26**	**53**	**75**
Electric Space and Water Heating in Buildings	21	43	57	65
Increased Electricity use in Other Manufacturing	8	17	26	34
Fuel Switching to Electricity in Other Industrial Sectors	6	12	19	23
Increased Electricity Generation for Buildings and Industry	-32	-46	-49	-46
Energy Efficiency in Residential, Commercial and Industry	**10**	**16**	**20**	**22**
Ground Source Heat Pumps in Buildings [a]	6	10	13	14
Improvements to Residential and Commercial Shells [a]	1	2	3	3
Other Improvements to Energy Efficiency	4	4	4	5
Controls on Process Greenhouse Gas Emissions	**53**	**55**	**54**	**53**
Landfill Gas Cap and Flare	26	27	28	28
Reduced Venting and Flaring in Upstream Oil & Gas [a]	20	19	18	16
Leak Detection and Repair in Upstream Oil & Gas [a]	3	3	3	3
Other Controls	4	5	5	5
Changes in Sector Output	**16**	**17**	**14**	**15**
Decline in Industrial Output	5	8	8	8
Decline in Transportation Demand	11	9	6	7
Other Actions	**3**	**6**	**12**	**17**
Total Reductions in Greenhouse Gas Emissions from all Actions	**250**	**480**	**648**	**779**

Notes: [a] Value is approximate.

Table ES 9 shows the emissions reductions enabled by the expansion of different methods for producing electricity and renewable fuels.

Table ES 9: Emissions reductions enabled by the expansion of the electricity and biofuels sectors (Mt CO_2e)

	2020	*2030*	*2040*	*2050*
Clean Electricity Generation	**37**	**89**	**125**	**146**
Generation from Renewables	20	39	50	54
Generation from Nuclear	5	12	15	15
Generation using Carbon Capture and Storage	12	38	60	77
Biofuel Production	**16**	**88**	**147**	**175**
Cellulosic Ethanol Production	8	52	63	55
Biofuel Production with Carbon Capture and Storage	3	19	47	73
Other Biofuel Production Methods [a]	4	17	37	47
Total Reductions from Expansion of Clean Energy Production	**53**	**177**	**272**	**321**

Notes: [a] Includes production methods that use electricity or renewable fuels to produce the heat necessary for biofuel production.

Table ES 10 shows the reduction in greenhouse gas emissions from the reference projection (e.g., greenhouse gas emissions in the residential sector are 36 Mt CO_2e lower in the policy scenario in 2050 than in the reference scenario in 2050). Emissions reductions are likely to be concentrated in the transportation, electricity generation and petroleum production sectors, which are forecasted to contribute to the majority of Canada's greenhouse gas emissions in the absence of a policy. Together, these sectors account for around 70% of Canada's total reductions. The landfill and natural gas sectors play an important role in the medium-term, because of potential early opportunities to reduce emissions from landfills and captured formation carbon dioxide.

Table ES 10: Reductions in greenhouse gas emissions from reference case by sector

	Emissions Reductions (Mt CO_2e)			
	2020	*2030*	*2040*	*2050*
Demand Sectors				
Residential	18	32	36	36
Commercial	12	25	38	47
Transportation	70	169	216	244
Manufacturing Industry	27	55	78	98
Landfills	26	27	28	29
Supply Sectors				
Electricity	-2	29	74	128
Fossil Fuel Extraction & Refining	100	146	183	203
Biofuel Manufacturing	-1	-4	-5	-6
Total	250	480	648	779

Total energy consumption in the Canadian economy increases – by 10% in 2050 – in response to the policy. Energy consumption rises, mostly due to an increase in output from the electricity and biofuels production sectors, but also due to greater energy requirements associated with carbon capture. Energy consumption declines in most other sectors of the economy (although energy consumption rises in some sub-sectors of manufacturing industry and fossil fuel extraction and refining).

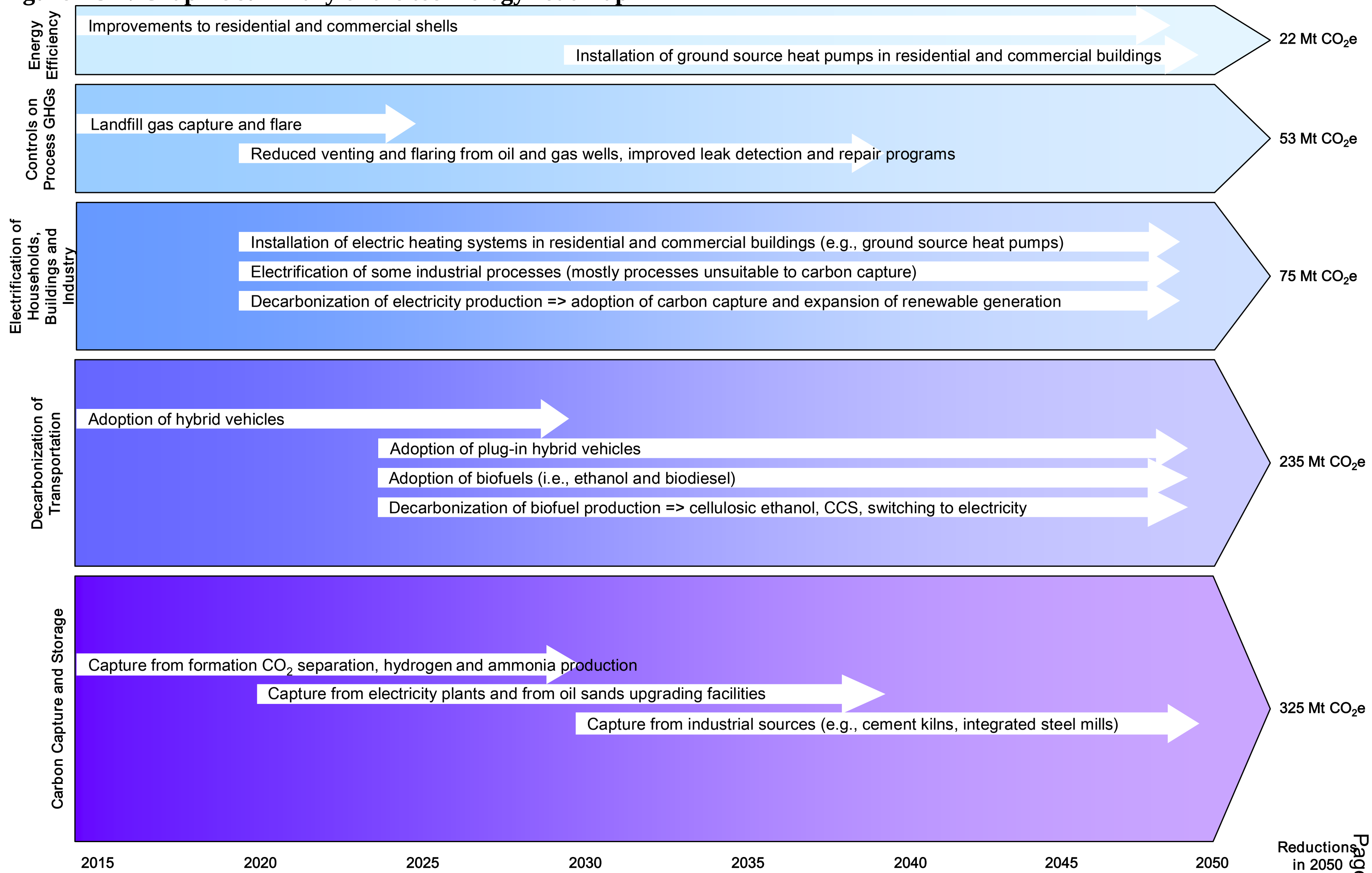
Table ES 11: Reductions in energy consumption from the reference case by sector

	Reduction in Energy Consumption (PJ)			
	2020	*2030*	*2040*	*2050*
Demand Sectors				
Residential	182	331	402	435
Commercial	159	323	511	650
Transportation	724	1,172	1,085	1,137
Manufacturing Industry	158	186	174	182
Landfills	11	14	16	17
Supply Sectors				
Electricity	-1,144	-2,618	-3,692	-4,394
Fossil Fuel Extraction & Refining	21	64	47	49
Biofuel Manufacturing	-37	-152	-269	-325
Total	73	-679	-1,728	-2,249

Graphic summary of the technology roadmap

Figure ES 1 highlights the key technologies and actions that contribute to the emissions reductions from the Canadian economy between 2015 and 2050. The arrow for each technology action (e.g., carbon capture from electricity and oil sands plants) indicates the period during which the technology begins to play a dominant role in the reductions and when it attains its maximum penetration. For example, the adoption of carbon capture at electricity and oil sands facilities begins around 2020, and most of these plants employ carbon capture by 2040. The adoption of carbon capture at smaller industrial facilities becomes significant later in the simulation.

Figure ES 1: Graphic summary of the technology roadmap



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Introduction

In *Getting to 2050: Canada's transition to a low emissions future,* the National Round Table on the Environment and the Economy (NRTEE) estimated the strength of policy that would be necessary to attain deep reductions in greenhouse gas emissions by 2050 (a 65% reduction from 2006 levels by 2050). The NRTEE retained J & C Nyboer and Associates to expand on the previous study to 1) assess the sectoral and regional implications of attaining deep reductions in greenhouse gas emissions, and 2) develop a technology roadmap that forecasts the technological developments that occur in order to attain these reductions. The technology roadmap identifies key technologies or their components for getting to this goal, the order in which they need to be achieved, and the required investment necessary for each step. It also shows which technologies may support the advancement of other sub-goals within the roadmap.

The purpose of this study is to forecast technological developments, rather than prescribe the technological developments that must occur to attain a deep reduction in greenhouse gas emissions. The forecast is highly uncertain, in part because there are often multiple methods of reducing greenhouse gas emissions from a specific sector. For example, passenger vehicles may be fueled with biofuels or hydrogen, neither of which produce net greenhouse gas emissions at the point of combustion. Our analysis shows that biofuels play a dominant role in the emissions abatement from the transportation sector, but hydrogen may play a dominant role if it is perceived to be more economically or politically favorable. Similarly, our analysis shows significant emissions reductions from carbon capture and storage in the electricity generation and oil sands upgrading sectors. However, nuclear energy could attain similar emissions reductions if it is deemed to be politically acceptable.

J & C Nyboer and Associates uses a detailed energy-economy model called CIMS to evaluate energy and climate change policies and to determine the cost of reducing greenhouse gas emissions. In this project, we use the CIMS model to estimate the technological developments that occur in response to a price on greenhouse gas emissions that achieves the deep reduction in greenhouse gas emissions described in *Getting to 2050*. We estimate these developments at sectoral and provincial levels in order to forecast how each sector and region will be affected by the policy. As part of the analysis, we highlight the sectors of the economy that contribute most significantly to the emission or abatement of greenhouse gas emissions. The report is accompanied with an appendix and spreadsheet that show most of the data used to develop the report.

Structure of this report

We begin this report with an overview of the methodology used to produce the quantitative results, including a general description of the CIMS model that was used for the analysis. We then discuss the assumptions and inputs used to develop the reference case forecast, and present the reference case forecast in detail. The following section presents the sectoral and regional implications of deep reductions in greenhouse gas emissions, and forecasts the technological developments that occur to reach these reductions.

Methodology

The primary objective of this study is to forecast technological developments that occur for Canada to attain deep reductions in greenhouse gas emissions by 2050. A deep reduction in greenhouse gas emissions is defined as a 20% reduction from 2006 levels by 2020 and a 65% reduction by 2050. To conduct the analysis, the CIMS energy-economy model was updated to reflect recent national data and trends, and used to forecast the developments that occur in response to a price on greenhouse gas emissions. The model is described very briefly here; a somewhat more comprehensive description of the model is provided in the Appendix B.

The CIMS model

The CIMS model, developed by the Energy and Materials Research Group at Simon Fraser University and by J & C Nyboer and Associates, simulates the technological evolution of fixed capital stocks (such as buildings, vehicles, and equipment) and the resulting effect on costs, energy use, emissions, and other material flows. The stock of capital is tracked in terms of energy service provided (m^2 of lighting or space heating) or units of physical product (metric tons of market pulp or steel). New capital stocks are acquired as a result of time-dependent retirement of existing stocks and growth in stock demand. Market shares of technologies competing to meet new stock demands are determined by standard financial factors as well as behavioral parameters from empirical research on consumer and business technology preferences. CIMS has three modules — energy supply, energy demand, and macro-economy — which can be simulated as an integrated model or individually. A model simulation comprises the following basic steps.

1. A base-case macroeconomic forecast initiates model runs. The macroeconomic forecast is at a sectoral or sub-sectoral level (for example, it estimates the growth in total passenger travel demand, or in airline passenger travel demand). The macroeconomic forecast adopted for this study is described in detail in the following section.
2. In each time period, some portion of existing capital stock is retired according to stock lifespan data. Retirement is time-dependent, but sectoral decline can also trigger retirement of some stocks before the end of their natural life spans. The output of the remaining capital stocks is subtracted from the forecast energy service or product demand to determine the demand for new stocks in each time period.
3. Prospective technologies compete for new capital stock requirements based on financial considerations (capital cost, operating cost), technological considerations (fuel consumption, lifespan), and consumer preferences (perception of risk, status, comfort), as revealed by behavioral-preference research. The model allows both firms and individuals to project future greenhouse gas prices with imperfect foresight when choosing between new technologies (somewhere between total

myopia and perfect foresight about the future). Market shares are a probabilistic consequence of these various attributes.

4. A competition also occurs to determine whether technologies will be retrofitted or prematurely retired. This is based on the same type of considerations as the competition for new technologies.
5. The model iterates between the macro-economy, energy supply and energy demand modules in each time period until equilibrium is attained, meaning that energy prices, energy demand and product demand are no longer adjusting to changes in each other. Once the final stocks are determined, the model sums energy use, changes in costs, emissions, capital stocks and other relevant outputs.

The key market-share competition in CIMS can be modified by various features depending on the evidence about factors that influence technology choices. Technologies can be included or excluded at different time periods. Minimum and maximum market shares can be set. The financial costs of new technologies can decline as a function of market penetration, reflecting economies of learning and economies of scale. Intangible factors in consumer preferences for new technologies can change to reflect growing familiarity and lower risks as a function of market penetration.

Personal mobility provides an example of CIMS' operation. The future demand for personal mobility is forecast for a simulation of, say, 30 years and provided to the energy demand module. After the first five years, existing stocks of personal vehicles are retired because of age. The difference between forecast demand for personal mobility and the remaining vehicle stocks to provide it determines the need for new stocks. Competition among alternative vehicle types (high and low efficiency gasoline, natural gas, electric, gasoline-electric hybrid, and eventually hydrogen fuel-cell) and even among alternative mobility modes (single occupancy vehicle, high occupancy vehicle, public transit, cycling and walking) determines technology market shares. The results from personal mobility and all other energy services determine the demand for fuels. Simulation of the energy supply module, in a similar manner, determines new energy prices, which are sent back to the energy demand module. The new prices may cause significant changes in the technology competitions. The models iterate until quantity and price changes are minimal, and then pass this information to the macro-economic module. A change from energy supply and demand in the cost of providing personal mobility may change the demand for personal mobility. This information will be passed back to the energy demand module, replacing the initial forecast for personal mobility demand. Only when the model has achieved minimal changes in quantities and prices does it stop iterating and move on to the next five-year time period.

Model limitations and uncertainties

Like all models, CIMS is a representation of the real world, and so does not represent it perfectly. Even though CIMS is very detailed compared to other models used for similar purposes, its broad scope (it represents all energy consumption throughout the economy) requires many simplifying assumptions. Main uncertainties and limitations in the model are:

- **Technological detail and dynamics –** CIMS contains considerable technological detail in each of its sectoral sub-models. This detail enables CIMS to show accelerated market penetration of alternative technologies in response to an energy or climate change policy and ensure that reference and policy scenarios are grounded in technological and economic reality. While care has been taken in representing the engineering and economic parameters of the many technologies in CIMS, uncertainty exists (particularly in industrial sectors) as to the appropriate cost and operating parameters of specific technologies.

  This uncertainty becomes larger over time. While CIMS contains a representation of dynamic technological change that depicts how the costs of new technologies can be reduced through economies of scale and production experience based on historical experience, there is no guarantee that these relationships will hold in the future. In addition, CIMS only contains technological options that are known today (including those that are not yet commercialized). By definition, CIMS does not contain a depiction of new technologies that have not yet been invented. As a result, CIMS could miss technological substitution options in later years of the forecast.

- **Behavioral realism –** The technology choice algorithm of CIMS takes into account implicit discount rates revealed by real-world technology acquisition behavior, intangible costs that reflect consumer and business preferences, and heterogeneity in the marketplace. Incorporating behavioral realism is critical in order to predict realistic consumer and firm response to policies, however, incorporating preferences at a detailed level into a model that is technologically explicit is challenging. In addition to the sheer volume of the data requirements, the non-financial preferences of consumers and firms are difficult to estimate, and can change over time. The complexities associated with estimating behavioral parameters, combined with the fact that information cannot be collected for all the technology competitions in CIMS, result in a high degree of uncertainty associated with these parameters overall. The potential for preference change is also a key uncertainty.

- **Equilibrium feedbacks -** Unlike most computable general equilibrium models (which do not contain technological detail), the current version of CIMS does not equilibrate government budgets and the markets for employment and investment. Also, its representation of the economy's inputs and outputs is skewed toward energy supply, energy intensive industries, and key energy end-uses in the residential, commercial/institutional, and transportation sectors. As a result, it is likely to underestimate the full structural response of the economy to energy and climate change policies.

- **External inputs –** CIMS requires external forecasts of macroeconomic activity in each sub-sector, population growth forecasts, and fuel price forecasts on which to base the analysis. These forecasts are uncertain and could affect the results of the simulations. In addition, since no individual forecast is available to provide all key inputs over the period of interest in this analysis, we have adopted inputs from several different sources. We have used respected sources, and attempted to ensure consistency between various sources, but it is likely that the various inputs we use are not perfectly consistent with one another.

Modelling scenario

In order to determine the greenhouse gas abatement opportunities in Canada, we use the concept of a reference scenario and a policy scenario. The reference scenario shows how the Canadian economy might evolve in the absence of specific new policies to reduce greenhouse gas emissions. The policy scenario shows how the economy might evolve under a given policy. The difference between the two scenarios is due to the effect of the policy.

In this report, we use an economy-wide price on greenhouse gas emissions to simulate deep reductions in greenhouse gas emissions – a 20% reduction from 2006 levels by 2020, and a 65% reduction by 2050. The emissions price pathway modeled in this analysis (See Table 1) does not reflect policies *per se*; instead it captures the strength of a market-based policy signal required to achieve a given level of emissions reductions.

The emissions price pathway modeled in this report is slightly lower than the pathway modeled in *Getting to 2050*, which showed an emissions price rising to $330 / tonne CO_2e (2005$) in order to attain deep reductions in emissions. Several modifications have been made to the CIMS model between the two contracts, and are discussed in the following section.

Table 1: Greenhouse gas price ($2005 / tonne CO_2e)

	2011-2015	*2016-2020*	*2021-2025*	*2026-2030*	*2031-2035*	*2036-2040*	*2041-2045*	*2046-2050*
Greenhouse Gas Price	$15	$115	$215	$300	$300	$300	$300	$300

The reference scenario

The reference scenario described in this report is based on several external inputs showing how the economy will evolve over the coming 42 years to 2050. Many key inputs underlying the reference scenario are highly uncertain, and if the economy evolves differently than as shown in this reference scenario, energy consumption and emissions will also differ from what we show here. We have used credible sources to guide key inputs wherever possible, but no amount of research allows perfect foresight into the future of the economy. As a result, the scenario described here should be considered just one possible reference scenario. We consider it a good "business as usual" forecast, based on historic trends and research into likely future technological and economic evolution, but the uncertainty remains large. We begin by highlighting our key assumptions, and follow by showing the results of our forecast.

Key economic drivers and assumptions

CIMS uses an external forecast for the economic or physical output of each economic sector to develop the business as usual forecast. For example, CIMS requires an external forecast for the number of residential households, and another for the amount of cement produced in the province. These forecasts can be internally adjusted when a policy is applied. We discuss the forecasts adopted for both the energy supply sectors and the energy demand sectors.

Energy demand sectors

For all energy demand sectors, the external forecast through 2020 is based on the same data used by Natural Resources Canada to develop the national energy outlook in 2006.[1] For years beyond 2020, the forecast for demand sectors is based on a long-run economic forecast of gross domestic product, population, and labor force participation prepared by Informetrica for the federal government, which is depicted in Table 2.[2] The population forecast used here is based on the medium growth scenario developed by Statistics Canada in a recent demographic forecast.[3]

Table 2: Canada's economic and demographic forecast

	Units	*2010*	*2020*	*2030*	*2040*	*2050*
Population	*Thousands*	33,639	36,344	38,812	40,644	41,896
Gross Domestic Product	*billion 2005$ [a]*	1,460	1,827	2,194	2,652	3,153

Note: [a] Gross domestic product is presented in basic prices

1 Natural Resources Canada, 2006, "Canada's Energy Outlook: The Reference Case 2006", Analysis and Modelling Division, Natural Resources Canada.

2 Infometrica, 2007, "Infometrica's Long-run Reference Population and Productivity Forecast". Natural Resources Canada also bases its forecast on Infometrica's macroeconomic and demographic projections.

3 Statistics Canada, 2006, "Population Projections for Canada, Provinces, and Territories: 2005-2031", Demography Division, Statistics Canada.

The residential sector is anticipated to grow rapidly because of continued population growth. The rates of both population growth and household formation are expected to slow later in the forecast, when Canada's population is anticipated to be about 25% larger than the current level.

The commercial sector is expected to undergo rapid expansion, driven by expanding economic output. By the end of the forecast period, the commercial sector is expected to be more than double its current size (based on physical building footprint).

Travel demand in the passenger transportation sector increases quickly in Canada, fuelled by growth in population as well as income. These trends are expected to continue in general, but slow throughout the forecast period. In the freight transportation sector, growth is based on gross domestic product and expansion of industrial output, which expand rapidly in the reference case.

Like other demand sectors, output is expected to grow in the industrial manufacturing sector. The output from the other manufacturing sector grows the most rapidly, while growth in other sectors is more muted.

Energy supply sectors

The main energy supply sectors in CIMS include crude oil extraction, natural gas extraction and processing, petroleum refining, electricity generation, coal mining and biofuels manufacturing. For crude oil and natural gas, we rely on external forecasts of production because a large percentage of Canada's production is exported to other regions. For petroleum refining, electricity generation, and coal mining, we base the supply forecast on Canada's projected energy demand and add in an external forecast of net exports of each commodity to calculate total production.

Canada's crude oil production forecast (Figure 1) is based on the moderate growth case of the Canadian Association of Petroleum Producers 2007 report.[4] Between 2025 and 2050, the output of conventional crude oil (light/medium and heavy) is projected to continue to decline due to existing reserve depletion. By 2050, conventional crude oil production is expected to account for only a small amount of total production.

Conversely, production of unconventional crude oil, from Alberta's oil sands, is forecast to increase dramatically during the forecast period. Total production of unconventional crude oil is expected to reach about 4.5 million barrels per day by 2025 and nearly 6.6 million barrels per day by 2050, a five-fold expansion in capacity from today's levels. Particularly rapid growth in the industry is expected in the coming two decades, both in blended bitumen operations and in synthetic crude oil operations.

According to the Alberta Energy and Utilities Board, the volume of crude bitumen in the oil sands is approximately 1.6 trillion barrels, with 175 billion barrels recoverable under current economic conditions and with existing technologies. The growth forecast of oil

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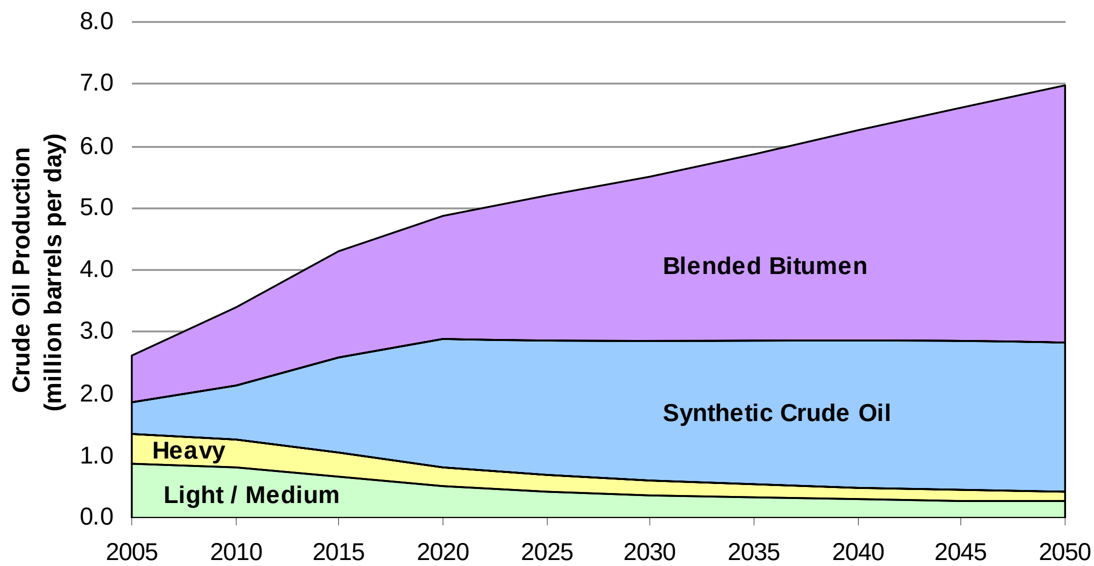
[4] Canadian Assocation of Petroleum Producers, 2007, "Crude oil forecast, markets, and pipeline expansions", June 2007. CAPP's forecast extends to 2025; after 2025, production in the sector is assumed to continue to grow for unconventional crude oil, and to continue to decline for conventional crude oil. The forecast after 2025 is very uncertain since projects are not announced with this much lead-time. CAPP's recent forecast is higher than the forecast adopted in NRCan's 2006 Energy Outlook.

sands development in our model has taken this resource constraint into consideration. During the modeling period, the forecasted cumulative output of blended bitumen and synthetic crude oil in Canada is about 73 billion barrels.

Figure 1: Crude oil supply forecast



Source: Forecast based on Moderate Growth case from Canadian Association of Petroleum Producers, 2007, "Crude oil forecast, markets, and pipeline expansions".

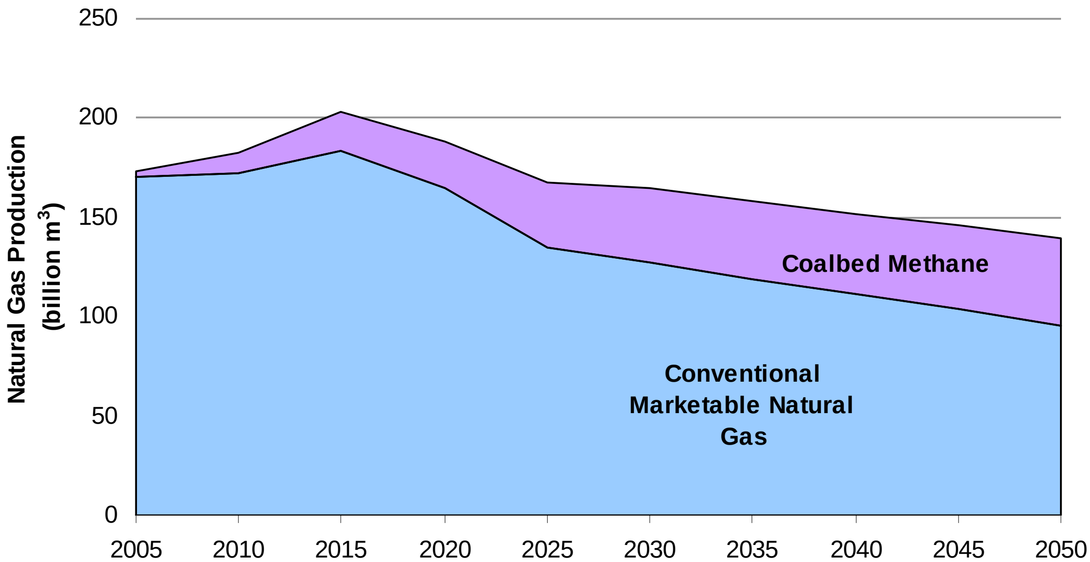
Marketable natural gas production in Canada between 2000 and 2020 is grounded in Natural Resources Canada's CEO 2006, but modified to reflect history and more recent material from the Canadian Association of Petroleum Producers and the Alberta Energy and Utility Board's 2006 forecast. The growth rate forecast between 2015 and 2025 comes from a recent National Energy Board report.[5] Key recent changes include the delay of large-scale production of Arctic gas, transmitted via the Mackenzie Valley, until after 2013, higher estimates of accessible coal bed methane, and increased optimism about replacement of reserves from the Western Canadian Sedimentary Basin, which underlies BC, the Northwest Territories, Alberta, Saskatchewan and Manitoba. While much of the accessible and inexpensive conventional gas reserves have been depleted, drilling technology (e.g., side and angle drilling and search software) and the ability to access tight gas have improved such that larger than previously expected additions to reserves are expected up to 2015.

The forecast of marketable natural gas production adopted for this report peaks near 2015 and then begins to decline fairly quickly, even with a substantial increase in coal bed methane supply (see Figure 2). Because coal bed methane is a relatively new resource,

[5] Alberta Energy Utilities Board, 2006, "Alberta's Energy Reserves 2005" and "Supply/Demand Outlook 2006-2015"; National Energy Board, 2003, "Canada's Energy Future: Supply and Demand Forecast to 2025"; National Energy Board, 2004, "Canada's Oil Sands: Challenges and Opportunities to 2015".

the forecast for extraction of coal bed methane adopted for this reference scenario is very uncertain.

Figure 2: Natural gas supply forecast



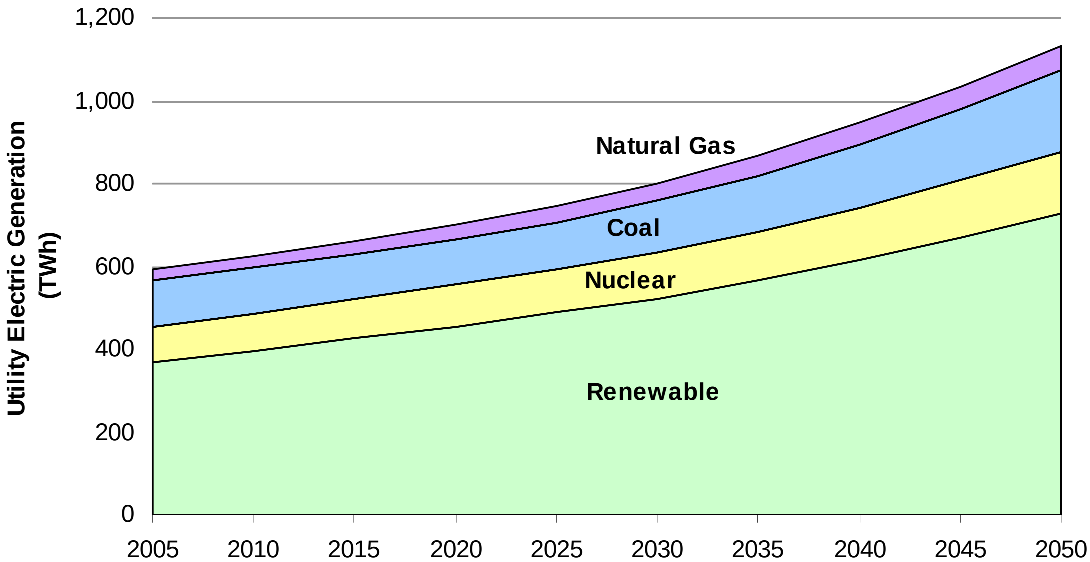
Source: Forecast based on Natural Resources Canada, “Canada’s Energy Outlook 2006”; Alberta Energy Utilities Board, “Alberta’s Energy Reserves 2005” and “Supply/Demand Outlook 2006-2015”; National Energy Board, 2007, “Canada’s Energy Future: Supply and Demand Forecast to 2030” and National Energy Board, 2004, “Canada’s Oil Sands: Challenges and Opportunities to 2015”.

The forecast of output for the electricity generation sector is based on the calculated demand from all other sectors in the model, and is adjusted to include net exports of electricity.[6] It does not include non-utility electricity generation, which is accounted for separately in the other sub-models (for example, electricity production by cogeneration in the oil sands is accounted for in the upstream oil sub-model).

The fuel source for electric generation varies considerably between provinces. British Columbia, Manitoba and Québec, have abundant hydroelectric potential, and most capacity additions until 2050 are forecasted to be hydroelectric. Ontario and the Atlantic provinces have a mixture of hydroelectric, nuclear and fossil fuel generation; while Alberta and Saskatchewan rely primarily on coal and natural gas to generate electricity. Figure 3 shows the reference case electricity generation by fuel type for Canada; generation by province is available in the appendix.

[6] Net exports of electricity are based on the recent Natural Resources Canada energy outlook through 2020 and are assumed to remain at historic levels thereafter.

Figure 3: Reference case utility electricity generation by fuel type



In the policy scenario, we assume that net exports of electricity and coal remain fixed at the levels in the reference case. For crude oil and natural gas in the policy scenarios, we assume that total provincial production of the commodity is fixed and adjust net exports based on the difference between total production and domestic demand. Although this assumption is likely imperfect, the US Energy Information Administration projects that international demand for crude oil and natural gas is likely to remain robust even with the introduction of climate change abatement policies.[7]

As has been emphasized throughout, the economic output forecast adopted here (see Table 5) reflects historic and anticipated future trends, but is highly uncertain, particularly in the later years of the forecast.

[7] Energy Information Administration, 1998, "Impacts of the Kyoto Protocol on US Energy Markets and Economic Activity", United States Department of Energy.

Table 3: Reference case output forecast

	Units	2010	2020	2030	2040	2050
Demand Sectors						
Residential	*thousands of households*	13,545	15,222	16,566	17,253	17,815
Commercial	*million m^2 of floorspace*	729	911	1,091	1,316	1,561
Transportation						
Passenger	*billion passenger-km*	742	944	1,152	1,339	1,493
Freight	*billion tonne-km*	966	1,198	1,420	1,689	1,987
Manufacturing Industry						
Chemical Products	*million tonnes* [a]	19	22	24	27	30
Industrial Minerals	*million tonnes* [b]	18	21	25	29	33
Iron and Steel	*million tonnes*	15	16	18	20	22
Metal Smelting	*million tonnes* [c]	5	5	5	5	5
Mineral Mining	*million tonnes*	262	274	282	292	304
Pulp and Paper	*million tonnes* [d]	20	22	24	26	27
Other Manufacturing	*billion $2005*	205	260	318	391	472
Supply Sectors						
Electricity Generation	*TWh*	625	701	802	947	1,133
Petroleum Refining	*million m^3*	101	115	117	124	136
Crude Oil						
Conventional Light	*thousand barrels per day*	823	502	365	295	257
Conventional Heavy	*thousand barrels per day*	438	322	238	186	151
Synthetic Crude	*thousand barrels per day*	878	2,075	2,249	2,375	2,418
Blended bitumen	*thousand barrels per day*	1,244	1,967	2,663	3,396	4,160
Natural Gas	*billion m^3* [e]	179	179	149	135	121
Coal Mining	*million tonnes*	72	87	92	97	106
Biofuels Manufacturing	*PJ*	9	16	31	65	103

Notes: [a] chemical product output is the sum of chlor-alkali, sodium chlorate, hydrogen peroxide, ammonia, methanol, and petrochemical production
[b] industrial mineral output is the sum of cement, lime, glass, and brick production
[c] metal smelting output is the sum of aluminium, copper, lead, magnesium, nickel, titanium and zinc smelting
[d] pulp and paper output is the sum of linerboard, newsprint, coated and uncoated paper, tissue and market pulp production
[e] natural gas production includes coalbed methane

Energy prices

CIMS requires an external forecast for energy prices. As for sectoral output, fuel prices can change while a policy scenario is running if the policy induces changes in the cost of fuel production. Reference case prices for most fuels through 2020 are derived from the recent energy outlook published by Natural Resources Canada (the industrial and electricity coal price forecasts were derived from forecasts by the US Environmental Protection Agency). The price for petroleum products has been updated to reflect the recent increase in the price for crude oil, which at the time of writing had exceeded $140 per barrel. The price for petroleum products is based on historic data until May 2008 and the price for oil from the Energy Information Administration's most recent forecast.[8] The fuel price forecast (excluding electricity) for Ontario that was used to develop the reference case forecast in this report is presented in Table 4. The values differ slightly by province depending on the supply cost and taxation, but prices in Ontario are reasonably representative of the prices in the rest of the country. The forecasts for electricity prices are lower in provinces with greater hydroelectric potential – specifically British Columbia, Manitoba and Québec – and greater in provinces with fossil fuel generation (see Table 5). Like the other forecasts that are used as inputs to CIMS, it should be recognized that the fuel price forecast adopted here is highly uncertain, particularly in the longer term. In addition, the fuel price forecasts that we have adopted are intended to reflect long-term trends only, and will not reflect short-term trends caused by temporary supply and demand imbalances.

Table 4: Reference case price forecast for key energy commodities in Ontario

	Units	*2010*	*2020*	*2030*	*2040*	*2050*
Crude Oil (WTI)	*2005$ US / barrel*	85.57	56.97	66.67	69.04	69.04
Natural Gas						
Industrial	*2005$ / GJ*	9.63	8.71	8.71	8.71	8.71
Residential	*2005$ / GJ*	12.63	11.30	11.30	11.30	11.30
Commercial	*2005$ / GJ*	11.01	9.87	9.87	9.87	9.87
Electricity Generation	*2005$ / GJ*	9.00	8.89	8.89	8.89	8.89
Coal						
Market	*2005$ / GJ*	3.36	3.36	3.36	3.36	3.36
Electricity Generation	*2005$ / GJ*	3.00	3.00	3.00	3.00	3.00
Gasoline	*2005¢ / L*	108.8	81.7	88.7	88.7	88.7
Diesel (Road)	*2005¢ / L*	98.9	73.0	80.1	80.1	80.1

Note: All prices other than the price for oil are in Canadian dollars.

[8] Energy Information Administration, 2008, "Annual Energy Outlook, 2008", United States Department of Energy.

Table 5: Reference case electricity price forecast in each province

	Units	*2010*	*2020*	*2030*	*2040*	*2050*
Industrial						
British Columbia	*2005¢ / kWh*	4.0	3.5	3.5	3.5	3.5
Alberta	*2005¢ / kWh*	6.2	5.6	5.6	5.6	5.6
Saskatchewan	*2005¢ / kWh*	6.0	5.5	5.5	5.5	5.5
Manitoba	*2005¢ / kWh*	3.7	2.7	2.7	2.7	2.7
Ontario	*2005¢ / kWh*	6.5	7.0	7.0	7.0	7.0
Québec	*2005¢ / kWh*	4.2	3.4	3.4	3.4	3.4
Atlantic	*2005¢ / kWh*	7.4	7.2	7.2	7.2	7.2
Residential						
British Columbia	*2005¢ / kWh*	7.4	6.5	6.5	6.5	6.5
Alberta	*2005¢ / kWh*	8.7	9.5	9.5	9.5	9.5
Saskatchewan	*2005¢ / kWh*	8.1	7.3	7.3	7.3	7.3
Manitoba	*2005¢ / kWh*	6.3	4.9	4.9	4.9	4.9
Ontario	*2005¢ / kWh*	8.9	9.9	9.9	9.9	9.9
Québec	*2005¢ / kWh*	8.3	8.4	8.4	8.4	8.4
Atlantic	*2005¢ / kWh*	11.4	10.8	10.8	10.8	10.8
Commercial						
British Columbia	*2005¢ / kWh*	4.5	4.0	4.0	4.0	4.0
Alberta	*2005¢ / kWh*	6.4	6.7	6.7	6.7	6.7
Saskatchewan	*2005¢ / kWh*	8.9	7.9	7.9	7.9	7.9
Manitoba	*2005¢ / kWh*	4.1	2.9	2.9	2.9	2.9
Ontario	*2005¢ / kWh*	7.7	9.1	9.1	9.1	9.1
Québec	*2005¢ / kWh*	4.6	3.7	3.7	3.7	3.7
Atlantic	*2005¢ / kWh*	9.1	8.8	8.8	8.8	8.8

Note: All prices are in Canadian dollars.

Policies included in the reference case

Both the federal and provincial governments have developed energy and climate policies over the past few years. We have attempted to include the most important of these in the reference case developed here. In particular, we include:

- The federal renewable power production incentive, which provides $0.01/kWh of renewable energy production during the first 10 years after commissioning of a new renewable energy facility;
- The federal ethanol excise tax exemption of $0.10/L and provincial tax exemptions for ethanol;
- The federal minimum energy performance standards for household appliances, including furnace regulations requiring 90% efficiency in new natural gas furnaces starting in 2009;
- The federal ecoENERGY for Efficiency policy, which provides incentives towards the replacement of lower efficiency energy consuming equipment with more efficient equipment.

Reference case energy and emissions outlook

Based on the key economic assumptions highlighted above, we used CIMS to develop an integrated reference case forecast for energy consumption and greenhouse gas emissions through 2050. The CIMS model captures virtually all energy consumption and production in the economy.

The reference case forecast for total energy consumption is shown in Table 6, while Table 7, Table 8, and Table 9 show natural gas, refined petroleum product, and electricity consumption, respectively. The residual energy consumption of other fuel types (total minus natural gas, refined petroleum product, and electricity) is not explicitly shown in this report.

Table 6: Reference case total energy consumption

	Unit	*2010*	*2020*	*2030*	*2040*	*2050*
Demand Sectors						
Residential	*PJ*	1,417	1,567	1,760	1,977	2,303
Commercial	*PJ*	1,195	1,412	1,639	1,956	2,298
Transportation	*PJ*	2,889	3,522	3,728	4,077	4,557
Manufacturing Industry	*PJ*	2,352	2,527	2,770	3,105	3,497
Supply Sectors						
Electricity Generation	*PJ*	3,881	4,127	4,626	5,448	6,560
Petroleum Refining	*PJ*	351	422	457	510	571
Crude Oil	*PJ*	1,034	1,996	2,202	2,342	2,506
Natural Gas	*PJ*	692	607	512	457	403
Coal Mining	*PJ*	22	24	25	26	27
Biofuels Manufacturing	*PJ*	2	4	13	16	20
Total	*PJ*	13,836	16,208	17,730	19,914	22,742

Note: Producer consumption of energy (e.g., consumption of hog fuel in the pulp and paper sector or refinery gas in the petroleum refining sector) is included in these totals. Energy consumption in the electricity generation sector includes consumption of water, wind, nuclear, and biomass using coefficients adopted from the International Energy Agency.[9]

[9] International Energy Agency, 2007, "Energy Balances of OECD Countries: 2004-2005". Renewable electricity generation is assumed to require 1 GJ of energy (e.g., wind, hydro) for each GJ of electricity generated. Nuclear electricity generation is assumed to require 1 GJ of energy for each GJ of thermal energy generated.

Table 7: Reference case natural gas consumption

	Unit	2010	2020	2030	2040	2050
Demand Sectors						
Residential	PJ	645	737	766	758	737
Commercial	PJ	613	745	880	1,055	1,235
Transportation	PJ	8	2	1	1	0
Manufacturing Industry	PJ	762	821	907	1,060	1,245
Supply Sectors						
Electricity Generation	PJ	265	304	346	421	488
Petroleum Refining	PJ	80	110	128	147	166
Crude Oil	PJ	542	955	1,058	1,072	1,162
Natural Gas	PJ	624	535	448	397	347
Coal Mining	PJ	3	3	4	4	4
Biofuels Manufacturing	PJ	1	1	5	7	7
Total	PJ	3,543	4,213	4,543	4,922	5,392

Table 8: Reference case refined petroleum product consumption

	Unit	2010	2020	2030	2040	2050
Demand Sectors						
Residential	PJ	66	18	11	9	7
Commercial	PJ	58	40	33	37	43
Transportation	PJ	2,873	3,503	3,660	3,931	4,348
Manufacturing Industry	PJ	147	161	160	183	203
Supply Sectors						
Electricity Generation	PJ	105	56	6	5	5
Petroleum Refining	PJ	92	92	90	98	109
Crude Oil	PJ	75	89	115	188	236
Natural Gas	PJ	25	24	20	18	16
Coal Mining	PJ	6	8	8	9	10
Biofuels Manufacturing	PJ	0	1	2	3	5
Total	PJ	3,448	3,993	4,106	4,482	4,982

Table 9: Reference case electricity consumption

	Unit	2010	2020	2030	2040	2050
Demand Sectors						
Residential	PJ	638	749	919	1,149	1,502
Commercial	PJ	524	627	726	864	1,020
Transportation	PJ	7	10	45	83	102
Manufacturing Industry	PJ	706	715	752	830	926
Supply Sectors						
Electricity Generation	PJ	0	0	0	0	0
Petroleum Refining	PJ	15	15	14	15	16
Crude Oil	PJ	60	92	92	88	86
Natural Gas	PJ	42	47	44	42	40
Coal Mining	PJ	4	5	4	5	5
Biofuels Manufacturing	PJ	0	0	2	2	3
Total	PJ	1,995	2,260	2,597	3,077	3,700

Based on total energy consumption as well as process emissions in the industrial and energy supply sectors, we calculate the greenhouse gas emissions associated with the reference case forecast (Table 10). While the CIMS model captures virtually all energy consumption and production in the economy, it does not capture the methane and nitrous oxide emissions from agriculture and the production of adipic and nitric acid, among other minor sectors. In 2005, these sectors represented about 10% of total greenhouse gas emissions, measured on an equivalent global warming potential basis.

Table 10: Reference case greenhouse gas emissions

	Unit	*2010*	*2020*	*2030*	*2040*	*2050*
Demand Sectors						
Residential	*Mt CO_2e*	39	40	41	40	39
Commercial	*Mt CO_2e*	35	41	47	56	66
Transportation	*Mt CO_2e*	208	253	263	282	312
Manufacturing Industry	*Mt CO_2e*	85	90	97	109	125
Landfills	*Mt CO_2e*	29	31	32	33	34
Supply Sectors						
Electricity Generation	*Mt CO_2e*	123	113	119	138	170
Petroleum Refining	*Mt CO_2e*	20	24	26	29	32
Crude Oil	*Mt CO_2e*	94	158	170	181	193
Natural Gas	*Mt CO_2e*	64	56	47	42	37
Coal Mining	*Mt CO_2e*	2	3	3	3	3
Biofuels Manufacturing	*Mt CO_2e*	0	0	1	1	1
Total	*Mt CO_2e*	698	807	845	915	1,012

In the absence of new policies to control greenhouse gas emissions, emissions are expected to grow from current levels in most sectors of the Canadian economy. Especially strong growth is expected in the crude oil and transportation sectors, as a result of rapidly expanding output.

Differences between the reference case and the reference case used in "Getting to 2050"

Since the modeling for *Getting to 2050*, CIMS has undergone several revisions of which we highlight the most major changes:

- **The price for refined petroleum products was updated to account for the recent rise in the price for oil and to incorporate the latest forecast from the Energy Information Administration.** In *Getting to 2050*, the price for oil was based on a forecast from Natural Resources Canada's *Canada's Energy Outlook*, which predicted that the world price oil would drop from $60 per barrel ($2003 US) in 2005 to $45 per barrel in 2010, and remain unchanged thereafter.[10] At the time of writing this report in 2008, the price for oil had exceeded $140 per barrel. In order to account for the higher price for oil, we revised the price for oil based

[10] The price for oil is based on the price of West Texas Intermediate at Cushing Oklahoma. Natural Resources Canada, 2006, "Canada's Energy Outlook".

the historic prices between January 2006 and May 2008 and the latest forecast from the Energy Information Administration (see Table 11).[11]

Table 11: Difference between the price for oil in *Getting to 2050* and the current report ($2005 US / barrel)

	2006-2010	*2011-2015*	*2016-2020*	*2021-2025*	*2026-2030*	*2031-2050*
Getting to 2050	$46.84	$46.84	$46.84	$46.84	$46.84	$46.84
Current Report (Historic & EIA, 2008)	$85.57	$64.24	$56.97	$61.22	$66.67	$69.04

- **Revised growth rates for the crude oil sector.** We reduced the growth rates for the crude oil sector to reflect the most recent forecast from the Canadian Association of Petroleum Producers. In *Getting to 2050*, the output from the crude oil sector reached 8,200 barrels per day in 2050, whereas in the present study, output reaches 7,000 barrels per day. We also increased the output of blended bitumen and reduced the output of synthetic crude, which reduces the emissions from the sector. By 2050, greenhouse gas emissions from the petroleum crude sector are approximately 110 Mt CO_2e lower in the current reference case than in *Getting to 2050*.
- **Revised growth rates for the transportation sector.** Since *Getting to 2050*, we increased the growth rates for passenger kilometers traveled by air and by road in the transportation sector. We revised the growth rates to reflect the growth rates reported in Natural Resources Canada's *Canada's Energy Outlook* (2006). The higher growth rates increase emissions from transportation, although the increase in emissions is moderated by the higher price for oil. In 2050, transportation emissions are approximately 40 Mt CO_2e greater than in *Getting to 2050*.
- **Revised growth rates for the industrial sectors.** In order to develop a forecast of industrial output to 2050, we extended the forecast from Natural Resources Canada, which ends at 2020. Since, *Getting to 2050*, we have moderated our growth rates for many industrial sectors, which reduced emissions by approximately 60 Mt CO_2e.
- **New landfill model.** We added a landfill model to account for the emissions and abatement opportunities from Canada's landfills. By 2050, we forecast landfills will produce approximately 34 Mt CO_2e in the absence of any mitigation policy.

In total, the changes made to CIMS between the *Getting to 2050* study and the current report reduced total greenhouse gas emissions in 2050 from 1,190 Mt to 1,015 Mt CO_2e.

The reference case in context

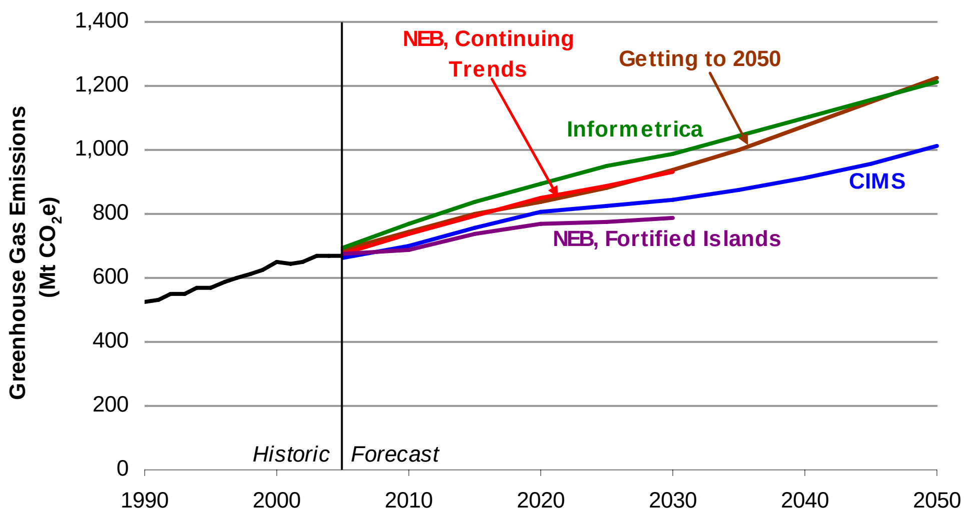
Figure 4 compares the total greenhouse gas emissions reported in this reference case to the reference case from *Getting to 2050*, a recent forecast by Informetrica Ltd. prepared for the federal government, and the recently released National Energy Board forecast. The National Energy Board published several forecasts with different assumptions about

[11] Energy Information Administration, 2008, "Annual Energy Outlook, 2008", United States Department of Energy.

energy prices: in the “Continuing Trends” forecast, the price for oil declines to $50 US per barrel by 2010, and in the “Fortified Islands” forecast, the price for oil remains at $85 per barrel through 2030. The price forecast for oil used in the present study is between the two forecasts from National Energy Board.

The forecast of greenhouse gas emissions in this report is generally lower than the forecasts from other sources, including the forecast from *Getting to 2050*. The lower forecast is mostly due to the increase in oil prices, but also due to changes in sector growth rates.

Figure 4: Reference case greenhouse gas emissions



Note: This chart excludes emissions from agroecosystems and some other sectors, which in 2005 represented about 10% of the Canada’s total. Historic emissions in this chart (1990-2005) are from Environment Canada, 2007, “National Inventory Report”.

A roadmap to deep reductions in greenhouse gas emissions

Context

This section explores how a deep reduction in greenhouse gas emissions affects the major sectors of the economy that contribute to greenhouse gas emissions and projects the environmental (measured in energy consumption and greenhouse gas emissions) and economic impacts (e.g., the cost of manufacturing cement or the cost of operating a household) of the reduction in greenhouse gas emissions. This section also forecasts the technological developments necessary to attain deep reductions in greenhouse gas emissions in each sector.

We use wedge diagrams to illustrate the relative contribution of different actions – taken by businesses and consumers – to a reduction in greenhouse gas emissions from their business as usual trajectory. In most cases, wedges are presented based on the *technical potential* for greenhouse gas reductions. While this can be a useful concept, it does not capture the relative cost of different actions, the behavior and preferences of firms and individuals, the interaction between different actions, or the types and stringency of policies that might be necessary to trigger the actions. Using CIMS, we instead present a wedge diagram for each sector based on the estimated response of firms and individuals to the regulatory framework as modeled. Because CIMS is an integrated model in which firm and consumer behavior has an empirical basis, the results account for preferences and behavior, the relative cost of different actions, and the interaction of actions, energy and goods and services prices and changes in output.

Each wedge corresponds to reductions of greenhouse gas emissions relative to the reference case as a result of key actions. The top wedge labeled “Energy Efficiency” represents the greenhouse gas reductions caused by increases in energy efficiency. Energy efficiency improves significantly in the reference case, and it should be noted that the wedge shown here only depicts the supplemental energy efficiency savings compared to the reference case. The wedge labeled “Carbon Capture & Storage” represents the greenhouse gas reductions from carbon capture and storage. The adoption of carbon capture and storage often increases the energy requirements of a sector, and offsets energy efficiency improvements in other end-uses. In order to show how the decline in energy efficiency from carbon capture offsets the other energy efficiency improvements, we show a wedge labeled “CCS Energy Penalty”. The wedge labeled “Fuel Switching” captures the reductions associated with switching from fuels with relatively higher greenhouse gas intensity (e.g., coal) to fuels with lower intensity (e.g., electricity, renewable fuels or natural gas). The wedge labeled “Output” represents the reduction in greenhouse gas emissions caused by declines in production from the sector. We show additional wedges that represent other actions taken by firms to reduce their emissions, but that do not fall into the categories described above. These actions include flaring landfill gas, improved computer controls in aluminum smelting that reduce the occurrence of anode events that produce perfluorocarbons, and actions taken by the upstream oil and gas sectors to reduce fugitive emissions.

The analysis is carried out under several key assumptions, including:

- The current version of CIMS does not include a representation of agroecosystems, the production of nitric and adipic acid or some other minor sectors. As a result, the results shown here do not include the emissions or the abatement opportunities from these sectors. However, this analysis accounts for 90% of Canada's total greenhouse gas emissions.
- The technologies in CIMS are limited to foreseen technologies that are likely become commercially available in the timeframe of the analysis. However, high prices on greenhouse gas emissions could also stir the invention and commercialization of currently unforeseen low emissions technologies and processes. CIMS does not simulate the potential impact of these technologies, so it is likely that the modeling has missed some technological developments that could lower the long-term cost of carbon mitigation.
- Carbon capture is 90% effective at removing carbon dioxide from a flue gas stream. After including an energy efficiency penalty, a technology with carbon capture has approximately 15% of the emissions of an equivalent technology without. Future developments may improve capture efficiencies; these are not included in the modeling here.
- No nuclear energy is allowed in provinces that did not have nuclear electricity generation in 2005. Nuclear energy in other provinces has been constrained so that its share of total electric generation does not increase. We made these assumptions because the development of nuclear energy is a political decision as much as an economic one, and therefore difficult to simulate in an economic model.
- The greenhouse gas price policy simulated here is revenue neutral from a fiscal perspective, meaning that any revenue attained from the carbon price is returned to the sector that paid it. As a result, a sector as a whole does not incur any net costs associated with paying an emissions tax, but only incurs the investment costs associated with abating its emissions.
- The policy does not change the world price for crude oil or the continental price for natural gas, and do not change the overall output of these sectors (although, since domestic demand can change, the net exports of these commodities can change).

Residential

Box 1: Key actions by the residential sector

- Most emissions reductions are attained through the adoption of electric space and water heating systems. By 2050, virtually the entire space heating stock consists of ground source heat pumps or electric baseboards, and the entire water heating stock is electric.
- Improvements to residential building shells (i.e., improved insulation or energy efficient windows) have a minimal role in the emissions reductions.

In the absence of any mitigation policy, the greenhouse gas emissions from the residential sector are projected to remain fairly stable at about 40 Mt CO_2e between 2005 and 2050. In 2050, the residential sector is projected to contribute around 3% of Canada's total greenhouse gas emissions.

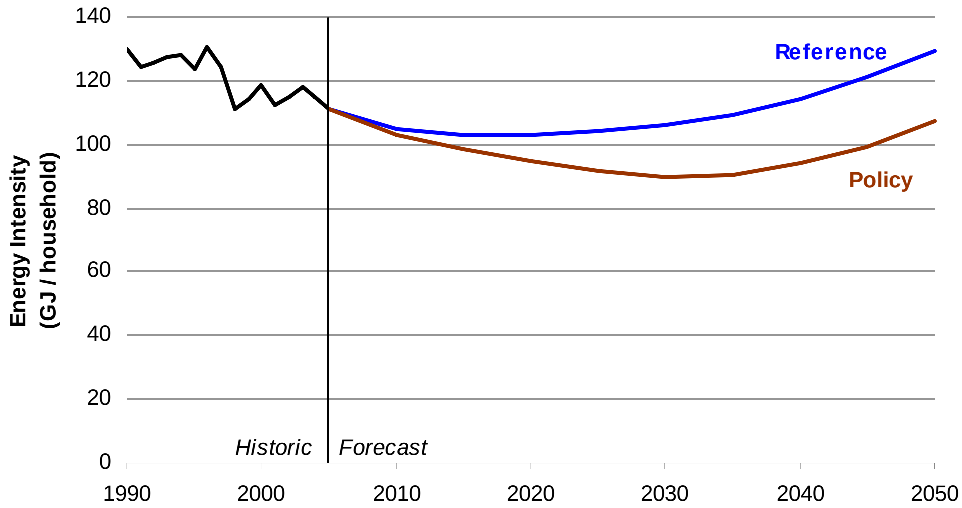
Two main energy end-uses produce almost all residential emissions: space heating accounts for approximately 58% of emissions, and water heating for around 42%. The emissions intensity of water heating is relatively similar across different provinces in Canada, but the emissions associated with space heating vary among provinces and depends largely on two factors. First, provinces with low prices for electricity – especially British Columbia, Manitoba and Québec – have lower greenhouse gas intensity for space heating because of a greater installation of electric baseboards. Second, the demand for space heating varies depending on climate. British Columbia and Ontario are generally warmer and require less space heating over the winter. These factors explain why Alberta, Ontario and Saskatchewan have the highest emissions intensity per unit of space heating.

Environmental impact of policy

The energy and greenhouse gas intensities of the sector in the reference and policy scenarios are shown in Figure 5 and Figure 6. In the reference scenario, energy intensity generally increases while greenhouse gas intensity declines. The increase in energy intensity is largely because of an increase in the energy consumption by miscellaneous appliances (e.g., televisions, cell phones). The forecast for the demand of miscellaneous appliances was estimated from historic data, which show a substantial increase between 1990 and 2005. The increase in energy consumption does not affect greenhouse gas intensity, however, because most miscellaneous appliances consume electricity. Greenhouse gas intensity declines in the reference scenario due mostly to energy efficiency improvements to residential shells and furnaces.

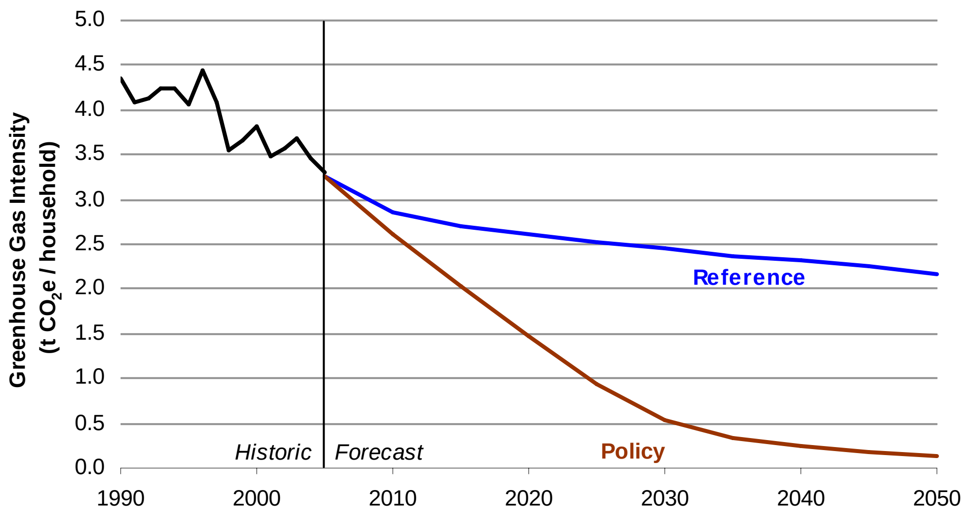
In the policy scenario, greenhouse gas intensity declines by 93% from the reference case projection. The installation of electric baseboards, ground source heat pumps and electric water heaters account for the majority of the decline.

Figure 5: Energy intensity of the residential sector



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

Figure 6: Greenhouse gas intensity of the residential sector



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

The residential sector switches primarily to electricity in response to the policy, most notably from natural gas (see Table 12). Electric baseboards, air and ground source heat pumps, which consume electricity, attain a significant market share by the end of the simulation. The shift away from renewable energy is caused by a decline in biomass space heating, which produces methane emissions.[12]

[12] Environment Canada, 2007, "National Inventory Report".

Table 12: Fuel switching in the residential sector

	2020	2030	2040	2050
Natural Gas	-18%	-32%	-34%	-30%
Electricity	20%	35%	36%	32%
Renewable	-2%	-2%	-1%	-1%

Economic impact of policy

Capital, operating and fuel costs increase with the policy's implementation (Table 13). Energy costs increase most significantly, because the policy encourages fuel switching from natural gas to electricity, which has a higher price per unit of energy produced. The rise in capital costs are more modest because the uptake of electric baseboards by some households – which are cheaper to install than natural gas furnaces – offset the cost of ground source heat pumps installed by other households. Overall, the total increase in cost per household is a fraction of one percent.

Table 13: Increase in the cost of the residential sector[13]

	Increase in Costs (2005$ / household)			
	2020	2030	2040	2050
Total Cost	$305.44	$447.05	$384.49	$366.42
Capital Costs	$73.41	$124.56	$114.38	$118.19
Operating & Maintenance Costs	$4.02	$5.44	$5.01	$5.57
Energy Costs	$228.00	$317.05	$265.10	$242.67

Provincial discussion

In response to the policy, households in all provinces make a shift towards low-emissions systems for space heating, but some provinces show a greater adoption of ground source heat pumps while others show greater penetration of electric baseboards. In Ontario, Alberta and Saskatchewan, 37%, 61% and 33% of households install ground source heat pumps by 2050, respectively. British Columbia, Manitoba, Québec and the Atlantic provinces show greater penetration of electric baseboards. By the end of the policy simulation, the difference in the greenhouse gas intensity of space heating is negligible among provinces (see Table 14).

Table 14: Space heating emissions intensity by province

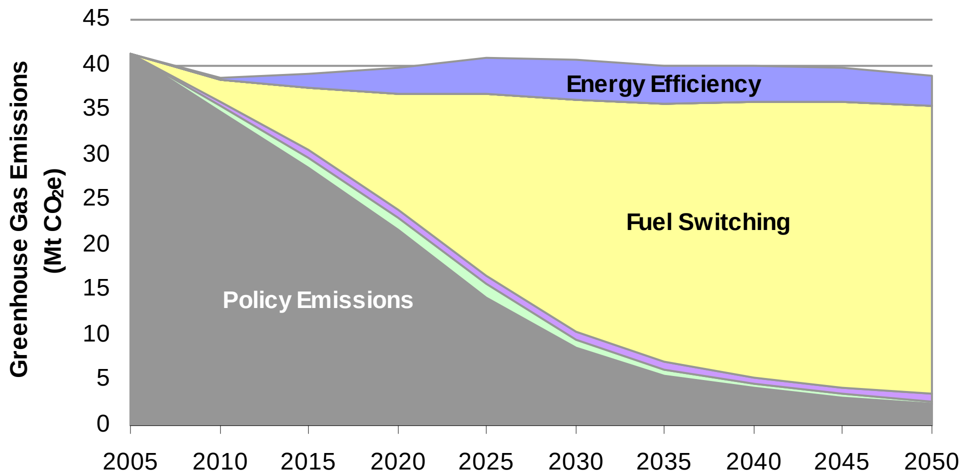
	Space Heating Emissions Intensity in Policy (t CO2e / m2 floorspace)				Increase due to Policy (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
British Columbia	0.004	0.001	0.001	0.000	-34%	-74%	-85%	-89%
Alberta	0.019	0.007	0.002	0.001	-31%	-73%	-92%	-97%
Saskatchewan	0.011	0.003	0.001	0.000	-42%	-82%	-96%	-98%
Manitoba	0.003	0.000	0.000	0.000	-57%	-96%	-99%	-99%
Ontario	0.010	0.004	0.002	0.001	-32%	-70%	-88%	-93%
Québec	0.001	0.000	0.000	0.000	-84%	-96%	-92%	-92%
Atlantic	0.005	0.001	0.000	0.000	-54%	-85%	-96%	-99%

[13] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

Technology roadmap to low emissions in the residential sector

Figure 7 illustrates the actions that contribute to the decline in greenhouse gas emissions in the residential sector. Fuel switching accounts for approximately 83% of the reduction, while energy efficiency (the adoption of ground source heat pumps contributes to energy efficiency in addition to fuel switching to electricity) contributes around 8%.

Figure 7: Wedge diagram for the residential sector



Residential shells show only a modest improvement in the policy scenario. The energy efficiency of building shells improves regardless of the policy – by 2050, residential shells are about 5% more efficient than standard construction in 2005. In the policy scenario, building shells improve slightly to around 8% more efficient than standard practices in 2005 (Table 15).

Table 15: Improvement in residential shells over standard practices in 2005

	2020	*2030*	*2040*	*2050*
Reference Case	0.2%	0.9%	2.4%	4.5%
Policy	0.5%	2.1%	4.8%	7.8%
Increase due to Policy	0.3%	1.2%	2.3%	3.3%

The main action to reduce greenhouse gas emissions in the residential sector is the adoption of electric space heating systems – by 2050 in the policy scenario, over 97% of installed heating systems use electricity (see Table 16). The installation of electric baseboards and ground source heat pumps account for the majority of installations, while air source heat pumps account for the remainder. Water heating also becomes mostly electric in response to the policy (Table 17).

Table 16: Penetration of electric space heating systems

	Technology Penetration (% of total stock)				*Increase due to Policy (%)*			
	2020	*2030*	*2040*	*2050*	*2020*	*2030*	*2040*	*2050*
Electric Baseboards	46%	51%	51%	51%	14%	19%	19%	19%
Air Source Heat Pumps	19%	31%	21%	13%	10%	19%	8%	1%
Ground Source Heat Pumps	0%	6%	22%	33%	0%	6%	21%	29%

Table 17: Penetration of electric water heating systems

	Technology Penetration (% of total stock)				*Increase due to Policy (%)*			
	2020	*2030*	*2040*	*2050*	*2020*	*2030*	*2040*	*2050*
Electric Water Heating	60%	83%	89%	93%	35%	62%	69%	72%

Provinces with higher forecasted electricity prices in the policy scenario – especially Alberta, Saskatchewan, Ontario and the Atlantic provinces – have greater incentives to reduce electricity costs by installing ground source heat pumps (see Table 18). Electric baseboards attain a greater penetration in provinces with lower electricity prices – British Columbia, Manitoba and Québec.

Table 18: Penetration of electric space heating systems by province in 2050

	Electric Baseboards	*ASHP*	*GSHP*
British Columbia	74%	13%	10%
Alberta	13%	10%	76%
Saskatchewan	44%	17%	38%
Manitoba	79%	12%	9%
Ontario	33%	19%	43%
Québec	94%	1%	3%
Atlantic	68%	5%	26%

The policy has a negligible impact on the capital expenditures of the sector (see Table 19). As discussed above, expenditures on ground source heat pumps tend to increase costs, but these are offset by reduced expenditures due to the installation of electric baseboards – which are generally cheaper to install than natural gas furnaces.

Table 19: Increase in capital expenditures in the residential sector

	Medium-Term (2011-2030)	*Long-term (2031-2050)*
Increase in Annual Capital Expenditures (2005$ Millions)	41	-117
Increase in Capital Expenditures (% above the reference case)	0%	0%

Commercial

Box 2: Key actions by the commercial sector

- The commercial sector reduces most of its greenhouse gas emissions through the adoption of electric heating systems – electric baseboards and ground source heat pumps. Ground source heat pumps have a greater adoption in provinces with higher electricity prices in the policy scenario.
- Building shells do not improve substantially in the policy scenario.

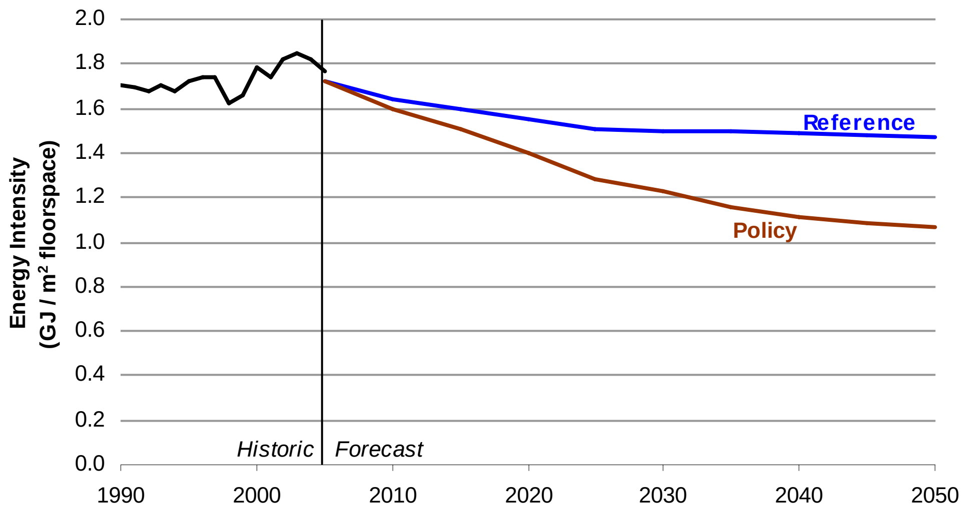
By the end of the simulation period, projected floor space in the commercial sector is expected to more than double, reaching 1,561 million m^2 in 2050. Greenhouse gas emissions mirror this growth and, in the absence of any emissions mitigation policy, increase from 34 Mt CO_2e in 2005 to 66 Mt CO_2e in 2050. Like the residential sector, space conditioning and water heating produce almost all commercial emissions: approximately 75% are attributed to space conditioning and 14% to water heating.

Many of the same factors responsible for provincial differences in the residential sector – differences in energy prices and climate – also influence the commercial sector. However, at the beginning of the simulation greenhouse gas intensity for space conditioning is reasonably similar among the provinces – around 0.05 t CO_2e per m^2 of floorspace for all provinces except British Columbia (which is lower) and Saskatchewan (which is higher).

Environmental impact of policy

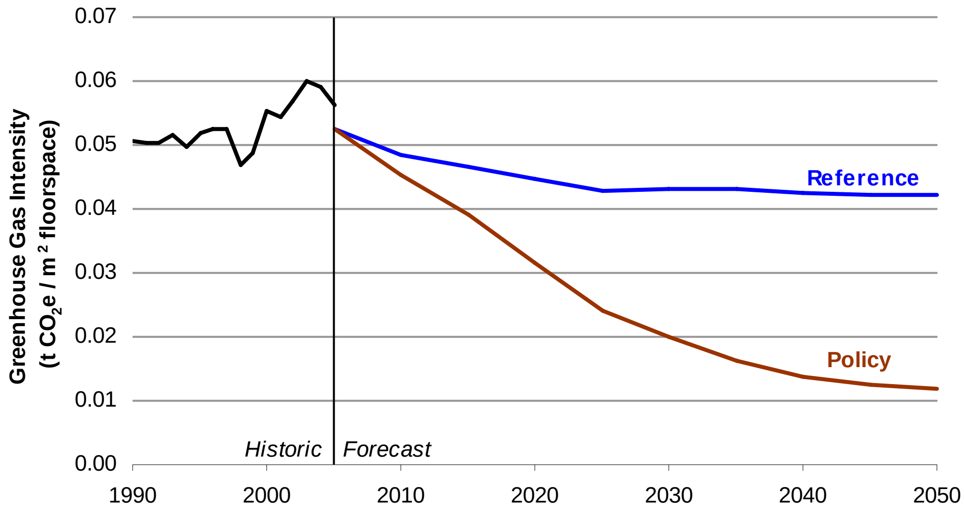
In the absence of any policy, the improvement in energy and greenhouse gas intensity over time is mostly the result of improvements in building shells and the installation of electric heating systems in some provinces. In the policy scenario, the adoption of electric space and water heating systems account for most of the reduction in energy and greenhouse gas intensity. By the end of the policy scenario, energy and greenhouse gas intensity decline by 38% and 70% from the reference case projection (see Figure 8 and Figure 9).

Figure 8: Energy intensity of the commercial sector



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

Figure 9: Greenhouse gas intensity of the commercial sector



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

Similar to the residential sector, the commercial sector switches to electricity in response to the policy, most notably from natural gas (see Table 20). The policy induces a significant penetration of ground source heat pumps, but these actions show up as an increase in electricity consumption, rather than an increase in renewable consumption.

Table 20: Fuel switching in the commercial sector

	2020	2030	2040	2050
Natural Gas	-12%	-24%	-32%	-35%
Electricity	12%	24%	33%	35%

Economic impact of policy

Table 21 shows the increase in capital, operating and fuel costs caused by the policy. Capital costs show the only significant increase because the policy encourages the installation of improved building shells and ground source heat pumps, both of which have higher capital requirements than alternative options. Energy costs decline from the energy efficiency improvements to shells as well as the installation of ground source heat pumps. Overall, the total increase in cost per m^2 of floorspace is a fraction of a percent.

Table 21: Increase in the cost of the commercial sector[14]

	Increase in Costs (2005$ / m^2 floorspace)			
	2020	2030	2040	2050
Total Cost	-$0.20	$0.38	$0.21	$0.07
Capital Costs	-$0.54	$0.27	$0.90	$1.23
Operating & Maintenance Costs	$0.00	$0.00	$0.00	$0.00
Energy Costs	$0.34	$0.11	-$0.69	-$1.15

[14] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

Provincial discussion

Similar to the residential sector, all provinces make a policy-induced shift towards more energy efficient building shells and electric space conditioning systems. In Ontario, Alberta and Saskatchewan, higher prices for electricity in the policy scenario encourage the adoption of ground source heat pumps, which meet most of the demand for space heating by 2050. British Columbia, Manitoba and Québec, which have lower electricity prices in the policy scenario, favor electric baseboards for space heating. Though technology choices differ, by 2050 at least 90% of installed heating systems in all provinces are either electric baseboard or ground source heat pumps, and the greenhouse gas intensity of space heating reaches approximately the same level in all provinces (see Table 22).

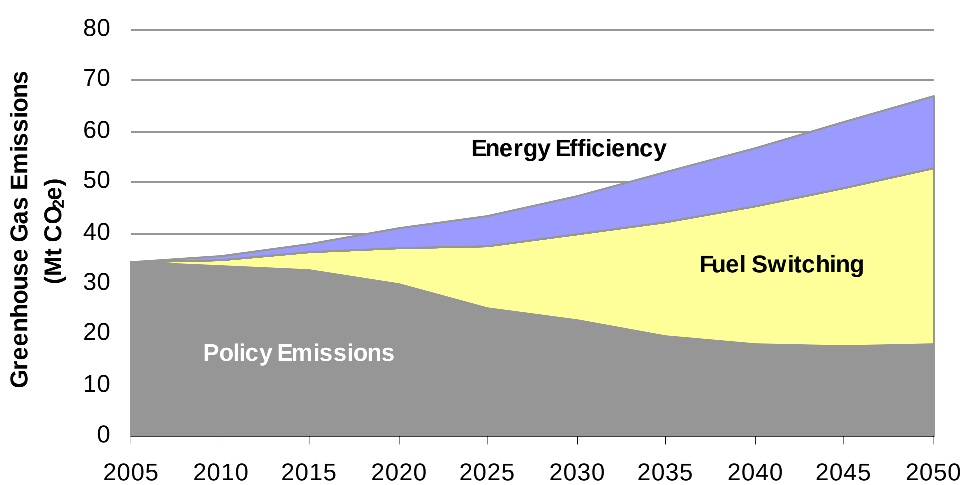
Table 22: Space conditioning emissions intensity by province

	Space Conditioning Emissions Intensity in Policy (t CO2e / m2 floorspace)				*Increase due to Policy (%)*			
	2020	*2030*	*2040*	*2050*	*2020*	*2030*	*2040*	*2050*
British Columbia	0.017	0.011	0.008	0.008	-27%	-49%	-61%	-63%
Alberta	0.029	0.019	0.011	0.008	-32%	-57%	-74%	-80%
Saskatchewan	0.036	0.023	0.015	0.013	-27%	-49%	-65%	-70%
Manitoba	0.015	0.008	0.007	0.007	-28%	-46%	-47%	-47%
Ontario	0.029	0.019	0.010	0.007	-31%	-55%	-75%	-82%
Québec	0.015	0.008	0.007	0.007	-25%	-40%	-38%	-33%
Atlantic	0.027	0.017	0.010	0.007	-32%	-57%	-76%	-81%

Technology roadmap to low emissions in the commercial sector

Two key actions contribute to the decline in greenhouse gas emissions in the commercial sector. Fuel switching accounts for approximately 70% of the reduction in greenhouse gas emissions, while energy efficiency actions account for around 30% (Figure 10). Some actions, such as the adoption of ground source heat pumps, contribute to both improvements in energy efficiency and fuel switching to electricity.

Figure 10: Wedge diagram for the commercial sector



The policy does not induce significant improvements in building shells (see Table 23). By 2050 in the reference case, the average building shell is around 8% more efficient than standard construction in 2005; in the policy scenario, the average shell shows a small improvement of 1%.

Table 23: Improvement in commercial shells over standard practices in 2005

	2020	*2030*	*2040*	*2050*
Reference Case	1.9%	4.4%	6.4%	7.8%
Policy	2.6%	5.6%	7.7%	8.9%
Increase due to Policy	0.8%	1.2%	1.3%	1.1%

The main action that reduces the greenhouse gas emissions from the commercial sector is the adoption of electric heating systems. By 2050, heating systems have almost been completely decarbonized, with electric baseboards and ground source heat pumps accounting for 97% of installed systems.

Table 24: Penetration of commercial space-heating systems

	Technology Penetration (% of total stock)				*Increase due to Policy (%)*			
	2020	*2030*	*2040*	*2050*	*2020*	*2030*	*2040*	*2050*
Electric Furnaces	35%	42%	40%	36%	16%	24%	23%	20%
Ground Source Heat Pumps	16%	33%	52%	61%	10%	24%	41%	50%

Table 25 shows the penetration for electric furnaces and ground source heat pumps by province. British Columbia, Manitoba, Québec and the Atlantic provinces favor the installation of electric furnaces. Alberta, Saskatchewan and Ontario adopt a greater number of ground source heat pumps (GSHP) due, mostly, to higher electricity prices.

Table 25: Penetration of heating systems by province

	Electric Furnaces	*GSHP*
British Columbia	94%	4%
Alberta	32%	63%
Saskatchewan	11%	87%
Manitoba	53%	47%
Ontario	8%	89%
Québec	59%	41%
Atlantic	71%	23%

Capital expenditures by the commercial sector increase modestly in response to the policy (see Table 26). The decline in expenditures in the medium-term is mostly due to a greater penetration of electric baseboards, which have lower installation costs. In the long-term, capital expenditures increase due to the uptake of ground source heat pumps in many provinces.

Table 26: Increase in capital expenditures in the commercial sector

	Medium-Term (2011-2030)	*Long-term (2031-2050)*
Increase in Annual Capital Expenditures (2005$ Millions)	-136	642
Increase in Capital Expenditures (% above the reference case)	-1%	2%

Transportation

Box 3: Key actions by the transportation sector

- The majority of emissions reductions are attained by fuel switching to electricity and renewable fuels (i.e., ethanol and biodiesel).
- By 2050 in the policy scenario, most passenger vehicles (85%) are plug-in hybrids.
- The policy causes significant increases in freight transport by rail, which has lower energy and greenhouse gas intensity per tonne of freight traveled. The policy also causes increases in passenger travel by transit.

Transportation is the largest contributor to Canada's greenhouse gas emissions by 2050, accounting for 310 Mt CO_2e and representing approximately 28% of total emissions.[15] Within the transportation sector, several end-uses contribute to greenhouse gas emissions, of which the most significant are passenger vehicles and road freight transportation. Passenger vehicles and road freight are each forecasted to produce approximately 40% of the transportation sector's emissions in 2050. Domestic aviation and domestic marine freight account for most of the remaining emissions.

The provincial differences in the transportation sector are relatively minor in comparison to other sectors, so we ignore them in this section. The key difference among provinces is that coastal provinces have marine freight transportation, whereas in-land provinces do not.

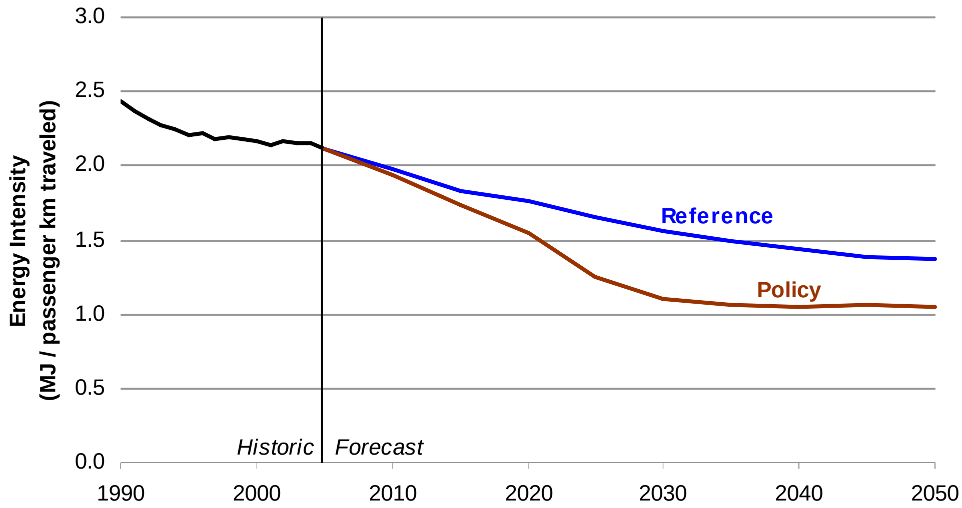
Environmental impact of policy

In the reference case, the decline in energy and emissions intensity is mostly the result of improvements to the energy efficiency of passenger vehicles (see Figure 11 and Figure 12). Energy efficiency of passenger vehicles increases due to improvements in engines (e.g., supercharged and turbo charged engines), as well as the adoption of hybrid cars, which account for 60% of the passenger vehicle stock in 2050.

After the policy's implementation, the energy and greenhouse gas intensity of passenger transportation decline by 23% and 68% from the reference case projection. The decline in emissions intensity is largely the result of a more rapid adoption of hybrid cars in the medium-term, and the adoption of plug-in hybrid vehicles and the consumption of biofuels (ethanol and biodiesel) in the long-term.

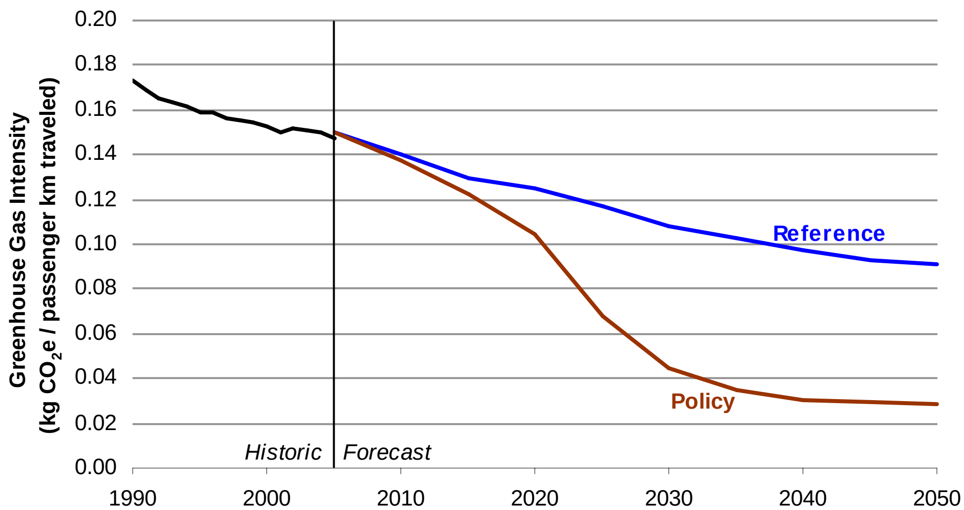
[15] The transportation sector excludes pipelines, which are accounted for in the fossil fuel extraction industries.

Figure 11: Energy intensity of personal transportation



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

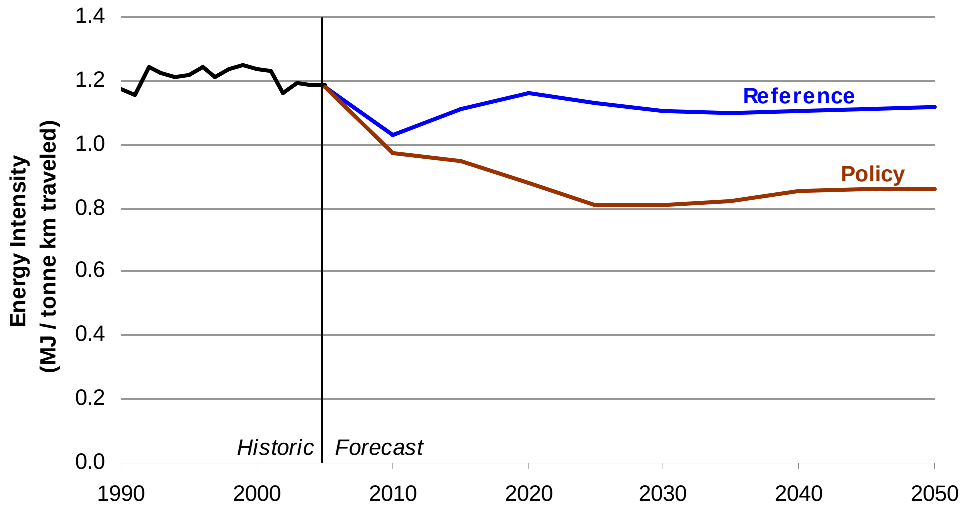
Figure 12: Greenhouse gas intensity of personal transportation



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

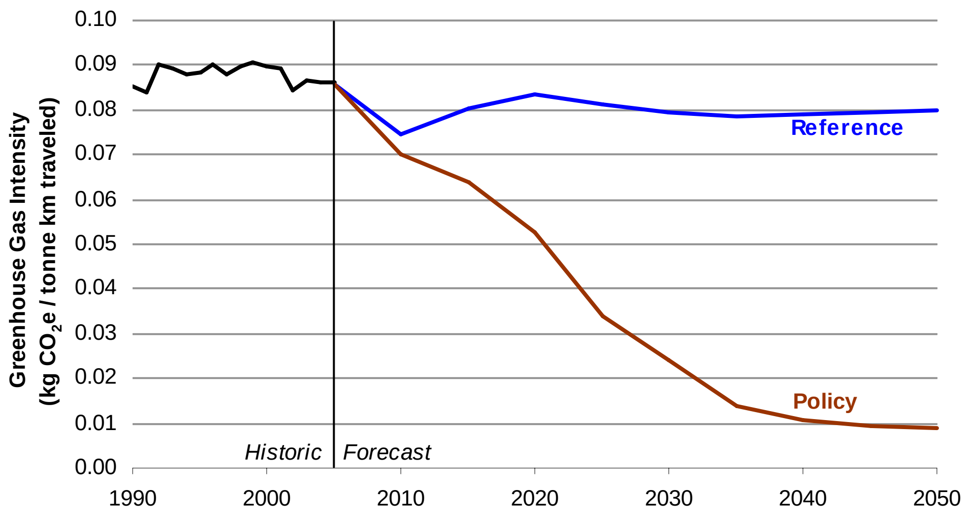
For freight transportation, energy and greenhouse gas intensity decline in the reference case, but less significantly than in the personal transportation sector (Figure 13 and Figure 14). In the policy scenario, the energy and greenhouse gas intensity of freight transportation decline from the reference case projection by 23% and 90%, respectively. The decline in emissions intensity is mostly the result of converting the road freight fleet to biodiesel, and a shift towards more transport by rail.

Figure 13: Energy intensity of freight transportation



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

Figure 14: Greenhouse gas intensity of freight transportation



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

The fuel share of refined petroleum products declines as a result of the policy, and the share of electricity and renewable fuels increases (Table 27). The increase in electricity consumption results mainly from the adoption of plug-in hybrid vehicles, which attain significant market shares by 2050.

Table 27: Fuel switching in transportation

	2020	*2030*	*2040*	*2050*
Refined Petroleum Products	-9%	-47%	-66%	-68%
Electricity	2%	9%	10%	10%
Renewable	7%	38%	55%	57%

Economic impact of policy

The costs of personal transportation decline by $12 per thousand person kilometer traveled, a 6% decrease (Table 28). The policy induces people to purchase smaller passenger vehicles and, to a lesser extent, to take public transit; therefore reducing the costs of personal transportation. The costs of freight transportation decline by approximately 6% in the policy scenario, mostly from a shift towards rail transport (Table 29). We note that the decline in the financial costs of passenger transportation does not reflect the full welfare cost caused by the policy, because it does not account for consumer preferences. Additionally, the decline in freight costs may be offset by rises in other costs (e.g., warehousing).

Table 28: Increase in the cost of passenger transportation[16]

	Increase in Costs (2005$ / '000 pkt)			
	2020	*2030*	*2040*	*2050*
Total Cost	-$16.51	-$24.05	-$13.56	-$12.00
Capital Costs	-$7.73	-$9.38	-$4.84	-$4.62
Operating & Maintenance Costs	-$4.36	-$5.42	-$3.61	-$3.51
Energy Costs	-$4.42	-$9.25	-$5.11	-$3.87

Table 29: Increase in the cost of freight transportation

	Increase in Costs (2005$ / '000 tkt)			
	2020	*2030*	*2040*	*2050*
Total Cost	-$15.25	-$12.14	-$4.45	-$4.46
Capital Costs	-$4.12	-$4.15	-$2.63	-$2.64
Operating & Maintenance Costs	-$5.86	-$5.60	-$4.71	-$5.10
Energy Costs	-$5.27	-$2.39	$2.89	$3.28

Technology roadmap to low emissions in transportation

The key actions that reduce emissions are fuel switching to renewables and electricity, and improvements in energy efficiency (see Figure 15). These actions account for 205 Mt CO_2e and 40 Mt CO_2e of emissions reductions in 2050, respectively.

16 The table does not show emissions costs, because all emissions costs are recycled back to the sector.

Figure 15: Wedge diagram for personal and freight transportation

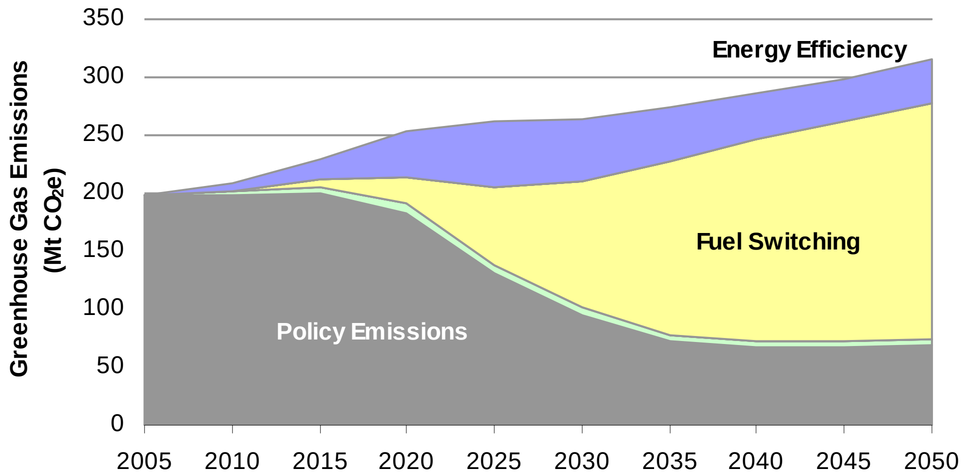


Table 30 shows the penetration of low- and zero-emissions passenger vehicles in the policy scenario and the increase relative to the reference case (i.e., a technology's penetration in policy minus its penetration in the reference case). The first response to the policy is that consumers begin purchasing hybrid vehicles. At the beginning of the policy simulation (up to 2030), the penetration of hybrid vehicles exceeds its penetration in the reference case, indicating that consumers select hybrid vehicles to reduce their emissions in the medium-term. By the end of the simulation, plug-in hybrids account for 83% of the passenger vehicle stock, while the penetration of hybrid vehicles is lower than its penetration in the reference case. Hybrid vehicles are likely transition technologies that enable manufacturers to accumulate experience with battery vehicles, and eventually apply that learning to develop plug-in hybrid vehicles.

Table 30: Penetration of low- and zero-emission passenger vehicles

	Technology Penetration (% of total Stock)				*Increase due to Policy (%)*			
	2020	*2030*	*2040*	*2050*	*2020*	*2030*	*2040*	*2050*
Hybrid	3%	6%	11%	12%	2%	3%	-14%	-29%
Plug-in Hybrid	6%	18%	21%	21%	6%	10%	7%	6%
Plug-in Hybrid Ethanol	7%	51%	62%	62%	7%	50%	60%	59%

By 2050, the policy induces a 3% increase in the occupancy of passenger vehicles and a 14% increase in transit ridership (Table 31). The increase in transit ridership and vehicle occupancy peaks in 2030 and declines thereafter due to two factors. First, the emissions costs of driving a passenger vehicle are greater in 2030 because the stock of vehicles is more greenhouse gas intensive. By 2050, the vehicle stock produces fewer greenhouse gases per kilometre traveled and driving increases. Second, the cost of purchasing low- and zero-emissions vehicles declines over the policy simulation as manufacturers accumulate experience with these vehicles. By 2050, the purchase cost of a low or zero-emission vehicle is lower than it was in 2030.

Table 31: Mode switching in personal transportation

	Mode Penetration				Increase due to Policy (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
Vehicle Occupancy (people per car)	2.3	2.3	2.3	2.2	5%	6%	4%	3%
Transit Ridership (billion pkm)	29.5	36.0	37.4	40.8	26%	27%	16%	14%

In freight transportation, the key actions that reduce greenhouse gas emissions are fuel switching to biodiesel in the road freight sector, and an increase in rail travel. By 2050 in the policy scenario, almost all freight trucks consume biodiesel instead of refined petroleum products (see Table 32). Rail transport increases in response to the policy – by 2050, rail freight accounts for about 70% of all freight transport (see Table 33).

Table 32: Fuel share for biodiesel among freight trucks

	Technology Penetration (% of total Stock)				Increase due to Policy (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
Biodiesel fuel share	20%	72%	96%	97%	20%	72%	96%	97%

Table 33: Freight transport by mode

	Technology Penetration (tonnes km traveled)				Increase due to Policy (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
Rail Freight	576	701	801	930	23%	19%	18%	20%
Truck Freight	194	211	312	379	-46%	-47%	-38%	-40%

Table 34 shows the increase in capital expenditures required to attain the reductions in the transportation sector. Capital expenditures decline in response to the policy for three reasons. First, the policy encourages consumers to adopt smaller vehicles and, to a lesser extent, to take public transit, which have lower capital requirements per unit of passenger travel. Second, the freight industry ships a greater portion of freight using rail, which also reduces capital expenditures. Third, the amount of freight travel declines, therefore reducing capital expenditures.

Table 34: Increase in capital expenditures in transportation

	Medium-Term (2011-2030)	Long-term (2031-2050)
Increase in Annual Capital Expenditures (2005$ Millions)	-8,414	-6,892
Increase in Capital Expenditures (% above the reference case)	-12%	-7%

Uncertainty in the analysis

The emissions reductions from the transportation sector are largely dependent on the availability of biofuels. The uncertainty associated with availability of renewable fuels is discussed in the section on biofuels. If biofuels are not available in the quantities required to attain deep reductions in the transportation sector, other fuels, such as hydrogen, may play a more prominent role in the sector.

Chemical products manufacturing

Box 4: Key actions by the chemical products sector

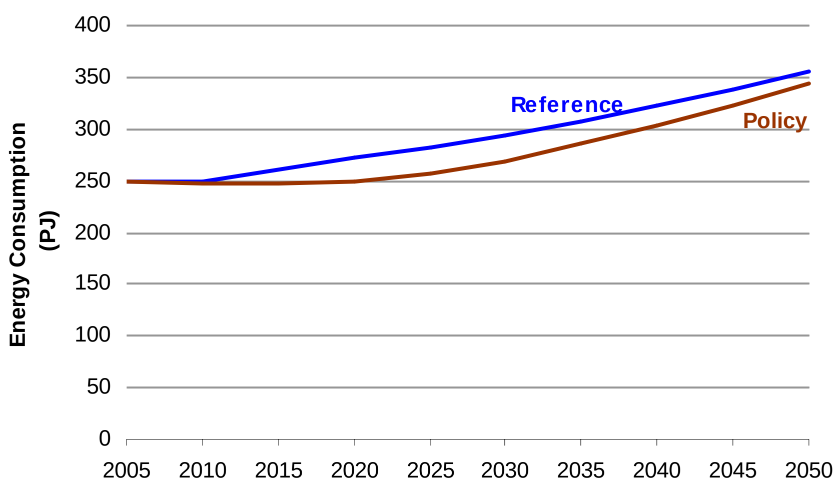
- Ammonia manufacturing produces a relatively pure stream of carbon dioxide, offering substantial opportunity for the rapid penetration of carbon capture and storage. As early as 2020 in the policy scenario, 67% of ammonia production employs carbon capture.

Greenhouse gas emissions from the chemicals manufacturing sector were 11 Mt CO_2e in 2005 and are forecasted to rise to 16 Mt CO_2e by 2050. Alberta and Ontario account for 75% and 20% of greenhouse emissions from the sector, respectively. The remaining 5% of emissions originate from British Columbia and Québec. The production of process heat required in petrochemical manufacturing and process emissions from ammonia manufacturing are expected to be the largest sources of emissions.

Environmental impact of policy

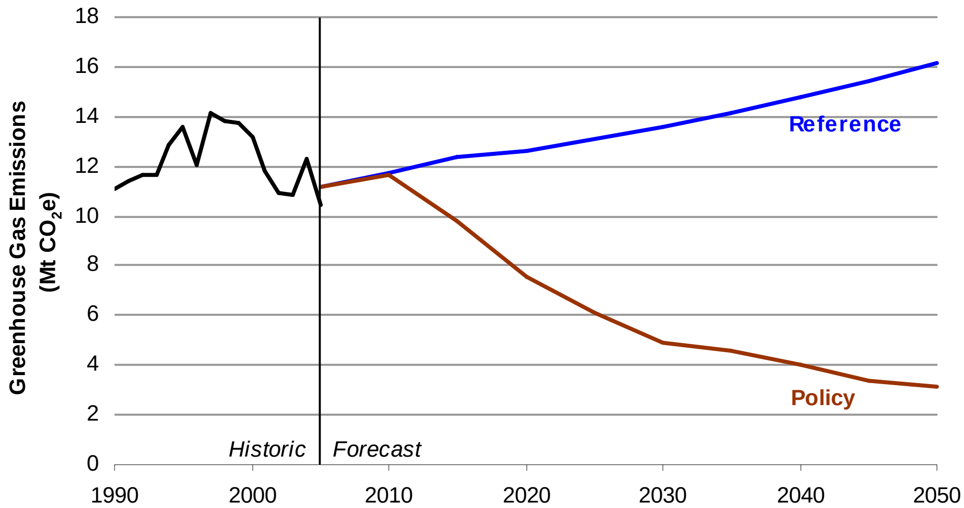
The chemicals manufacturing sector consumed 249 PJ in 2005, and in the reference scenario, consumption rises to 355 PJ in 2050, an increase of 42% (see Figure 16). Energy consumption is only slightly lower in the policy scenario, reaching 349 PJ in 2050. Energy efficiency improvements are outweighed by carbon capture and storage, which requires additional energy consumption.

Figure 16: Energy consumption from chemicals manufacturing



Greenhouse gas emissions also increase steadily in the reference scenario, from 11 Mt CO_2e in 2005 to 16 Mt CO_2e in 2050 (Figure 17). However, in the policy scenario the emissions drop sharply after 2015, reaching 3.4 Mt CO_2e in 2050. The dominant action responsible for decreasing emissions is carbon capture and storage associated with the production of ammonia and process heat.

Figure 17: Greenhouse gas emissions from chemicals manufacturing



Source: Historic data for combustion greenhouse gas emissions are from NRCan, 2008, "Comprehensive Energy Use Database"; historic data for process emissions are from Environment Canada, 2007, "National Inventory Report"

In response to the policy, natural gas consumption declines in favor of electricity (see Table 35). Coal consumption shows a modest increase due to its potential to be combusted in boilers using carbon capture and storage.

Table 35: Fuel switching in chemicals manufacturing

	2020	*2030*	*2040*	*2050*
Natural Gas	-9%	-14%	-15%	-15%
Coal	3%	3%	2%	1%
Refined Petroleum Products	0%	0%	0%	0%
Electricity	6%	11%	13%	14%
Renewable	0%	0%	0%	0%

Economic impact of policy

Table 36 shows the increase in the cost of chemicals manufacturing that results from the policy. Energy costs increase most significantly due to a greater consumption of electricity, which is more costly per unit of energy. Overall, total costs are $22.18 per tonne higher in 2050 than in the reference scenario, an increase of 2.6%.

Table 36: Increase in the cost of chemicals manufacturing[17]

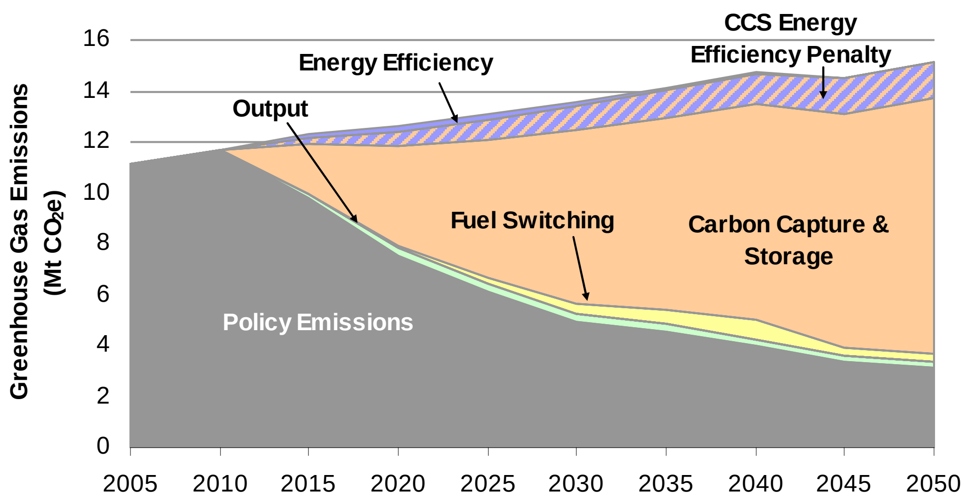
	Increase in Costs (2005$ / tonne product)			
	2020	*2030*	*2040*	*2050*
Total Cost	$7.70	$16.05	$19.26	$22.18
Capital Costs	$1.48	$2.63	$2.98	$3.20
Operating & Maintenance Costs	$3.39	$4.28	$4.56	$4.68
Energy Costs	$2.83	$9.14	$11.73	$14.29

[17] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

Technology roadmap to low emissions in chemicals manufacturing

In 2050, the policy induces a 13 Mt CO_2e reduction in the greenhouse gas emissions from the chemicals manufacturing sector. Carbon capture and storage is responsible for the majority of emissions reductions, while fuel switching and a modest decline in output contribute to the remaining reductions (see Figure 18).

Figure 18: Wedge diagram for chemicals manufacturing



The adoption of carbon capture and storage in ammonia production may be an early opportunity for experimenting with the technology. Hydrogen production for ammonia manufacturing can be designed or retrofitted to produce a relatively pure stream of carbon dioxide, therefore avoiding the process of separating the carbon dioxide from other flue gases, which is considered the most costly process involved in carbon capture and storage. The Intergovernmental Panel on Climate Change estimates the cost of carbon capture associated with ammonia production to be between \$5 and \$55 (USD) / tonne CO_2e.[18] In addition, the majority of ammonia production occurs in Alberta (90%), which has significant potential for the geologic storage of carbon dioxide.[19]

Table 37 shows the penetration of carbon capture and storage in ammonia production and process heat generation. By 2050 in the policy scenario, 67% of ammonia production occurs in facilities using carbon capture and storage, rising to virtually 100% by 2040. The penetration of carbon capture and storage is less rapid in process heat generation, reaching 66% in 2050.

Table 37: Penetration of carbon capture and storage in chemicals manufacturing

	2020	*2030*	*2040*	*2050*
Ammonia Production	67%	93%	98%	99%
Process Heat Generation	12%	38%	52%	66%

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[18] Intergovernmental Panel on Climate Change, 2005, “Carbon Dioxide Capture and Storage”.

[19] ecoENERGY Carbon Capture and Storage Task Force, 2008, “Canada’s Fossil Energy Future,” http://www.energy.gov.ab.ca/Org/pdfs/Fossil_energy_e.pdf

Capital expenditures decrease in the policy scenario due to a modest decline in output (output declines by 3% relative to the reference scenario in 2050). The decline in output offsets the increase in capital expenditures due to the adoption of carbon capture and storage (see Table 38).

Table 38: Increase in capital expenditures in chemical manufacturing

	Medium-Term (2011-2025)	*Long-term (2026-2050)*
Increase in Annual Capital Expenditures (2005$ Millions)	-7	-1
Increase in Capital Expenditures (% above the reference case)	-1%	0%

Uncertainty in the analysis

This analysis does not consider the potential to reduce emissions from adipic or nitric acid production, which contributed to 1.4 Mt CO_2e in 2005. A variety of abatement technologies are currently available that can reduce the majority of these emissions.[20]

Cement and lime manufacturing

Box 5: Key actions by the cement and lime manufacturing sector

- Most emissions reductions are attained through the adoption of carbon capture and storage.

In the absence of any mitigation policy, greenhouse gas emissions from cement and lime manufacturing are expected to rise from 15 Mt CO_2e in 2005 to 30 Mt CO_2e in 2050; by the end of the simulation period, the cement and lime sectors account for approximately 3% of Canada's total greenhouse gas emissions. Almost all greenhouse gases are emitted during the operation of the cement and lime kilns, which require process heat to decompose calcium carbonate ($CaCO_3$) into lime (CaO). The calcination process also produces carbon dioxide in amounts that typically exceed the emissions generated through combustion alone. In the reference case scenario, coal combustion meets most of the demand for process heat.

Cement and lime manufacturing is relatively similar in all provinces, so we omit any provincial discussion.

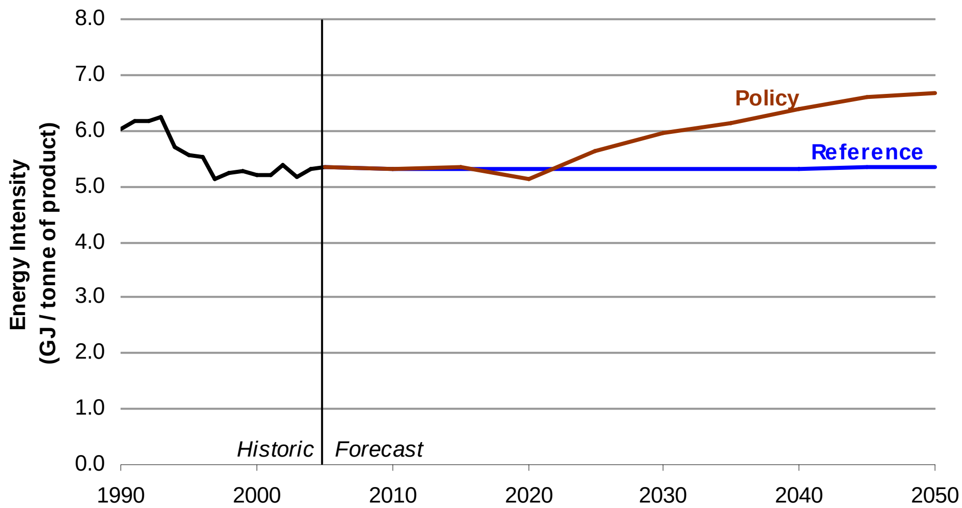
Environmental impact of policy

In the reference case, both the energy and greenhouse gas intensity remain stable because we project few opportunities for improvement in energy efficiency (see Figure 19 and Figure 20). In the policy scenario, energy intensity initially drops, but then increases as these sectors begin to adopt carbon capture and storage. The early decline is due mostly to a greater decline in the output of the lime sector relative to the cement sector, which is less energy intensive. Therefore, this decline does not represent a substantial improvement in the energy efficiency of the cement or lime sectors. By the end of the

[20] Environment Canada, 2008, "National Inventory Report"; Mainhardt & Kruger, 2008, "N_2O Emissions from Adipic Acid and Nitric Acid Production," http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/3_2_Adipic_Acid_Nitric_Acid_Production.pdf

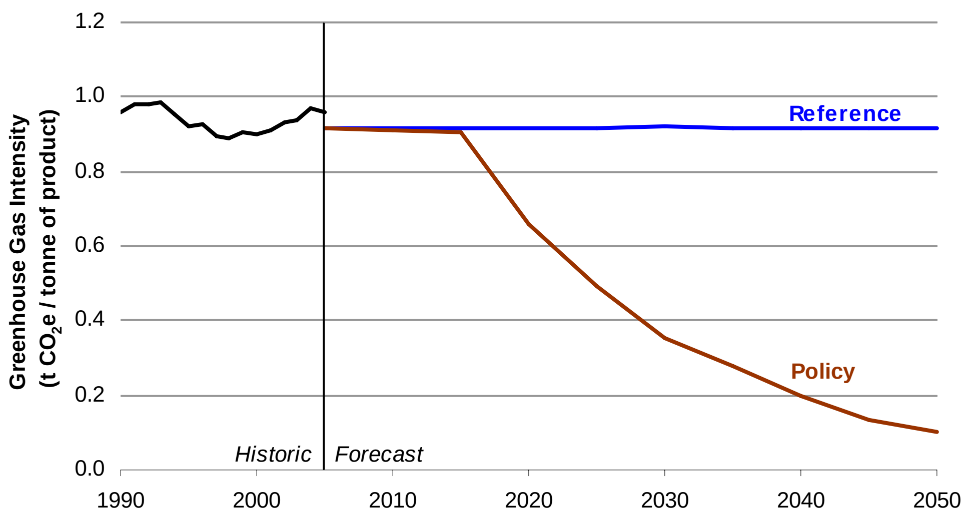
simulation period, the energy intensity of these sectors increases as they adopt carbon capture and storage. The greenhouse gas intensity of cement and lime manufacturing declines by 89% in the policy scenario.

Figure 19: Energy intensity of cement and lime manufacturing



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

Figure 20: Greenhouse gas intensity of cement and lime manufacturing



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

By 2050, the sector increases its use of natural gas to provide the process heat for kiln operations, and it reduces its consumption of coal and petroleum products (mostly petroleum coke). The increase in electricity consumption is due to the electricity requirements for operating the carbon capture equipment (see Table 39).

Table 39: Fuel switching in cement and lime manufacturing

	2020	2030	2040	2050
Natural Gas	14%	32%	28%	24%
Coal	8%	-7%	-3%	1%
Petroleum Products	-23%	-28%	-29%	-29%
Electricity	3%	5%	6%	6%
Other	-1%	-2%	-2%	-2%

Economic impact of policy

The cost of producing cement and lime rises by approximately $34 per tonne by 2050 in response to the policy, an 11% increase from the reference case projection (Table 40). Capital and energy expenditures account for the greatest portion of the increase in costs because carbon capture increases the capital and energy requirements of producing a unit of cement or lime. Fuel switching to natural gas from coal adds to the increase in energy costs, because it is relatively more costly per unit of energy.

Table 40: Increase in the cost of cement and lime manufacturing[21]

	Increase in Costs (2005$ / tonne of cement or lime)			
	2020	2030	2040	2050
Total Cost	$11.24	$28.11	$32.32	$33.62
Capital Costs	$6.05	$11.24	$13.19	$13.40
Operating & Maintenance Costs	-$0.55	-$0.66	-$0.74	-$0.80
Energy Costs	$5.75	$17.53	$19.87	$21.01

Technology roadmap to low emissions in cement and lime manufacturing

Figure 21 shows the actions that contribute to the decline in greenhouse gas emissions for the cement and lime sector. In 2050, carbon capture and storage accounts for 70% of the emissions reductions, while fuel switching to natural gas and the decline in output each account for 15%.

[21] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

Figure 21: Wedge diagram for cement and lime manufacturing

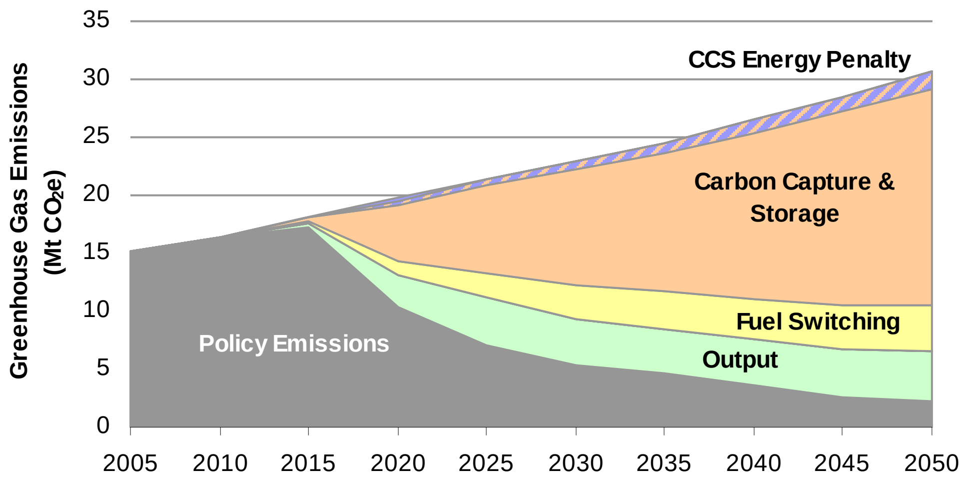


Table 41 illustrates the penetration of carbon capture in the cement and lime manufacturing sectors. The penetration in the cement industry is more rapid than in the lime industry because lime kilns are often smaller point-sources of greenhouse gas emissions. Therefore, the cost of pipeline construction is likely to be more expensive for the lime industry – the capital cost of building the pipeline is roughly the same, but it transports less carbon dioxide. By 2050, most lime and cement facilities in Canada employ carbon capture.

Table 41: Penetration of carbon capture and storage in cement and lime manufacturing

	2020	*2030*	*2040*	*2050*
Lime	11%	35%	68%	99%
Cement	48%	59%	85%	99%

Capital expenditures by the sector generally decline in response to the policy due to the decline in output (Table 42). The decline in output offsets the increase in capital expenditures from adopting carbon capture equipment.

Table 42: Increase in capital expenditures in cement and lime manufacturing

	Medium-Term (2011-2030)	*Long-term (2031-2050)*
Increase in Annual Capital Expenditures (2005$ Millions)	-227	-425
Increase in Capital Expenditures (% above the reference case)	-38%	-52%

Uncertainty in the analysis

Adding cementitious material (e.g., iron and steel blast furnace slag, pozzolanic earths or fly ash) to the ground clinker would reduce emissions intensity of the final product (ground clinker or the final end product, cement), and may be the initial response to any reduction technique in the cement industry. Adding cementitious material is not included in our analysis because the amount of cementitious material that can be added to cement is both regulated by government and limited by physical constraints. However, adding cementious material may enable the sector to attain appreciable emissions reductions at little additional cost.

This analysis shows a significant decline in output from the sector as a result of the policy's implementation. In our analysis, we have assumed that Canada remains an open economy and that many developing countries do not take the same efforts to reduce greenhouse gas emissions. As a result, the cement industry may have an incentive to move production overseas to a country with lower constraints on greenhouse gas emissions. We have not examined how policies can prevent the displacement of these industries.[22]

Iron and steel manufacturing

Box 6: Key actions by the iron and steel sector

- Most emissions reductions are attained through the adoption of carbon capture and storage.

Greenhouse gas emissions from the iron and steel manufacturing sector increase modestly in the reference case, from 15 Mt CO_2e in 2005 to 17 Mt CO_2e in 2050. In 2050, the iron and steel sector is projected to contribute 2% of Canada's total greenhouse gas emissions.

Steel can be produced in integrated steel mills or in mini-mills using electric arc furnaces. Integrated steel mills produce virgin steel from raw materials and are projected to contribute to approximately 51% of the sector's steel and 85% of the sector's greenhouse gas emissions by 2050. Currently, these mills produce steel using three energy and emissions-intensive processes. First, the production of metallurgical coke, used to reduce iron ore to pig iron, requires process heat to bake coal in an airless chamber. In the blast furnace, which is responsible for approximately 70% of an integrated steel mill's greenhouse gas emissions, the coke is ignited at high temperature to produce carbon monoxide. The carbon monoxide strips oxygen from the iron ore to generate pig iron and carbon dioxide. Most of the remaining carbon monoxide within the flue gas is captured and used as fuel elsewhere in the plant. Steel is produced in the final phase, where high purity oxygen is passed over the molten iron to remove any excess carbon. The oxygen reacts with the carbon to produce carbon dioxide or carbon monoxide, which is again captured and used for fuel elsewhere in the plant.[23]

Electric arc furnaces in mini-mills, which produce recycled steel, are expected to account for 49% of the sector's steel and 5% of its greenhouse gas emissions. By 2050, electric arc steel-making is much less energy and emissions intensive because it avoids the coking, blast furnace and basic oxygen furnace processes. It also uses electricity as the main source of energy, which does not produce direct greenhouse gas emissions. Some process emissions are generated as the carbon anodes oxidize, which are used to deliver

[22] For information on policies to prevent the displacement of industries overseas, see Fischer C., Fox A., 2007, "Comparing policies to combat emissions leakage: Border tax adjustments versus rebates".

[23] Environmental Protection Agency, 1995, "AP-42", http://www.epa.gov/ttn/chief/ap42/; Intergovernmental Panel on Climate Change, 2005, "Carbon Dioxide Capture and Storage".

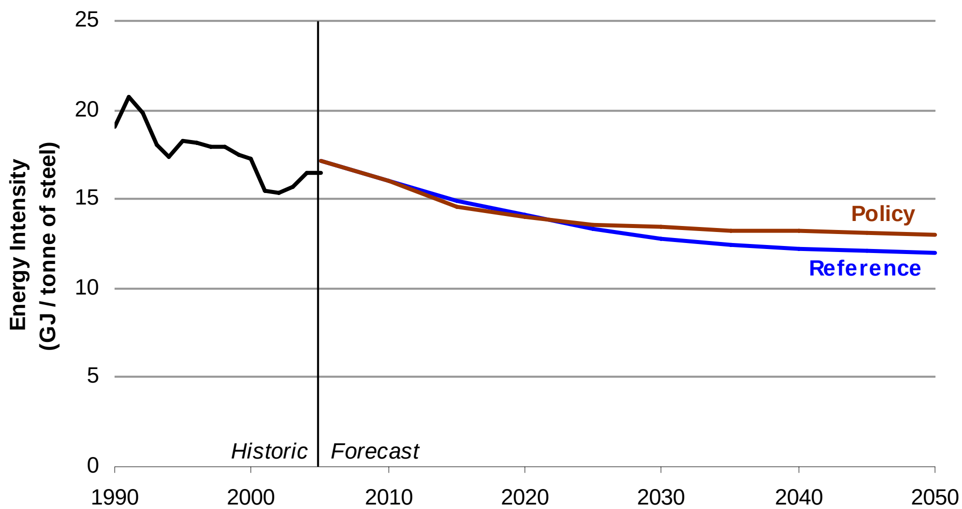
electricity to the mass of steel. Fossil fuels may also be injected into the furnaces to purify the metals.

Environmental impact of policy

Energy and greenhouse gas intensity decline in the reference case, largely due to an increase in production from electric arc furnaces, which rises from 36% of Canada's total steel output in 2005 to 49% in 2050 (Figure 22 and Figure 23). However, the energy and emissions intensity of both integrated mills and mini-mills decline in the reference case.

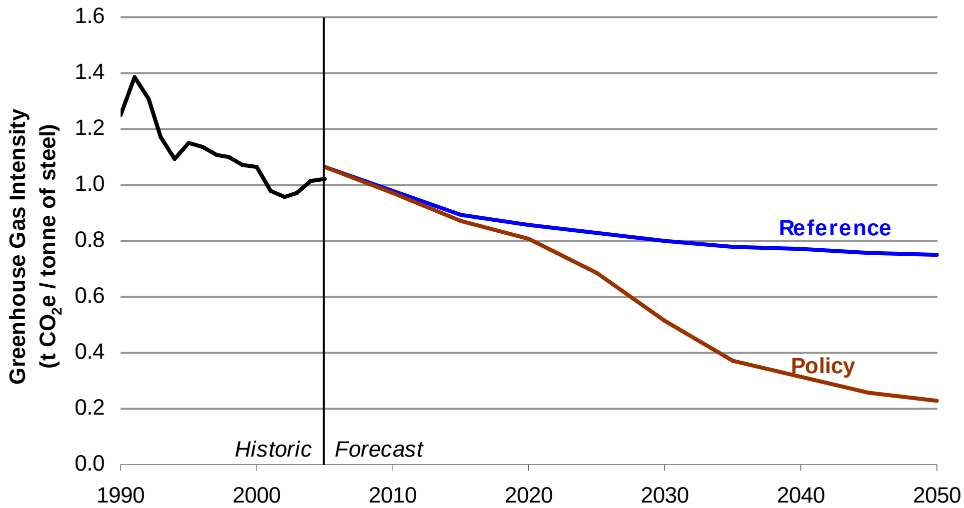
In the policy scenario, steel manufacturing becomes more energy intensive as a result of the energy penalty associated with carbon capture and storage. The increase in energy intensity caused by carbon capture and storage offsets any other improvements in energy efficiency, such as the adoption of the COREX® process in integrated steel making (which reduces the input of coal). Greenhouse gas intensity is projected to be 70% lower in the policy scenario projection (0.24 tonne CO_2e per tonne of steel) than in the reference case.

Figure 22: Energy intensity of iron and steel manufacturing



Source: Historic data are from CIEEDAC, 2008, "Database on Energy, Production and Intensity Indicators for Canadian Industry"

Figure 23: Greenhouse gas intensity of iron and steel manufacturing



Source: Historic data are from CIEEDAC, 2008, "Database on Energy, Production and Intensity Indicators for Canadian Industry"

Table 43 shows changes in fuel shares that result from the policy's implementation. The sector shows minor fuel switching to electricity from coal, refined petroleum products and natural gas. Many energy inputs into iron and steel making are not flexible because they are part of the production process – metallurgical coal is required to reduce iron ore into pig iron. The modest increase in electricity consumption is mostly from the electricity requirements of capturing the carbon dioxide.

Table 43: Fuel switching in iron and steel manufacturing

	2020	2030	2040	2050
Natural Gas	-1%	1%	1%	2%
Coal	1%	-3%	-5%	-6%
Refined Petroleum Products	0%	1%	2%	3%
Electricity	1%	1%	2%	2%

Economic impact of policy

In 2050, the cost of producing steel increases by $25 per tonne of steel in response to the policy, a 1.5% increase in the total cost (Table 44). The rise in costs is mostly the result of increased capital and energy costs caused by the adoption of carbon capture and storage. Greater electricity and natural gas consumption also contribute to the higher energy costs.

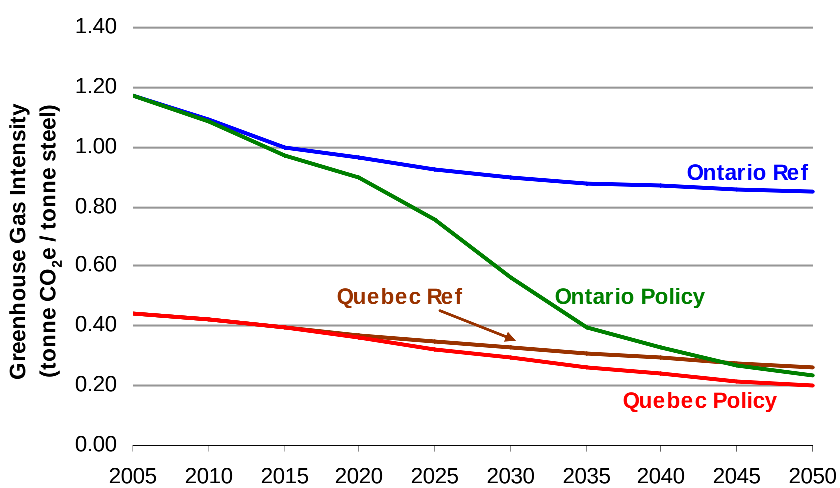
Table 44: Increase in the cost of steel manufacturing[24]

	Increase in Costs (2005$ / tonne of steel)			
	2020	*2030*	*2040*	*2050*
Total Cost	$0.35	$14.68	$22.01	$24.92
Capital Costs	$0.30	$4.71	$6.80	$7.11
Operating & Maintenance Costs	-$1.46	-$0.83	-$0.83	-$0.48
Energy Costs	$1.51	$10.80	$16.04	$18.29

Provincial discussion

The iron and steel industry is concentrated in Ontario and Québec, with the remaining provinces only producing a minimal amount of steel. Ontario manufactures most of its steel in integrated steel mills, while in Québec where electricity prices are cheaper, mini-mills account for the majority of steel production. As seen in Figure 24, the greenhouse gas intensity of steel making is substantially lower in Québec in the reference case, thus limiting opportunities to reduce emissions in that province. The greenhouse gas intensity in Ontario declines by 70% in response to the policy, whereas it declines by 16% in Québec.

Figure 24: Greenhouse gas intensity of iron and steel manufacturing in Ontario and Québec

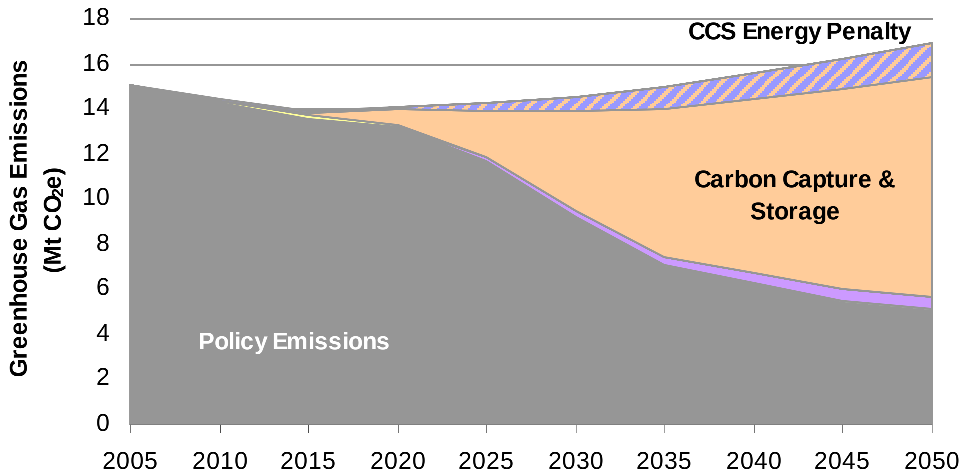


Technology roadmap to low emissions in iron and steel manufacturing

Figure 25 shows the wedge diagram for the iron and steel sector. Virtually all the emissions reductions are the result of the adoption of carbon capture and storage.

[24] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

Figure 25: Wedge diagram for iron and steel manufacturing



Carbon capture and storage has the greatest potential for use in integrated steel mills, rather than mini-mills. The combustion of blast furnace gas yields a relatively pure stream of carbon dioxide (about 27% by volume) that can be captured. The cost of carbon capture from the blast furnace gas is uncertain and dependent on the size of the facility, but the cost could be as low as $35 / tonne CO_2e for large facilities.[25] The capture of carbon dioxide is also possible from the flue gas of the basic oxygen furnace and during the production of process heat. Table 45 shows the penetration of carbon capture and storage in integrated steel mills. Even though the data show a 93% penetration of carbon capture in 2050, it should be interpreted that all mills would employ carbon capture because there are only a few mills in Canada.

Table 45: Penetration of carbon capture and storage in integrated steel manufacturing

	2020	*2030*	*2040*	*2050*
Carbon Capture & Storage	8%	49%	81%	93%

Capital expenditures increase by around 3% in response to the policy, mostly due to increased expenditures on carbon capture equipment (Table 46).

Table 46: Increase in capital expenditures in iron and steel manufacturing

	Medium-Term (2011-2030)	*Long-term (2031-2050)*
Increase in Annual Capital Expenditures (2005$ Millions)	25	33
Increase in Capital Expenditures (% above the reference case)	3%	3%

Uncertainty in the analysis

A structural change towards producing more steel in mini-mills could reduce emissions, but has not been included in our analysis. In 2005, mini-mills emitted approximately 0.13 tonne CO_2e per tonne of steel produced (although mini-mills are electricity intensive

[25] Intergovernmental Panel on Climate Change, 2005, "Carbon Dioxide Capture and Storage".

and may produce emissions at the point of electric generation), integrated mills emitted around 1.45 t CO_2e per tonne of steel. The industry trend indicates a shift towards producing more steel in mini-mills regardless of the policy and this trend may accelerate in a greenhouse gas constrained future. An increase in mini-mill production would likely reduce the contribution of carbon capture and storage to greenhouse gas abatement, and a greater portion of the reduction would be attained through improved energy efficiency and fuel switching (mini-mills depend mostly on electricity). We note that an increase in mini-mill production may be limited by the availability of scrap steel.

Metal Smelting

Box 7: Key actions by the metal smelting sector

- The sector largely decarbonizes regardless of the policy, mostly due to the uptake of inert anodes in aluminum smelting. The policy accelerates the adoption of inert anodes.

Greenhouse gas emissions from metal smelting are expected to decline from 11 Mt CO_2e in 2005 to 4.8 Mt CO_2e in 2050 in the absence of any greenhouse mitigation policy. The decline in emissions occurs despite an 18% increase in the production from the sector between 2005 and 2050.

The metal smelting sector consists of several smelting industries, of which aluminium smelting is the most significant contributor to greenhouse gas emissions. In 2005, the aluminium smelting sector generated approximately 9 Mt CO_2e; however its contribution to sector emissions declines substantially over the simulation period, from 82% in 2005 to 45% in 2050. The majority of emissions from aluminium smelting are process emissions from the smelting process. Current standard practice in aluminium smelting requires the dissolution of alumina (Al_2O_3) in a fluorine bath, where it is electrically reduced to aluminium (Al) using a carbon anode. In this process, the carbon anode reacts with free oxygen to produce carbon dioxide. Perfluorocarbons, which have 6,500 to 9,000 times the greenhouse warming effect of carbon dioxide, can also be produced in aluminum smelting during anode events, which can occur when the concentration of alumina around the carbon anode falls below approximately 2% by weight. During these events, the temperature around the anode rises and the fluorine bath can react with the anode to produce perfluorocarbons.[26]

The remaining sectors comprise copper, zinc, lead, and magnesium smelting, among other smelting industries. These sectors account for a small amount of emissions, and are not discussed in detail here. We also do not discuss any provincial differences because this sector's contribution to total greenhouse gas emissions is minor.

Environmental impact of policy

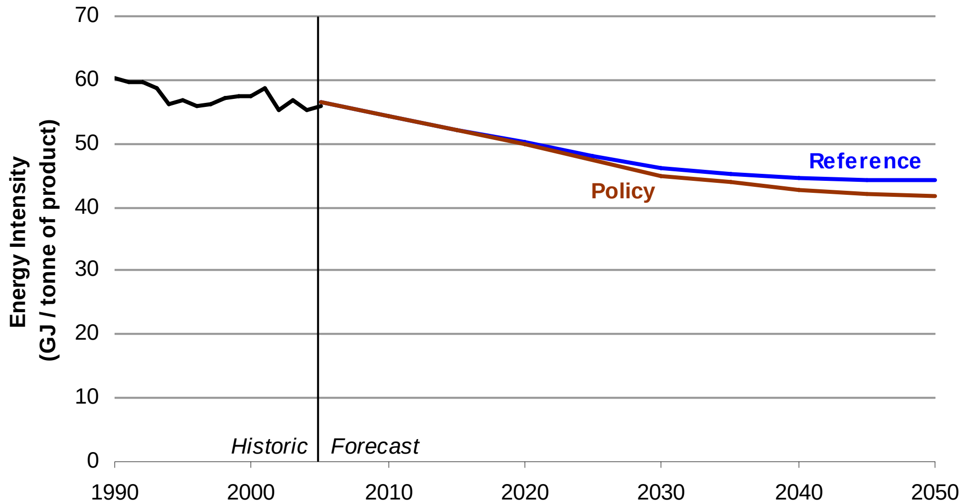
Figure 26 and Figure 27 show the energy and greenhouse gas intensity of metal smelting. In the short-term, the decline in both intensity measures is the result of gradual replacement of Soderberg anodes with pre-baked anodes, which are less energy and

[26] Environment Canada, 2007, "National Inventory Report".

greenhouse gas intensive. The decline in greenhouse gas intensity in the aluminium sector is also partially the result of the adoption of computer controls that reduce the occurrence of anode events. In the long-term, the decline in energy and greenhouse gas intensity in the reference case is primarily the result of the adoption of inert anodes. Inert anodes are not carbon based (metals and ceramics are the most promising material to produce inert anodes) and are expected to be better electricity conductors thereby reducing both energy consumption and greenhouse gas emissions. Inert anodes are still in the experimental phase, but are expected to become available in the near future.[27] The energy and greenhouse gas intensity from other metal smelting declines, but not as dramatically.

The policy causes a slight improvement in energy and greenhouse gas intensity, due largely to a more rapid adoption of inert anodes.

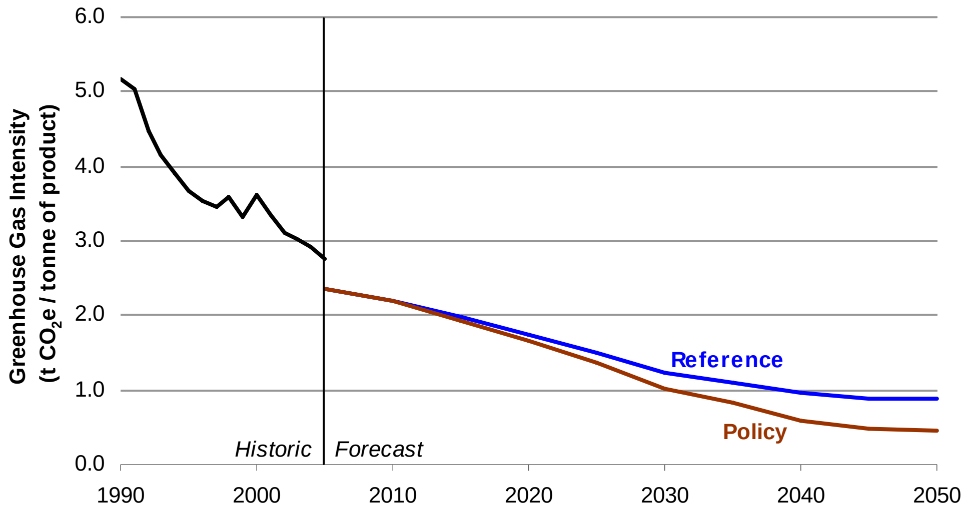
Figure 26: Energy intensity of metal smelting



Source: Historic data are from CIEEDAC, 2008, "Database on Energy, Production and Intensity Indicators for Canadian Industry"

[27] Sadoway, 2001, "Inert Anodes for the Hall-Heroult Cell: The Ultimate Materials Challenge", *JOM*, 34-35.

Figure 27: Greenhouse gas intensity of metal smelting



Source: Historic data are from CIEEDAC, 2008, "Database on Energy, Production and Intensity Indicators for Canadian Industry"

The share of electricity consumption increases in response to the policy, mostly from fuel switching in the smelting of metals other than aluminium (Table 47). Aluminium is already relatively electricity intensive, and there are fewer opportunities to fuel switch.

Table 47: Fuel switching in metal smelting

	2020	*2030*	*2040*	*2050*
Natural Gas	-1%	-2%	-2%	-2%
Coal	0%	-2%	-3%	-4%
Refined Petroleum Products	0%	-1%	-1%	-1%
Electricity	1%	4%	5%	6%

Economic impact of policy

By 2050, the cost of metal smelting increases by $5 per tonne of production ($2005), a negligible increase in the total costs of the sector (Table 48). The increase in cost is relatively evenly divided between an increase in capital and energy costs. The increase in capital costs is mostly attributed to the adoption of inert anodes, whereas the increase in energy costs is mostly attributed to the increase in electricity prices that results from the policy. Operating and maintenance costs decline because inert anodes are forecasted to require less maintenance.

Table 48: Increase in the cost of metal smelting[28]

	Increase in Costs (2005$ / tonne of product)			
	2020	2030	2040	2050
Total Cost	$32.99	$34.24	$15.61	$4.91
Capital Costs	$2.65	$7.89	$8.84	$9.85
Operating & Maintenance Costs	-$2.00	-$6.16	-$13.10	-$15.17
Energy Costs	$32.34	$32.52	$19.87	$10.22

Technology roadmap to low emissions in metal smelting

The adoption of inert anodes and fuel switching to electricity each account for approximately 45% of emissions reductions (see Figure 28). We do not discuss other actions to reduce emissions, because they account for less than 1 Mt CO_2e of reductions.

Figure 28: Wedge diagram for metal smelting

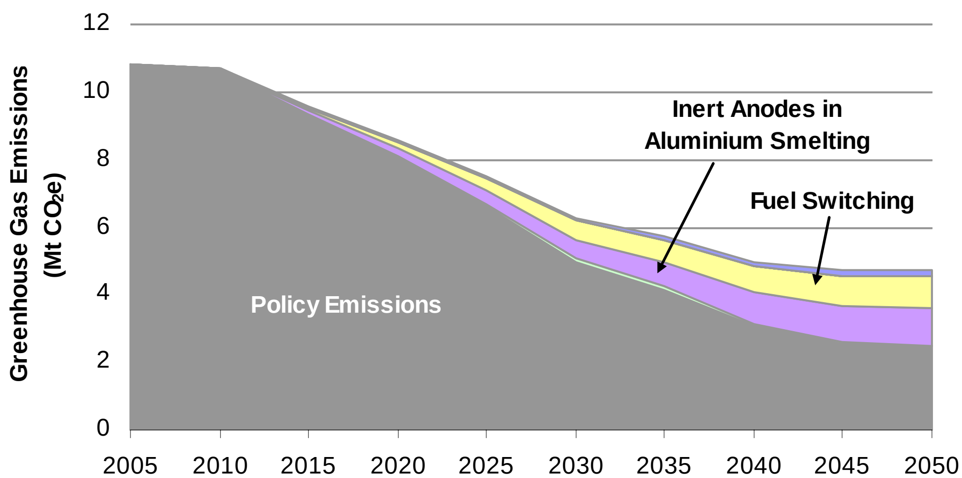


Table 49 shows the penetration of key abatement technologies in the aluminum-smelting sector as a percentage of total installed stock. The policy induces a more rapid adoption of inert anodes, which eliminate most of the carbon dioxide and perfluorocarbons emitted by the industry. By 2050, the majority of aluminum-smelting plants in Canada are projected to use inert anodes.

Table 49: Penetration of key technologies in aluminum smelting

	Policy Penetration of Anodes (%)				Increase due to Policy (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
Pre-baked Anodes with computer Controls	48%	49%	32%	9%	-1%	-6%	-12%	-17%
Inert Anodes	11%	36%	66%	91%	2%	7%	13%	19%

The remaining emissions reductions in the metal smelting sector are mostly from fuel switching to electricity for the production of process heat in the smelting of metals other than aluminum. In total these actions amount to a 1 Mt CO_2e reduction in greenhouse gases in 2050.

[28] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

The policy induces a moderate decline in capital expenditures in the medium-term, due to a small decline in the output from the sector (approximately 2%). In the long-term, output returns to its business-as-usual trajectory but the capital requirements increase from the uptake of inert anodes (Table 50).

Table 50: Increase in capital expenditures in metal smelting

	Medium-Term (2011-2030)	*Long-term (2031-2050)*
Increase in Annual Capital Expenditures (2005$ Millions)	-8	9
Increase in Capital Expenditures (% above the reference case)	-1%	1%

Uncertainty in the analysis

The key uncertainty with this analysis is whether and when inert anodes for aluminium smelting become available. If inert anodes do not become available and the sector continues to rely on carbon-based anodes, the anticipated emissions reductions from the aluminium sector may not be possible. Perfluorocarbons can be largely abated through improved computer controls, but the sector would still produce a substantial amount of process carbon dioxide due to the degradation of the anodes.

Mineral and Coal Mining

Box 8: Key actions by the mineral and coal mining sectors

- The sector does not play a large role in Canada's total emissions or emissions reductions. Most emissions reductions in this sector are attained through fuel switching to electricity and renewable fuels.

The mineral and coal mining sectors are forecasted to emit 12 Mt CO_2e by 2050, and account for around 1% of Canada's total greenhouse gas emissions. Two end-uses account for 95% of the sectors' greenhouse gas emissions: 1) cleaning or concentrating mineral ores or coal before transport, which requires hot water in some cases and 2) the extraction and transport of ores and coal, which produces combustion emissions. We ignore any provincial discussion for mineral and coal mining because the sector contributes little to Canada's total emissions.

Environmental impact of policy

In the reference case, the energy and greenhouse gas intensity of mineral and coal mining rise in response to accelerated growth rates in Saskatchewan's potash mining sector, which is more energy and greenhouse gas intensive than the mining sectors in other provinces (Figure 29 and Figure 30). The energy and emissions intensity for individual sub-sectors is relatively stable.

The policy induces a 50% decline in greenhouse gas intensity from the reference scenario. This decline is mostly a result of the electrification of hot water production for cleaning systems and the adoption of renewable fuels for extraction and transportation of mineral ores and coal.

Figure 29: Energy intensity of mineral and coal mining

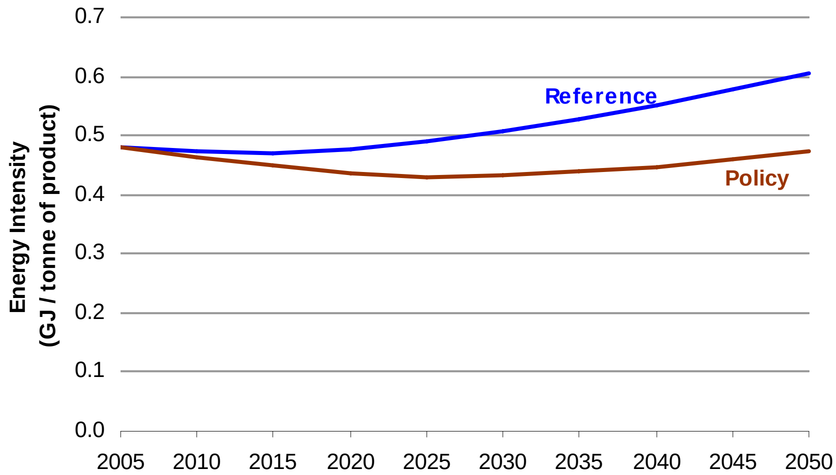
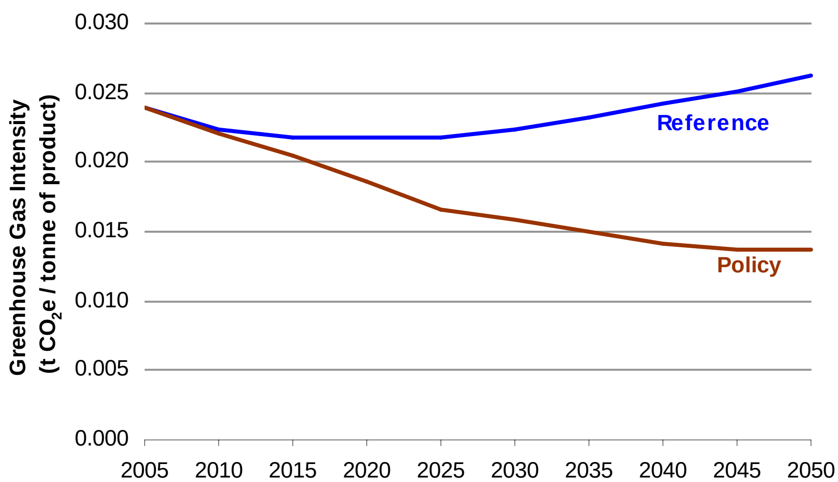


Figure 30: Greenhouse gas intensity of mineral and coal mining



The mining sectors generally switch to electricity and renewable fuels in response to the policy (see Table 51). In some mining operations, electric conveyors may be used instead of diesel motors and electricity can be used to heat water instead of natural gas. Renewable biofuels are used to power trucks and excavators.

Table 51: Fuel switching in mineral and coal mining

	2020	*2030*	*2040*	*2050*
Natural Gas	-6%	-14%	-22%	-27%
Coal	0%	-1%	-2%	-2%
Refined Petroleum Products	-2%	-3%	-4%	-3%
Electricity	6%	15%	24%	29%
Renewable	2%	3%	4%	5%

Economic impact of policy

The financial costs of operation decline by approximately 4%, in response to the policy (see Table 52). Electric motors and heaters have lower capital and maintenance requirements, but have greater energy costs because electricity is more expensive than other fossil fuels on an energy basis.

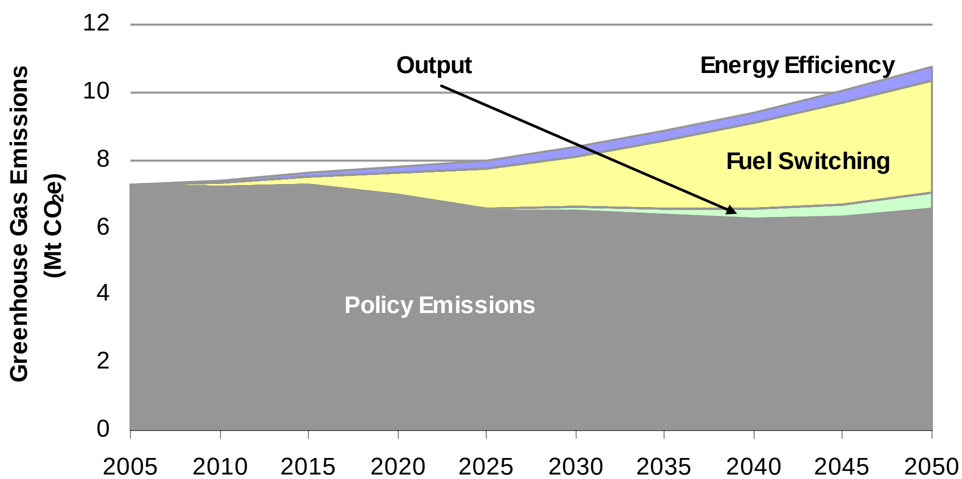
Table 52: Increase in the cost of mineral and coal mining[29]

	Increase in Costs (2005$ / tonne of product)			
	2020	*2030*	*2040*	*2050*
Total Cost	-$0.92	-$1.71	-$2.33	-$2.76
Capital Costs	-$0.69	-$1.29	-$1.79	-$2.13
Operating & Maintenance Costs	-$0.23	-$0.42	-$0.58	-$0.69
Energy Costs	-$0.01	$0.00	$0.05	$0.05

Technology roadmap to low emissions in mineral and coal mining

Figure 31 shows that fuel switching to electricity and renewables accounts for the majority of the reductions in greenhouse gas emissions.

Figure 31: Wedge diagram for mineral and coal mining



By 2050, approximately half of the energy consumption from the major sources of emissions is met by electricity or biodiesel (see Table 53).

Table 53: Zero emissions fuel consumption in mineral and coal mining

	2020	*2030*	*2040*	*2050*
Biodiesel in Extraction and Transportation	28%	32%	36%	47%
Electricity in Cleaning and Concentrating	21%	39%	52%	52%

The capital expenditures from mineral and coal mining increase in response to the policy, due to an expansion of the coal mining sector (see Table 50). The demand for coal increases due to an expansion of electricity generation from coal.

[29] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

Table 54: Increase in capital expenditures in mineral and coal mining

	Medium-Term (2011-2030)	*Long-term (2031-2050)*
Increase in Annual Capital Expenditures (2005$ Millions)	75	137
Increase in Capital Expenditures (% above the reference case)	3%	4%

Pulp and paper manufacturing

Box 9: Key actions by the pulp and paper manufacturing sector

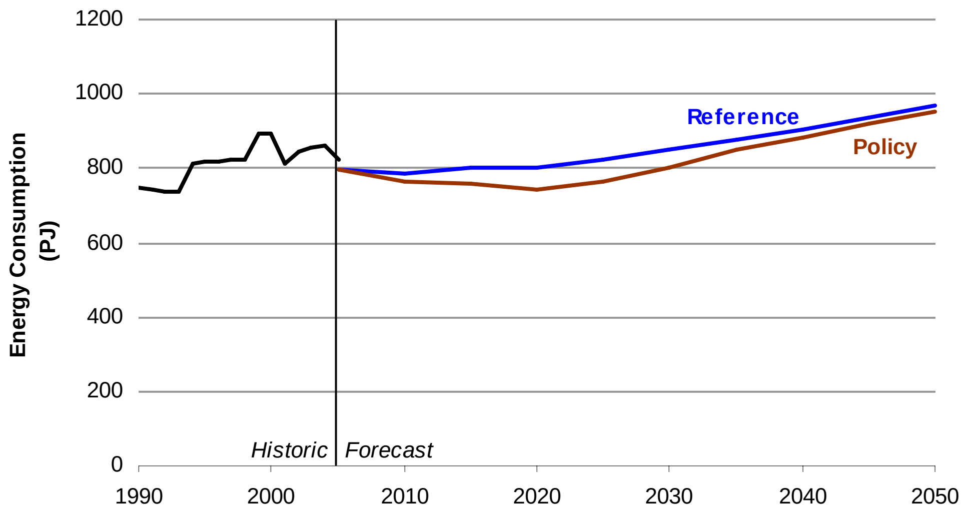
- The pulp and paper sector largely decarbonizes regardless of the policy, due to a shift towards using wood waste material as fuel.

The pulp and paper sector largely decarbonizes in the reference case, where greenhouse gas emissions decline from 7 Mt CO_2e in 2005 to 2 Mt CO_2e in 2050. This decline occurs despite a 37% increase in the output of pulp and paper products. The sector is mostly concentrated in Québec, with smaller sectors in British Columbia and Ontario. The differences among these provinces are relatively small, so we exclude a provincial discussion.

Environmental impact of policy

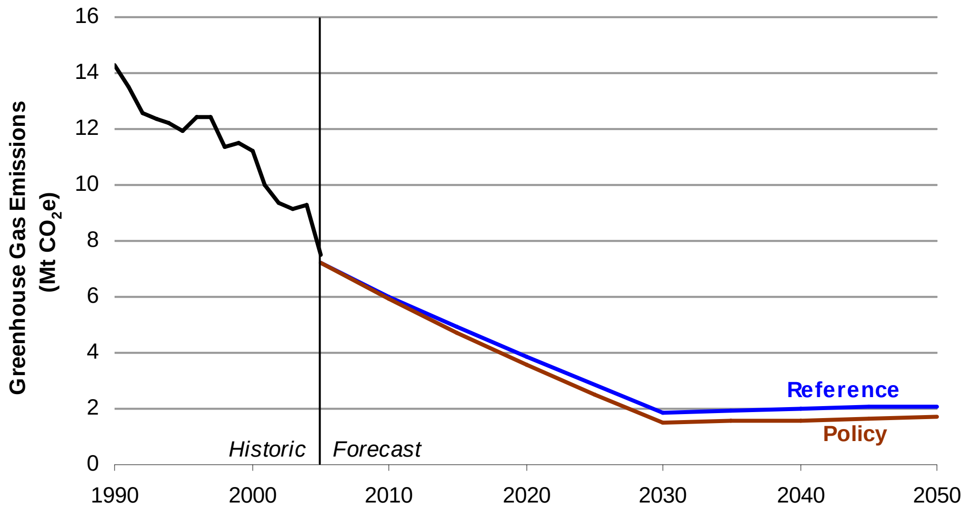
In the reference case, energy consumption and greenhouse gas emissions roughly follow historical trends, with a moderate increase in energy consumption and a significant decline of 70% in greenhouse gas emissions over the simulation period (Figure 32 and Figure 33). The sector has an abundance of waste wood material and by-products from the pulping process (i.e., black liquor) that can be used as fuel. Since 1990, the sector has gradually displaced the consumption of fossil fuels in favour of renewable fuels. In the policy scenario, this trend is accelerated.

Figure 32: Energy consumption from pulp and paper manufacturing



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

Figure 33: Greenhouse gas emissions from pulp and paper manufacturing



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

The share of renewable fuels increases slightly in response to the policy (Table 55). By 2050 in the policy scenario, renewable fuels supply 95% of the process heat required by the sector.

Table 55: Fuel switching in pulp and paper manufacturing

	2020	2030	2040	2050
Electricity	2%	1%	0%	0%
Renewable	-2%	-1%	1%	1%

Economic impact of policy

The cost of manufacturing pulp and paper products increases modestly in response to the policy, by a fraction of a percent (Table 56). The impacts are minor because the policy merely accelerates an ongoing transition towards a greater consumption of renewable fuels.

Table 56: Increase in the cost of pulp and paper manufacturing[30]

	Increase in Costs (2005$ / tonne of product)			
	2020	2030	2040	2050
Total Cost	$2.90	$5.67	$4.04	$2.21
Capital Costs	-$3.93	-$2.12	$0.05	$0.44
Operating & Maintenance Costs	-$2.30	-$1.20	$0.18	$0.57
Energy Costs	$9.13	$8.98	$3.80	$1.20

Technology roadmap to low emissions in pulp and paper manufacturing

Fuel switching to renewables accounts for most of the emissions reductions of the sector (Figure 34). These actions reduce emissions by 0.4 Mt CO_2e in 2050.

[30] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

Figure 34: Wedge diagram for pulp and paper manufacturing

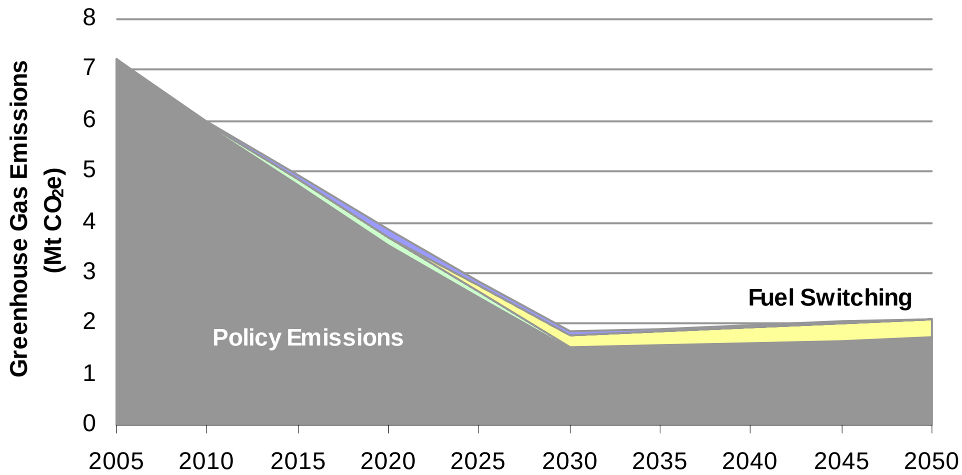


Table 57 shows heat production from the renewable waste fuels as a percentage of total heat production, excluding the heat produced in lime kilns. By 2030, most heat production comes from renewable fuels.

Table 57: Heat production from wood waste and spent pulping liquor

	2020	*2030*	*2040*	*2050*
Heat Production from Renewable	83%	98%	98%	98%

Capital expenditures decline slightly in response to the policy (see Table 58), due to a modest reduction in output.

Table 58: Increase in capital expenditures in pulp and paper manufacturing

	Medium-Term (2011-2030)	*Long-term (2031-2050)*
Increase in Annual Capital Expenditures (2005$ Millions)	-54	-33
Increase in Capital Expenditures (% above the reference case)	-3%	-2%

Other Manufacturing

Box 10: Key actions by the other manufacturing sector

- The other manufacturing sector reduces its emissions by switching to electricity from fossil fuels.

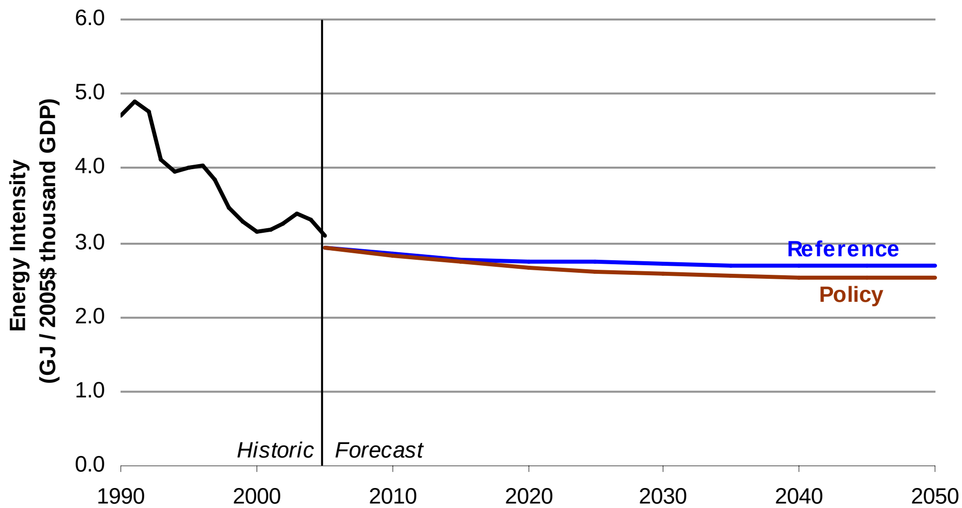
The gross domestic product of the other manufacturing sector grows over the simulation period by 160% to $472 billion in 2050. By 2050, the other manufacturing sector is projected to generate 47 Mt CO_2e, about 5% of Canada's projected greenhouse gas emissions. The production of process heat and hot water account for the majority of greenhouse gas emissions from the sector, with process heating contributing approximately 79% and water heating accounting for the most of the remainder. This section excludes a provincial discussion.

Environmental impact of policy

In the reference case, energy and greenhouse gas intensity remain fairly stable despite significant historical declines (Figure 35 and Figure 36). This discrepancy is likely because gross domestic product is used as the measure of the sector's output, rather than physical production. Measures of energy and emissions intensity based on gross domestic product are imperfect because energy consumption and emissions are more closely linked to physical output (i.e., the number of cars built rather than the value-added by each car). Additionally, energy intensity can decline in response to structural shifts within the sector. If a sub-sector with low intensity begins to contribute more to gross domestic product, the intensity from the sector as a whole would decline. We have not examined the degree to which these factors have contributed to the historic decline in energy and greenhouse gas intensity.

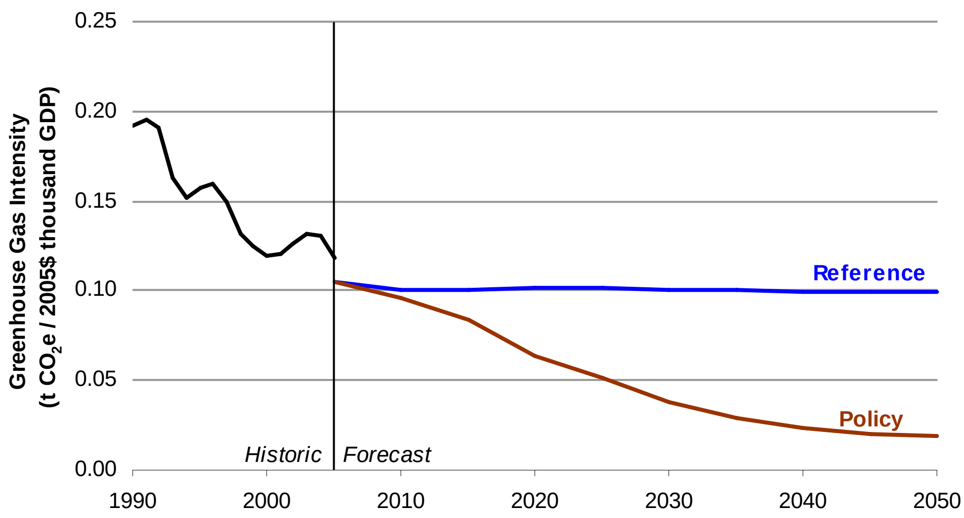
In the policy scenario, energy intensity declines slightly from the reference case projection, while greenhouse gas intensity declines by 82% from the reference case projection by 2050. The decline in greenhouse gas intensity is primarily due to the adoption of technologies that consume electricity rather than fossil fuels.

Figure 35: Energy intensity of other manufacturing



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

Figure 36: Greenhouse gas intensity of other manufacturing



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

The sector generally switches from natural gas and refined petroleum products to electricity, in response to the policy (see Table 59). The share of renewable energy in the form of biomass also rises as the use of wood-fuelled boilers increases.

Table 59: Fuel switching in other manufacturing

	2020	2030	2040	2050
Natural Gas	-19%	-34%	-42%	-45%
Coal	0%	-1%	-1%	-2%
Refined Petroleum Products	-5%	-7%	-8%	-7%
Electricity	21%	38%	47%	50%
Renewable	3%	4%	4%	4%

Economic impact of policy

Table 60 shows how capital, operating and fuel costs contribute to total costs in the other manufacturing sector. The total increase in cost is just under 3%, and the rise in energy costs accounts for the entire increase, while capital and operating costs decline. These changes are due to the uptake of electric heating systems, which require less maintenance and have lower capital investments, but have higher energy costs because electricity is more expensive per unit of energy produced. The energy costs are further increased by the rise in the price of electricity caused by the policy.

Table 60: Increase in cost of other manufacturing[31]

	Increase in Costs (2005$/thousand 2005$ GDP)			
	2020	*2030*	*2040*	*2050*
Total Cost	$3.04	$6.18	$8.03	$8.51
Capital Costs	-$0.01	-$0.08	-$0.13	-$0.12
Operating & Maintenance Costs	-$0.01	-$0.05	-$0.06	-$0.06
Energy Costs	$3.07	$6.30	$8.22	$8.69

Technology roadmap to low emissions in other manufacturing

Figure 37 illustrates the actions that contribute to the decline in greenhouse gas emissions in the other manufacturing sector: fuel switching accounts for almost all of the emissions reductions.

Figure 37: Wedge diagram for other manufacturing

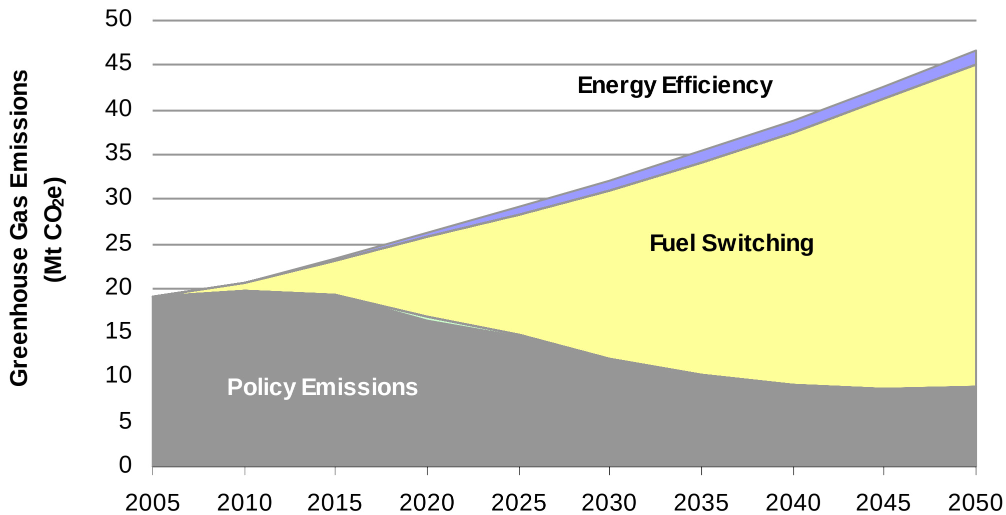


Table 61 and Table 62 display the penetration rates of key abatement technologies as a percentage of total installed stock. In 2050, electric and biomass fuelled heat systems show an overall penetration rate of nearly 69%, with electric systems comprising nearly 62% of that total. Water heating constitutes a smaller portion of total emissions within the other manufacturing sector, but show a more aggressive – by 2050 electric water heaters meet virtually all the demand for hot water.

Table 61: Penetration of other manufacturing process heat systems

	Technology Penetration (% of total stock)				Increase due to Policy (%)			
	2020	*2030*	*2040*	*2050*	*2020*	*2030*	*2040*	*2050*
Electric Heating Systems	31.7%	48.2%	59.1%	61.9%	18.8%	34.9%	45.6%	48.4%
Biomass Heating Systems	7.2%	7.5%	7.4%	7.5%	3.0%	3.4%	3.4%	3.5%

[31] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

Table 62: Penetration of other manufacturing water heating systems

	Technology Penetration (% of total stock)				Increase due to Policy (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
Electric Water Heating	79.3%	98.4%	99.2%	99.2%	38.0%	57.1%	58.2%	58.6%

Table 63 shows that the capital expenditures by the sector decline in response to the policy. Expenditures decline due to a modest decline in output and the investment in electric boilers and heaters which are cheaper relative to those using fossil fuels.

Table 63: Increase in capital expenditures of other manufacturing

	Medium-Term (2011-2030)	Long-term (2031-2050)
Increase in Annual Capital Expenditures (2005$ Millions)	-33	-42
Increase in Capital Expenditures (% above the reference case)	-3%	-2%

Electricity generation

Box 11: Key actions by the utility electricity generation sector

- Electricity supply expands to meet an increased demand for electricity in the policy scenario. By 2050, electricity supply reaches 1,700 TWh per year.
- Carbon capture and storage is the key action to reduce the direct greenhouse gas emissions of the sector.
- The expansion of electric generation from renewable sources (especially hydro and wind) reduces greenhouse gas emissions at the point of electricity consumption. Most new renewable capacity is added in provinces already dependent on generation from renewables – British Columbia, Manitoba and Québec – and does not reduce emissions at the point of electricity production. The expansion of electricity generation from renewables enables other sectors (e.g., residential and commercial) to reduce fossil fuel consumption by switching to electricity.

In the absence of any mitigation policy, the greenhouse gas emissions from the utility generation of electricity are expected to grow from 129 Mt CO_2e in 2005 to 170 Mt CO_2e by 2050. The projected rise is mainly the result of an increase in electricity generation from approximately 600 TWh in 2005 to over 1,100 TWh in 2050. Over this period, generation from fossil fuels remains relatively stable – generation from coal and natural gas remain at approximately 18% and 5% between 2005 and 2050, respectively.

More than in most other sectors of the economy, the electricity generation sector has substantial differences among provinces. British Columbia, Manitoba and Québec rely heavily on hydroelectricity. Alberta and Saskatchewan do not have the same potential for hydroelectric power, but have an abundance of fossil fuels – especially coal. In Ontario, nuclear generation is projected to contribute 43% of total generation by 2050, while coal and renewables (mostly hydroelectricity with some wind) account for 27% and 26%, respectively. The Ontario government has stated that it will close all coal plants in Ontario by 2014, so we have simulated the closure of all single cycle coal plants, but allowed the competition of new coal plants with improved energy efficiency and environmental controls.[32] In the Atlantic Provinces, electric generation by utilities is expected to be 77% hydroelectric by 2050 due to production from Labrador, which is mostly exported to Québec. The Atlantic Provinces also generate electricity from coal, nuclear, and a small amount of natural gas in 2050. Because provincial differences in this sector are significant, we provide a more detailed discussion at a provincial level.

Environmental impact of policy

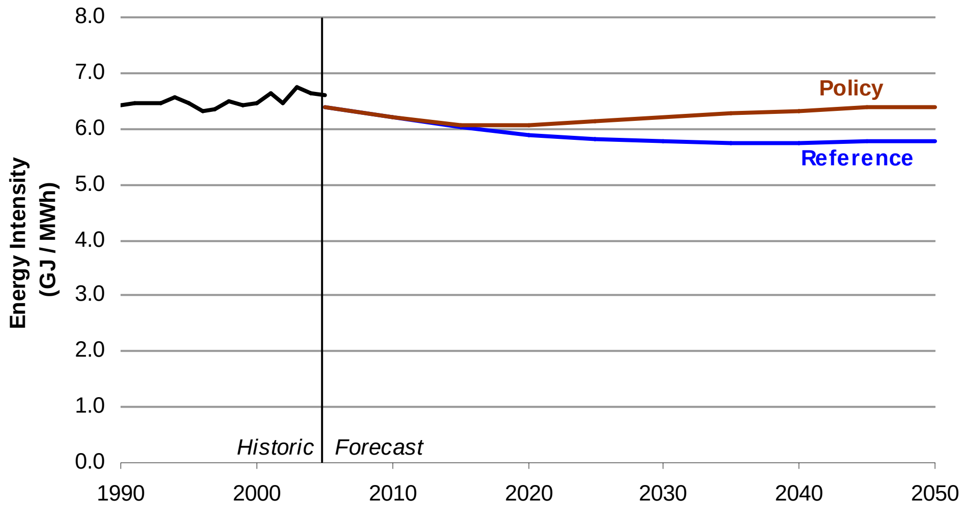
In the reference case, energy and greenhouse gas intensity decline over the simulation period (Figure 38 and Figure 39).[33] Although electricity generation by fuel remains relatively unchanged between 2005 and 2050, single cycle coal and natural gas plants are gradually replaced with advanced coal technologies and combined cycle natural gas plants. The decline in greenhouse gas intensity in the reference case is largely due to the improvement in energy intensity.

In the policy scenario, greenhouse gas intensity declines to 0.02 tonnes CO_2e / MWh in 2050, an 83% decline from the reference case projection, while energy intensity increases by 10%. The decline in greenhouse gas intensity is primarily the result of an increase in carbon capture and storage in Alberta, Saskatchewan and Ontario. The addition of new renewable capacity in British Columbia, Manitoba and Québec has little impact on greenhouse gas intensity, because these provinces have low emissions regardless of the policy. Energy intensity is higher in the policy scenario due to the energy penalty associated with carbon capture and storage.

[32] Ontario Ministry of Energy and Infrastructure, 2008, http://www.energy.gov.on.ca/index.cfm?fuseaction=english.news&body=yes&news_id=176.

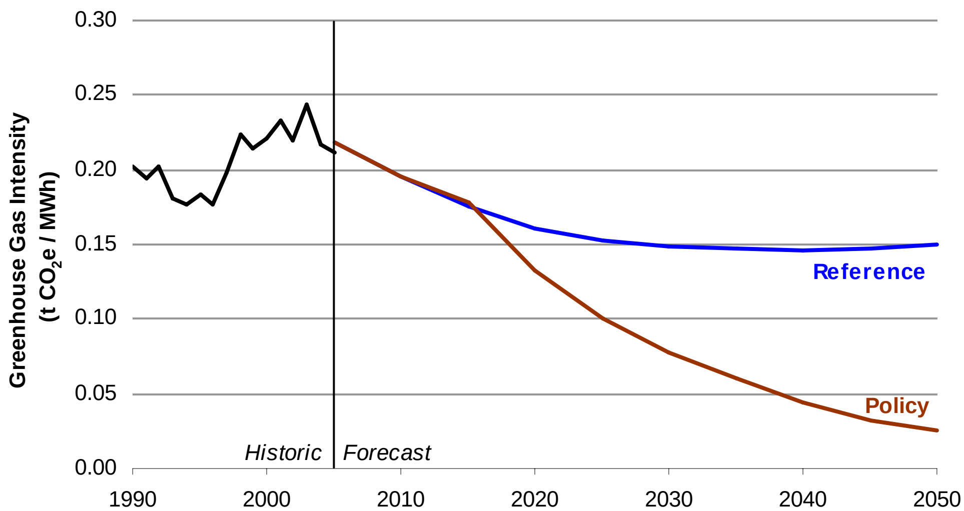
[33] Renewable electricity generation is assumed to require 1 GJ of energy (e.g., wind, hydro) for each GJ of electricity generated. Nuclear electricity generation is assumed to require 1 GJ of energy for each GJ of thermal energy generated. See International Energy Agency, 2007, “Energy Balances of OECD Countries: 2004-2005”.

Figure 38: Energy intensity of utility electricity generation



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

Figure 39: Greenhouse gas intensity of utility electricity generation



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

Table 64 shows the greenhouse gas intensity for Alberta, Saskatchewan, Ontario and the Atlantic provinces. We exclude the provinces that rely mostly on hydroelectric generation because their greenhouse gas intensities are low in the reference case and remain so after the policy's implementation (approximately 0.01 tonnes CO_2e / MWh in 2005). The greenhouse gas intensities for all provinces are available in Appendix A. The adoption of carbon capture and storage is the most important action to reduce greenhouse gas intensity in Alberta and Saskatchewan. In Ontario and the Atlantic provinces, carbon capture and storage also plays a significant role, but an increase in electricity production from renewable sources also contributes to the reduction in greenhouse gas intensity.

Table 64: Greenhouse gas intensity of electric generation by utilities by province

	Greenhouse Gas Intensity (t CO_2e / MWh)				*Decline due to Policy (t CO_2e / MWh)*			
	2020	*2030*	*2040*	*2050*	*2020*	*2030*	*2040*	*2050*
Alberta	0.51	0.27	0.15	0.08	0.20	0.37	0.43	0.46
Saskatchewan	0.54	0.30	0.15	0.09	0.22	0.43	0.54	0.59
Ontario	0.13	0.09	0.05	0.03	0.02	0.08	0.14	0.18
Atlantic	0.13	0.04	0.02	0.01	0.03	0.07	0.09	0.11

Table 65 shows the increase in electricity generation by fuel that results from the policy's implementation. Both the electricity generation using carbon capture and the generation from renewables rise in response to the policy – the generation using carbon capture and generation from renewables account for 52% and 37% of the increase, respectively.

Table 65: Increase in generation of electricity by fuel and generation type (TWh)

	2020	*2030*	*2040*	*2050*
Renewable	91	187	256	304
Nuclear	25	59	80	85
Coal	5	-37	-106	-188
Natural Gas	-11	-28	-41	-50
Carbon Capture & Storage	57	183	309	429
Total Increase in Generation	167	364	498	579

Economic impact of policy

Table 66 shows the increase in the cost of electricity generation. Alberta and Saskatchewan show the largest increase in the cost of producing electricity, mostly because their electricity sectors are projected to be more greenhouse gas intensive and therefore require greater capital investments to decarbonize than those in other provinces. The rise in electricity costs is more modest in the remaining provinces. In the predominately hydroelectric provinces, the greater costs are mostly due to the substantial increase in electric capacity, which requires new capital investments. British Columbia shows greater increases in the cost of electric generation due to additions of small hydroelectric plants (which are relatively more costly than large plants).

Table 66: Increase in the cost of electricity generation by province

	Increase in Costs (2005$ / MWh)			
	2020	*2030*	*2040*	*2050*
British Columbia	$11.15	$12.76	$11.13	$8.71
Alberta	$15.29	$22.09	$19.79	$18.32
Saskatchewan	$10.84	$16.11	$17.51	$18.50
Manitoba	$6.28	$7.46	$6.24	$4.83
Ontario	$5.40	$7.69	$8.10	$8.63
Québec	$4.01	$5.61	$5.13	$4.19
Atlantic	$2.22	$6.71	$7.55	$8.27
Canada (weighted by generation)	$8.60	$13.54	$13.55	$12.42

Table 67 separates the total costs into capital, operating and energy costs. An increase in capital expenditures contributes most significantly to the rise in costs, whereas energy cost increases are modest. The adoption of carbon capture and storage increases coal consumption, but the price for coal is relatively low. Additionally, the adoption of renewable electricity generation reduces energy costs.

Table 67: Increase in the cost of electricity generation[34]

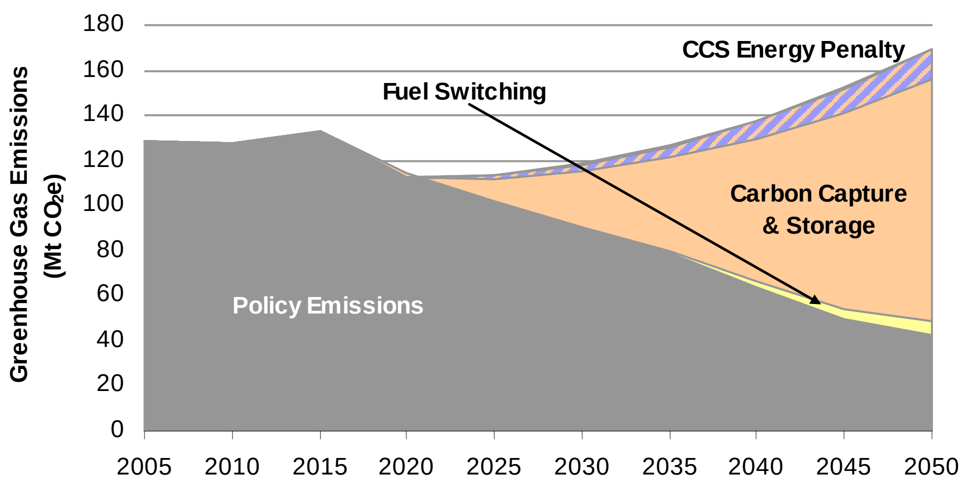
	Increase in Costs (2005$ / MWh)			
	2020	*2030*	*2040*	*2050*
Total Cost	$8.60	$13.54	$13.55	$12.42
Capital Costs	$7.25	$10.34	$9.68	$8.28
Operating & Maintenance Costs	$0.73	$1.28	$1.59	$1.79
Energy Costs	$0.61	$1.92	$2.27	$2.35

Technology roadmap to low emissions in electricity generation

Carbon capture and storage is the most important action to reduce greenhouse gas emissions in the electricity generation sector (see Figure 40). Carbon capture (excluding transport) at integrated gasification combined cycle coal and combined cycle natural gas plants is expected to cost between $25 and $100 (2005$) per tonne of CO_2e avoided, depending on fuel and whether the plant is used for base load or peak load demand. The emissions price in the policy scenario should be sufficient to prevent any new construction of fossil fuel plants without carbon capture. Furthermore, it is likely to induce many utilities to retrofit existing fossil fuel plants.

The figure only shows a small reduction from fuel switching to renewables, even though generation from renewable sources increases by 43% in the policy scenario. Most renewable capacity is added in provinces that already have low greenhouse gas intensity, and does not reduce the direct emissions from the sector. However, the expansion of the electricity sector in these provinces enables other sectors (e.g., residential and commercial sectors) to reduce fossil fuel consumption in favour of electricity consumption.

Figure 40: Wedge diagram for utility electricity generation



[34] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

Table 68 shows the generation from zero- and low-emission technologies in the policy scenario. By 2050, the electricity stock has been almost completely de-carbonized. Generation by hydroelectric power plants accounts for the majority of generation (52%). Integrated gasification combined cycle coal plants and combined cycle natural gas turbines with carbon capture (IGCC CCS and NGCC CCS) account for 17% and 7% of total installed capacity, respectively. The pulverized coal plants with carbon capture (PC CCS) are existing facilities that have been retrofitted.

Table 68: Generation by plant type

	Total Generation (TWh)				*Increase due to Policy (%)*			
	2020	*2030*	*2040*	*2050*	*2020*	*2030*	*2040*	*2050*
Hydro	505	633	759	890	17%	31%	37%	39%
Wind	33	63	91	110	84%	118%	104%	77%
Other Renew	3	7	10	13	117%	150%	144%	134%
Nuclear	124	168	204	232	26%	54%	64%	57%
PC CCS	11	23	28	30	NA	NA	NA	NA
IGCC CCS	26	100	195	300	NA	NA	NA	NA
NGCC CCS	25	71	105	126	NA	NA	NA	NA
Total Generation	868	1,166	1,445	1,712	24%	45%	53%	51%

Table 69, Table 70 and Table 71 show electricity generation by plant type in different regions in Canada. Carbon capture plays a significant role in Alberta and Saskatchewan, while the hydroelectric provinces generally increase generation from hydropower in response to the policy. Ontario and the Atlantic provinces show increases in generation from fossil energy using carbon capture and storage, nuclear energy and renewable energy.

Table 69: Generation by plant type in Alberta and Saskatchewan

	Total Generation (TWh)				*Increase due to Policy (%)*			
	2020	*2030*	*2040*	*2050*	*2020*	*2030*	*2040*	*2050*
Hydro	12	17	22	27	30%	65%	87%	99%
Wind	6	12	17	20	111%	159%	146%	106%
Other Renew	0	1	1	2	139%	215%	239%	272%
Nuclear	0	0	0	0	NA	NA	NA	NA
PC CCS	8	16	19	20	NA	NA	NA	NA
IGCC CCS	15	54	104	158	NA	NA	NA	NA
NGCC CCS	15	41	61	72	NA	NA	NA	NA
Total Generation	137	198	256	304	40%	80%	102%	103%

Table 70: Generation by plant type in Ontario and the Atlantic Provinces

	Total Generation (TWh)				Increase due to Policy (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
Hydro	103	134	166	196	21%	44%	59%	69%
Wind	19	35	49	60	72%	114%	104%	80%
Other Renew	1	2	3	4	130%	212%	204%	206%
Nuclear	115	157	193	220	26%	55%	66%	59%
PC CCS	3	7	9	10	NA	NA	NA	NA
IGCC CCS	11	46	90	142	NA	NA	NA	NA
NGCC CCS	7	22	32	39	NA	NA	NA	NA
Total Generation	317	444	562	674	28%	57%	65%	61%

Table 71: Generation by plant type in British Columbia, Manitoba and Québec

	Total Generation (TWh)				Increase due to Policy (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
Hydro	390	483	571	668	16%	27%	30%	31%
Wind	7	17	25	31	99%	103%	83%	58%
Other Renew	2	4	5	7	108%	118%	106%	89%
Nuclear	8	10	12	12	26%	40%	39%	28%
PC CCS	0	0	0	0	NA	NA	NA	NA
IGCC CCS	0	0	0	0	NA	NA	NA	NA
NGCC CCS	2	8	12	16	NA	NA	NA	NA
Total Generation	414	524	627	735	17%	28%	31%	30%

Capital expenditures rise to meet the growth in the demand for electricity that results from the policy, as well as a more capital intensive electricity stock (Table 72).

Table 72: Increase in capital expenditures for utility electricity generation

	Medium-Term (2011-2030)	Long-term (2031-2050)
Increase in Annual Capital Expenditures (2005$ Millions)	12,512	9,553
Increase in Capital Expenditures (% above the reference case)	148%	67%

Uncertainty in the analysis

In this analysis, we have constrained the construction of new nuclear plants to provinces that had nuclear plants in 2005, and constrained the expansion of nuclear generation in provinces with nuclear power. We assume that the adoption of nuclear generation technologies will be a political rather than economic decision. If the constraints on nuclear power are relaxed, it could substantially contribute to emissions reductions. The adoption of nuclear power would likely reduce the contribution of carbon capture and storage.

We have not simulated how changes in the inter-provincial or international trade of electricity could contribute to the emissions reductions from the province. It may be possible for provinces with hydroelectric potential to increase generation and export excess production to provinces with higher greenhouse gas intensities.

Petroleum refining

Box 12: Key actions by the petroleum refining sector

- The output of refined petroleum products declines in the policy scenario due to increases in biofuel consumption in the transportation sector. The decline in output is responsible for most of the emissions reductions.
- The remaining emissions reductions are attained through the adoption of carbon capture and storage.

In the absence of any greenhouse gas mitigation policy, the petroleum refining sector is expected to play an increasingly important role in Canada's total greenhouse gas emissions. Greenhouse gas emissions from petroleum refining are expected to rise in the reference case from approximately 19 Mt CO_2e in 2005 to 32 Mt CO_2e by 2050, when it would account for 3% of Canada's projected greenhouse gas emissions.

The petroleum refining sector transforms crude oil into gasoline and diesel, mainly for use as transportation fuels. Demand for refining is therefore linked to demand for fuels from transportation – if transportation becomes more efficient or fossil substitutes such as ethanol become available in significant quantity at a reasonable cost, demand for petroleum products will fall.

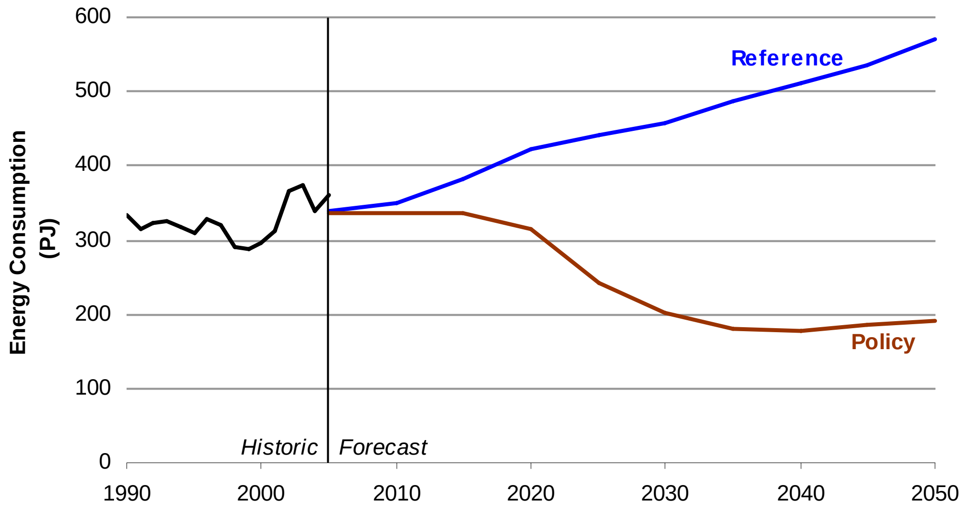
Crude oil comes in variable "grades", generally classed as light, medium, heavy and synthetic. Lighter crude has less carbon and more hydrogen, and heavy crude the opposite. Lighter crude is more similar to the final products (i.e., gasoline and diesel) so it is less costly and less energy intensive to refine. But as light crude deposits have been depleted worldwide, there is a general trend towards use of heavier crudes, which are more plentiful. Much of Canada's remaining known onshore crude is heavy, and the amount of heavy crude to be processed in Canada is projected to increase significantly.

The process of refining divides into four main processes: 1) distillation (separation of the components of crude by variable volatility); 2) cracking (breaking of longer, less useful carbon chains into shorter chains); 3) coking (reduction of the carbon content of crude through direct removal); and 4) hydrotreating (the addition of hydrogen to carbon chains to produce useful products like gasoline). The amount of each process necessary depends on the desired end product, but heavier crudes generally require more cracking, coking and hydrotreating. All of these processes require significant amounts of process heat.

Environmental impact of policy

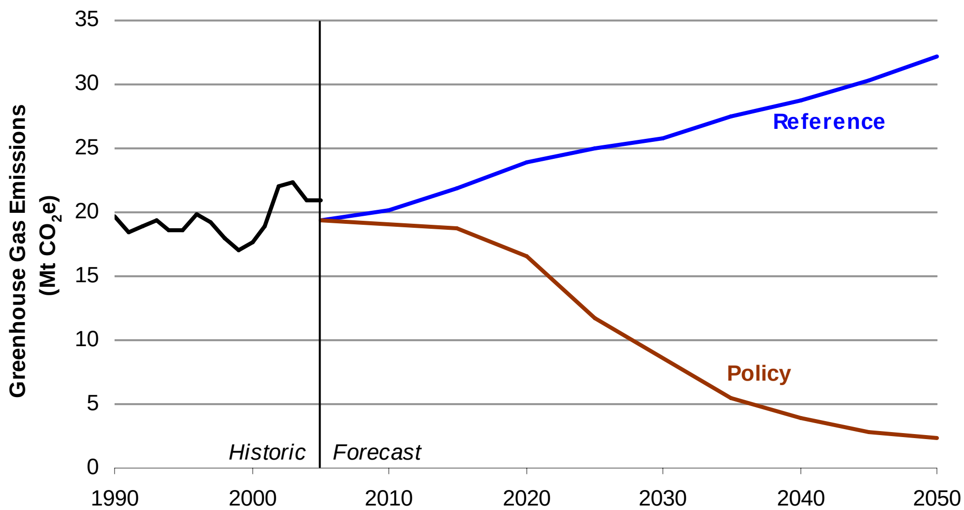
The increase in energy and greenhouse gas emissions in the reference case is the result of increased demand for petroleum products, in addition to the ongoing switch from lighter to heavier crudes (Figure 41 and Figure 42). Both energy consumption and greenhouse gas emissions decline in the policy scenario, mostly due to an increase in biofuel demand from transportation and an associated decline in the demand and supply of petroleum products. By 2050 in the policy scenario, the output of refined petroleum is 65% lower than in the reference projection. The adoption of carbon capture and storage also contributes to the decline in greenhouse gas emissions.

Figure 41: Energy consumption from petroleum refining



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

Figure 42: Greenhouse gas emissions from petroleum refining



Source: Historic data are from NRCan, 2008, "Comprehensive Energy Use Database".

While the reduction in output and the use of CCS contribute to most of the emissions reductions, fuel switching to electricity modestly reduces greenhouse gas emissions. Table 73 shows that natural gas use falls about 18% by 2050, while electricity use rises by about 22%.

Table 73: Fuel switching in petroleum refining

	2020	2030	2040	2050
Natural Gas	-3%	-7%	-14%	-18%
Refined Petroleum Products	-1%	-1%	0%	2%
Electricity	4%	8%	18%	22%
Other	0%	0%	-4%	-6%

Economic impact of policy

The most important impact of the policy on refining costs is on purchased energy, specifically natural gas and electricity. As the sector demands more electricity and the price for electricity increases in the policy scenario, the energy costs from the sector rise. Overall, the cost of refining petroleum increase by 1.5%.

Table 74: Increase in the cost of petroleum refining[35]

	Increase in Costs (2005¢ / L RPP)			
	2020	2030	2040	2050
Total Cost	0.1	0.1	0.6	1.0
Capital Costs	0.0	0.0	0.1	0.1
Operating & Maintenance Costs	0.0	0.0	0.0	0.0
Energy Costs	0.1	0.2	0.6	0.8

Provincial discussion

Canada’s refining capacity is concentrated in Alberta and Saskatchewan – which mainly process heavy crude but also some synthetic light crude – and Ontario and Québec – which process imported light crude from Norway, the United Kingdom and other oil exporting countries. Refining in Canada mainly meets domestic transportation demand; and this demand and associated supply is projected to fall in response to the policy.

Technology roadmap to low emissions in petroleum refining

The decline in output from the petroleum refining accounts for over 50% of the sector’s emissions reductions in 2050, while carbon capture and storage accounts for approximately 35% (see Figure 43). As discussed above, the decline in output is mostly due to renewable fuel consumption in the transportation sector.

[35] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

Figure 43: Wedge diagram for the petroleum refining sector

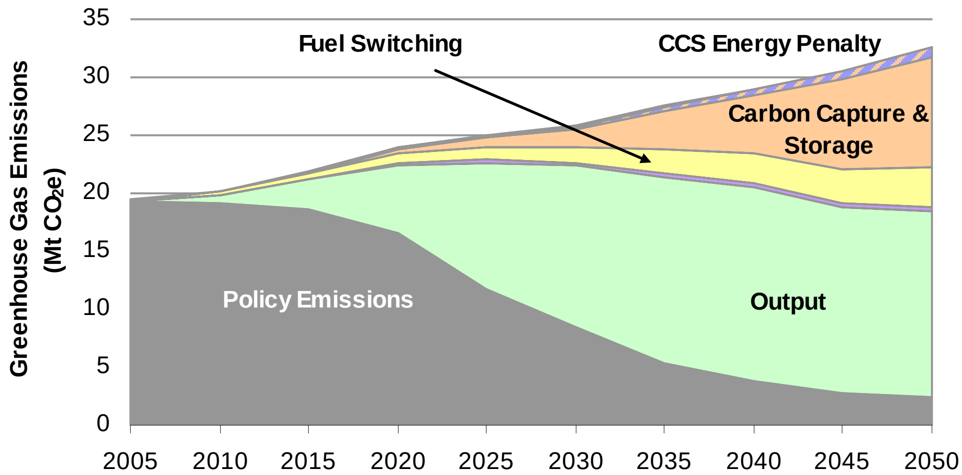


Table 75 shows the penetration of carbon capture and storage in petroleum refining. By 2050, most process heat – 86% – is produced using capture equipment.

Table 75: Penetration of carbon capture and storage

	2020	*2030*	*2040*	*2050*
Carbon Capture & Storage	5%	21%	63%	86%

The reduction in demand for refined petroleum products has the largest impact on the capital expenditures of the sector. Capital expenditures decline by approximately 55% in response to the policy.

Table 76: Increase in capital expenditures of petroleum refining

	Medium-Term (2011-2030)	*Long-term (2031-2050)*
Increase in Annual Capital Expenditures (2005$ Millions)	-270	-399
Increase in Capital Expenditures (% above the reference case)	-55%	-60%

Petroleum crude production

Box 13: Key actions by the petroleum crude sector

- The petroleum crude sector is forecasted to expand considerably due to the development of Alberta's oil sands. By 2050, the sector is expected to produce 190 Mt CO_2e in the absence of any mitigation policy.
- The key action to reduce greenhouse gas emissions is the adoption of carbon capture and storage, which contributes to 85% of the sector's greenhouse gas emissions reductions.
- Hydrogen production in oil sands upgraders may be an early opportunity for adopting carbon capture and storage.

The petroleum extraction sector is expected to play an increasingly important role in Canada's total greenhouse gas emissions. In the absence of any mitigation policy, the greenhouse gas emissions from petroleum extraction are expected to rise from approximately 66 Mt CO_2e in 2005 to 190 Mt CO_2e by 2050, which would account for 17% of Canada's projected greenhouse gas emissions in 2050. The projected increase in emissions is partially due to a substantial growth in petroleum production, which increases from 2.6 million barrels per day in 2005 to 7.0 million barrels per day in 2050. The sector is also projected to become more greenhouse gas intensive over the period, as the conventional production of petroleum declines and unconventional production from Alberta's oil sands increases. By 2050, the production of petroleum from oil sands (which includes synthetic crude oil and blended bitumen) is projected to reach 6.6 million barrels per day and emit 185 Mt CO_2e per year.

Within the oil sands sector, the main source of greenhouse gas emissions is from the production of process heat for oil sands upgrading and bitumen extraction from in-situ operations. In 2000, the production of process heat for oil sands upgrading accounted for approximately 78% of the greenhouse gas emissions from oil sands upgrading. Most of the remaining greenhouse gas emissions are process emissions from the production of hydrogen in oil sands upgrading, which accounted for approximately 14% of total upgrading emissions in 2000.[36] Most of the emissions from the conventional production of petroleum are fugitive emissions from oil well operations.

Environmental impact of policy

In the reference case, both the energy and greenhouse gas intensity of petroleum extraction increases until 2020, and declines thereafter (Figure 44 and Figure 45). The rise in energy and greenhouse gas intensity until 2020 is the result of the projected increase in unconventional oil production relative to conventional production. After 2020, unconventional production dominates the industry, and energy and greenhouse gas intensity declines due to improving energy efficiency of unconventional production.

In the policy scenario, energy intensity increases as a result of the policy's implementation. Carbon capture and storage accounts for the majority of the decline in greenhouse gas intensity, although capturing carbon dioxide requires greater energy requirements and increases the energy intensity of petroleum production. The greenhouse gas intensity of oil production is projected to decline from approximately 0.07 tonnes CO_2e per barrel in 2005 to 0.015 tonnes CO_2e per barrel in 2050. The intensity figures for each sub-sector within the petroleum crude sector (i.e., the production of conventional crude, synthetic crude and blended bitumen) are available in Appendix A.

[36] Canadian Association of Petroleum Producers, 2004, "A national inventory of greenhouse gas, criteria air contaminant and hyrogen sulphide emissions by the upstream oil and gas industry".

Figure 44: Energy intensity of petroleum crude production

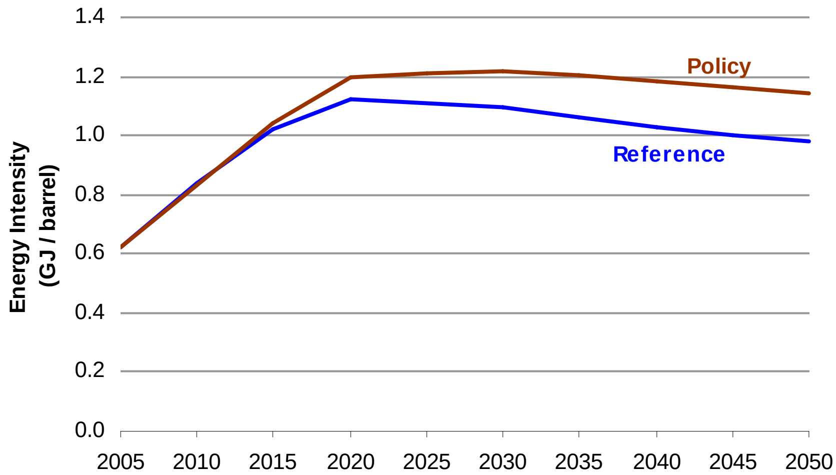
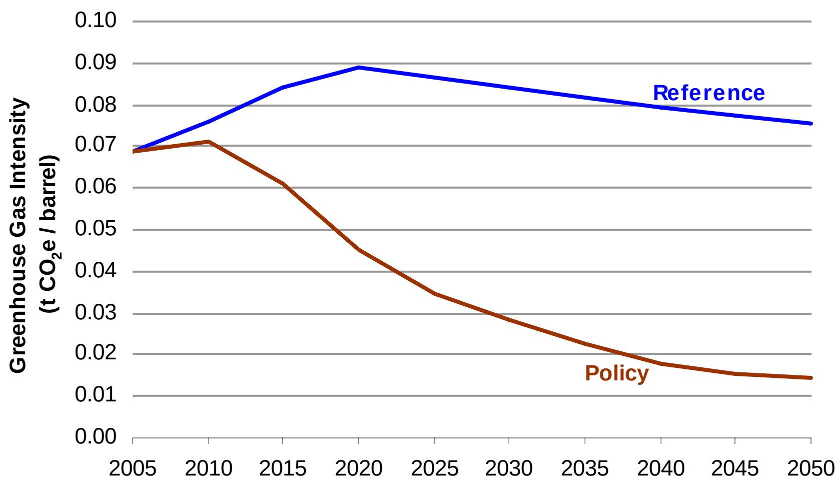


Figure 45: Greenhouse gas intensity of petroleum crude production



The amount of fuel switching is relatively modest in comparison to other sectors (see Table 77). In general, the sector switches from refined petroleum products to electricity. We have excluded the option for the industry to produce process heat and electricity from nuclear energy because the decision is more political than economic. However, nuclear energy could be an option in Alberta's oil sands.

Table 77: Fuel switching in petroleum crude production

	2020	*2030*	*2040*	*2050*
Natural Gas	-1%	-1%	-1%	-1%
Coal	0%	-1%	-1%	-1%
Refined Petroleum Products	-1%	-2%	-4%	-5%
Electricity	2%	3%	5%	6%
Nuclear	0%	0%	0%	0%

Economic impact of policy

In the policy scenario, the cost of oil production rises by $3.23 per barrel, a 14% increase (Table 78). The increase in the cost of producing oil is primarily a result of the adoption of carbon capture and storage. Carbon capture and storage requires greater capital investments and energy costs due to higher energy intensity. The production of synthetic crude from oil sands upgrading facilities experiences the greatest increase in the cost of production – in 2050, the cost of producing a barrel of synthetic crude from oil sands is $5.72 greater than in the reference case. The cost increase of producing blended bitumen is lower largely because blended bitumen is upgraded outside the sector.

Table 78: Increase in the cost of petroleum crude production by sub-sector

	Increase in Costs (2005$ / barrel)			
	2020	*2030*	*2040*	*2050*
All Production	$1.88	$2.69	$3.12	$3.23
Conventional	$1.18	$1.73	$1.83	$1.93
Synthetic	$3.28	$4.65	$5.48	$5.72
Blended bitumen	$0.69	$1.25	$1.65	$1.90

Table 79 shows how capital, operating and fuel costs contribute to the rise in cost of producing a barrel of oil. Energy costs increase significantly for two main reasons. First, the sector becomes more energy intensive per barrel of oil produced, largely due to the energy penalty associated with carbon capture and storage. Second, the policy encourages fuel switching away from petroleum products (e.g., petroleum coke and heavy fuel oil) to natural gas and electricity, which are forecasted to have higher prices per unit of energy produced. Capital costs also increase significantly, mostly due to the adoption of carbon capture and storage.

Table 79: Increase in the cost of petroleum crude production[37]

	Increase in Costs (2005$ / barrel)			
	2020	*2030*	*2040*	*2050*
Total Cost	$1.88	$2.69	$3.12	$3.23
Capital Costs	$0.87	$1.09	$1.14	$1.10
Operating & Maintenance Costs	$0.23	$0.33	$0.40	$0.40
Energy Costs	$0.77	$1.26	$1.58	$1.72

Provincial discussion

The production of crude oil is forecasted to be highly concentrated within Alberta as the production of conventional crude declines and the production of synthetic crude and blended bitumen from Alberta's oil sands increases. By 2050, Alberta is expected to produce approximately 6.7 million barrels per day, which will account for approximately 95% of Canada's crude oil production. Therefore, the results shown above are mostly indicative of petroleum sector in Alberta. The remaining oil-producing provinces are expected to produce conventional crude.[38]

[37] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

[38] The potential development of oil sands in Saskatchewan has not been considered in this analysis. However, this development is a strong possibility (National Energy Board, 2007, "Canada's Energy

Figure 46 shows the greenhouse gas intensity of conventional crude production outside Alberta. The increase in greenhouse gas intensity in the reference case is due to the relative decline of light and medium production (which is less greenhouse gas intensive) in comparison to the production of heavy crude. The policy encourages the adoption of technologies that limit the fugitive emissions (mostly venting and flaring) from conventional oil production. As a result, the greenhouse gas intensity of oil production declines by approximately 80% from the business-as-usual projection.

Figure 46: Greenhouse gas intensity of conventional petroleum crude production outside Alberta

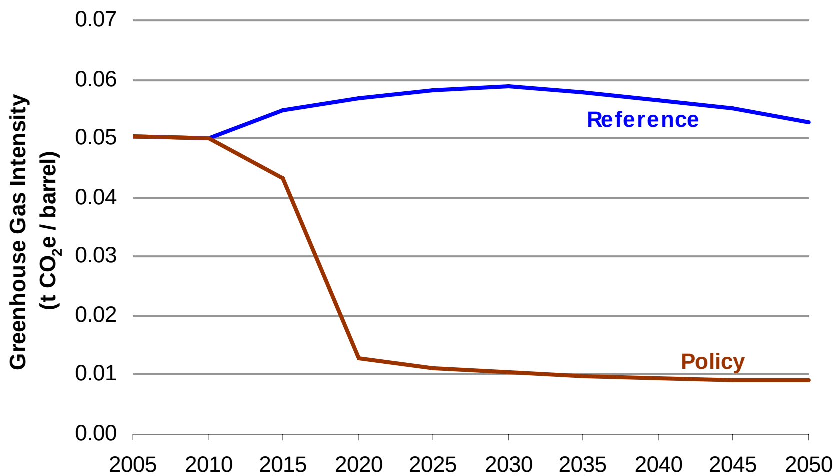


Table 80 shows the cost of oil production outside Alberta. The adoption of abatement technologies increases the cost of producing a barrel of oil by $1.55 ($2005) or approximately 7% in 2050. The increase in cost of production is lower outside Alberta because all production is forecasted to be conventional.

Table 80: Increase in the cost of petroleum crude production outside Alberta

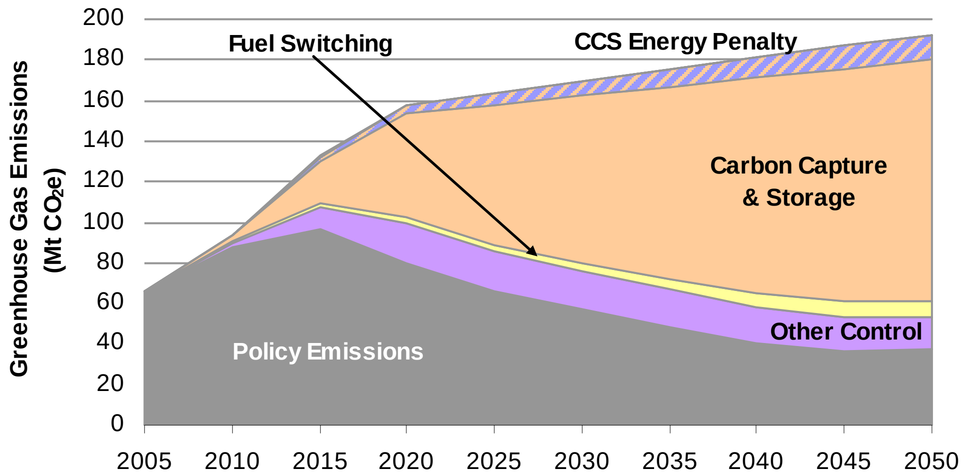
	Increase in Costs (2005$ / barrel)			
	2020	*2030*	*2040*	*2050*
All Production	$0.87	$1.33	$1.46	$1.55

Technology roadmap to low emissions for petroleum crude production

Carbon capture and storage accounts for approximately 85% of the reduction in greenhouse gas emissions in 2050, while other controls (e.g., reduced venting and flaring) and fuel switching to low carbon fuels account for approximately 10% and 5% of emissions reductions, respectively (see Figure 47).

Future"). The remaining provinces are not currently known to have any unconventional sources of petroleum that could be developed.

Figure 47: Wedge diagram for petroleum crude production



The oil sands sector employs three processes which are suitable for carbon capture and storage: 1) the production of hydrogen in oil sands upgrading; 2) the production of process heat for oil sands upgrading; and 3) the production of steam for in-situ operations. Hydrogen production via steam methane reforming or coke gasification can be designed or retrofitted to produce a relatively pure stream of carbon dioxide, which avoids the costly process of separating the carbon dioxide from other flue gases. Estimates of the costs of carbon capture from hydrogen production range from $5-50 / tonne CO_2e. Therefore, hydrogen production represents an opportunity for the early adoption for carbon capture.[39]

The emissions generated during the production of process heat for oil sands upgrading and from bitumen extraction at in-situ operations can also be captured. The cost of carbon capture from these sources is likely to be similar to the costs of capture from the electricity generation sector – between $15 and $75 ($US) per tonne of CO_2e avoided.[40]

Table 81 shows the penetration of carbon capture and storage in the oil sands sector in the policy scenario as a percentage of total installed stock. Hydrogen production shows the fastest penetration of carbon capture and storage, while penetration is slightly slower for the production of process heat for upgrading and steam production in in-situ extraction. By 2050, all hydrogen production and oil sands upgrading employs carbon capture and storage. Steam and heat production in in-situ operations predominately adopt carbon capture and storage, however a small portion of steam is produced from low emissions sources of energy (e.g., electricity). In-situ operations could also use nuclear energy to produce heat and steam if it becomes politically acceptable to do so. As discussed above, the option of nuclear power in this sector has been excluded from this analysis.

[39] Intergovernmental Panel on Climate Change, 2005, “Carbon Dioxide Capture and Storage”; Keith D., 2002, “Toward a Strategy for Implementing CO_2 Capture and Storage in Canada”.

[40] Intergovernmental Panel on Climate Change, 2005, “Carbon Dioxide Capture and Storage”.

Table 81: Penetration of carbon capture and storage in oil sands sector

	2020	*2030*	*2040*	*2050*
Hydrogen Production	91%	98%	100%	100%
Oil Sands Upgrading	58%	88%	96%	99%
In-situ	35%	54%	57%	55%

In addition to carbon capture and storage, significant emissions reductions result from fuel switching and from actions that reduce fugitive emissions, such as reducing venting and flaring from conventional oil wells. The sector switches from petroleum products (e.g., petroleum coke and heavy fuel oil) to natural gas and electricity as a result of the policy, primarily for steam and heat production.

Our analysis includes several in-situ extraction technologies with the potential to greatly reduce the steam requirement of extraction. These include solvent-based systems to reduce the viscosity of the bitumen (e.g., VAPEX) and underground combustion processes (e.g., Toe to Heel) that liquefy and push the bitumen to the surface. We expect these technologies to be adopted regardless of the policy because they reduce energy costs, but the policy is likely to accelerate their adoption. Overall, these technologies are projected to improve the energy efficiency of the sector over time, but not significantly in response to the policy.

The capital expenditures required to attain the emissions reductions in the petroleum extraction sector are 23% greater in the medium-term, and 17% greater in the long-term than in the reference scenario (Table 82). The rise in capital expenditures is greater in the medium-term due to the retrofitting of existing oil sands upgraders with carbon capture equipment. In the long-term, most investments in carbon capture are made in new facilities.

Table 82: Increase in capital expenditures of petroleum crude production

	Medium-Term (2011-2030)	*Long-term (2031-2050)*
Increase in Annual Capital Expenditures (2005$ Millions)	1,236	768
Increase in Capital Expenditures (% above the reference case)	23%	17%

Uncertainty in the analysis

The petroleum crude sector may have the option to use nuclear energy to produce the heat and steam required for oil sands upgrading and bitumen extraction in in-situ operations. We have excluded this option from the analysis because the decision is more political than economic. The adoption of nuclear energy to power oil sands production would significantly reduce the role of carbon capture and storage in heat production. Nuclear power could also be used to produce hydrogen by electrolysis.

The impact of the policy on the output from the sector is also significantly uncertain. In this analysis, we assume that the Canadian production of petroleum will not change when the policy is implemented. We assume that the selling price of petroleum (i.e., the global price for oil) will exceed the cost of producing it in Canada regardless of the policy – in other words, the sector generates economic profits or rents. This assumption is likely imperfect, but the US Energy Information Administration projects that international demand for crude oil and natural gas is likely to remain robust even with the introduction of climate change abatement policies.[41] However, if the price for oil declines significantly, the policy may reduce production from high cost sources of petroleum.

Natural gas extraction, transmission and distribution

Box 14: Key actions by the natural gas extraction sector

- Most emissions reductions are attained from carbon capture and storage.
- The separation of formation carbon dioxide from raw natural gas is likely to be an early opportunity to adopt carbon capture. The process produces a relatively pure stream of carbon dioxide, which can be captured at low cost – approximately \$20/tonne CO_2e.

The natural gas extraction and processing sector is projected to play a declining role in Canada's greenhouse gas emissions, as the output from conventional natural gas fields declines. The development of coal bed methane partially offsets the decline from conventional fields, but total output is projected to decrease from 174 billion m^3 in 2005 to 140 billion m^3 in 2050. In the reference case, greenhouse gas emissions also decline from 65 Mt CO_2e in 2005 to 37 Mt CO_2e in 2050, reflecting the reduction in output. Approximately half of the greenhouse gas emissions are from combustion sources – engines and the production of process heat at natural gas processing plants – while half are process emissions. Process emissions from natural gas extraction include formation carbon dioxide, fugitive emissions from natural gas wells and leaks from pipelines. Formation carbon dioxide is extracted from the well with the raw natural gas and is removed and vented before it is marketed.

Environmental impact of policy

The energy and greenhouse gas intensity of the industry decline in the reference case, mostly as a result of improvements in the energy efficiency of natural gas extraction and processing (see Figure 48 and Figure 49). These improvements offset the transition towards extracting natural gas from coal beds, which is more energy and greenhouse gas intensive. Greenhouse gas intensity further declines from a modest adoption of leak detection and repair programs, which increase costs but also reduce losses of natural gas.

In the policy scenario, both the energy and greenhouse gas intensity of the sector decline. These improvements in energy efficiency offset the energy efficiency penalty associated with carbon capture and storage. The greenhouse gas intensity of natural gas production drops as a result of the capture of formation carbon dioxide and combustion emissions from processing plants, as well as from leak detection and repair programs.

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[41] Energy Information Administration, 1998, "Impacts of the Kyoto Protocol on US Energy Markets and Economic Activity", United States Department of Energy.

Figure 48: Energy intensity of natural gas extraction, transmission and distribution

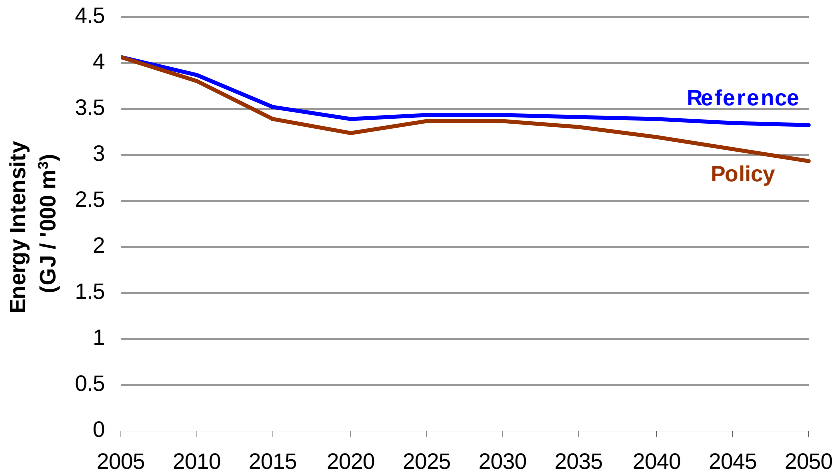
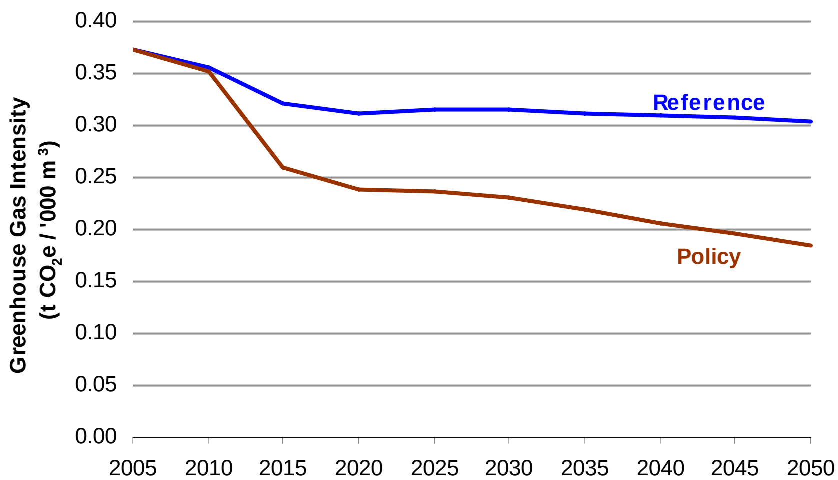


Figure 49: Greenhouse gas intensity of natural gas extraction, transmission and distribution



The share of electricity increases in response to the policy, while the share of natural gas declines (see Table 83). The increase in electricity consumption is mostly due to a greater use of electric motors to drive pipelines and operate natural gas wells.

Table 83: Fuel switching in natural gas extraction, transmission and distribution

	2020	2030	2040	2050
Natural Gas	-4%	-6%	-11%	-19%
Refined Petroleum Products	0%	0%	1%	1%
Electricity	3%	6%	11%	18%

Economic impact of policy

Table 84 shows the rise in the costs of extracting and transporting natural gas that results from the policy. Overall, the change in the cost of producing, transmitting and distributing natural gas is negligible – less than a percent. Capital expenditures show the only increase is due to the adoption of carbon capture and leak detection programs.

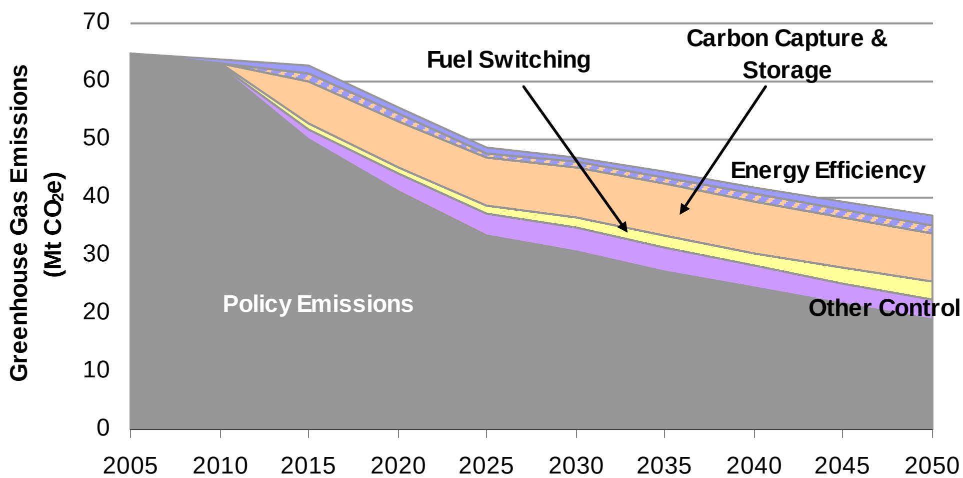
Table 84: Cost of natural gas extraction, transmission and distribution[42]

	Increase in Costs (2005$ / GJ)			
	2020	*2030*	*2040*	*2050*
Total Cost	-$0.02	-$0.04	-$0.04	-$0.03
Capital Costs	$0.01	$0.02	$0.04	$0.06
Operating & Maintenance Costs	-$0.02	-$0.04	-$0.05	-$0.06
Energy Costs	-$0.01	-$0.02	-$0.02	-$0.02

Technology roadmap to low emissions in natural gas extraction, transmission and distribution

Carbon capture and storage accounts for approximately 45% of the emissions reductions, while leak detection and repair programs and fuel switching each account for about 20% (Figure 50).

Figure 50: Wedge diagram for natural gas extraction, transmission and distribution



Capturing formation carbon dioxide is likely to be an early opportunity for implementing carbon capture and storage. In response to regulations on flaring acid gas (H_2S), one option for disposing this gas in small plants is to store the entire acid gas stream (including the formation carbon dioxide) in a geological formation. Carbon capture and storage from these sources would have little to zero additional cost. For larger plants, which are more likely to recover the sulphur instead of store the entire acid gas stream, carbon capture is still a relatively cheap option because the technology can be designed or retrofitted to produce a relatively pure stream of carbon dioxide. The cost of capturing formation carbon dioxide is estimated at approximately $20/tonne CO_2e.[43] Carbon capture from combustion sources is likely to have similar costs to combustion sources in

[42] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

[43] Keith, 2002, "Toward a Strategy for Implementing CO_2 Capture and Storage in Canada".

other sectors – around \$50/tonne CO_2e. Table 85 shows the penetration of carbon capture for formation carbon dioxide and the combustion sources in natural gas processing plants.

Table 85: Penetration of carbon capture in natural gas extraction

	2020	*2030*	*2040*	*2050*
Formation Carbon Dioxide	100%	100%	100%	100%
Combustion Emissions in Processing Plants	32%	63%	98%	100%

In addition to carbon capture, the sector reduces fugitive emissions through leak detection and repair programs. These programs identify and fix leaks at natural gas wells and pipelines. Table 86 shows fugitive emissions per unit of natural gas production. Fugitive emissions decline regardless of the policy because the reduction of fugitive methane increases natural gas production. However fugitive emissions decline by 28% from the reference case projection in the policy scenario.

Table 86: Fugitive emission rate from natural gas wells and pipelines

	Fugitive Emissions (tonne CO_2e / '000 m^3)			
	2020	*2030*	*2040*	*2050*
Reference Case	0.098	0.094	0.091	0.089
Policy	0.081	0.070	0.067	0.064
Reduction due to Policy (%)	17%	25%	27%	28%

The motors that drive pipelines and operate wells may use electricity instead of natural gas. Table 87 shows the penetration of electric motors for operating wells and pipelines. By 2050, close to 80% of all motors use electricity, a 60% increase from the reference projection.

Table 87: Penetration of electric motors for operating wells and pipelines

	Penetration of Electric motors (%)			
	2020	*2030*	*2040*	*2050*
Reference Case	8%	12%	15%	18%
Policy	22%	33%	53%	77%
Increase due to Policy (%)	13%	22%	38%	59%

Table 88 shows that attaining deep reductions in greenhouse gas emissions requires around a 5% increase capital expenditures over the reference case. The increase in capital costs is mostly from the addition of carbon capture and storage and leak detection and repair equipment.

Table 88: Increase in capital expenditures of natural gas extraction, transmission and distribution

	Medium-Term (2011-2030)	*Long-term (2031-2050)*
Increase in Annual Capital Expenditures (2005\$ Millions)	88	127
Increase in Capital Expenditures (% above the reference case)	4%	6%

Biofuels manufacturing

Box 15: Key actions by the biofuels manufacturing sector

- The policy induces a significant increase in the production of biofuels. In the reference projection, the demand and production of biofuels is negligible, but increases to 2,095 PJ in 2050 in the policy scenario.

- In the policy scenario, the sector reduces its greenhouse gas intensity by adopting carbon capture and storage and producing ethanol from cellulose instead of corn.

The production of biofuels (liquid transport fuels derived from biomass) is expected to remain relatively minor in the reference scenario, reaching just 103 PJ in 2050. However, substituting conventional fossil fuels with biofuels has the potential to reduce greenhouse gas emissions from the transportation sector, and other sectors such as petroleum extraction and mining. Production of biofuels increases dramatically in the policy scenario, reaching 2,095 PJ in 2050. Switching to biofuels reduces greenhouse gas emissions by 175 Mt CO_2e in 2050, accounting for 16% of total emissions reductions for Canada.

Several types of biofuels exist, with multiple methods of producing them. The two dominant forms of biofuels today are ethanol and esters, the latter more commonly known as biodiesel. Ethanol is usually produced from sugar or starchy crops, and in Canada is primarily distilled from corn and wheat, while biodiesel is produced mainly from oil-seed crops such as rapeseed, palm and sunflowers.[44] Ethanol can be used in most automotive engines when blended in low concentrations with gasoline, but requires modifications to the vehicle engine to be used in high or pure blends. However, biodiesel can be used easily in most compression-ignition engines in its pure form or blended with conventional diesel fuel.[45] Some types of biodiesel freeze at lower temperatures than others, although fuel additives and engine block or fuel filter heaters can remedy this problem.[46]

The production of agricultural crops and the conversion of these crops into biofuels, especially corn-based ethanol, can be energy intensive; however advanced methods of producing biofuels (such as enzymatic hydrolysis and gasification of woody ligno-cellulosic feedstock) may reduce these requirements in the future. Note that the following discussion concerning biofuels manufacturing ignores inter-provincial differences because production processes are likely to be similar among regions.

Environmental impact of policy

Figure 51 and Figure 52 show the energy intensity of ethanol and biodiesel production in the reference and policy scenarios. The energy intensity of ethanol production decreases markedly in both the reference and policy scenarios, due to the adoption of cellulosic production techniques which are less energy intensive. In the policy scenario, the energy intensity of ethanol production reaches 0.07 GJ / GJ ethanol by 2050, 92% lower than in 2005 and 64% lower than the reference projection for 2050. The energy intensity of

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[44] Natural Resources Canada, 2006, "Ethanol: The Road to a Greener Future," http://oee.nrcan.gc.ca/publications/infosource/pub/vehiclefuels/ethanol/M92_257_2003.cfm

[45] International Energy Agency, 2006, "World Energy Outlook," Paris: OECD/IEA.

[46] Natural Resources Canada, 2008, "Biodiesel: Safety & Performance," http://www.oee.nrcan.gc.ca/transportation/fuels/biodiesel/biodiesel-safety.cfm?attr=8

biodiesel production does not change significantly in the reference or policy scenario, remaining at about 0.20 GJ / GJ biodiesel.

Figure 51: Energy intensity of ethanol production

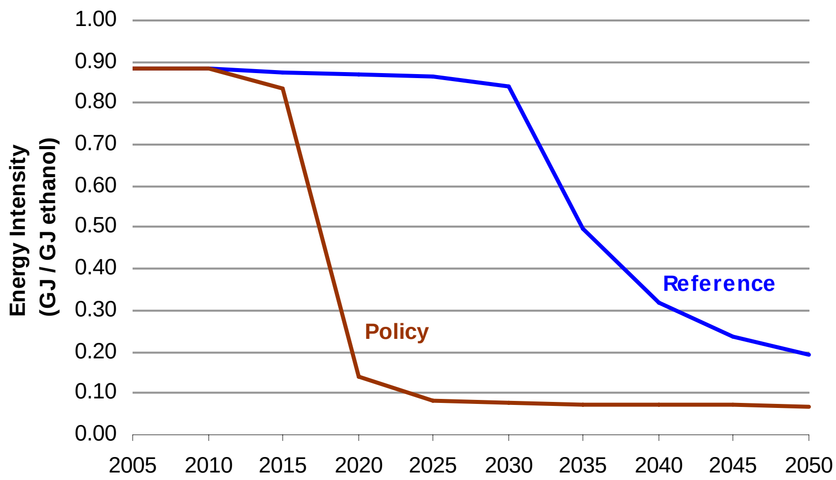


Figure 52: Energy intensity of biodiesel production

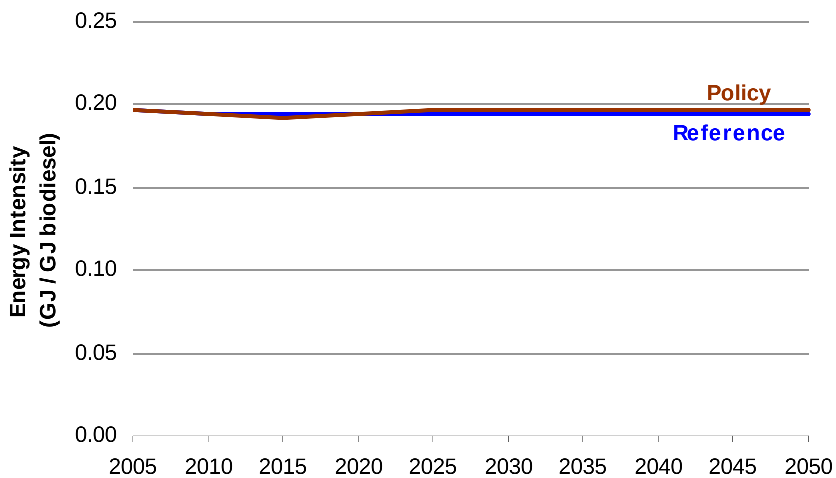


Figure 53 and Figure 54 show the greenhouse gas intensity of ethanol and biodiesel production in the reference and policy scenarios. The greenhouse gas intensity decreases substantially in both scenarios, but is accelerated in the policy scenario. In the policy scenario, the greenhouse gas intensity of ethanol production drops from 0.045 tonne CO_2e / GJ ethanol in 2005 to 0.002 tonne CO_2e / GJ ethanol in 2050, a decrease of 95%. The switch to cellulosic ethanol production plays a large role in reducing greenhouse gas emissions from ethanol production. The greenhouse gas intensity of biodiesel production also decreases substantially, from 0.015 t CO_2e / GJ biodiesel in 2005 to 0.004 t CO_2e / GJ biodiesel in 2050, a decrease of 73%. The decline in greenhouse gas intensity from biodiesel production is mostly from installing electric boilers and adopting carbon capture and storage.

Figure 53: Greenhouse gas intensity of ethanol production

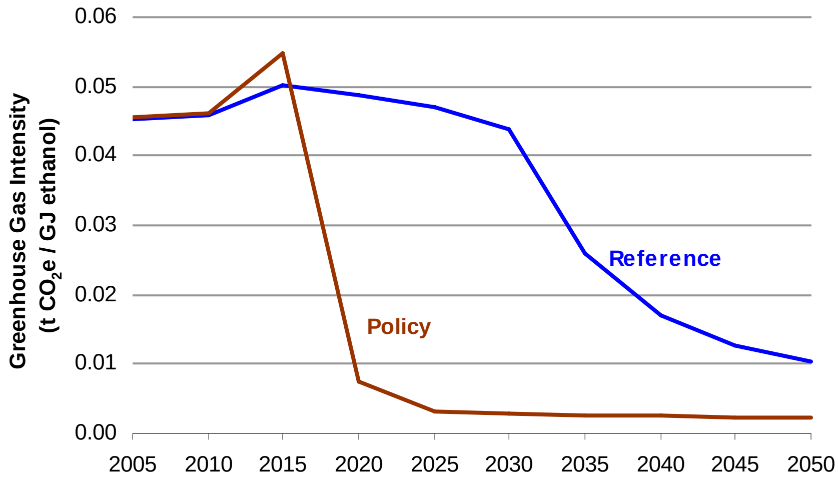


Figure 54: Greenhouse gas intensity of biodiesel production

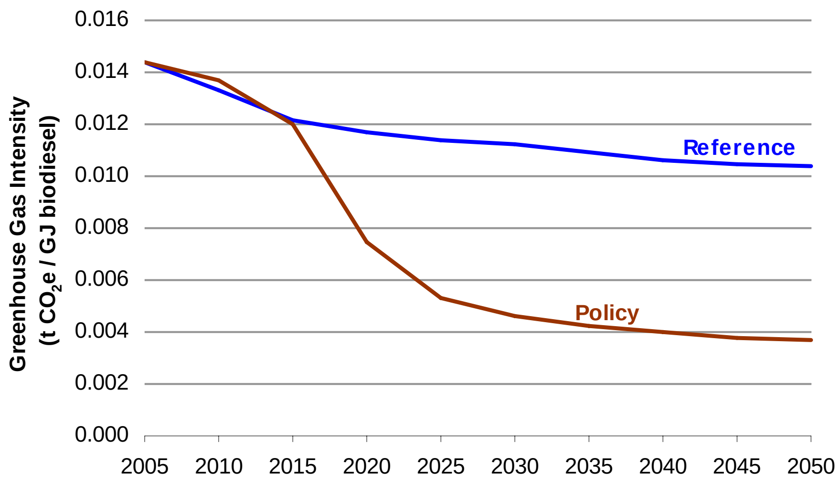


Table 89 shows the change in fuel shares that result from the policy scenario. Overall, the sector shifts from coal and natural gas towards electricity and renewable energy. The majority of the observed shifts in fuel consumption occur from the energy used to produce process heat, although a shift to biodiesel for fuel in agricultural machinery also contributes to the increase in renewable energy.

Table 89: Fuel switching in biofuels manufacturing

	2020	2030	2040	2050
Natural Gas	-14%	-18%	-15%	-11%
Coal	-9%	-14%	-12%	-12%
Refined Petroleum Products	3%	10%	3%	-1%
Electricity	16%	15%	14%	15%
Renewable	4%	8%	9%	9%

Economic impact of policy

Table 90 and Table 91 show the increase in production costs relative to the reference case for ethanol and biodiesel, respectively. The production costs for ethanol decrease because the policy scenario results in a more rapid and widespread adoption of cellulosic ethanol, which requires up to 90% less energy. The capital requirements of producing a unit of ethanol also decline, as manufacturers accumulate experience more rapidly with cellulosic ethanol. In 2050, ethanol production costs are 6% lower than in the reference case in 2050, and 36% lower than in 2005. On the other hand, production costs for biodiesel increase modestly, and in 2050 are 3% higher than in the reference case. This increase is due to the higher energy costs of electricity and renewable energy relative to conventional fossil fuels in the policy scenario.

Table 90: Increase in the cost of ethanol production[47]

	Increase in Costs (2005$ / GJ Ethanol)			
	2020	*2030*	*2040*	*2050*
Total Cost	-$4.11	-$7.01	-$2.15	-$1.03
Capital Costs	$2.03	-$0.50	-$0.10	-$0.04
Operating & Maintenance Costs	-$0.17	-$0.18	-$0.06	-$0.03
Energy Costs	-$5.98	-$6.33	-$1.99	-$0.96

Table 91: Increase in the cost of biodiesel production

	Increase in Costs (2005$ / GJ Biodiesel)			
	2020	*2030*	*2040*	*2050*
Total Cost	$0.42	$0.64	$0.61	$0.60
Capital Costs	$0.06	$0.10	$0.12	$0.11
Operating & Maintenance Costs	$0.00	-$0.01	$0.00	$0.00
Energy Costs	$0.36	$0.55	$0.49	$0.49

Technology roadmap to low emissions in biofuels manufacturing

The increase in biofuels production in the policy scenario results in an increase in energy consumption and greenhouse gas emissions. Most of the declines in emissions intensity are the result of improved energy efficiency and carbon capture and storage. Table 92 shows the emissions reductions by action in biofuels manufacturing.

Table 92: Emissions reductions by action in biofuels manufacturing (Mt CO_2e)

	2020	*2030*	*2040*	*2050*
Output	-1.95	-5.98	-8.06	-8.75
Fuel Switching	0.13	0.35	0.44	0.45
CCS	0.08	0.44	0.64	0.81
CCS Energy Efficiency Penalty	0.01	0.06	0.08	0.10
Energy Efficiency	0.28	1.36	0.98	0.72
Total Reductions	-1.44	-3.77	-5.93	-6.68

Switching to cellulosic ethanol production methods substantially reduces the energy intensity of producing biofuels. Conventional ethanol production from corn currently accounts for all ethanol production, but the development of cellulosic ethanol technology

[47] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

is accelerated in the policy scenario, and accounts for all production by 2030 (see Table 93).

Table 93: Penetration of cellulosic ethanol

	2020	*2030*	*2040*	*2050*
Reference	0%	3%	68%	84%
Policy	91%	99%	100%	100%
Increase due to Policy	91%	96%	32%	16%

The policy scenario results in a large switch away from conventional fossil fuel-fired heat production towards electricity and carbon capture and storage. Table 94 shows the penetration of these technologies in the biofuels sector. By 2050, electricity and carbon capture and storage account for virtually all heat production.

Table 94: Penetration of electricity and carbon capture and storage in heat production

	2020	*2030*	*2040*	*2050*
Electric	25%	44%	49%	52%
Carbon Capture and Storage	37%	45%	46%	46%

Table 95 shows the increase in capital expenditures in the policy scenario. Capital expenditures must rise dramatically to meet the rapid growth in demand in the policy scenario.

Table 95: Increase in capital expenditures that results from policy

	Medium-Term (2011-2025)	*Long-term (2026-2050)*
Increase in Annual Capital Expenditures (2005$ Millions)	1,519	2,637
Increase in Capital Expenditures (% above the reference case)	3,336%	1,819%

Uncertainty in the analysis

Several sources of uncertainty are present in this analysis. First, as agricultural land is devoted to the production of biofuel crops, the costs of these crops should increase as less additional land is available for production. However, the possibility for alternative inputs (such as a variety of fibres for cellulosic ethanol) and higher agricultural yields may diminish these price feedbacks.[48] This analysis assumes that the cost of agricultural inputs does not vary according to production of biofuels.

Second, a variety of other factors could impact the potential for biofuels to reduce greenhouse gas emissions in Canada. For example, concerns about food costs and land availability could minimize the desired role for biofuels; alternatively, additional support could be given to biofuels in order to increase revenue for agricultural producers.

Landfills

Box 16: Key actions by the landfill sector

- Capturing and flaring landfill gas, which has high concentrations of methane, may

[48] International Energy Agency, 2006, "World Energy Outlook," Paris: OECD/IEA.

be an early opportunity for abating greenhouse gas emissions in Canada. By 2020, the policy induces almost all landfills in Canada to control landfill gas emissions.

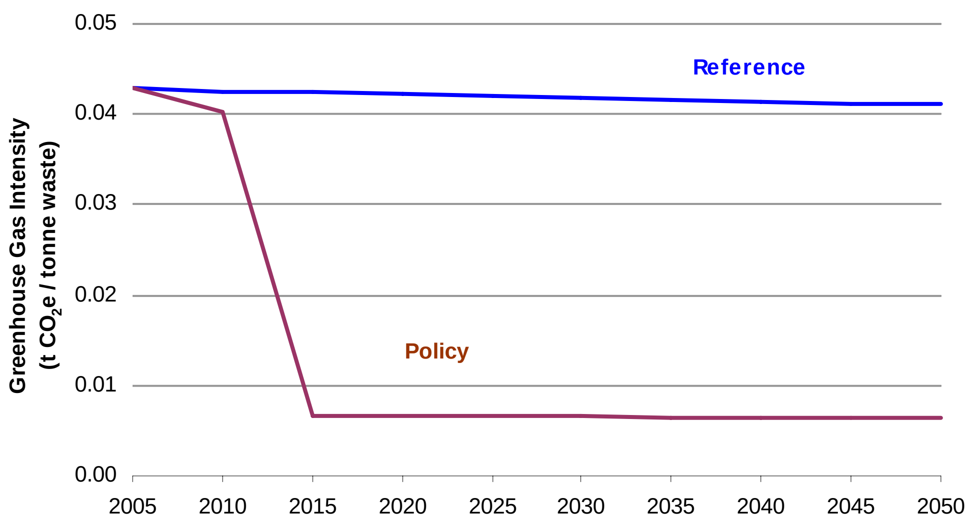
Canadian landfills emitted approximately 27.5 Mt CO_2e in 2005, and in the reference scenario are expected to emit 33.9 Mt by 2050.[49] The decomposition of organic waste in these landfills produces methane and carbon dioxide, which are generally released into the atmosphere. Some landfills capture and flare landfill gas to control odours or to generate electricity from methane, although the capture of landfill gas is unlikely to expand substantially without a policy intervention.

In 2005, about 29% of landfill waste was subjected to gas flaring across Canada, and less than 1% of waste was used for electricity generation. The remaining 70% of landfill waste was not subject to any control measures. Although the current status of flaring varies among provinces, the following discussion ignores regional differences because the potential for mitigation actions is judged to be largely similar among regions.

Environmental impact of policy

Landfills may present an early opportunity for reducing greenhouse gas emissions. In the reference scenario, the greenhouse gas intensity of landfills remains stable (see Figure 55). In the policy scenario, greenhouse gas intensity drops dramatically to 0.007 tonnes CO_2e per tonne of waste in 2015, a decrease of 84%.

Figure 55: Greenhouse gas intensity of landfills



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[49] Note that Environment Canada has recently revised this estimate downward to 21 Mt CO_2e in 2005 (Environment Canada, 2008, "National Inventory Report"). This revision has not been included in the analysis.

Economic impact of policy

The costs of capturing landfill gas are presented in Table 96. Capital costs and operating and maintenance costs increase relative to the reference scenario, but are offset in large part by revenue from electricity generation. In 2050, total costs are $5.71 per tonne of waste higher than in the reference scenario.

Table 96: Increase in the cost of landfill waste processing[50]

	Increase in Costs (2005$ / tonne waste)			
	2020	*2030*	*2040*	*2050*
Total Cost	$5.49	$5.39	$5.56	$5.71
Capital Costs	$5.57	$5.51	$5.70	$5.86
Operating & Maintenance Costs	$0.15	$0.17	$0.18	$0.19
Energy Costs	-$0.23	-$0.29	-$0.32	-$0.33

Technology roadmap to low emissions in landfills

The wedge diagram in Figure 56 illustrates the rapid reduction of emissions from Canada's landfills. By 2015, greenhouse gas emissions are only 4.6 Mt CO_2e – 84% below the reference scenario. The reduction in emissions is possible because of a rapid uptake of flaring and electricity generation among landfills. In the reference scenario, 70% of landfill waste is not subjected to any greenhouse gas control. In the policy scenario, all landfill waste is subjected to control measures by 2015 (see Table 97). After 2015, the proportion of waste used to generate electricity gradually increases, reaching 62% in 2050. By 2050, the sector generates 5.4 TWh of electricity.

Figure 56: Wedge diagram for landfills

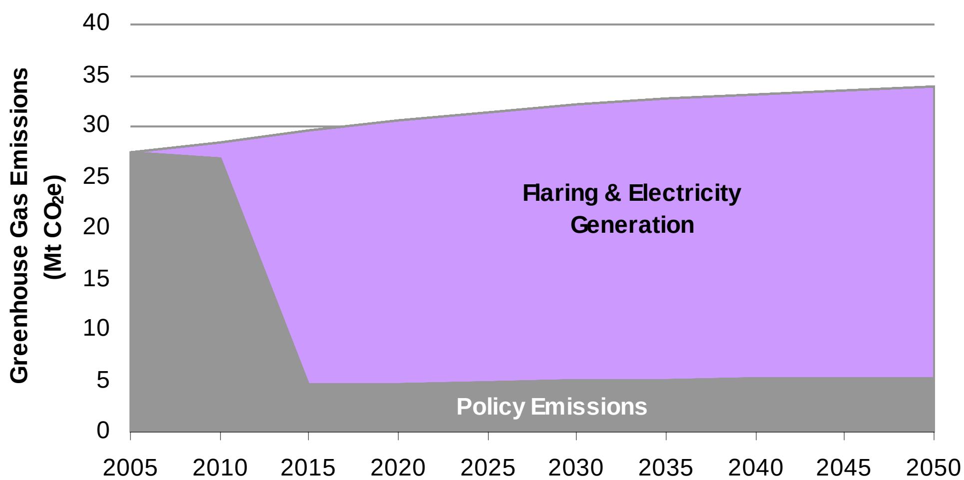


Table 97: Proportion of landfill waste subjected to greenhouse gas control measures

	2020	*2030*	*2040*	*2050*
No Control	0%	0%	0%	0%
Flaring	61%	50%	43%	38%
Electricity Generation	39%	50%	57%	62%

[50] The table does not show emissions costs, because all emissions costs are recycled back to the sector.

Table 98 shows the increase in capital expenditures from the policy scenario. Capital expenditures must rise to cap landfills and install the flaring equipment, especially in the medium term.

Table 98: Increase in capital expenditures of landfills

	Medium-Term (2011-2025)	*Long-term (2026-2050)*
Increase in Annual Capital Expenditures (2005$ Millions)	70	19
Increase in Capital Expenditures (% above the reference case)	1,656%	570%

Uncertainty in the analysis

This analysis assumes that all landfills are capable of capturing and flaring landfill gas. The cost of capturing and flaring landfill gas varies depending on the size of the landfill, and whether the landfill gas could be used to generate electricity. However, most landfills in Canada should capture and flare their emissions once the price for emissions has exceeded $80/tonne CO_2e.[51]

[51] Marbek, 2002, "Business Plan for GMIF Investments: Landfill Gas Sector".

Appendix A – Detailed Quantitative Results

Reference case – Canada

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	40	41	40	39
Commercial	41	47	56	66
Transportation	253	263	282	312
Manufacturing Industry	90	97	109	125
Landfills	31	32	33	34
Supply Sectors				
Electricity Generation	113	119	138	170
Petroleum Refining	24	26	29	32
Crude Oil	158	170	181	193
Natural Gas	56	47	42	37
Coal Mining	3	3	3	3
Biofuels Manufacturing	0	1	1	1
Total	807	845	915	1,012

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	1,567	1,760	1,977	2,303
Commercial	1,412	1,639	1,956	2,298
Transportation	3,522	3,728	4,077	4,557
Manufacturing Industry	2,527	2,770	3,105	3,497
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	4,127	4,626	5,448	6,560
Petroleum Refining	422	457	510	571
Crude Oil	1,996	2,202	2,342	2,506
Natural Gas	607	512	457	403
Coal Mining	24	25	26	27
Biofuels Manufacturing	4	13	16	20
Total	16,208	17,730	19,914	22,742

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	4,213	4,543	4,922	5,392
Coal	1,578	1,765	2,039	2,465
Refined Petroleum Products	3,993	4,106	4,482	4,982
Electricity	2,260	2,597	3,077	3,700
Nuclear	1,062	1,174	1,346	1,596
Biofuel	16	31	65	103
Renewable	2,312	2,666	3,062	3,524
Other	775	849	922	981
Total	16,208	17,730	19,914	22,742

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	103	106	115	129
Household Emissions Intensity (t CO_2e / household)	2.6	2.4	2.3	2.2
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.39	0.35	0.33	0.31
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.013	0.011	0.010	0.010
Annual Energy Costs (2005$ / household)	$1,807	$1,914	$2,150	$2,548
Electricity Price (2005¢ / kWh)	8.7	8.7	8.7	8.7
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.5	1.5	1.5	1.5
Emissions Intensity (t CO_2e / m^2 floorspace)	0.045	0.043	0.043	0.042
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.86	0.82	0.80	0.79
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.035	0.033	0.032	0.032
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.8	1.6	1.4	1.4
Passenger Emissions Intensity (kg CO_2e / pkt)	0.12	0.11	0.10	0.09
Passenger Vehicle Energy Intensity (MJ / vkt)	3.1	2.7	2.5	2.3
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.22	0.19	0.17	0.16
Annual Passenger Vehicle Fuel Costs (2005$ / vehicle)	$1,460	$1,394	$1,276	$1,208
Freight Energy Intensity (MJ / tkt)	1.2	1.1	1.1	1.1
Freight Emissions Intensity (kg CO_2e / tkt)	0.08	0.08	0.08	0.08
Average Vehicle Fuel Prices (2005¢ / L gasoline eq.)	82.9	90.6	90.8	90.8
Electricity Generation				
Energy Intensity (GJ / MWh)	5.9	5.8	5.8	5.8
Emissions Intensity (t CO_2e / MWh)	0.16	0.15	0.15	0.15
Renewable Generation (TWh)	450	515	603	709
Nuclear Generation (TWh)	98	109	125	148
Coal Generation (TWh)	107	123	149	193
Natural Gas Generation (TWh)	37	44	50	56
CCS Generation (TWh)	4	10	19	27
Other Generation (TWh)	5	1	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	1.1	1.1	1.0	1.0
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.09	0.08	0.08	0.08
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Reference case – British Columbia

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	3	3	3	3
Commercial	4	5	5	7
Transportation	39	40	44	49
Manufacturing Industry	9	10	12	13
Landfills	6	6	7	7
Supply Sectors				
Electricity Generation	1	2	2	3
Petroleum Refining	2	2	2	3
Crude Oil	0	0	0	0
Natural Gas	13	12	12	11
Coal Mining	2	2	2	2
Biofuels Manufacturing	0	0	0	0
Total	79	82	89	97

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	153	192	224	270
Commercial	165	193	234	280
Transportation	537	571	634	716
Manufacturing Industry	454	503	562	624
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	340	449	566	703
Petroleum Refining	26	30	37	45
Crude Oil	3	2	2	2
Natural Gas	118	113	105	97
Coal Mining	14	14	14	14
Biofuels Manufacturing	1	3	3	4
Total	1,809	2,071	2,381	2,755

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	345	376	424	481
Coal	18	21	22	24
Refined Petroleum Products	579	606	661	736
Electricity	283	356	433	526
Nuclear	0	0	0	0
Biofuel	6	8	13	18
Renewable	564	686	807	943
Other	15	18	23	28
Total	1,809	2,071	2,381	2,755

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	76	79	87	101
Household Emissions Intensity (t CO_2e / household)	1.6	1.3	1.2	1.1
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.24	0.21	0.20	0.19
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.007	0.004	0.003	0.003
Annual Energy Costs (2005$ / household)	$1,224	$1,302	$1,468	$1,731
Electricity Price (2005¢ / kWh)	6.5	6.5	6.5	6.5
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.2	1.2	1.1	1.1
Emissions Intensity (t CO_2e / m^2 floorspace)	0.029	0.027	0.027	0.027
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.65	0.62	0.61	0.60
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.024	0.022	0.022	0.022
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.8	1.6	1.5	1.4
Passenger Emissions Intensity (kg CO_2e / pkt)	0.12	0.11	0.10	0.09
Passenger Vehicle Energy Intensity (MJ / vkt)	3.1	2.7	2.5	2.3
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.22	0.19	0.16	0.15
Annual Passenger Vehicle Fuel Costs (2005$ / vehicle)	$1,523	$1,433	$1,290	$1,224
Freight Energy Intensity (MJ / tkt)	1.0	0.9	0.9	0.9
Freight Emissions Intensity (kg CO_2e / tkt)	0.07	0.07	0.07	0.07
Average Vehicle Fuel Prices (2005¢ / L gasoline eq.)	86.0	93.2	92.7	92.6
Electricity Generation				
Energy Intensity (GJ / MWh)	4.0	4.2	4.3	4.4
Emissions Intensity (t CO_2e / MWh)	0.01	0.02	0.02	0.02
Renewable Generation (TWh)	82	101	122	148
Nuclear Generation (TWh)	0	0	0	0
Coal Generation (TWh)	0	0	0	0
Natural Gas Generation (TWh)	3	5	6	8
CCS Generation (TWh)	0	1	2	3
Other Generation (TWh)	0	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	0.2	0.2	0.2	0.2
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.04	0.03	0.03	0.03
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Reference case – Alberta

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	8	8	9	9
Commercial	6	7	9	10
Transportation	40	42	45	51
Manufacturing Industry	15	16	18	20
Landfills	3	3	3	4
Supply Sectors				
Electricity Generation	55	55	57	63
Petroleum Refining	6	6	7	7
Crude Oil	147	162	175	188
Natural Gas	32	25	22	18
Coal Mining	1	1	1	1
Biofuels Manufacturing	0	0	0	0
Total	312	327	346	371

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	204	231	257	293
Commercial	193	223	264	304
Transportation	551	588	647	734
Manufacturing Industry	339	369	406	454
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	686	722	786	893
Petroleum Refining	103	113	124	136
Crude Oil	1,967	2,181	2,324	2,490
Natural Gas	346	276	238	201
Coal Mining	8	8	8	9
Biofuels Manufacturing	0	1	2	2
Total	4,398	4,713	5,055	5,517

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	1,895	2,000	2,062	2,196
Coal	864	907	954	1,036
Refined Petroleum Products	652	715	836	963
Electricity	262	294	336	396
Nuclear	0	0	0	0
Biofuel	2	3	6	10
Renewable	104	118	134	155
Other	619	676	728	761
Total	4,398	4,713	5,055	5,517

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	131	130	135	145
Household Emissions Intensity (t CO_2e / household)	5.1	4.8	4.5	4.2
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.59	0.53	0.49	0.46
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.028	0.025	0.024	0.022
Annual Energy Costs (2005$ / household)	$1,733	$1,815	$2,028	$2,415
Electricity Price (2005¢ / kWh)	9.5	9.5	9.5	9.5
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.6	1.6	1.6	1.5
Emissions Intensity (t CO_2e / m^2 floorspace)	0.053	0.053	0.053	0.052
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.99	0.96	0.96	0.94
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.044	0.043	0.043	0.043
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.8	1.7	1.6	1.5
Passenger Emissions Intensity (kg CO_2e / pkt)	0.13	0.12	0.11	0.10
Passenger Vehicle Energy Intensity (MJ / vkt)	3.3	3.0	2.7	2.6
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.24	0.21	0.19	0.18
Annual Passenger Vehicle Fuel Costs (2005$ / vehicle)	$1,494	$1,460	$1,347	$1,280
Freight Energy Intensity (MJ / tkt)	0.9	0.9	0.9	0.9
Freight Emissions Intensity (kg CO_2e / tkt)	0.07	0.06	0.06	0.07
Average Vehicle Fuel Prices (2005¢ / L gasoline eq.)	78.9	87.0	87.4	87.6
Electricity Generation				
Energy Intensity (GJ / MWh)	8.9	8.3	7.9	7.6
Emissions Intensity (t CO_2e / MWh)	0.71	0.64	0.58	0.54
Renewable Generation (TWh)	8	10	14	17
Nuclear Generation (TWh)	0	0	0	0
Coal Generation (TWh)	54	58	62	72
Natural Gas Generation (TWh)	12	15	17	19
CCS Generation (TWh)	3	4	7	9
Other Generation (TWh)	0	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	1.2	1.2	1.1	1.0
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.09	0.09	0.08	0.08
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Reference case – Saskatchewan

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	1	1	1	1
Commercial	2	2	2	2
Transportation	11	11	11	11
Manufacturing Industry	2	3	4	5
Landfills	1	1	1	1
Supply Sectors				
Electricity Generation	16	17	19	22
Petroleum Refining	1	1	1	1
Crude Oil	10	7	6	5
Natural Gas	4	3	3	2
Coal Mining	0	0	0	0
Biofuels Manufacturing	0	0	0	0
Total	48	46	47	51

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	39	36	36	38
Commercial	52	56	64	74
Transportation	155	151	154	165
Manufacturing Industry	62	79	104	136
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	200	211	239	275
Petroleum Refining	16	16	16	18
Crude Oil	21	16	13	11
Natural Gas	34	27	24	21
Coal Mining	3	3	3	4
Biofuels Manufacturing	0	1	1	1
Total	581	596	654	742

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	171	170	188	212
Coal	157	175	200	236
Refined Petroleum Products	175	163	160	168
Electricity	56	64	77	92
Nuclear	0	0	0	0
Biofuel	0	1	3	5
Renewable	17	19	21	23
Other	4	5	5	5
Total	581	596	654	742

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	91	91	95	108
Household Emissions Intensity (t CO_2e / household)	3.0	2.6	2.3	2.1
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.43	0.38	0.33	0.32
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.019	0.015	0.013	0.012
Annual Energy Costs (2005$ / household)	$1,284	$1,343	$1,490	$1,771
Electricity Price (2005¢ / kWh)	7.3	7.3	7.3	7.3
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.7	1.6	1.6	1.6
Emissions Intensity (t CO_2e / m^2 floorspace)	0.059	0.055	0.053	0.053
Space Heating Energy Intensity (GJ / m^2 floorspace)	1.11	1.01	0.97	0.96
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.050	0.045	0.043	0.043
Transportation				
Passenger Energy Intensity (MJ / pkt)	2.1	1.8	1.7	1.6
Passenger Emissions Intensity (kg CO_2e / pkt)	0.15	0.12	0.11	0.10
Passenger Vehicle Energy Intensity (MJ / vkt)	3.3	2.8	2.6	2.4
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.23	0.20	0.17	0.16
Annual Passenger Vehicle Fuel Costs (2005$ / vehicle)	$1,576	$1,493	$1,356	$1,281
Freight Energy Intensity (MJ / tkt)	1.7	1.6	1.6	1.6
Freight Emissions Intensity (kg CO_2e / tkt)	0.12	0.11	0.11	0.11
Average Vehicle Fuel Prices (2005¢ / L gasoline eq.)	84.6	92.5	92.4	92.4
Electricity Generation				
Energy Intensity (GJ / MWh)	9.4	8.9	8.6	8.5
Emissions Intensity (t CO_2e / MWh)	0.76	0.73	0.69	0.68
Renewable Generation (TWh)	5	5	6	6
Nuclear Generation (TWh)	0	0	0	0
Coal Generation (TWh)	13	16	18	23
Natural Gas Generation (TWh)	3	2	2	2
CCS Generation (TWh)	0	1	1	2
Other Generation (TWh)	0	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	0.2	0.2	0.2	0.2
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.08	0.08	0.08	0.07
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Reference case – Manitoba

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	1	1	1	1
Commercial	1	1	1	2
Transportation	7	7	6	7
Manufacturing Industry	1	1	1	1
Landfills	1	1	1	1
Supply Sectors				
Electricity Generation	0	0	0	0
Petroleum Refining	NA	NA	NA	NA
Crude Oil	0	0	0	0
Natural Gas	1	0	0	0
Coal Mining	NA	NA	NA	NA
Biofuels Manufacturing	0	0	0	0
Total	12	11	11	11

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	47	52	60	74
Commercial	62	69	81	94
Transportation	99	95	96	102
Manufacturing Industry	39	42	47	52
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	170	195	225	261
Petroleum Refining	NA	NA	NA	NA
Crude Oil	2	1	1	1
Natural Gas	9	7	6	5
Coal Mining	NA	NA	NA	NA
Biofuels Manufacturing	0	1	1	1
Total	427	462	517	592

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	61	56	59	64
Coal	5	2	2	2
Refined Petroleum Products	102	96	93	98
Electricity	93	116	141	170
Nuclear	0	0	0	0
Biofuel	0	1	3	4
Renewable	166	192	219	252
Other	0	0	0	0
Total	427	462	517	592

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	94	101	116	143
Household Emissions Intensity (t CO_2e / household)	1.6	1.2	1.1	1.0
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.34	0.30	0.27	0.26
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.008	0.005	0.004	0.003
Annual Energy Costs (2005$ / household)	$1,230	$1,333	$1,546	$1,909
Electricity Price (2005¢ / kWh)	4.9	4.9	4.9	4.9
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.5	1.4	1.4	1.4
Emissions Intensity (t CO_2e / m^2 floorspace)	0.033	0.027	0.025	0.024
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.74	0.66	0.62	0.61
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.021	0.015	0.013	0.012
Transportation				
Passenger Energy Intensity (MJ / pkt)	2.1	1.8	1.7	1.6
Passenger Emissions Intensity (kg CO_2e / pkt)	0.15	0.12	0.11	0.10
Passenger Vehicle Energy Intensity (MJ / vkt)	3.5	3.0	2.7	2.5
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.25	0.20	0.17	0.15
Annual Passenger Vehicle Fuel Costs (2005$ / vehicle)	$1,600	$1,480	$1,322	$1,228
Freight Energy Intensity (MJ / tkt)	1.2	1.1	1.1	1.1
Freight Emissions Intensity (kg CO_2e / tkt)	0.08	0.08	0.08	0.08
Average Vehicle Fuel Prices (2005¢ / L gasoline eq.)	80.8	87.7	86.6	85.9
Electricity Generation				
Energy Intensity (GJ / MWh)	3.7	3.7	3.7	3.7
Emissions Intensity (t CO_2e / MWh)	0.01	0.00	0.00	0.00
Renewable Generation (TWh)	46	53	61	70
Nuclear Generation (TWh)	0	0	0	0
Coal Generation (TWh)	0	0	0	0
Natural Gas Generation (TWh)	0	0	0	0
CCS Generation (TWh)	0	0	1	1
Other Generation (TWh)	0	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	0.3	0.3	0.3	0.3
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.04	0.04	0.04	0.04
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Reference case – Ontario

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	22	23	23	23
Commercial	20	24	30	35
Transportation	86	92	102	116
Manufacturing Industry	41	47	55	64
Landfills	8	9	10	11
Supply Sectors				
Electricity Generation	26	34	48	68
Petroleum Refining	8	9	10	12
Crude Oil	0	0	0	0
Natural Gas	4	4	3	3
Coal Mining	NA	NA	NA	NA
Biofuels Manufacturing	0	0	0	0
Total	214	242	282	332

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	663	747	849	998
Commercial	585	706	864	1,025
Transportation	1,200	1,309	1,471	1,679
Manufacturing Industry	806	905	1,047	1,211
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	1,434	1,675	2,094	2,674
Petroleum Refining	130	150	177	208
Crude Oil	0	0	0	0
Natural Gas	58	52	51	48
Coal Mining	NA	NA	NA	NA
Biofuels Manufacturing	1	3	4	5
Total	4,878	5,547	6,558	7,848

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	1,299	1,454	1,670	1,884
Coal	400	538	733	1,009
Refined Petroleum Products	1,326	1,425	1,590	1,805
Electricity	595	706	886	1,128
Nuclear	943	1,046	1,218	1,462
Biofuel	2	6	15	26
Renewable	258	304	365	437
Other	56	68	81	96
Total	4,878	5,547	6,558	7,848

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	111	113	119	131
Household Emissions Intensity (t CO_2e / household)	3.6	3.4	3.2	3.0
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.35	0.31	0.29	0.27
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.015	0.013	0.012	0.012
Annual Energy Costs (2005$ / household)	$1,882	$1,985	$2,220	$2,621
Electricity Price (2005¢ / kWh)	9.9	9.9	9.9	9.9
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.6	1.6	1.6	1.6
Emissions Intensity (t CO_2e / m^2 floorspace)	0.055	0.055	0.056	0.055
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.94	0.92	0.92	0.91
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.042	0.042	0.042	0.042
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.6	1.4	1.3	1.2
Passenger Emissions Intensity (kg CO_2e / pkt)	0.11	0.10	0.09	0.08
Passenger Vehicle Energy Intensity (MJ / vkt)	3.0	2.6	2.4	2.3
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.22	0.18	0.17	0.16
Annual Passenger Vehicle Fuel Costs (2005$ / vehicle)	$1,383	$1,329	$1,226	$1,160
Freight Energy Intensity (MJ / tkt)	1.5	1.4	1.4	1.4
Freight Emissions Intensity (kg CO_2e / tkt)	0.11	0.10	0.10	0.10
Average Vehicle Fuel Prices (2005¢ / L gasoline eq.)	80.7	88.6	89.0	89.2
Electricity Generation				
Energy Intensity (GJ / MWh)	8.6	8.3	8.2	8.2
Emissions Intensity (t CO_2e / MWh)	0.15	0.17	0.19	0.21
Renewable Generation (TWh)	41	50	64	81
Nuclear Generation (TWh)	87	97	113	135
Coal Generation (TWh)	29	41	60	86
Natural Gas Generation (TWh)	9	10	12	14
CCS Generation (TWh)	1	3	6	9
Other Generation (TWh)	0	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	0.3	0.2	0.2	0.2
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.04	0.03	0.03	0.03
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Reference case – Québec

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	3	3	3	3
Commercial	5	4	4	5
Transportation	49	50	53	57
Manufacturing Industry	18	16	16	18
Landfills	8	9	9	9
Supply Sectors				
Electricity Generation	2	2	2	3
Petroleum Refining	5	5	5	5
Crude Oil	NA	NA	NA	NA
Natural Gas	0	0	0	0
Coal Mining	NA	NA	NA	NA
Biofuels Manufacturing	0	0	0	0
Total	90	90	93	99

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	370	411	456	528
Commercial	269	292	333	386
Transportation	682	719	774	846
Manufacturing Industry	680	720	781	851
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	868	968	1,121	1,308
Petroleum Refining	82	85	91	98
Crude Oil	NA	NA	NA	NA
Natural Gas	6	6	6	6
Coal Mining	NA	NA	NA	NA
Biofuels Manufacturing	1	3	4	6
Total	2,959	3,203	3,567	4,029

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	289	309	332	364
Coal	25	27	28	30
Refined Petroleum Products	756	754	796	857
Electricity	807	892	1,021	1,181
Nuclear	69	80	92	103
Biofuel	5	9	17	28
Renewable	961	1,084	1,230	1,410
Other	47	48	51	55
Total	2,959	3,203	3,567	4,029

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	100	107	118	137
Household Emissions Intensity (t CO_2e / household)	0.9	0.9	0.8	0.7
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.48	0.45	0.42	0.40
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.005	0.005	0.004	0.003
Annual Energy Costs (2005$ / household)	$2,066	$2,239	$2,529	$3,007
Electricity Price (2005¢ / kWh)	8.4	8.4	8.4	8.4
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.6	1.5	1.5	1.4
Emissions Intensity (t CO_2e / m^2 floorspace)	0.028	0.021	0.019	0.018
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.75	0.64	0.59	0.56
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.020	0.013	0.011	0.010
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.9	1.7	1.6	1.5
Passenger Emissions Intensity (kg CO_2e / pkt)	0.14	0.12	0.11	0.10
Passenger Vehicle Energy Intensity (MJ / vkt)	3.1	2.7	2.5	2.3
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.22	0.19	0.17	0.15
Annual Passenger Vehicle Fuel Costs (2005$ / vehicle)	$1,513	$1,433	$1,305	$1,234
Freight Energy Intensity (MJ / tkt)	1.3	1.2	1.2	1.2
Freight Emissions Intensity (kg CO_2e / tkt)	0.09	0.09	0.08	0.08
Average Vehicle Fuel Prices (2005¢ / L gasoline eq.)	85.5	93.0	93.1	93.2
Electricity Generation				
Energy Intensity (GJ / MWh)	3.9	3.9	3.9	3.9
Emissions Intensity (t CO_2e / MWh)	0.01	0.01	0.01	0.01
Renewable Generation (TWh)	213	237	273	318
Nuclear Generation (TWh)	6	7	9	10
Coal Generation (TWh)	0	0	0	0
Natural Gas Generation (TWh)	3	5	6	7
CCS Generation (TWh)	0	0	1	1
Other Generation (TWh)	1	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	NA	NA	NA	NA
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	NA	NA	NA	NA
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Reference case – Atlantic Provinces

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	2	1	1	1
Commercial	3	3	4	5
Transportation	22	21	21	21
Manufacturing Industry	4	4	4	4
Landfills	3	3	3	2
Supply Sectors				
Electricity Generation	13	9	9	11
Petroleum Refining	4	4	4	4
Crude Oil	0	0	0	0
Natural Gas	2	2	2	2
Coal Mining	0	0	0	0
Biofuels Manufacturing	0	0	0	0
Total	52	47	47	50

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	91	91	94	101
Commercial	86	100	116	135
Transportation	299	295	302	314
Manufacturing Industry	147	151	159	168
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	429	405	416	447
Petroleum Refining	64	63	65	66
Crude Oil	3	2	1	1
Natural Gas	36	30	27	24
Coal Mining	0	0	0	0
Biofuels Manufacturing	0	1	2	2
Total	1,155	1,138	1,182	1,259

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	154	179	188	190
Coal	109	94	101	128
Refined Petroleum Products	402	347	346	355
Electricity	164	169	185	206
Nuclear	50	48	36	30
Biofuel	1	2	9	11
Renewable	241	263	284	304
Other	34	34	33	35
Total	1,155	1,138	1,182	1,259

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	89	95	107	127
Household Emissions Intensity (t CO_2e / household)	1.5	1.3	1.2	1.1
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.39	0.35	0.32	0.30
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.011	0.009	0.008	0.007
Annual Energy Costs (2005$ / household)	$2,195	$2,410	$2,803	$3,464
Electricity Price (2005¢ / kWh)	10.8	10.8	10.8	10.8
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.4	1.4	1.4	1.4
Emissions Intensity (t CO_2e / m^2 floorspace)	0.048	0.048	0.048	0.047
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.82	0.83	0.84	0.83
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.040	0.039	0.039	0.039
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.7	1.5	1.4	1.4
Passenger Emissions Intensity (kg CO_2e / pkt)	0.12	0.11	0.10	0.09
Passenger Vehicle Energy Intensity (MJ / vkt)	2.9	2.5	2.3	2.2
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.21	0.18	0.16	0.15
Annual Passenger Vehicle Fuel Costs (2005$ / vehicle)	$1,448	$1,387	$1,280	$1,213
Freight Energy Intensity (MJ / tkt)	0.9	0.8	0.8	0.8
Freight Emissions Intensity (kg CO_2e / tkt)	0.06	0.06	0.06	0.06
Average Vehicle Fuel Prices (2005¢ / L gasoline eq.)	88.1	96.1	96.6	96.8
Electricity Generation				
Energy Intensity (GJ / MWh)	5.4	5.0	4.8	4.8
Emissions Intensity (t CO_2e / MWh)	0.16	0.11	0.11	0.12
Renewable Generation (TWh)	55	60	65	70
Nuclear Generation (TWh)	5	4	3	3
Coal Generation (TWh)	10	9	9	12
Natural Gas Generation (TWh)	5	7	7	6
CCS Generation (TWh)	0	1	2	2
Other Generation (TWh)	4	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	0.1	0.1	0.1	0.1
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.00	0.00	0.00	0.00
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Policy scenario – Canada

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	22	9	4	2
Commercial	28	22	18	18
Transportation	183	95	67	68
Manufacturing Industry	63	41	31	27
Landfills	5	5	5	5
Supply Sectors				
Electricity Generation	115	90	64	43
Petroleum Refining	17	9	4	2
Crude Oil	80	57	41	37
Natural Gas	41	31	24	19
Coal Mining	3	3	3	3
Biofuels Manufacturing	2	4	6	7
Total	557	365	266	232

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	1,385	1,429	1,575	1,868
Commercial	1,253	1,315	1,446	1,648
Transportation	2,798	2,556	2,993	3,420
Manufacturing Industry	2,369	2,584	2,931	3,315
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	5,271	7,243	9,140	10,955
Petroleum Refining	315	201	178	191
Crude Oil	2,127	2,450	2,699	2,925
Natural Gas	559	450	375	302
Coal Mining	27	31	35	40
Biofuels Manufacturing	42	164	285	345
Total	16,145	18,423	21,657	25,009

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	3,488	3,338	3,380	3,594
Coal	2,011	2,699	3,400	4,199
Refined Petroleum Products	2,909	1,575	1,219	1,292
Electricity	2,827	3,823	4,755	5,649
Nuclear	1,334	1,812	2,208	2,509
Biofuel	224	1,023	1,749	2,100
Renewable	2,599	3,354	4,070	4,740
Other	753	798	876	926
Total	16,145	18,423	21,657	25,009

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	95	90	94	107
Household Emissions Intensity (t CO_2e / household)	1.5	0.5	0.2	0.1
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.35	0.28	0.23	0.21
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.008	0.003	0.001	0.001
Increase in Annual Energy Costs (2005$ / household) [1]	$228	$317	$265	$243
Increase in Electricity Price (2005¢ / kWh) [1]	0.7	1.0	0.9	0.8
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.4	1.2	1.1	1.1
Emissions Intensity (t CO_2e / m^2 floorspace)	0.032	0.020	0.014	0.012
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.73	0.59	0.49	0.45
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.024	0.015	0.009	0.008
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.6	1.1	1.1	1.1
Passenger Emissions Intensity (kg CO_2e / pkt)	0.10	0.05	0.03	0.03
Passenger Vehicle Energy Intensity (MJ / vkt)	2.9	2.0	1.9	1.9
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.20	0.07	0.04	0.04
Increase in Annual Passenger Vehicle Fuel Costs (2005$ / vehicle) [1]	$379	$152	$122	$162
Freight Energy Intensity (MJ / tkt)	0.9	0.8	0.9	0.9
Freight Emissions Intensity (kg CO_2e / tkt)	0.05	0.02	0.01	0.01
Increase in Average Vehicle Fuel Prices (2005¢ / L gasoline eq.) [1]	28.4	46.1	42.3	38.2
Electricity Generation				
Energy Intensity (GJ / MWh)	6.1	6.2	6.3	6.4
Emissions Intensity (t CO_2e / MWh)	0.13	0.08	0.04	0.02
Renewable Generation (TWh)	540	703	860	1,013
Nuclear Generation (TWh)	124	168	204	232
Coal Generation (TWh)	111	86	43	5
Natural Gas Generation (TWh)	26	15	9	6
CCS Generation (TWh)	62	193	328	456
Other Generation (TWh)	5	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	1.2	1.2	1.2	1.1
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.04	0.03	0.02	0.01
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	$1.18	$1.73	$1.83	$1.93
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	$3.28	$4.65	$5.48	$5.72
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	$0.69	$1.25	$1.65	$1.90

[1] Represents an increase over the reference case

Policy scenario – British Columbia

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	2	1	0	0
Commercial	3	2	2	2
Transportation	28	16	13	13
Manufacturing Industry	6	3	2	2
Landfills	1	1	1	1
Supply Sectors				
Electricity Generation	1	1	1	1
Petroleum Refining	1	0	0	0
Crude Oil	0	0	0	0
Natural Gas	7	6	5	4
Coal Mining	2	1	1	1
Biofuels Manufacturing	0	1	1	1
Total	50	32	26	25

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	140	170	199	244
Commercial	154	175	210	252
Transportation	430	412	494	566
Manufacturing Industry	433	483	544	606
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	458	704	915	1,115
Petroleum Refining	10	0	0	0
Crude Oil	3	3	2	2
Natural Gas	102	93	82	71
Coal Mining	14	14	14	14
Biofuels Manufacturing	7	24	43	53
Total	1,751	2,077	2,504	2,923

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	230	179	168	176
Coal	18	16	15	15
Refined Petroleum Products	421	255	210	211
Electricity	368	537	681	822
Nuclear	0	0	0	0
Biofuel	38	159	277	342
Renewable	669	929	1,149	1,351
Other	6	2	3	6
Total	1,751	2,077	2,504	2,923

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	72	72	79	92
Household Emissions Intensity (t CO_2e / household)	0.9	0.3	0.1	0.1
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.22	0.18	0.17	0.17
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.004	0.001	0.001	0.000
Increase in Annual Energy Costs (2005$ / household) [1]	$163	$164	$119	$80
Increase in Electricity Price (2005¢ / kWh) [1]	1.2	1.1	0.9	0.6
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.2	1.1	1.0	1.0
Emissions Intensity (t CO_2e / m^2 floorspace)	0.020	0.013	0.010	0.009
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.62	0.57	0.55	0.54
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.017	0.011	0.008	0.008
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.6	1.2	1.1	1.1
Passenger Emissions Intensity (kg CO_2e / pkt)	0.10	0.05	0.03	0.03
Passenger Vehicle Energy Intensity (MJ / vkt)	2.9	2.0	1.9	1.9
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.19	0.06	0.03	0.03
Increase in Annual Passenger Vehicle Fuel Costs (2005$ / vehicle) [1]	$328	$7	-$8	$25
Freight Energy Intensity (MJ / tkt)	0.8	0.8	0.8	0.8
Freight Emissions Intensity (kg CO_2e / tkt)	0.05	0.03	0.02	0.02
Increase in Average Vehicle Fuel Prices (2005¢ / L gasoline eq.) [1]	27.5	35.3	28.8	23.9
Electricity Generation				
Energy Intensity (GJ / MWh)	4.2	4.4	4.5	4.5
Emissions Intensity (t CO_2e / MWh)	0.01	0.00	0.00	0.00
Renewable Generation (TWh)	107	155	197	237
Nuclear Generation (TWh)	0	0	0	0
Coal Generation (TWh)	0	0	0	0
Natural Gas Generation (TWh)	2	1	1	1
CCS Generation (TWh)	1	5	8	10
Other Generation (TWh)	0	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	0.3	0.3	0.3	0.3
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.02	0.02	0.01	0.01
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	$0.68	$1.21	$1.14	$1.02
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Policy scenario – Alberta

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	5	3	1	1
Commercial	4	3	2	2
Transportation	28	15	10	10
Manufacturing Industry	8	4	3	2
Landfills	0	0	0	0
Supply Sectors				
Electricity Generation	57	44	32	20
Petroleum Refining	4	3	2	1
Crude Oil	78	55	40	36
Natural Gas	25	17	12	9
Coal Mining	1	1	2	2
Biofuels Manufacturing	0	1	1	1
Total	211	147	105	84

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	169	156	162	191
Commercial	166	168	177	192
Transportation	426	386	449	519
Manufacturing Industry	311	339	381	435
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	990	1,430	1,866	2,257
Petroleum Refining	86	73	70	74
Crude Oil	2,096	2,425	2,678	2,907
Natural Gas	323	243	188	136
Coal Mining	10	12	15	18
Biofuels Manufacturing	7	27	50	62
Total	4,583	5,259	6,038	6,791

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	1,835	1,974	2,084	2,229
Coal	1,084	1,380	1,683	1,989
Refined Petroleum Products	479	300	255	293
Electricity	375	546	706	837
Nuclear	0	0	0	0
Biofuel	34	155	280	345
Renewable	136	177	220	257
Other	640	727	810	841
Total	4,583	5,259	6,038	6,791

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	118	95	89	97
Household Emissions Intensity (t CO_2e / household)	3.8	1.6	0.7	0.4
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.50	0.33	0.24	0.20
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.019	0.007	0.002	0.001
Increase in Annual Energy Costs (2005$ / household) [1]	$225	$421	$363	$347
Increase in Electricity Price (2005¢ / kWh) [1]	1.1	1.5	1.3	1.2
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.4	1.2	1.1	1.0
Emissions Intensity (t CO_2e / m^2 floorspace)	0.037	0.023	0.015	0.012
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.82	0.67	0.53	0.46
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.029	0.019	0.011	0.008
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.6	1.2	1.1	1.1
Passenger Emissions Intensity (kg CO_2e / pkt)	0.11	0.05	0.04	0.04
Passenger Vehicle Energy Intensity (MJ / vkt)	3.1	2.2	2.0	2.0
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.21	0.08	0.06	0.06
Increase in Annual Passenger Vehicle Fuel Costs (2005$ / vehicle) [1]	$416	$256	$219	$264
Freight Energy Intensity (MJ / tkt)	0.7	0.6	0.6	0.6
Freight Emissions Intensity (kg CO_2e / tkt)	0.04	0.02	0.00	0.00
Increase in Average Vehicle Fuel Prices (2005¢ / L gasoline eq.) [1]	28.8	53.3	50.8	47.0
Electricity Generation				
Energy Intensity (GJ / MWh)	9.0	8.9	8.9	9.1
Emissions Intensity (t CO_2e / MWh)	0.51	0.27	0.15	0.08
Renewable Generation (TWh)	12	20	29	35
Nuclear Generation (TWh)	0	0	0	0
Coal Generation (TWh)	56	41	22	2
Natural Gas Generation (TWh)	10	7	4	3
CCS Generation (TWh)	32	94	155	209
Other Generation (TWh)	0	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	1.3	1.3	1.2	1.2
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.05	0.03	0.02	0.01
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	$1.71	$2.40	$2.49	$2.63
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	$3.28	$4.65	$5.48	$5.72
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	$0.69	$1.25	$1.65	$1.90

[1] Represents an increase over the reference case

Policy scenario – Saskatchewan

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	1	0	0	0
Commercial	1	1	1	1
Transportation	7	3	2	2
Manufacturing Industry	2	1	1	2
Landfills	0	0	0	0
Supply Sectors				
Electricity Generation	15	11	7	5
Petroleum Refining	1	0	0	0
Crude Oil	2	1	1	1
Natural Gas	3	2	2	2
Coal Mining	0	0	0	0
Biofuels Manufacturing	0	0	0	0
Total	31	21	15	12

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	35	29	28	31
Commercial	45	43	44	48
Transportation	111	97	105	114
Manufacturing Industry	55	66	84	109
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	247	322	412	500
Petroleum Refining	11	5	3	4
Crude Oil	23	19	16	13
Natural Gas	33	26	23	20
Coal Mining	3	4	6	7
Biofuels Manufacturing	2	8	11	12
Total	563	620	733	859

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	140	121	121	127
Coal	192	251	319	396
Refined Petroleum Products	121	59	40	41
Electricity	75	106	138	167
Nuclear	0	0	0	0
Biofuel	8	46	67	75
Renewable	24	35	46	52
Other	3	2	1	2
Total	563	620	733	859

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	84	75	76	88
Household Emissions Intensity (t CO_2e / household)	1.6	0.4	0.1	0.1
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.39	0.28	0.23	0.21
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.011	0.003	0.001	0.000
Increase in Annual Energy Costs (2005$ / household) [1]	$188	$247	$212	$241
Increase in Electricity Price (2005¢ / kWh) [1]	0.5	0.8	0.9	1.0
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.5	1.3	1.1	1.1
Emissions Intensity (t CO_2e / m^2 floorspace)	0.043	0.027	0.019	0.017
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.91	0.70	0.58	0.51
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.036	0.023	0.015	0.013
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.8	1.3	1.2	1.2
Passenger Emissions Intensity (kg CO_2e / pkt)	0.12	0.04	0.03	0.03
Passenger Vehicle Energy Intensity (MJ / vkt)	3.1	2.1	2.0	2.0
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.20	0.06	0.04	0.04
Increase in Annual Passenger Vehicle Fuel Costs (2005$ / vehicle) [1]	$375	$46	$54	$99
Freight Energy Intensity (MJ / tkt)	1.3	1.2	1.2	1.3
Freight Emissions Intensity (kg CO_2e / tkt)	0.08	0.02	0.01	0.00
Increase in Average Vehicle Fuel Prices (2005¢ / L gasoline eq.) [1]	27.6	37.8	35.0	30.7
Electricity Generation				
Energy Intensity (GJ / MWh)	9.1	8.8	8.9	9.0
Emissions Intensity (t CO_2e / MWh)	0.54	0.30	0.15	0.09
Renewable Generation (TWh)	6	9	12	13
Nuclear Generation (TWh)	0	0	0	0
Coal Generation (TWh)	13	10	4	1
Natural Gas Generation (TWh)	2	1	0	0
CCS Generation (TWh)	6	17	30	41
Other Generation (TWh)	0	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	0.2	0.2	0.2	0.2
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.02	0.01	0.01	0.01
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	$1.11	$1.55	$1.66	$1.84
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Policy scenario – Manitoba

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	0	0	0	0
Commercial	1	1	1	1
Transportation	5	2	1	1
Manufacturing Industry	1	0	0	0
Landfills	0	0	0	0
Supply Sectors				
Electricity Generation	0	0	0	0
Petroleum Refining	NA	NA	NA	NA
Crude Oil	0	0	0	0
Natural Gas	1	0	0	0
Coal Mining	NA	NA	NA	NA
Biofuels Manufacturing	0	0	0	0
Total	8	4	3	3

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	46	48	56	69
Commercial	58	62	73	85
Transportation	76	62	67	73
Manufacturing Industry	38	41	46	51
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	189	227	262	299
Petroleum Refining	NA	NA	NA	NA
Crude Oil	2	1	1	1
Natural Gas	9	7	6	5
Coal Mining	NA	NA	NA	NA
Biofuels Manufacturing	1	4	6	6
Total	418	454	516	590

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	41	28	28	32
Coal	5	1	1	0
Refined Petroleum Products	72	31	21	21
Electricity	109	143	172	203
Nuclear	0	0	0	0
Biofuel	5	27	40	46
Renewable	185	223	254	289
Other	0	0	0	0
Total	418	454	516	590

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	91	99	113	140
Household Emissions Intensity (t CO_2e / household)	0.6	0.1	0.0	0.0
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.34	0.30	0.27	0.26
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.003	0.000	0.000	0.000
Increase in Annual Energy Costs (2005$ / household) [1]	$87	$125	$97	$84
Increase in Electricity Price (2005¢ / kWh) [1]	0.4	0.4	0.3	0.2
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.4	1.3	1.3	1.2
Emissions Intensity (t CO_2e / m^2 floorspace)	0.023	0.012	0.010	0.010
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.69	0.61	0.58	0.57
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.015	0.008	0.007	0.007
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.9	1.3	1.3	1.3
Passenger Emissions Intensity (kg CO_2e / pkt)	0.12	0.05	0.03	0.03
Passenger Vehicle Energy Intensity (MJ / vkt)	3.2	2.1	2.0	2.1
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.21	0.05	0.02	0.02
Increase in Annual Passenger Vehicle Fuel Costs (2005$ / vehicle) [1]	$361	-$184	-$214	-$149
Freight Energy Intensity (MJ / tkt)	0.8	0.7	0.7	0.8
Freight Emissions Intensity (kg CO_2e / tkt)	0.04	0.01	0.00	0.00
Increase in Average Vehicle Fuel Prices (2005¢ / L gasoline eq.) [1]	26.2	19.7	10.3	6.5
Electricity Generation				
Energy Intensity (GJ / MWh)	3.7	3.7	3.7	3.7
Emissions Intensity (t CO_2e / MWh)	0.01	0.00	0.00	0.00
Renewable Generation (TWh)	51	61	70	80
Nuclear Generation (TWh)	0	0	0	0
Coal Generation (TWh)	0	0	0	0
Natural Gas Generation (TWh)	0	0	0	0
CCS Generation (TWh)	0	1	1	1
Other Generation (TWh)	0	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	0.3	0.3	0.3	0.3
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.03	0.02	0.02	0.02
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	$1.10	$1.75	$1.81	$1.84
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Policy scenario – Ontario

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	12	5	2	1
Commercial	14	11	9	9
Transportation	62	31	22	23
Manufacturing Industry	29	21	16	15
Landfills	1	1	2	2
Supply Sectors				
Electricity Generation	30	30	22	16
Petroleum Refining	5	1	1	0
Crude Oil	0	0	0	0
Natural Gas	4	3	3	3
Coal Mining	NA	NA	NA	NA
Biofuels Manufacturing	1	2	2	3
Total	157	105	79	72

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	570	574	630	757
Commercial	503	519	546	609
Transportation	950	887	1,068	1,244
Manufacturing Industry	747	831	971	1,127
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	1,946	2,925	3,837	4,709
Petroleum Refining	84	29	12	17
Crude Oil	0	0	0	0
Natural Gas	57	51	49	45
Coal Mining	NA	NA	NA	NA
Biofuels Manufacturing	13	61	109	133
Total	4,870	5,876	7,223	8,642

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	953	783	743	788
Coal	570	944	1,302	1,729
Refined Petroleum Products	943	487	356	386
Electricity	801	1,197	1,559	1,906
Nuclear	1,190	1,637	2,026	2,331
Biofuel	68	367	641	772
Renewable	309	446	582	707
Other	35	16	13	24
Total	4,870	5,876	7,223	8,642

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	100	90	90	101
Household Emissions Intensity (t CO_2e / household)	2.1	0.8	0.3	0.2
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.31	0.23	0.19	0.16
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.010	0.004	0.002	0.001
Increase in Annual Energy Costs (2005$ / household) [1]	$241	$356	$299	$284
Increase in Electricity Price (2005¢ / kWh) [1]	0.5	0.7	0.7	0.8
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.4	1.2	1.0	1.0
Emissions Intensity (t CO_2e / m^2 floorspace)	0.039	0.026	0.017	0.014
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.75	0.57	0.41	0.34
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.029	0.019	0.010	0.007
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.4	1.0	0.9	0.9
Passenger Emissions Intensity (kg CO_2e / pkt)	0.10	0.04	0.03	0.03
Passenger Vehicle Energy Intensity (MJ / vkt)	2.9	1.9	1.8	1.8
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.19	0.07	0.05	0.05
Increase in Annual Passenger Vehicle Fuel Costs (2005$ / vehicle) [1]	$390	$172	$159	$200
Freight Energy Intensity (MJ / tkt)	1.1	1.0	1.1	1.1
Freight Emissions Intensity (kg CO_2e / tkt)	0.07	0.03	0.01	0.01
Increase in Average Vehicle Fuel Prices (2005¢ / L gasoline eq.) [1]	28.7	48.4	46.5	42.8
Electricity Generation				
Energy Intensity (GJ / MWh)	8.5	8.5	8.5	8.5
Emissions Intensity (t CO_2e / MWh)	0.13	0.09	0.05	0.03
Renewable Generation (TWh)	57	89	122	153
Nuclear Generation (TWh)	110	152	188	216
Coal Generation (TWh)	33	31	16	2
Natural Gas Generation (TWh)	8	4	3	2
CCS Generation (TWh)	19	68	124	182
Other Generation (TWh)	0	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	0.3	0.3	0.3	0.3
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.02	0.01	0.01	0.01
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	$0.73	$1.43	$1.51	$1.51
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Policy scenario – Québec

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	1	0	0	0
Commercial	3	2	2	2
Transportation	36	18	12	13
Manufacturing Industry	15	9	6	4
Landfills	1	1	1	1
Supply Sectors				
Electricity Generation	1	0	0	0
Petroleum Refining	3	2	1	0
Crude Oil	NA	NA	NA	NA
Natural Gas	0	0	0	0
Coal Mining	NA	NA	NA	NA
Biofuels Manufacturing	0	1	1	1
Total	62	34	24	23

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	341	370	415	485
Commercial	252	269	309	362
Transportation	563	498	577	654
Manufacturing Industry	644	681	752	824
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	979	1,169	1,364	1,569
Petroleum Refining	66	43	38	40
Crude Oil	NA	NA	NA	NA
Natural Gas	6	6	6	6
Coal Mining	NA	NA	NA	NA
Biofuels Manufacturing	9	29	48	57
Total	2,860	3,064	3,510	3,996

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	183	149	145	152
Coal	30	24	22	20
Refined Petroleum Products	566	280	202	208
Electricity	904	1,065	1,234	1,418
Nuclear	87	112	128	133
Biofuel	50	201	334	396
Renewable	1,002	1,207	1,423	1,646
Other	38	25	23	25
Total	2,860	3,064	3,510	3,996

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	95	101	112	131
Household Emissions Intensity (t CO_2e / household)	0.2	0.0	0.1	0.0
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.45	0.41	0.39	0.36
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.001	0.000	0.000	0.000
Increase in Annual Energy Costs (2005$ / household) [1]	$270	$334	$280	$226
Increase in Electricity Price (2005¢ / kWh) [1]	0.7	0.9	0.7	0.5
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.6	1.4	1.4	1.4
Emissions Intensity (t CO_2e / m^2 floorspace)	0.021	0.011	0.009	0.009
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.68	0.59	0.55	0.54
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.015	0.008	0.007	0.007
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.7	1.2	1.1	1.1
Passenger Emissions Intensity (kg CO_2e / pkt)	0.11	0.05	0.03	0.03
Passenger Vehicle Energy Intensity (MJ / vkt)	2.9	2.0	1.9	1.9
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.20	0.07	0.04	0.04
Increase in Annual Passenger Vehicle Fuel Costs (2005$ / vehicle) [1]	$373	$153	$79	$108
Freight Energy Intensity (MJ / tkt)	1.0	0.9	1.0	1.0
Freight Emissions Intensity (kg CO_2e / tkt)	0.06	0.02	0.01	0.01
Increase in Average Vehicle Fuel Prices (2005¢ / L gasoline eq.) [1]	28.2	44.1	37.3	32.4
Electricity Generation				
Energy Intensity (GJ / MWh)	3.9	3.9	3.9	3.9
Emissions Intensity (t CO_2e / MWh)	0.00	0.00	0.00	0.00
Renewable Generation (TWh)	241	286	335	389
Nuclear Generation (TWh)	8	10	12	12
Coal Generation (TWh)	0	0	0	0
Natural Gas Generation (TWh)	1	1	0	0
CCS Generation (TWh)	1	2	4	4
Other Generation (TWh)	1	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	NA	NA	NA	NA
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	NA	NA	NA	NA
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Policy scenario – Atlantic Provinces

Greenhouse Gas Emissions (Mt CO_2e)

	2020	2030	2040	2050
Demand Sectors				
Residential	1	0	0	0
Commercial	2	1	1	1
Transportation	16	9	7	7
Manufacturing Industry	3	2	2	2
Landfills	0	0	0	0
Supply Sectors				
Electricity Generation	11	4	2	1
Petroleum Refining	3	2	1	1
Crude Oil	0	0	0	0
Natural Gas	2	1	1	1
Coal Mining	0	0	0	0
Biofuels Manufacturing	0	0	0	0
Total	39	22	15	13

Energy Consumption (PJ)

	2020	2030	2040	2050
Demand Sectors				
Residential	84	82	84	92
Commercial	76	79	86	99
Transportation	244	214	233	250
Manufacturing Industry	141	143	152	162
Landfills	NA	NA	NA	NA
Supply Sectors				
Electricity Generation	461	466	483	506
Petroleum Refining	58	52	54	56
Crude Oil	3	2	1	1
Natural Gas	30	25	22	19
Coal Mining	0	0	0	0
Biofuels Manufacturing	4	12	19	22
Total	1,101	1,074	1,135	1,207

Energy Consumption by Fuel Type (PJ)

	2020	2030	2040	2050
Natural Gas	106	104	92	91
Coal	112	83	58	50
Refined Petroleum Products	307	163	135	133
Electricity	194	229	265	295
Nuclear	57	62	54	45
Biofuel	21	68	110	126
Renewable	274	337	396	439
Other	31	27	26	28
Total	1,101	1,074	1,135	1,207

Detailed Sectoral Results

	2020	2030	2040	2050
Residential				
Household Energy Intensity (GJ / household)	86	87	96	117
Household Emissions Intensity (t CO_2e / household)	0.6	0.2	0.0	0.0
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.36	0.30	0.25	0.24
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.005	0.001	0.000	0.000
Increase in Annual Energy Costs (2005$ / household) [1]	$222	$333	$303	$373
Increase in Electricity Price (2005¢ / kWh) [1]	0.2	0.8	0.9	1.0
Commercial				
Energy Intensity (GJ / m^2 floorspace)	1.2	1.1	1.1	1.0
Emissions Intensity (t CO_2e / m^2 floorspace)	0.032	0.020	0.012	0.010
Space Heating Energy Intensity (GJ / m^2 floorspace)	0.67	0.60	0.54	0.52
Space Heating Emissions Intensity (t CO_2e / m^2 floorspace)	0.027	0.017	0.010	0.007
Transportation				
Passenger Energy Intensity (MJ / pkt)	1.6	1.2	1.1	1.1
Passenger Emissions Intensity (kg CO_2e / pkt)	0.11	0.06	0.04	0.04
Passenger Vehicle Energy Intensity (MJ / vkt)	2.7	1.9	1.8	1.8
Passenger Vehicle Emissions Intensity (kg CO_2e / vkt)	0.19	0.08	0.06	0.06
Increase in Annual Passenger Vehicle Fuel Costs (2005$ / vehicle) [1]	$362	$268	$234	$295
Freight Energy Intensity (MJ / tkt)	0.7	0.7	0.7	0.7
Freight Emissions Intensity (kg CO_2e / tkt)	0.04	0.03	0.02	0.01
Increase in Average Vehicle Fuel Prices (2005¢ / L gasoline eq.) [1]	28.9	58.6	55.7	53.2
Electricity Generation				
Energy Intensity (GJ / MWh)	5.2	4.7	4.4	4.2
Emissions Intensity (t CO_2e / MWh)	0.13	0.04	0.02	0.01
Renewable Generation (TWh)	66	81	96	107
Nuclear Generation (TWh)	5	6	5	4
Coal Generation (TWh)	10	5	1	0
Natural Gas Generation (TWh)	2	1	0	0
CCS Generation (TWh)	2	6	7	8
Other Generation (TWh)	4	0	0	0
Petroleum Extraction				
Petroleum Extraction Energy Intensity (GJ / barrel)	0.1	0.1	0.1	0.1
Petroleum Extraction Emissions Intensity (t CO_2e / barrel)	0.00	0.00	0.00	0.00
Increase in Cost of Conventional Oil Production (2005$ / barrel) [1]	$0.37	$0.67	$0.87	$0.91
Increase in Cost of Synthetic Crude Production (2005$ / barrel) [1]	NA	NA	NA	NA
Increase in Cost of Blended Bitumen Production (2005$ / barrel) [1]	NA	NA	NA	NA

[1] Represents an increase over the reference case

Appendix B – Description of CIMS

Introduction to the CIMS model

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

CIMS simulations reflect the energy, economic and physical output, greenhouse gas emissions, and CAC emissions from its sub-models as shown in Table 99. CIMS does not include solvent, or hydrofluorocarbon (HFC) emissions. CIMS covers nearly all CAC emissions in Canada except those from open sources (like forest fires, soils, and dust from roads).

Table 99: Sector Sub-models in CIMS

Sector	*BC*	*Alberta*	*Sask.*	*Manitoba*	*Ontario*	*Quebec*	*Atlantic*
Residential	■	■	■	■	■	■	■
Commercial/Institutional	■	■	■	■	■	■	■
Transportation	■	■	■	■	■	■	■
Personal	■	■	■	■	■	■	■
Freight	■	■	■	■	■	■	■
Industry							
Chemical Products	■	■			■	■	
Industrial Minerals	■	■			■	■	■
Iron and Steel					■	■	
Non-Ferrous Metal Smelting*	■			■	■	■	■
Metals and Mineral Mining	■		■	■	■	■	■
Other Manufacturing	■	■	■	■	■	■	■
Pulp and Paper	■	■			■	■	■
Energy Supply							
Coal Mining	■	■	■				■
Electricity Generation	■	■	■	■	■	■	■
Natural Gas Extraction	■	■	■	■	■	■	■
Petroleum Crude Extraction	■	■	■		■		■
Petroleum Refining	■	■	■		■	■	■
Ethanol	■	■	■	■	■	■	■
Biodiesel	■	■	■	■	■	■	■
Waste	■	■	■	■	■	■	■

* Metal smelting includes Aluminium.

Model structure and simulation of capital stock turnover

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

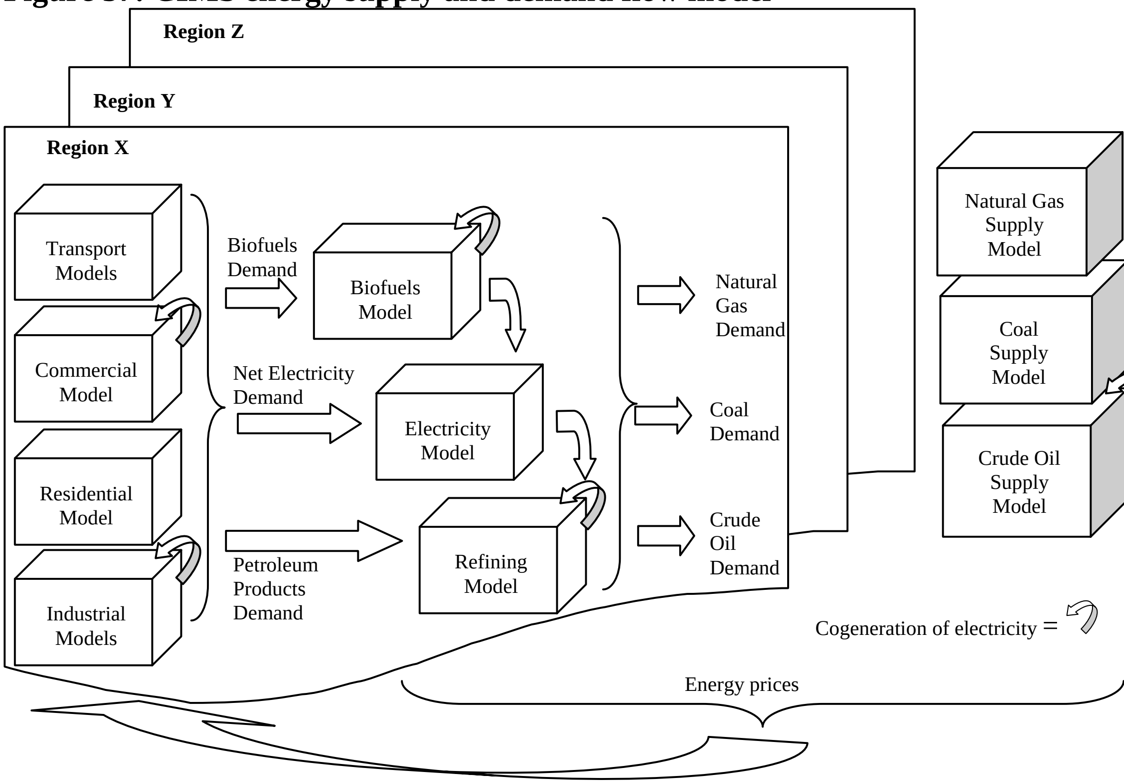
CIMS simulates the competition of technologies at each energy service node in the economy based on a comparison of their life cycle cost (LCC) and some technology-specific controls, such as a maximum market share limit in the cases where a technology is constrained by physical, technical or regulatory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

Equilibrium feedbacks in CIMS

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

CIMS estimates the effect of a policy by comparing a business-as-usual forecast to one where the policy is added to the simulation. The model solves for the policy effect in two phases in each run period. In the first phase, an energy policy (e.g., ranging from a national emissions price to a technology specific constraint or subsidy, or some combination thereof) is first applied to the final goods and services production side of the economy, where goods and services producers and consumers choose capital stocks based on CIMS' technological choice functions. Based on this initial run, the model then calculates the demand for electricity, refined petroleum products and primary energy commodities, and calculates their cost of production. If the price of any of these commodities has changed by a threshold amount from the business-as-usual case, then supply and demand are considered to be out of equilibrium, and the model is re-run based on prices calculated from the new costs of production. The model will re-run until a new equilibrium set of energy prices and demands is reached. Figure 57 provides a schematic of this process. For this project, while the quantities produced of all energy commodities were set endogenously using demand and supply balancing, endogenous pricing was used only for electricity and refined petroleum products; natural gas, crude oil and coal prices remained at exogenously forecast levels (described later in this section), since Canada is assumed to be a price-taker for these fuels.

Figure 57: CIMS energy supply and demand flow model



In the second phase, once a new set of energy prices and demands under policy has been found, the model measures how the cost of producing traded goods and services has changed given the new energy prices and other effects of the policy. For internationally traded goods, such as lumber and passenger vehicles, CIMS adjusts demand using price elasticities that provide a long-run demand response that blends domestic and international demand for these goods (the "Armington" specification).[52] Freight transportation is driven by changes in the combined value added of the industrial sectors, while personal transportation is adjusted using a personal kilometres-travelled elasticity (-0.02). Residential and commercial floor space is adjusted by a sequential substitution of home energy consumption vs. other goods (0.5), consumption vs. savings (1.29) and goods vs. leisure (0.82). If demand for any good or service has shifted more than a threshold amount, supply and demand are considered to be out of balance and the model re-runs using these new demands. The model continues re-running until both energy and goods and services supply and demand come into balance, and repeats this balancing procedure in each subsequent five-year period of a complete run.

Empirical basis of parameter values

Technical and market literature provide the conventional bottom-up data on the costs and energy efficiency of new technologies. Because there are few detailed surveys of the annual energy consumption of the individual capital stocks tracked by the model

[52] CIMS' Armington elasticities are econometrically estimated from 1960-1990 data. If price changes fall outside of these historic ranges, the elasticities offer less certainty.

(especially smaller units), these must be estimated from surveys at different levels of technological detail and by calibrating the model's simulated energy consumption to real-world aggregate data for a base year.

Fuel-based greenhouse gas emissions are calculated directly from CIMS' estimates of fuel consumption and the greenhouse gas coefficient of the fuel type. Process-based greenhouse gas emissions are estimated based on technological performance or chemical stoichiometric proportions. CIMS tracks the emissions of all types of greenhouse gas emissions, and reports these emissions in terms of carbon dioxide equivalents.[53]

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

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

Simulating endogenous technological change with CIMS

CIMS includes two functions for simulating endogenous change in individual technologies' characteristics in response to policy: a declining capital cost function and a declining intangible cost function. The declining capital cost function links a technology's financial cost in future periods to its cumulative production, reflecting economies-of-learning and scale (e.g., the observed decline in the cost of wind turbines as their global cumulative production has risen). The declining capital cost function is composed of two additive components: one that captures Canadian cumulative production and one that captures global cumulative production. The declining intangible cost function links the intangible costs of a technology in a given period with its market share in the previous period, reflecting improved availability of information and decreased perceptions of risk as new technologies become increasingly integrated into the wider economy (e.g., the "champion effect" in markets for new technologies); if a popular and well respected community member adopts a new technology, the rest of the community becomes more likely to adopt the technology.

[53] CIMS uses the 2001 100-year global warming potential estimates from Intergovernmental Panel on Climate Change, 2001, "Climate Change 2001: The Scientific Basis", Cambridge, UK, Cambridge University Press.

2020 CLIMATE CHANGE PLANS

NRT

NATIONAL
ROUND TABLE ON
THE ENVIRONMENT
AND THE ECONOMY

MINISTERIAL
REFERENCE

REALITY CHECK: THE STATE OF CLIMATE PROGRESS IN CANADA

A REPORT BY
THE NATIONAL
ROUND TABLE ON
THE ENVIRONMENT
AND THE ECONOMY

Canadä

THE STATE OF CLIMATE PROGRESS IN CANADA

THIS NEW REPORT, REQUESTED BY THE FEDERAL MINISTER OF THE ENVIRONMENT, REMINDS US OF HOW FAR THE COUNTRY HAS COME, BUT ALSO OF HOW FAR IT MUST GO. IT SERVES AS A REALITY CHECK ON THE STATE OF CLIMATE PROGRESS IN CANADA TODAY.

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NRT
NATIONAL ROUND TABLE ON THE ENVIRONMENT AND THE ECONOMY

Disclaimer: The views expressed in this document do not necessarily represent those of the organizations with which individual Round Table members are associated or otherwise employed. The NRT strives for consensus but does not demand unanimity. The NRT's deliberations included vigorous discussion and debate reflecting diversity of opinion.

ACKNOWLEDGEMENTS

The NRT wishes to thank the many people who participated in our research and convening process to make this important report not just a reality check, but a reality.

The heart of the report is its original economic modeling and analysis. This was conducted by Navius Consulting led by Chris Bataille and Noel Melton. Dale Beugin of Skycurve Consulting coordinated their efforts, helped present results, and contributed drafts of two of the chapters dealing with this research. Dr. Andrew Leach of the University of Alberta provided early strategic advice and acted as that essential interpreter of this unique piece of work, particularly on the cost-effectiveness issues. The NRT was well-served by these leading Canadian energy/environment researchers and modelers and thanks them.

We wish to thank Andre Juneau and his team at the Institute for Intergovernmental Relations at Queen's University for hosting our dialogue session with governments and climate policy experts in March, 2012. This Canadian Climate Policies Dialogue Session was instrumental in bringing almost all governments to the same table to hear our research results and contribute their perspectives.

Participation by the federal and provincial/territorial governments was critical for this report to succeed. The NRT thanks deputy ministers, and assistant deputy ministers of environment and their officials from all jurisdictions who gave us their time, information, and helped us understand each of the climate policy plans being implemented across the country. Their interest and engagement in the NRT's work was gratifying.

Our own NRT staff applied their dedicated skills and commitment to meet the requirements of the Ministerial Reference to us and contribute to this final product. Julie St-Amour organized the Kingston Conference with Rachel Faulkner. Suzanne Loney provided her usual detailed eye for editing and form. The communications unit of Marie-Josée Lapointe, Tony Bégin, Richard Pilon, Edwin Smith, and Nadra Meigag met the compressed timeframes to produce the final English and French versions for public release.

Finally, the NRT wishes to particularly thank and acknowledge the contribution of Beth Hardy, research associate, to this report. Beth conducted the provincial climate plans analysis, engaged provinces directly to get their input, contributed draft chapters, and kept all the loose ends together. Beth's commitment and hard work were essential for this report to progress.

MESSAGE FROM THE VICE-CHAIR

In 2011, the Minister of the Environment asked the NRT to conduct a comprehensive assessment of provincial/territorial climate change plans and how they will contribute to meeting the federal government's 2020 target to reduce emissions. The minister stated the NRT was "uniquely positioned" to carry out this charge on his behalf. This report is the result of our work.

As an independent policy advisory agency on sustainable development, the NRT is providing original analysis, assessment, and advice to the Government of Canada and all provincial/territorial governments. This is the first such assessment of all the data and all the trends of government climate change policies to show progress towards reducing greenhouse gas emissions and meet our international climate change target.

The NRT believes it is essential that governments and policy makers in this field read what we found and consider our advice to move ahead. Canada will not make the progress it needs without this frank assessment of what we can really expect from climate policies now or soon to be underway. Nor will Canada achieve its climate goals without considering a better way to unify governments in a more coordinated approach with shared understanding that all must contribute.

R.W. Slater, CM, PH.D.
NRT Vice-Chair

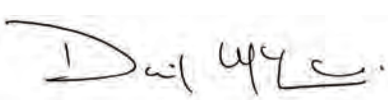
MESSAGE FROM THE PRESIDENT AND CEO

Reality Check is just that: a reality check on where Canada really is in reducing greenhouse gas emissions to meet the federal government's 2020 target. The NRT's work is original and needed. Billions of dollars of investment and effort have been and will be expended by governments, industry, and consumers on various climate policies and programs to reduce carbon emissions. But how effective are they? Will they yield results? The NRT provides some answers.

We show, for the first time, comprehensively just where we are on the path to 2020. We illustrate the actual and expected contributions of federal and provincial governments to meeting this challenge. We demonstrate what it will take, and what it will cost, to close the emissions gap to Canada's 2020 target.

Carbon emissions in our country do not belong to any one level of government. National climate policy progress has been slow and difficult in Canada given the sources and trends in emissions across Canada. Governments have talked, have acted to some degree, but sustained progress Canadians can count on is not yet taking place. The NRT sets out advice on how to coordinate climate policies across the country so they work better, together.

Our message is clear. We need to move beyond current approaches and have a truly pan-Canadian dialogue on how to do this better. If not, Canada's 2020 target will remain a hope not a reality.



David McLaughlin
NRT President and Chief Executive Officer

ABOUT US

Through the development of innovative policy research and considered advice, our mission is to help Canada achieve sustainable development solutions that integrate environmental and economic considerations to ensure the lasting prosperity and well-being of our nation.

Emerging from the famous Brundtland Report, *Our Common Future*, the NRT has become a model for convening diverse and competing interests around one table to create consensus ideas and viable suggestions for sustainable development. The NRT focuses on sustaining Canada's prosperity without borrowing resources from future generations or compromising their ability to live securely.

The NRT is in the unique position of being an independent policy advisory agency that advises the federal government on sustainable development solutions. We raise awareness among Canadians and their governments about the challenges of sustainable development. We advocate for positive change. We strive to promote credible and impartial policy solutions that are in the best interest of all Canadians.

We accomplish that mission by fostering sound, well-researched reports on priority issues and by offering advice to governments on how best to reconcile and integrate the often divergent challenges of economic prosperity and environmental conservation.

The NRT brings together a group of distinguished sustainability leaders active in businesses, universities, environmentalism, labour, public policy, and community life from across Canada. Our members are appointed by the federal government for a mandate of up to three years. They meet in a round table format that offers a safe haven for discussion and encourages the unfettered exchange of ideas leading to consensus.

We also reach out to expert organizations, industries, and individuals to assist us in conducting our work on behalf of Canadians.

The *NRTEE Act* underlines the independent nature of the Round Table and its work. The NRT reports, at this time, to the Government of Canada and Parliament through the Minister of the Environment. The NRT maintains a secretariat, which commissions and analyzes the research required by its members in their work.

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NATIONAL ROUND TABLE ON THE ENVIRONMENT AND THE ECONOMY

OUR PROCESS IS THE WAY WE WORK

FINDING SUSTAINABLE PATHWAYS

RESEARCH

We rigorously research and conduct high quality analysis on issues of sustainable development. Our thinking is original and thought provoking.

CONVENE

We convene opinion leaders and experts from across Canada around our table to share their knowledge and diverse perspectives. We stimulate debate and integrate polarities. We create a context for possibilities to emerge.

ADVISE

We generate ideas and provide realistic solutions to advise governments, Parliament and Canadians. We proceed with resolve and optimism to bring Canada's economy and environment closer together.

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1.0 INTRODUCTION

NATIONAL CLIMATE CHANGE POLICY HAS BEEN AN ELUSIVE GOAL IN CANADA. AS A NORTHERN COUNTRY, CANADA FACES BOTH COLD WINTERS AND HOT SUMMERS THAT CONTRIBUTE TO HIGH ENERGY DEMAND AND EMISSIONS; AS A COUNTRY FORTUNATE TO HAVE ABUNDANT FOSSIL FUEL RESOURCES, IT IS ALSO CHALLENGED BY THE HIGH EMISSIONS CREATED BY THEIR EXTRACTION AND USE; AS A LARGE COUNTRY WITH LOW POPULATION DENSITY, CANADA CONFRONTS THE REALITY OF HIGH EMISSIONS FROM TRANSPORTATION; AND AS A GROWING COUNTRY, IT SEES UPWARD PRESSURES ON EMISSIONS.

All of these challenges and many others have made greenhouse gas (GHG) reduction policy quite contentious — politically and economically. The hard reality of developing an effective and acceptable national climate policy plan within a federation that shares responsibility for emissions management, places natural resource ownership in the hands of one level of government, sees uneven emission sources across the country, and needs to speak with one voice internationally has been tough to overcome. A new political economy with shifting patterns of economic growth, population change, and political power across the country now bears down even more on the issue.

Unsurprisingly, climate change policy in Canada has proved difficult to develop and divisive to implement. Successive governments, federally and provincially, have struggled to find the right formula that reduces GHG emissions within their jurisdiction while maintaining — indeed advancing — economic growth. Canada signed the Kyoto Protocol and is now withdrawing from it. Canada announced a national plan and new targets and then sought to align with developments in the United States, leading to a different plan and different targets. Provinces and territories acted both independently and banded together to reduce carbon emissions through a range of innovative, diverse, and traditional measures. Canada now has 14 climate policy plans on the books, one for the federal government and each province and territory. How is this to be reconciled?

As public interest and media attention on climate change ebbs and flows, the ability to maintain political momentum on the issue has ebbed and flowed with it. Climate policy horizons do not fit easily with political cycles here in Canada or elsewhere. Yet as the climate changes and awareness grows about the costs of climate inaction — of simply letting climate change play out — Canadians are reminded of our confronting the challenge of climate change at home and around the world.

Overall, some progress has been made in recent years. All governments — federal and provincial — have set GHG targets, put plans and policies in place to reduce emissions; most importantly, emission reductions have occurred. Despite this progress, climate change mitigation policy is fragmented, incomplete and remains a steep challenge for Canada.

This new report by the National Round Table on the Environment and the Economy (NRT), requested by the federal Minister of the Environment, reminds us of how far the country has come, but also of how far it must go. It serves as a reality check on the state of climate progress in Canada today. It reinforces some key truths about climate policy today in Canada: that a national target needs a concerted national policy behind it, that policy uncertainty still exists and stifles progress, that the country has yet to implement effective policies to address some large sources of emissions, and that all this means progress has been and will remain difficult and uneven across the country.

This is the context in which the NRT's report is submitted.

1.1 THE MINISTERIAL REFERENCE

In March 2011, the Honourable Peter Kent, Canada's Minister of the Environment, requested that the NRT provide independent analysis to the Government of Canada on provincial/territorial climate change plans and measures in support of the government's environmental agenda (see Appendix 7.1). His letter stated the NRT "is in a unique position to advise the federal government on sustainable development solutions."

The NRT was directed in this Ministerial Reference to conduct a comprehensive review of provincial and territorial climate change plans and assess their likely contribution to Canada's 2020 greenhouse gas emission-reduction target of 17% below 2005 levels. The Minister asked the NRT to:

1. analyze provincial plans to reduce emissions,
2. analyze progress to date in implementing their plans, and
3. estimate the emission reductions expected from current and future provincial and territorial climate change initiatives by 2020.

The specific purpose in doing so was to inform the Government of Canada's overall effort to achieve its 2020 target for GHG emissions through its sector-by-sector regulatory approach.

This report was developed in response to the Ministerial Reference. It includes our analysis and assessment of provincial GHG reduction plans and progress toward the 2020 target, together with advice on how Canada can meet this target. This is the first national-level study of this type that specifically models both federal and provincial/territorial climate policy actions to assess the extent to which they close the gap to Canada's 2020 target. It should not be the last.

It contains original modelling and forecasting informed by our own analysis and expertise but benefits from the input of the federal government and provincial and territorial governments in determining which policies to consider. Its importance lies not just in the numbers presented but also in the recognition that both levels of government are making contributions, as a whole, to emission reductions. The federal government set the target for Canada but emission reductions will have to occur right across the country to achieve those targets. For the first time, answers to four basic questions about climate policy progress in Canada and the 2020 target are answered in one report:

1. Where are we now?
2. Why are we here?
3. Can we reach our target?
4. What do we have to do to get there?

The NRT's work is new and vital for several reasons. No other objective analysis has modelled as many policies at one time. No other organization has brought governments together in one room to discuss these four questions. No other report has developed forecasts based on such comprehensive modelling to say authoritatively what the country can expect. But beyond original modelling and forecasting, the NRT looked at both the *why* and *how* of Canada's path to 2020 to draw lessons for the future. We examine the choices governments have made to date and consider what this means for choices they will have to make in the future.

Similarly it is important to note what the report is not. It isn't an individual audit of federal and provincial/territorial (P/T) policies to determine effectiveness. Our aim was to realistically and accurately estimate the amount of emission reductions Canada could expect by 2020, the likely contributions of both levels of government to these reductions through their respective policies, how cost-effective Canada's approach has been as a result, and what might be required to close any emission gap to 2020. The NRT's focus has always been longer term, building on current policy approaches by governments to determine sustainable pathways ahead.

The NRT was directed in this Ministerial Reference to conduct a comprehensive review of provincial and territorial climate change plans and assess their likely contribution to Canada's 2020 greenhouse gas emission-reduction target of 17% below 2005 levels.

This report is of limited applicability to the territories. Absolute emissions are very small from each of these jurisdictions. Climate change plans do exist for each, but territorial governments have focused most of their efforts to date on adaptation to the impacts of climate change due to the extent of impacts in the north. NRT modelling reports likely territorial emission reductions within our national-level forecasts but is unable to provide a breakdown for each territory. A summary of mitigation-related challenges facing the three territories is provided in Chapter 3.

Consulting with Aboriginal communities was not part of the scope of the Ministerial Reference. However, all communities and all governments have a role to play in working to meet Canada's target.

1.2 THE NRT'S APPROACH

The NRT's approach was to conduct original *analysis* of Canadian climate policies, undertake a clear *assessment* of our progress to date, and offer considered *advice* on a path forward to achieving the 2020 target. Here's how we did this.

RESEARCH

MODELLING

Analysis and assessment required original economic modelling of Canadian GHG emission-reduction scenarios and policies. The NRT analyzed emissions trends from 1990 through current day and projected out to 2020 as well as 2030, both nationally and at the provincial level. From there, we considered not just existing, but proposed, federal and P/T climate policies and corresponding emission reductions to determine their likely contributions toward achieving Canada's 2020 emission-reduction target. This was necessary to draw a full picture of what Canadians could reasonably expect from government actions. A clear and transparent vetting process was undertaken by the NRT in consultation with the federal and provincial governments to arrive at the list of policies to include in our modelling (see Appendix 7.7 for full list). All provincial governments were given the opportunity on two occasions to provide their views on our proposed actions to model for their respective jurisdictions. The NRT made some adjustments in response.

To carry out the actual modelling, the NRT contracted Navius Research Inc., a leading environment/economy consulting firm that has conducted work on this topic for the federal government, several provincial governments, as well as the NRT. Navius used the CIMS model, an energy-economy model, to generate forecasts of GHG emission reductions as well as to estimate the cost of achieving emission reductions under three policy scenarios. This approach allowed the NRT to provide much more detail than previously had been available about contributions needed from various provinces and sectors and their cost of achieving the 2020 target. A detailed explanation of how CIMS works is contained in Appendix 7.2, and the scenarios we used in the modelling work are spelled out in Chapters 4 and 5.

As noted, the NRT also pushed the analysis beyond the stated target date of 2020 to better understand the cost implications of meeting targets later. While the federal approach and a number of provincial plans congruently targeted a specified emissions level in 2020, it was clear to the NRT that the full effectiveness of some policies may not become apparent until after that date. As climate change is a long-term issue requiring long-term policy solutions, going out to 2030 might illuminate options and impacts in a clearer manner for governments. At some point in the future, Canada, as well as other countries around the world, may decide on new targets for 2030 to further address climate change. Our analysis can help inform that consideration for our country.

The NRT based its modelling analysis on Environment Canada's own forecasting inputs to ensure symmetry with its approach. We used established data from the National Energy Board and Environment Canada's *Emissions Trends* report. The NRT consulted provinces and territories directly and as often as possible to secure their input into our work as spelled out below. Our analysis is therefore based on sound and established emissions reporting data and information.

QUALITATIVE ASSESSMENT

The NRT also reviewed federal and provincial climate policy plans in detail. We performed a qualitative assessment of each to understand its focus, common and distinct elements, and how they complement the federal approach. Our qualitative assessment characterizes provincial plans based on a set of criteria, identifies leading practices from each jurisdiction, explores key considerations for policy design, and highlights future emission-reduction plans and emerging trends. We also undertook a past review of Canadian emissions trends to help explain why Canada is where it is today.

COMMISSIONED ACADEMIC RESEARCH

In order to provide perspective on the dynamics of climate policy in Canada, the NRT commissioned three research papers by top academic experts in the field. Topics included U.S. climate policy and its influence on Canadian intergovernmental climate policy coordination, intergovernmental collaboration and coordination in the context of federalism, and the environmental and economic impacts of overlap between federal and provincial climate policies.

CONVENING

PROVINCIAL/TERRITORIAL ENGAGEMENT

The NRT began its work by advising provinces and territories of the Ministerial Reference and seeking bilateral meetings with each government to help inform our work. Meetings were conducted with every province and Yukon to present information on the Ministerial Reference, as well as to strengthen our understanding of progress on the climate change file both internal to that province or territory and on an intergovernmental level.[a] All meetings included discussions about both broad policy approaches and specific details of the P/T's climate change plan, perspectives on the federal sector-by-sector approach, and evaluation and assessment of their own emissions estimates where available. They also included discussions about intergovernmental co-operation to date. Appendix 7.7 includes a list of meetings held, participants in attendance, and the NRT's request for information sent to provinces and territories.

During our meetings, the NRT received constructive engagement from governments. We committed to reconnect with each jurisdiction as we proceeded. Prior to commencing our modelling, the NRT asked each province to review the list of policies we planned to model derived from their plans to ensure that the policies and time frames accurately reflected their own information. Provinces were offered two further opportunities to pass along their suggestions and review our proposals prior to any modelling being conducted. This was necessary as some jurisdictions expressed concern that past Environment Canada modelling did not sufficiently incorporate their realities. More importantly for the purposes of our work, the NRT needed an accurate assessment of any and all proposed policy actions by governments so their likely emission reductions could be measured and considered in terms of achieving our 2020 target. We made efforts to include as many initiatives as practical in our data inputs to ensure a complete a picture as possible.

CANADIAN CLIMATE POLICIES DIALOGUE

On March 5 and 6, 2012, the NRT, in conjunction with Queen's University, Institute of Intergovernmental Relations, convened officials from the federal and P/T governments, several NRT Members, climate public policy experts, and intergovernmental experts in Kingston, Ontario. The purpose of the event was to present our early research findings; engage in a dialogue of the issues raised by the assessment; hear about ideas, solutions, and processes to move forward; and invite advice on the report's content and recommendations. Appendix 7.8 contains the agenda and participants' list alongside a brief summary of what we heard is contained in Appendix 7.8.

This unique event gave officials and experts the opportunity to discuss this issue in the same room. Three roundtable discussions were used to structure the dialogue. The first session focused on forecasted emission reductions from our modelling. The second session concentrated on provincial and territorial climate change plans. The last session focused on future directions for climate policy in Canada, including institutions and successful mechanisms required to achieve emission reductions, development of targets

a The NRT did not meet with the Northwest Territories and Nunavut.

and reporting, and inter-jurisdictional collaboration options. Each session included presentations, a roundtable discussion, and audience questions and comments. The dialogue from all participants provided valuable information and advice that has informed this report.

1.3 REPORT STRUCTURE

The report is presented as follows:

Chapter 2 provides historical context on the GHG reductions file in Canada and presents past and current emissions trends and levels, including sectoral and geographic composition. Its purpose is to factually ground where we are today and how we got here.

Chapter 3 includes a qualitative assessment of provincial climate plans. It sets out criteria for assessing the strength of provincial plans, highlights best practices at the provincial level, and discusses several policy challenges that need to be confronted moving forward. Its purpose is to provide information and assessment of provincial climate policy plans.

Chapter 4 presents results of the NRT's original modelling, including estimated emission reductions from current and future federal, provincial, and territorial climate change initiatives by 2020 and 2030. These results estimate the extent to which existing and proposed initiatives will contribute to achieving both provincial and federal targets. It estimates the extent of overlap between policies by both levels of government. Regional- and sector-level perspectives are also provided. Its purpose is to assess Canada's progress toward 2020 and see how much of a gap remains.

Chapter 5 builds on previous modelling results, providing new modelling data to assess the cost-effectiveness of Canadian climate policy to date and going forward. This is used as a base for then identifying the sectors and provinces that should be targeted for future cost-effective emission reductions and the level of costs associated with these additional actions en route to achieving the 2020 target. Its purpose is to establish a cost-effective road map forward for the country.

Chapter 6 draws our analysis and assessment together and sets out the report's conclusions and implications. Its purpose is to summarize key findings and provide the NRT's advice to the Minister of the Environment.

2.0 CANADA'S EMISSIONS STORY

THIS CHAPTER SITUATES OUR ASSESSMENT OF PROVINCIAL CLIMATE CHANGE PLANS BY PROVIDING AN OVERVIEW OF THE HISTORY OF MITIGATION POLICY IN CANADA, THE CURRENT EMISSIONS CONTEXT AT A SECTORAL AND REGIONAL LEVEL, AND FEDERAL MEASURES TO ENCOURAGE EMISSION REDUCTIONS ACROSS THE COUNTRY.

2.1
HISTORY OF FEDERAL CLIMATE POLICY

The Government of Canada has been engaged on the climate file for over two decades. In 1988, at "The Changing Atmosphere: Implications for Global Security" conference in Toronto, the Progressive Conservative government of Prime Minister Brian Mulroney committed Canada to reducing its GHG emissions 20% by 2005.[1] This target was altered later that year at a meeting of the G7 countries where Prime Minister Mulroney made a commitment to stabilize national GHG emissions at 1990 levels by the year 2000.[2] Two years later, the federal government introduced a *Green Plan* that contained $175 million for 24 GHG reduction policies mostly focused on energy efficiency and alternative energy. This plan came with a revised target to stabilize GHG emissions at 1990 levels by 2000. This was a non-binding target that Canada also embraced in the Framework Convention on Climate Change in 1992.[3]

In the last decade, three unique climate approaches have been taken by the federal government, which can be described, respectively, as the Kyoto approach, the *Turning the Corner* approach, and the Copenhagen approach.

In 1993, Prime Minister Jean Chrétien proposed the same GHG emission-reduction target that was committed to at The Changing Atmosphere conference in 1988 of 20% below 1988 levels by 2005.[4] In 1995, the federal government launched the *National Action Program on Climate Change*, which focused on information programs and small subsidies. The federal government estimated that this program would reduce GHG emissions by 66 megatonnes carbon-dioxide equivalent (Mt CO_2e) by 2010.[5] The main elements in the program were the Voluntary Challenge and Registry, asking for a voluntary submission of GHG emission-reduction plans and regular progress reports by companies; the Federal Buildings Initiative, supporting federal government building retrofits with higher energy efficiency standards; and the National Communication Program, a climate change education program for Canadians.[6]

In the five years leading up to the signing of the Kyoto Protocol, Canada went through multi-stakeholder consultations on emission reductions. There was agreement among the federal and provincial ministers of environment and energy (with the exception of Québec which sought a more ambitious target) that Canada's position would match the U.S.'s commitment to reduce emissions to 1990 levels by 2010. Although this target was agreed upon in the opening days of the Kyoto meeting, the federal government unilaterally announced that Canada would reduce its emissions to 6% below 1990 levels by 2010. After signing the Kyoto Protocol, in 1998 (before ratifying in 2002) the federal government released its *Action Plan 2000 on Climate Change*. This plan set in place subsidies for renewable energy alongside consumer/business energy information programs.

In the last decade, three unique climate approaches have been taken by the federal government, which can be described, respectively, as the Kyoto approach, the *Turning the Corner* approach, and the Copenhagen approach. Each approach is marked by differing emission reductions targets and measures to achieve these targets (see Table 1).

TABLE 1: CANADA'S CHANGING TARGETS

YEAR TARGET WAS SET	TARGET	BASE YEAR EMISSIONS (Mt CO_2e)	PROJECTED EMISSIONS TARGET (Mt CO_2e)
1988	20% below 1988 levels by 2005	588*	470 in 2005*
1990	Remain at 1990 levels by 2000	590	590 in 2000
1993	20% below 1988 levels by 2005	588*	470 in 2005*
1995	66Mt below 1995 levels by 2010	640	574 in 2010
1998	49Mt below 1998 levels by 2010	677	628 in 2010
2002	6% below 1990 levels by 2012[7]	590	555 in 2012
2007	20% below 2006 levels by 2020[8]	719	575 in 2020
2010	17% below 2005 levels by 2020[9]	731	607 in 2020

** This is an approximate number based on data in Environment Canada 1999 and NRT calculations*

THE KYOTO APPROACH

In 2002, Canada ratified the Kyoto Protocol it had signed in 1998 committing to reduce GHG emissions by 6% from 1990 levels by 2012.[10] At that time Canada's emissions had climbed from 1990 levels of 590 Mt to 717 Mt.

In 2000, the federal government began to outline steps to achieve the Kyoto target, including a federal commitment of $1.1 billion to incent GHG emission-reduction measures over a five-year period.[11] This plan was supplemented in 2002 with a *Climate Change Plan for Canada* that committed to establishing GHG reduction targets for large industry; providing flexible compliance through trading and other measures; co-funding emission reductions with provinces, municipalities, and others; and undertaking additional targeted measures.[12] In 2005, under Project Green, the government confirmed its intent to regulate large final emitters and provide compliance flexibility through emissions trading, offsets, and a technology fund.[13]

THE TURNING THE CORNER APPROACH

In 2006 the new Conservative federal government led by Prime Minister Stephen Harper announced that Canada was not on track to meet its Kyoto obligations.[14] Subsequently, in 2007, a new GHG reduction target of 20% below 2006 levels by 2020 was announced.[15] Canada's emissions had peaked around that same time at about 750 Mt, some 27% higher than 1990 levels.[16]

To meet the new target, the government introduced *Turning the Corner*, a domestic air emissions management plan with emissions intensity as the base measurement for emission reductions. *Turning the Corner* proposed the regulation of industrial emitters in a cap-and-trade system that would provide compliance flexibility through trading, offsets, and a technology fund, as part of a broader regulatory program aimed at reducing GHG and air pollution emissions.

THE COPENHAGEN APPROACH

In 2010, as a signatory to the Copenhagen Accord, Canada announced a new target of 17% reduction from 2005 levels by 2020, aligning with the United States' target.[17] This would yield roughly 30 Mt CO_2e fewer emission reductions per year by 2020 than the *Turning the Corner* plan. Emissions in Canada had meanwhile been declining at this point in time from 748 Mt CO_2e in 2007 to 690 Mt CO_2e in 2009, principally because of reduced economic growth and higher energy prices.[18]

To achieve this target, a new "sector-by-sector regulatory approach" was initiated. The centerpiece of the regulatory regime is a set of emissions performance standards starting with regulations for the electricity sector. In addition to the sector-by-sector approach, the government is also developing performance requirements for various products, which are referred to as product performance standards. Appendix 7.4 provides more information on the federal approach.[19]

KEY ISSUES

Despite a shift in targets and approaches over time, the Government of Canada remained a signatory to the Kyoto Protocol until the end of 2011, when the government announced its intention to withdraw on the grounds that the Protocol did not include the majority of global emitters and that the costs of compliance would be excessive without yielding environmental benefits.[20] Since 2007, the *Kyoto Protocol Implementation* Act has required the Government of Canada to provide an annual report on progress toward achieving the Kyoto commitment and created statutory obligations for the NRT to provide an assessment of these annual plans. The NRT's 2011 assessment report supported the government's own analysis indicating that Canada would exceed its Kyoto target by about 161 Mt CO_2e per year during the compliance period.[21]

Issues of international competitiveness — particularly with the U.S. — have been an important factor in developing Canadian climate policy as the NRT pointed out in *Parallel Paths: Canada--U.S. Climate Policy Choices*. In 2009 the government began to place more focus on working with the U.S. to achieve clean energy and climate change goals, primarily through co-operation on clean energy research and development and enhancing the electricity grid in ways that favour increased use of clean energy.[22] However, working closely with the U.S. on this file is a challenge given both the lack of a comprehensive U.S. plan to confront climate change and the important role that sub-national jurisdictions are playing on both sides of the border.[b] Canada has moved away from plans to implement a trading system for large emitters and has instead focused on harmonizing regulations and standards with those of the U.S. wherever feasible, as in the case of fuel economy standards.

2.2 HISTORY OF PROVINCIAL CLIMATE ACTION

The federal and provincial governments share jurisdiction over environmental matters under the Constitution of Canada (see Text box 1). This offers both benefits and challenges, which are discussed in the next chapter. As Canada worked to develop policies to manage climate change in the late 1990s and early 2000s, the federal and provincial governments

b A report providing details on the history of climate policy in the U.S. is available upon request (Rabe 2012).

initially sought a joint approach. This proved to be challenging, with widely divergent natural resource endowments yielding differing total and per capita GHG emissions and leading to differing economic interests with respect to climate policy. The choice of target under the Kyoto Protocol and the manner in which it was decided, together with the ensuing U.S. withdrawal, also proved divisive, with a number of provinces opposing Canadian ratification at the time. Once the federal government made the decision to ratify Kyoto, attempts at joint federal/provincial action on climate change basically dissipated and have not been formally resurrected.[23]

Following several years of federal policy uncertainty, provinces began to act more unilaterally in the mid-2000s. As the report discusses in Chapter 3 and in Appendix 7.6, the provinces are currently implementing a number of actions to address GHG emissions both independently and in co-operation with other provinces and some U.S. states.

Following several years of federal policy uncertainty, provinces began to act more unilaterally in the mid-2000s.

TEXT BOX 1

JURISDICTION OVER ENVIRONMENTAL CONSIDERATIONS

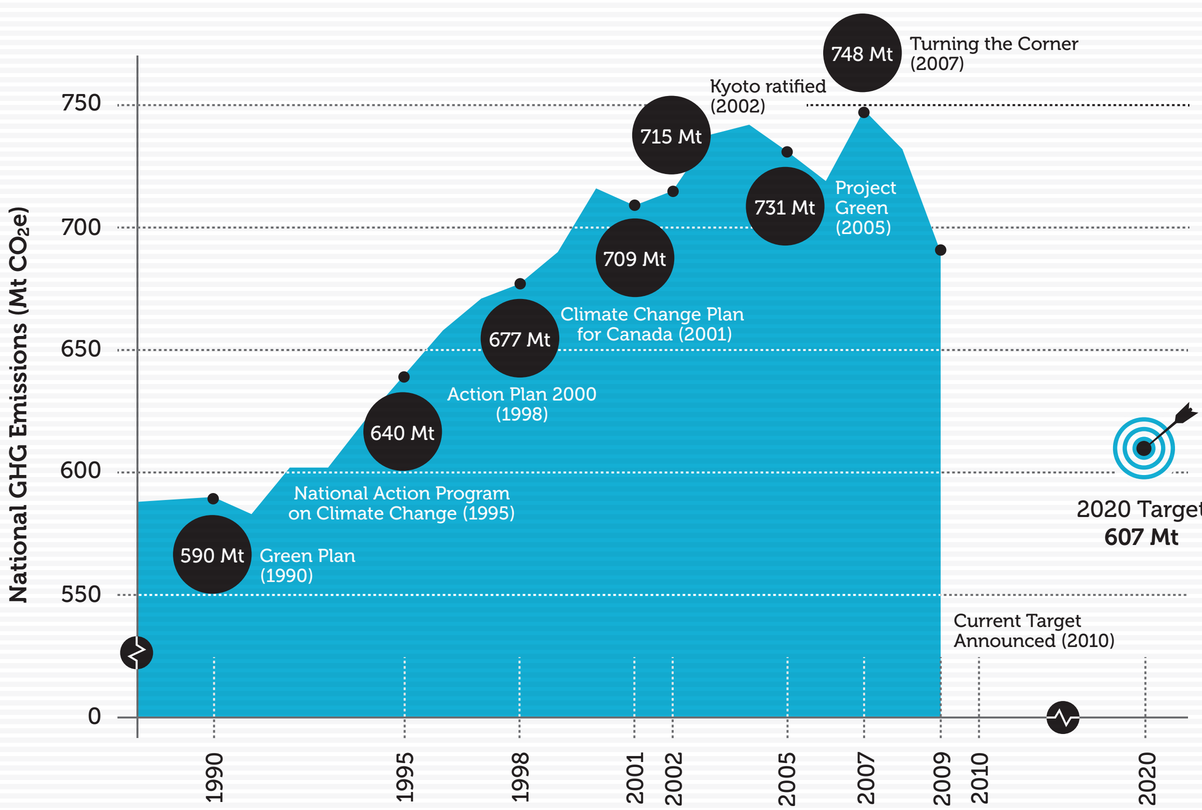
The Constitution of Canada entrenches authority over land and natural resources with the provinces. This gives provinces the power to determine the pace and scale of resource exploitation, receive royalties and rents and by extension, strong influence over the actual GHG emissions resulting from this development. However, the Constitution also allows for federal power over climate change policy in Canada, based on peace, order, and good government, or regulation of trade and commerce powers.[24] The extra-provincial, interprovincial, transcontinental and international nature of the challenge further points to a federal role. In addition, climate change can be viewed as a matter of national concern because addressing it requires one national law that can be met with flexible provincial action but cannot be satisfied by co-operative provincial action because the failure of one province to co-operate would carry with it adverse consequences for the residents of other provinces.[25]

In circumstances when there is conflict over jurisdictional authority, co-operation is a possible remedy. Tools for inter-jurisdictional co-operation include “memoranda of understanding to establish mutually supportive objectives, equivalency agreements which allow one jurisdiction’s laws (usually the federal government) to be withdrawn from application if there are equivalent provisions at the other level (usually provincial), and express incorporation by reference of another jurisdiction’s legislation.”[26]

2.3
EMISSIONS TRENDS (1990–2009)

Figure 1 shows Canada's emissions trends since 1990 with federal climate policies overlaid. Emissions trends over time reflect a combination of forces including resource use, environmental policy, and economic trends. While Canada's emissions increased 17% between 1990 and 2009, a 6% reduction occurred between 2005 and 2009. The year 2005 is a useful benchmark as many provincial measures have been introduced since that time; 2005 now marks the baseline for measuring Canada's progress.

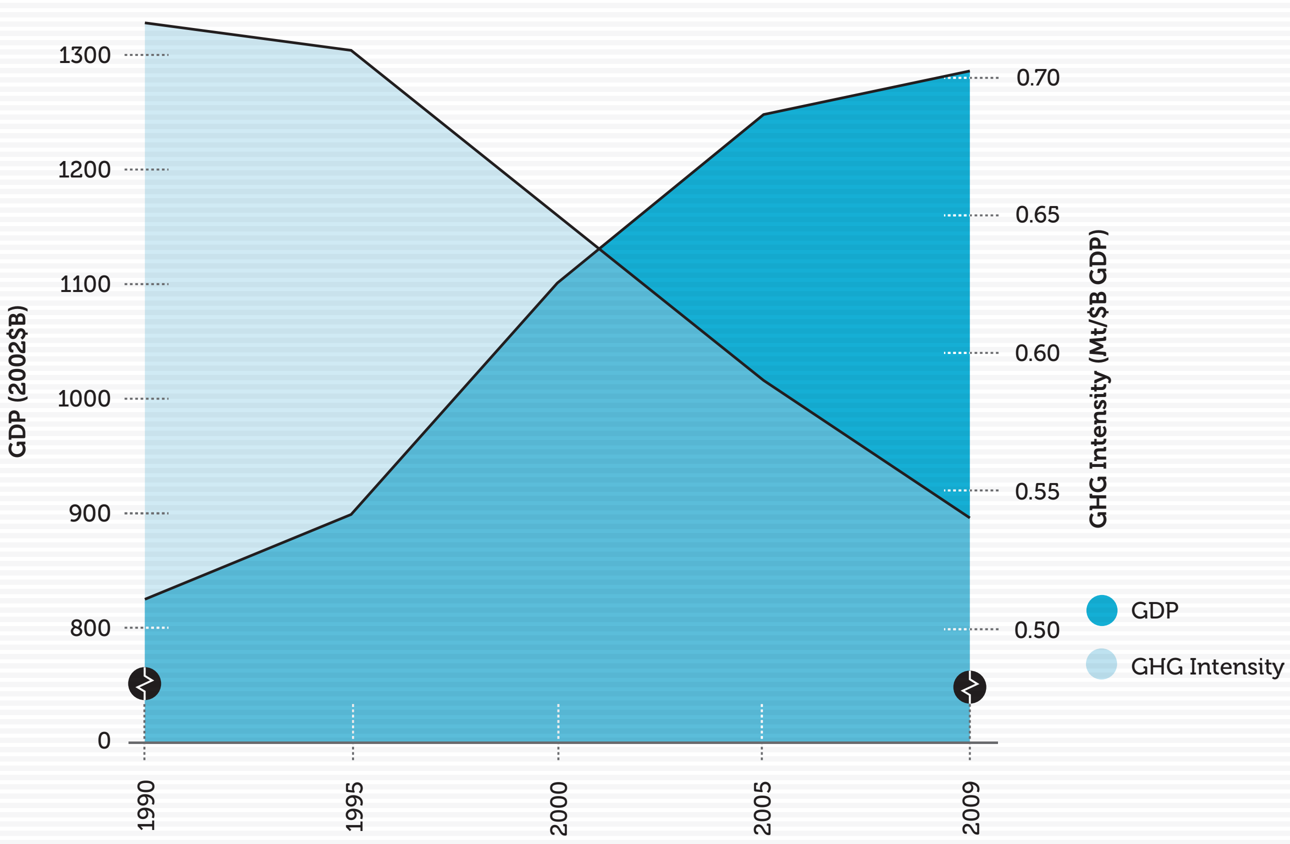
FIGURE 1: TIMELINE OF FEDERAL APPROACHES TO CLIMATE CHANGE AND EMISSIONS TRENDS



Source: Data taken from Environment Canada 2011b

Figure 2 demonstrates the connection between economic development and Canada's GHG emissions. Over the last two decades, our overall emissions have risen as has our GDP, but the emissions intensity of our economic output has fallen dramatically.

FIGURE 2: ECONOMIC GROWTH AND GHG INTENSITY OF ECONOMY (1990–2009)

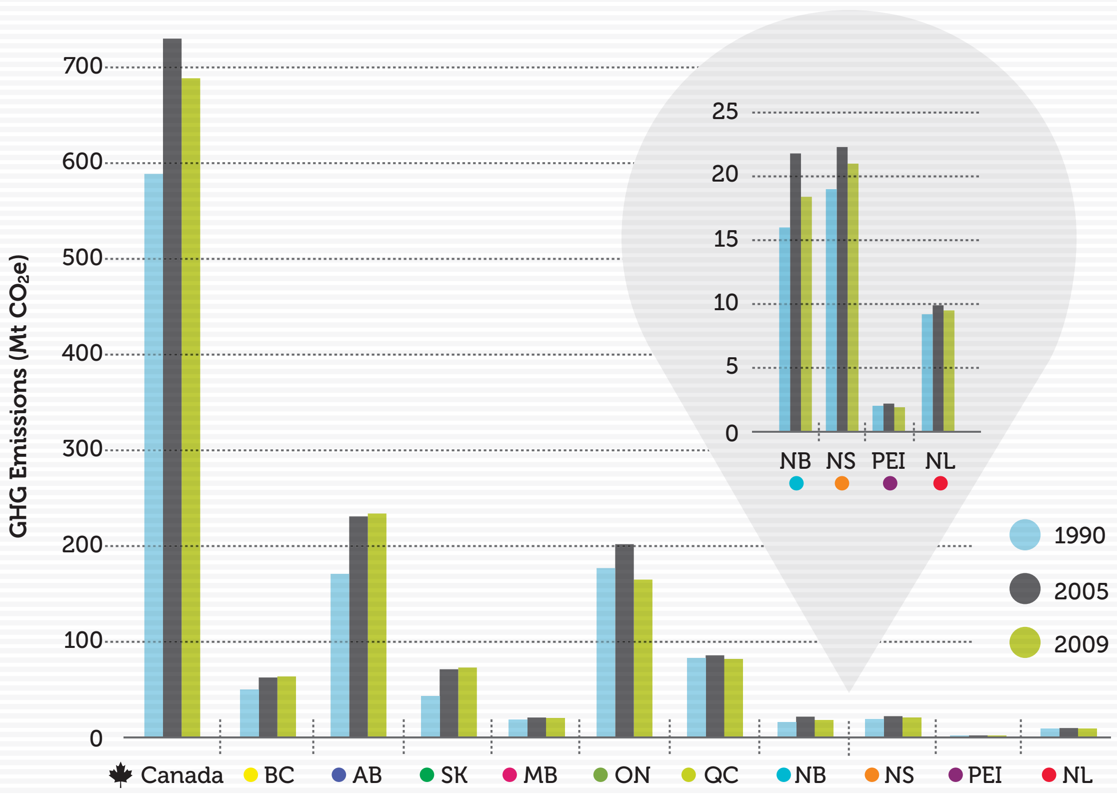


Source: Data taken from Environment Canada 2011b; and Statistics Canada ND

Figure 3 disaggregates emissions trends at the provincial level, indicating changes in emissions over time since 1990 and 2005. As shown, the most rapid growth in emissions over the last two decades occurred in Saskatchewan and Alberta. In contrast, Ontario, Québec, and Prince Edward Island have seen emissions fall over that period. In the 2005 to 2009 period, all provinces to the east of Saskatchewan along with British Columbia show overall reductions while Alberta and Saskatchewan reported more limited emissions growth. These recent trends can be explained by the economic downturn and the ramp-up of provincial GHG mitigation policies.

FIGURE 3: EMISSIONS TRENDS (1990–2009)

	Canada	BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL
GROWTH 1990–2009	17%	28%	37%	69%	10%	-7%	-2%	15%	11%	-4%	3%
GROWTH 2005–2009	-6%	2%	1%	3%	-3%	-18%	-5%	-16%	-6%	-15%	-5%

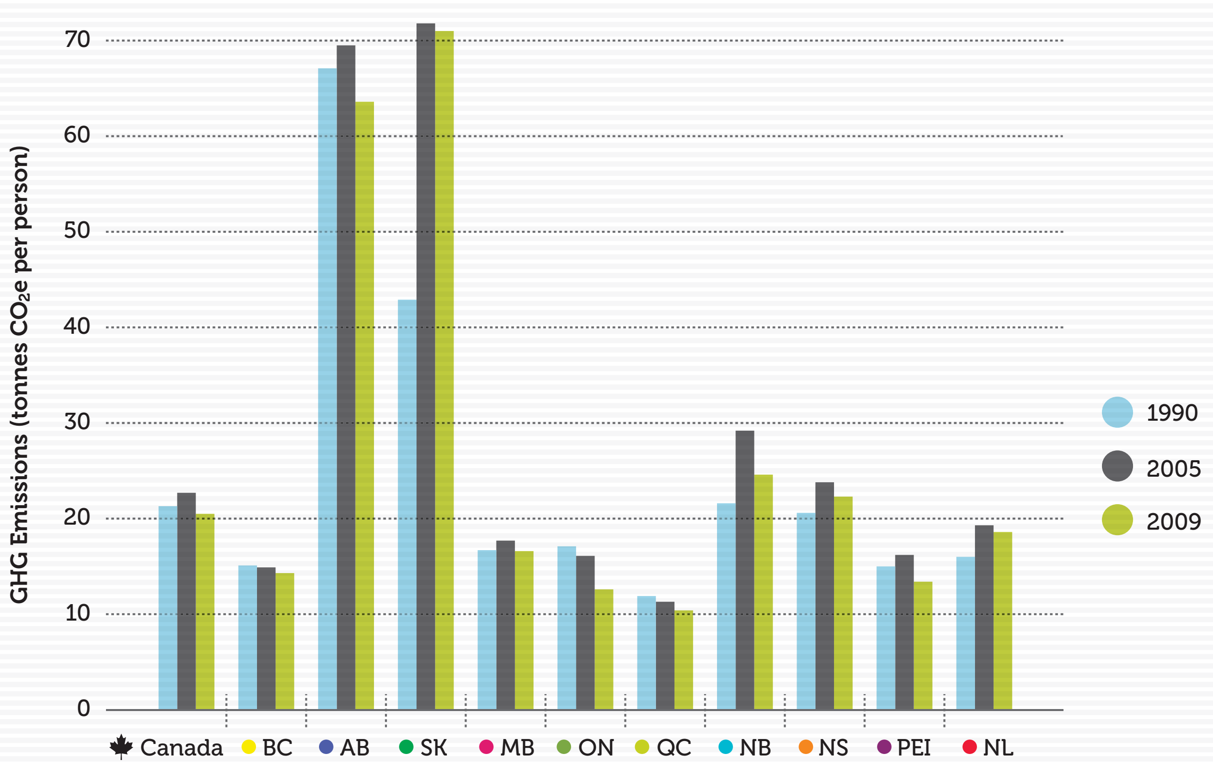


Source: Data taken from Environment Canada 2011b

On a per capita basis, there has been a slight downward trend for Canada overall since 1990, though the evolution is markedly different across provinces as shown in Figure 4.

In Chapter 4 of this report, we build from these historical trends to forecast future emissions to 2020 based on existing and proposed policies at the federal and provincial levels to assess the extent to which Canada is on track to achieve its 2020 target.

FIGURE 4: PER CAPITA EMISSIONS TRENDS (1990–2009)

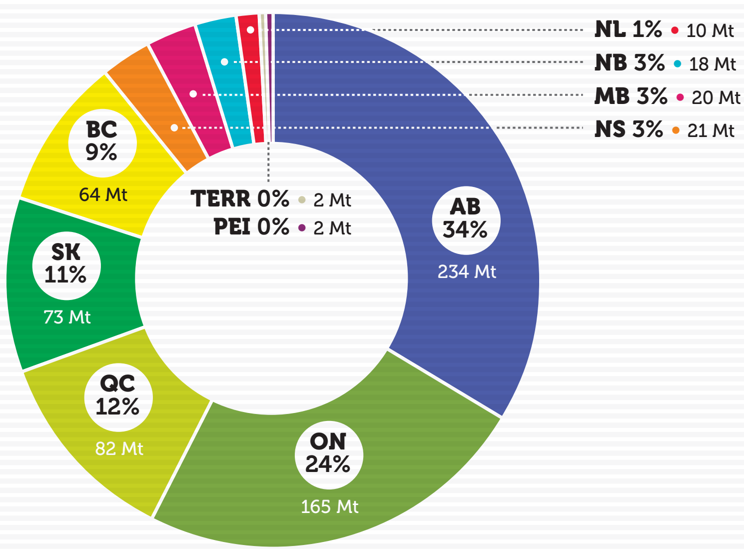


Source: Data taken from Environment Canada 2011b

2.4 EMISSIONS SOURCES BY PROVINCE/TERRITORY

Emissions vary significantly across the country, driven by diversity in population size, economic activities, and resource base among other factors. For example, regions where the economy is oriented more toward resource extraction will tend to have higher emission levels whereas more service-based economies tend to have lower emissions levels. Also, the key electricity generation sources vary across the country with provinces that rely on fossil fuels for their electricity generation having higher emissions than provinces that rely more on hydroelectricity. Figure 5 shows the provincial/territorial distribution of 2009 emissions across the country in absolute terms as well as the share this represents of total Canadian emissions.

FIGURE 5: PROVINCIAL/TERRITORIAL CONTRIBUTIONS TO CANADA'S TOTAL EMISSIONS (2009)



Source: Data taken from Environment Canada 2011b

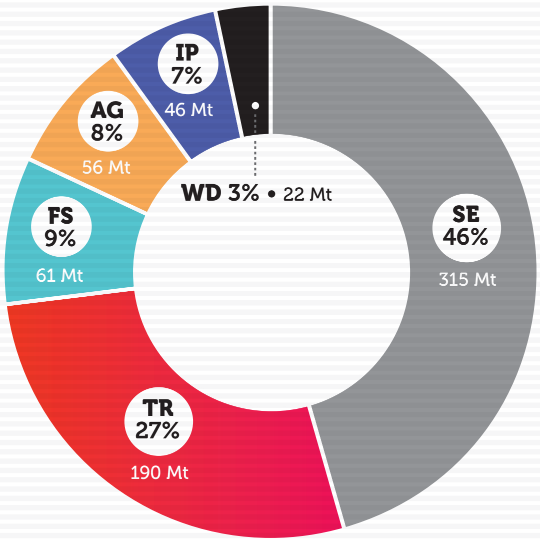
On an absolute basis, the majority of emissions (58%) originate from just two provinces — Alberta and Ontario. Alberta has the highest number of GHG emissions because it is the largest energy producer in the country. In 2009, stationary combustion energy sources represented 56% of the province's emissions. Within that, electricity and heat generation accounted for 48 Mt CO_2e, fossil fuel production and refining emitted 36 Mt CO_2e, and mining and oil and gas extraction emitted 23 Mt CO_2e.[27] Ontario is the second-highest emitter because of its population size, energy consumption, and sizeable transportation emissions. Transportation accounted for 58 Mt CO_2e, and manufacturing industries contributed 16 Mt CO_2e, followed closely by electricity and heat generation with 15 Mt CO_2e.[28]

Figure 4 shows that, in per capita terms, Saskatchewan and Alberta have the highest emissions levels. Saskatchewan's per capita emissions are high due to a small population and high stationary combustion and agriculture emissions. In Alberta, Saskatchewan, New Brunswick, and Nova Scotia, relatively high per capita emissions can be explained in part because of reliance on coal for electricity generation.

2.5 EMISSIONS SOURCES BY ACTIVITY

Under the United National Framework Convention on Climate Change, Canada's emissions are reported through activities including stationary energy, transport, fugitive sources, agriculture, industrial processes, and waste disposal. Figure 6 provides a snapshot of the composition of Canada's emissions by activity. As demonstrated, stationary energy and transportation are Canada's key sources, accounting for 73% of total emissions in 2009.

FIGURE 6: CANADA'S GHG EMISSIONS BY ACTIVITY (2009)



- **Stationary Energy (SE)**
  Emissions from fuel combustion (e.g., for energy and heat production, manufacturing, construction, etc.).
- **Transport (TR)**
  Emissions from fuel combustion related to passenger and freight transportation.
- **Fugitive Sources (FS)**
  Intentional and unintentional emissions from fossil fuel production, processing, transmission, storage and delivery.
- **Agriculture (AG)**
  Emissions from the production of crops and animals.
- **Industrial Processes (IP)**
  Emissions from processes such mineral, chemical, and metal production.
- **Waste Disposal (WD)**
  Emissions from the disposal of solid waste and handling of wastewater.

Source: Data taken from Environment Canada 2011b

Activity-based reporting is widely used, but a sector-by-sector emissions breakdown is also sometimes employed, particularly in support of sector-based GHG regulations. Text box 2 provides an explanation of the difference between these approaches.

TEXT BOX 2

MEASURING EMISSIONS SOURCES

Each year Environment Canada publishes emissions by activity in the National Inventory Report (NIR) on Greenhouse Gas Sources and Sinks in Canada to support its obligations as a signatory to the United Nations Framework Convention on Climate Change (UNFCCC). In contrast, Environment Canada's Emissions Trends Report categorizes emissions by economic sector. Our report relies primarily on activity-based data from the NIR to portray Canada's emissions story since this data was available for 2009, while sector-based data was only available for 2008. We wished to use the most recently available data in both cases. However, when referring to the federal regulations being developed under a sector-by-sector approach we present data by economic sector which is from 2008.

Since the completion of our report, the 2012 National Inventory Report has been released containing 2010 data and which for the first time now presents both activity-based economic sector-based emissions data. There is little material difference between the two sets of reports for total Canadian emissions reported from 2009 and 2010. Total emissions for Canada are virtually unchanged, rising only slightly from 2009 levels of 690 Mt CO_2e to 692 Mt CO_2e in 2010. And total emissions remain constant at 692 Mt CO_2e whether they are calculated and presented on an activity-based or an economic sector-based approach. Canada's 2020 target remains at 607 Mt CO_2e in all cases which is the focus of the NRT's modeling.

ENERGY EMISSIONS

In Canada, roughly 82% of emissions come from energy, which includes stationary combustion sources, transportation, and fugitive sources.[29] From 1990 to 2009, energy-related GHG emissions grew by 98 Mt CO_2e. This represents 87% of the total increase in GHG emissions over that period.

Stationary combustion alone represents almost half of Canada's total emissions. A breakdown of emissions from stationary combustion is provided in Table 2. Electricity and heat generation as well as fossil fuel production and refining are the largest contributors. Stationary combustion is a growing source of emissions attributable to growth in fuel consumed by mining and oil and gas extraction. Emissions from these sectors leaped from 7 Mt CO_2e in 1990 to 31 Mt CO_2e in 2009, and from 3 Mt CO_2e to 23 Mt CO_2e in Alberta alone.[30] In contrast, emissions from fuel consumed by construction, manufacturing industries, and agriculture and forestry have all decreased slightly since 1990, with a combined decrease of just over 14 Mt CO_2e.

TABLE 2: SOURCES OF EMISSIONS FROM STATIONARY ENERGY IN CANADA (1990 AND 2009)

ACTIVITY	2009 Mt CO_2e	1990 Mt CO_2e	% CHANGE (1990–2009)
Electricity and heat generation	98	92	7%
Fossil fuel production and refining	64	51	25%
Manufacturing industries	43	56	-24%
Residential	41	43	-5%
Commercial and institutional	36	26	40%
Mining and oil and gas extraction	31	7	367%
Agriculture and forestry	2	2	-13%
Construction	1	2	-42%
TOTAL	**315**	**278**	**13%**

Source: Data taken from Environment Canada 2011b

Transportation is the second largest source of emissions and grew 30% between 1990 and 2009 in part because of a shift from light-duty gasoline vehicles such as cars to trucks, minivans, and sport-utility vehicles; increased vehicle usage overall; and greater use of heavy-duty diesel vehicles. Domestic aviation and marine emissions also fall into this category but have not contributed to this rise in emissions.[31]

Fugitive sources denote the intentional and unintentional releases of GHG emissions from coal mining and oil and natural gas exploration, production, transportation, and distribution. The vast majority of emissions are from fugitive oil and natural gas, in particular GHG emissions released through the venting process. Emissions from fugitive sources increased 44% since 1990 due primarily to growth in oil and gas extraction.[32]

NON-ENERGY EMITTING ACTIVITIES

In 2009, Canada's agricultural emissions contributed 8% of the country's total GHG emissions. These emissions come primarily from the release of methane from the digestive processes of ruminants and of nitrous oxide from the soil. Agricultural emissions rose 19% since 1990 primarily because of growth in livestock populations and increased application of fertilizers.[33]

GHG emissions resulting from industrial processes include emissions from the production of industrial goods (as distinct from emissions from fuel consumed by manufacturing). Emissions from this source overall fell by 18% since 1990 because of a decline in emissions from adipic acid, aluminum, magnesium, and iron and steel production.[34]

Waste disposal produced 22 Mt CO_2e in Canada in 2009, with the vast majority of emissions resulting from methane emissions from landfill waste management sites. Emissions from waste rose 16% since 1990. This rate of growth is lower than the population growth over that period due to higher use of landfill gas capture systems across the country.[35]

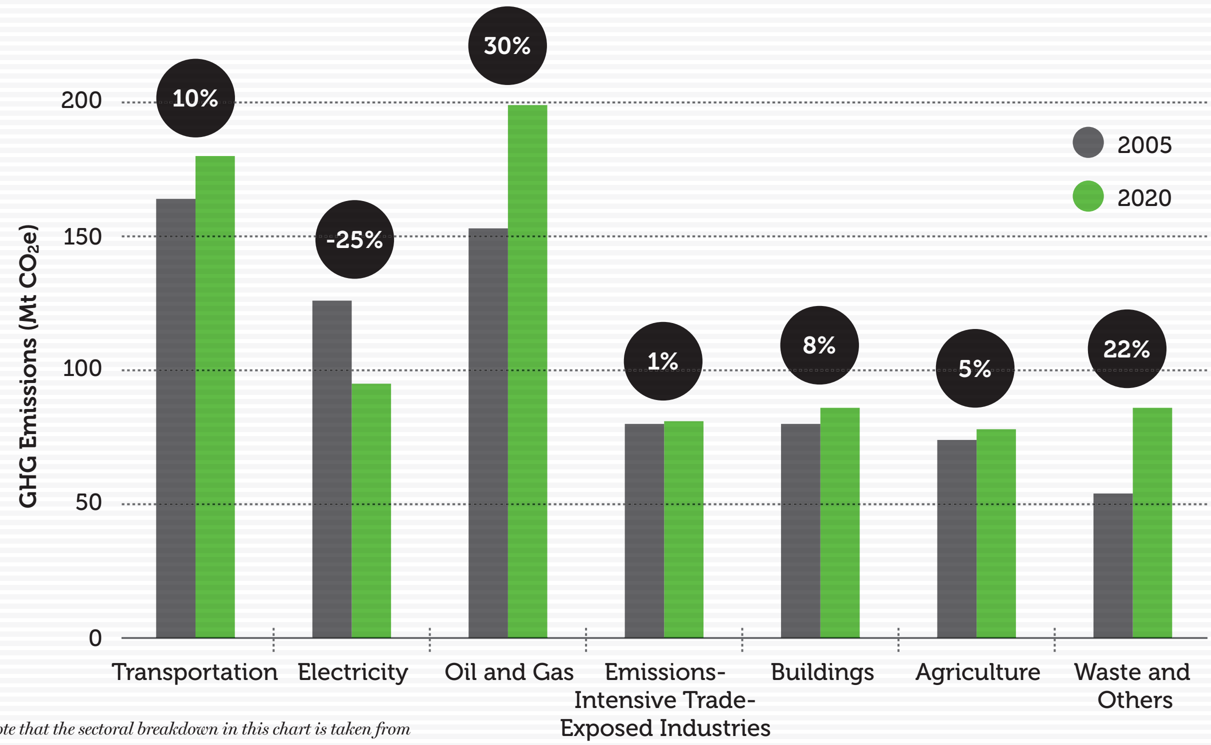
2.6 CONCLUSION

While this chapter summarized emissions policy and trends over the last two decades, Chapter 3 begins our current and forward assessment. Looking to the past, the largest sources of emissions growth are from oil and gas followed by waste and transportation.

Figure 7 shows an estimated 30% growth in the oil and gas sector from 2005 to 2020. Since it is the number-one growth sector, oil and gas emissions require priority policy considerations to address the rapid emissions increase. Looking ahead, our modelling that we set out in Chapter 4 shows the largest sources of emission growth remains from these three sectors: oil and gas, followed by transportation, and then waste.[36] Additional policies that target these sectors hold a lot of promise to stabilize emissions over time.

An iterative and collaborative approach to federal and provincial policy development offers the benefit of avoiding costly overlap and promoting co-operation toward shared objectives.

FIGURE 7: FORECASTED CHANGE IN EMISSIONS BY ECONOMIC SECTOR (2005-2020)



Note that the sectoral breakdown in this chart is taken from Environment Canada's Emissions Trends Report, not the National Inventory Report as in the rest of this chapter.

Source: Data taken from Environment Canada 2011a

At this point in time, the federal government is proceeding with a sector-by-sector regulatory approach that includes both emissions performance standards and product performance standards. There are indicators that oil and gas will be the next priority sector once the coal-fired regulations are completed. Regulation of this sector will be challenging due to its strong growth as well as the diverse nature of Canada's oil and gas industry where conventional drilling in Alberta has very different processes and GHG implications relative to offshore drilling in Newfoundland and Labrador.

At the same time, we can see that provinces are moving forward to manage emissions in their own jurisdictions by developing and implementing their own targets and measures, many of which are diverse and innovative. As Canada's emissions profile shows, the sources of emissions vary substantially across the country and are heavily concentrated in stationary energy and transportation. The challenge to the political economy of designing and implementing a national climate policy plan that is both effective and equitable is sharply represented. An iterative and collaborative approach to federal and provincial policy development offers the benefit of avoiding costly overlap and promoting co-operation toward shared objectives. However, it is not apparent. The next chapter assesses the provincial climate change plans that have been set out to date.

3.0 PROVINCIAL CLIMATE PLANS

PROVINCES ACROSS THE COUNTRY HAVE COMMITTED TO REDUCING THEIR GHG EMISSIONS AND HAVE INTRODUCED POLICIES TO MAKE PROGRESS IN THAT DIRECTION. A BROAD AND DIVERSE RANGE OF MEASURES EXISTS ACROSS PROVINCIAL CLIMATE PLANS. COMMON FEATURES OF PROVINCIAL PLANS INCLUDE PUBLIC EDUCATION CAMPAIGNS, ENERGY EFFICIENCY AND RENEWABLE ELECTRICITY PROGRAMS, AND GREENING GOVERNMENT OPERATIONS. DIVERSE MEASURES INCLUDE MARKET-BASED INSTRUMENTS SUCH AS CARBON TAXES, REGULATORY MEASURES, AND LEGISLATED RENEWABLES TARGETS. SINCE PROVINCES OWN, OPERATE, OR REGULATE POWER UTILITY SYSTEMS, THE LINK BETWEEN ENERGY AND EMISSIONS IS A CORE DRIVER OF PROVINCIAL EFFORTS TO COMBAT CLIMATE CHANGE.

This chapter begins the NRT's assessment of provincial plans and measures, identifying key elements of effective provincial plans, assessing the completeness of plans against this set of criteria and drawing out shared challenges and leading practices.

3.1 CHARACTERISTICS OF PROVINCIAL CLIMATE PLANS

In response to the Minister of Environment's request, the NRT has developed a framework to assess provincial climate plans. Consistent with earlier NRT advice (see, for example, *Achieving 2050: a Carbon Pricing Policy for Canada*[37]), this framework emphasizes the importance of establishing concrete goals and effective implementation plans alongside a strategy to assess results over time. While each province is unique and there is no common standard against which provinces articulate their climate policies, this framework can be applied across the board. Key characteristics of such a framework are explained on page 45.

Throughout the next three chapters of this report, we use this framework to assess provincial progress. The first three elements are addressed in this chapter. The last two elements warrant a more thorough analysis that builds on the qualitative analysis conducted in this chapter with quantitative analysis relating to elements 4 and 5, provided in Chapter 4 and 5 respectively. In Appendix 7.6 we provide a brief summary of each province's emissions profile, GHG reduction plan, and measures in place.

CHARACTERISTICS

CHARACTERISTIC 1 **IDENTIFICATION OF TARGETS AND TIMELINES** page 46	Provincial governments should publicly disclose targets and timelines to communicate the level of ambition of a climate plan, bring people and organizations together around a shared objective, and create accountability through a benchmark against which progress can be measured over time.
CHARACTERISTIC 2 **MEASURES THAT ADDRESS KEY EMISSION SOURCES** page 49	Plans should focus on establishing measures that confront the largest emissions sources to create the greatest environmental benefit.
CHARACTERISTIC 3 **EVALUATION MECHANISMS** page 51	Provincial governments should establish mechanisms to evaluate progress, provide transparency on results achieved, and strengthen plans over time in response to learnings.
CHARACTERISTIC 4 **ENVIRONMENTAL EFFECTIVENESS** page 81	Building on element 2, provincial plans should include sufficient measures to achieve the GHG reduction targets established.
CHARACTERISTIC 5 **COST-EFFECTIVENESS** page 96	Provincial plans should avoid delays and incent low-cost reductions to achieve the greatest environmental benefit at the lowest cost.

CHARACTERISTIC 1
IDENTIFICATION OF TARGETS AND TIMELINES

Provincial climate change plans should set out clear GHG emission targets with corresponding dates so that provinces can track their success over time. As shown in Table 3, all provinces have established GHG reduction targets and timelines but the choice of baseline year, target year, and emission-reduction goals varies between provinces.

TABLE 3: CANADA'S GHG EMISSION REDUCTIONS TARGETS*

	2020 TARGET (%)	2020 TARGET ($Mt\ CO_2e$)	2020 TARGET ($Mt\ CO_2e$)	2009 EMISSIONS ($Mt\ CO_2e$)
Canada	**17% below 2005**	**124 Mt below 2005**	**607 Mt**	**690 Mt**
BC	33% below 2007	21.5 Mt below 2007	43.7 Mt	63.8 Mt
AB**	18% above 2005	50 Mt *below BAU*	272 Mt	234.0 Mt
SK	20% below 2006	14.1 Mt below 2006	56.3 Mt	73.1 Mt
MB	Under Development (1.1 Mt or 6% below 1990 by 2012)			20.3 Mt
ON	15% below 1990	26.6 Mt below 1990	150.5 Mt	165.0 Mt
QC	20% below 1990	16.6 Mt below 1990	66.6 Mt	81.7 Mt
NB	10% below 1990	1.6 Mt below 1990	14.4 Mt	18.4 Mt
NS	10% below 1990	1.9 Mt below 1990	17.1 Mt	21.0 Mt
PEI	10% below 1990	0.2 Mt below 1990	1.8 Mt	1.9 Mt
NL	10% below 1990	0.9 Mt below 1990	8.3 Mt	9.5 Mt

* Unless otherwise noted, numbers in this column have been calculated by the NRT based on stated provincial and federal targets and data supplied in Environment Canada 2011b (see Appendix 7.6 for details).

** Alberta is the only province to state its 2020 emission reductions target in terms of megatonnes reduction from business as usual (BAU). This target comes from NRT calculations based on The Pembina Institute 2011 data which indicates that Alberta's BAU emissions in 2020 are projected to be 322 Mt.

The majority of provinces use 1990 as the baseline year against which subsequent reductions are set out, consistent with the baseline year used for the Kyoto Protocol. However, the official federal target under the Copenhagen Accord is based on a 2005 baseline. The use of differing base years makes it difficult to compare the stringency of targets across provinces. The Intergovernmental Panel on Climate Change recommends that developed countries set 2020 targets at 10–40% below 1990 levels and 2050 targets of 40–95% below 1990 levels.[38] As things stand, eight Canadian provinces are targeting reductions from 1990 levels by 2020 (anywhere between a 10% and 20% reduction) while two provinces — Alberta and Saskatchewan — have targets that would lead to an increase in emissions over 1990 levels. In the case of Alberta, its 2020 provincial target would exceed the province's 2005 emissions.[39]

If the provinces are unable to meet their respective 2020 targets, should federal policies ensure that Canada as a whole still reaches the target of 607 Mt CO_2e?

Summing up the targets set out by the provinces in Table 3, they yield a total Canada-wide emission level of 648 Mt CO_2e in 2020.[c] This sits 41 Mt CO_2e above the federal government's 2020 GHG emissions target of 607 Mt CO_2e. Assuming these targets are met, a key question is whether federal, provincial, or other actions will drive these remaining 41 Mt CO_2e of reductions. A further question remains: If the provinces are unable to meet their respective 2020 targets, should federal policies ensure that Canada as a whole still reaches the target of 607 Mt CO_2e?

Most provinces have stated additional interim targets to help reach their 2020 targets. Setting an interim target allows provinces to monitor their progress to their 2020 target not only to determine how effective measures have been with time, but also to guide the province in determining if other measures need to be implemented so 2020 targets can be achieved.

c This number comes from the 2020 emissions targets for each province calculated in Table 3. Manitoba's 2020 target is assumed to be 15% below 2005 (17.9 Mt CO_2e) from NRT calculations based on Environment Canada 2011a.

PROVINCES WITH INTERIM TARGETS	
British Columbia	6% below 2007 levels by 2012; 18% below 2007 levels by 2016
Alberta	20 Mt CO_2e below BAU by 2010
Manitoba	6% below 1990 levels by 2012
Ontario	6% below 1990 levels by 2014
Québec	6% below 1990 levels by 2012
New Brunswick	reduce to 1990 levels by 2010; 5.5 Mt below 2007 levels by 2012
Nova Scotia	2.5 Mt CO_2e below 2009 levels by 2015
Newfoundland and Labrador	reduce to 1990 levels by 2010

Several provinces have also indicated a 2050 emission reductions target. Setting future targets reminds provinces that achieving GHG emission reductions is a process that requires long-term commitments.

PROVINCES WITH 2050 TARGETS	
British Columbia	80% below 2007 levels
Alberta	200 Mt CO_2e below BAU
Ontario	80% below 1990 levels
Nova Scotia	up to 80% below current levels
Newfoundland and Labrador	75–85% below 2001 levels

In addition to setting overall targets and timelines, individual measures committed to in climate plans should also have specified targets and timelines so that their own contribution to the overall plan is known and success can be evaluated over time.[40] Over half of the provinces do set out targets and timelines for specific measures within their plans. A summary of each province's approach is provided in Table 5.

CHARACTERISTIC 2
MEASURES THAT ADDRESS KEY EMISSION SOURCES

To effectively reduce emissions, provinces need to identify and quantify their major sources of emissions and then set out measures to reduce emissions from these sources. Current climate plans generally set out measures that largely align with the major sources of emissions that are identified and ranked according to contribution to overall provincial emissions in Table 4.

TABLE 4: EMISSIONS BY ACTIVITY BY PROVINCE (2009 Mt CO_2e) AND RANKED BY SIZE OF CONTRIBUTION TO OVERALL PROVINCIAL EMISSIONS

		BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL
Stationary Energy	Mt CO_2e	23.5	132.0	29.3	4.4	69.7	23.4	12.2	14.5	0.6	4.4
	Ranking	2	1	1	3	1	2	1	1	2	1
Transport	Mt CO_2e	24.6	35.2	14.2	7.0	58.2	35.6	4.6	5.2	0.8	3.6
	Ranking	1	3	3	1	2	1	2	2	1	2
Fugitive Sources	Mt CO_2e	6.0	35.7	15.2	0.6	1.6	0.7	0.2	0.1	-	0.6
	Ranking	3	2	2	6	6	6	6	6	-	3
Agriculture	Mt CO_2e	2.1	17.0	12.0	6.7	10.0	7.3	0.4	0.4	0.4	0.1
	Ranking	6	4	4	2	4	4	4	3	3	6
Industrial Processes	Mt CO_2e	3.7	12.0	1.6	0.7	18.2	9.1	0.4	0.3	0.0	0.2
	Ranking	5	5	5	5	3	3	4	5	5	5
Waste Disposal	Mt CO_2e	3.9	1.7	0.7	0.9	7.3	5.5	0.5	0.4	0.1	0.6
	Ranking	4	6	6	4	5	5	3	3	4	3

Source: Data taken from Environment Canada 2011b

There is also evidence of many provinces conducting forecasting and emissions trends analyses to inform the development of suitable measures. In addition, integration of measures across departments appears to be more and more the norm linking environmental and economic mandates.

The effectiveness of measures is heavily influenced by the choice of mandatory versus voluntary approaches. Generally speaking, mandatory measures provide more certainty that a given amount of emission reductions will be achieved because of the regulatory burden imposed. This *quantity certainty* exists in a cap-and-trade system where the emissions limit is established but the price of compliance is unknown. In contrast, a mandatory carbon tax provides *price certainty* but the level of emission reductions that will occur is uncertain. The forthcoming federal coal-fired power regulations and Québec's cap-and-trade system are examples of mandatory measures that will provide a more predictable amount of GHG reductions. Conversely, voluntary measures can raise awareness of energy conservation by consumers, but are not as effective as carbon pricing or regulations at changing behaviour or drawing investment that leads to reduced emissions.

With energy-related emissions (stationary energy, transportation and fugitive emissions) contributing 82% of Canada's total emissions in 2009, any provincial strategy must confront energy issues. As noted earlier, stationary energy and transportation are key emission sources across all provinces. A common measure to address stationary energy emissions has been investing in non-emitting electricity generation, which can yield large GHG reductions and offer co-benefits for local air quality and ecosystem health. Several provinces have pursued new electricity generation strategies that will make major progress in support of GHG reduction goals. Examples include Ontario's coal phase-out, Nova Scotia's renewable portfolio standard, Point Lepreau nuclear refurbishment in New Brunswick, and Newfoundland and Labrador's Lower Churchill hydroelectricity project. Large-scale hydro plants are already a main renewable energy strategy for British Columbia, Manitoba, and Québec.

Energy efficiency programs are also widely used to drive GHG reductions, improve air quality, and moderate the demand for new electricity generation capacity in response to economic and demographic growth. In addition, three provinces representing 75% of Canada's total population — Québec, Ontario, and British Columbia — continue to indicate their formal intention to introduce a cap-and-trade system that will affect energy emissions, although progress remains slow. Québec has moved the furthest along by adopting the Western Climate Initiative (WCI) regulation for establishing the system. British Columbia and Québec are also using forms of carbon taxes to lower energy emissions.

Many provinces are pursuing efforts to drive down transportation emissions through vehicle emissions standards, investment in public transportation, investments in research and development, and public awareness campaigns to reduce transportation emissions. However, addressing emissions from this source has proved challenging, as we see later in this chapter.

CHARACTERISTIC 3
EVALUATION MECHANISMS

Strong evaluation plans monitor and assess performance over time and incorporate adaptive management strategies to improve policies and practices.41 In addition, they include public reporting provisions so citizens and stakeholders can be made aware of progress. Many provinces are committing to providing interim reports prior to 2020 as a way of evaluating the effectiveness of individual measures, publicly indicating progress to date, and detailing areas that require more efforts so that the target can be reached. Nevertheless, these are not yet as comprehensive overall as they should be to independently evaluate progress and effectiveness.

Table 5 lays out three components that support measuring and evaluating climate change plans. Public reporting on progress toward meeting climate change objectives provides transparency and accountability. As a best practice, a third-party audit or assessment is ideal. This could be conducted by the province's Auditor General or another independent body, for example the Environmental Commissioner in Ontario and the Sustainable Development Commissioner in Québec.

Across the country, many climate change plans do include provisions for public reporting on progress and for periodic evaluation. Some provinces have already conducted evaluations and made program adjustments in response, with several going as far as publishing revised climate change plans. Independent assessments have taken place in three provinces already.

TABLE 5: ASSESSMENT OF PROVINCIAL CLIMATE CHANGE PLANS

	BC	AB	SK*	MB**	ON	QC**	NB**	NS	PEI	NL
CHARACTERISTIC 1 / TARGETS AND TIMELINES										
Targets with corresponding timelines are established	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Emission-reduction targets have been legislated	✓	-	-	✓	-	-	-	✓	-	-
Measures within the plan are assigned targets with corresponding timelines	✓	✓	-	✓	✓	✓	✓	✓	✓	✓
CHARACTERISTIC 2 / MEASURES TO ADDRESS KEY EMISSIONS SOURCES* **										
Key emissions sources are identified	✓	-	✓	✓	✓	✓	✓	✓	-	✓
Measures are set out to reduce emissions from key sources	✓	-	-	✓	✓	✓	✓	✓	✓	✓
Measures have been informed by emissions trends and forecasting	✓	✓	✓	-	✓	✓	✓	-	-	✓
There is coordination between the provincial environment department and departments responsible for effected sectors	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CHARACTERISTIC 3 / MEASUREMENT AND EVALUATION										
Provisions are set out for regular public reporting on progress	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Evaluation has occurred and new measures have been developed in response	-	-	UD	UD	-	UD	UD	-	-	§§
There has been an independent audit, assessment, or evaluation	-	✓	UD	✓	✓	-	-	••	-	§§

* Saskatchewan has not published an up-to-date climate change plan. To populate this table we relied on the province's earlier climate plan and more recent information provided by the province.

•• Nova Scotia's Minister's Round Table on Environment and Sustainable Prosperity will perform a public evaluation of the target every 5 years.

** The province is currently developing a new climate change plan. This table was populated using earlier climate change plans and more recent publicly available information (see Appendix 7.6 for references).

§§ The climate change plan is too recent to have been evaluated.

*** Key sources are generally defined here as the top three categories of emissions. However, where the third emissions source represents less than 10% of provincial emissions, we only considered the top two sources.

UD Under Development

3.2 SOME KEY CHALLENGES

TRANSPORTATION ISSUES

Transportation is the second-highest emissions source across the country with road transportation as the leading contributor.[42] Addressing emission reductions in this sector is particularly challenging given where and how Canadians live; quality of life and convenience when it comes to vehicle use; urban design; and the cost, choice, and availability of road transport options. In addition, investments in the transportation fleet are long-lived. Even when new technology becomes available, it takes time for that technology to make its way into the majority of the vehicle fleet. Federal vehicle performance standards and fuel regulation standards will contribute to emission reductions over time from transportation;[43] many provinces indicated to the NRT the need for continued federal focus in this area. At the same time, provinces will likely need to continue to invest in public transit and infrastructure, with and without federal support.

INTEGRATING ENVIRONMENTAL MANAGEMENT WITH ECONOMIC DEVELOPMENT

All provinces face competing pressures to invest in economic growth while seeking to reduce GHG emissions from that growth. Reconciling GHG emission reductions and economic growth is a particular challenge in provinces like Saskatchewan and Alberta where activities comprising emissions-intensive natural resource extraction contribute significantly to both the provincial and national economies. Both provinces have coupled economic growth with GHG mitigation in their regulations on large final emitters.[44] Policies in these provinces base requirements on emissions intensity, allowing for contributions to a technology fund as a compliance option to incent R&D for low-emitting technologies. Strong domestic and international demand for Canadian natural resource commodities, particularly oil and gas, will keep upward pressure on provincial and, by extension, national climate emissions goals. We further explore the economic efficiency of provincial plans in Chapter 5.

JURISDICTIONAL OVERLAP[d]

Jurisdictional overlap can have the drawbacks of leading to conflict, buck-passing, inefficient duplication of efforts, reduced democratic accountability, and the establishment of national standards that reflect the lowest common denominator. The potential advantages of this overlap are less commonly recognized but they include supporting provincial innovation and diffusion of novel policies, supporting oversight between orders of government, and tailoring of roles to each government's strengths. Federalism has been a particular challenge in Canada when it comes to developing and sustaining climate plans, relative to others like the European Union and Australia. Canada's difficulties are due to limited public support for deep action, the potential for

d Based on Harrison 2012, available upon request.

significant regional disparities in abatement costs, and a strong norm of federal-provincial consensus in intergovernmental relations. Going forward, policy makers should keep in mind that intergovernmental consensus is not the objective in itself; indeed consensus may mask or even contribute to lack of progress as individual jurisdictions act on their own. Furthermore, compatibility of federal and provincial climate change objectives can be more important than a shared plan on meeting those objectives. But the variation in provincial greenhouse gas intensities and emissions trends, and corresponding economic stakes, present tremendous challenges.

POLICY OVERLAP[e]

In a federation with fragmented climate policy plans, overlap between provincial and federal policies can be problematic depending on the policy instruments involved. We assessed the implications of overlap assuming that the federal government maintains its focus on emissions performance standards (e.g., coal-fired electricity generation regulations) and product performance standards (e.g., renewable fuels content) and that provinces move forward with a variety of price, quantity and regulatory measures. We found that in many instances overlap does not present policy problems, but there are cases where unintended consequences can arise such as redistributing emission-reduction requirements without creating overall environmental benefits, and increasing the overall cost of achieving a level of emission reductions. To avoid this problem, provinces should be cognizant of these risks in designing future policies and the federal government should consider regulatory approaches that do not penalize those provinces wanting to make similar or extra efforts. Equivalency agreements or negotiated regional and pan-Canadian approaches are tools to avoid problematic overlap. Appendix 7.5 provides additional details on our assessment.

INTER-JURISDICTIONAL COORDINATION

In Canada, while two bodies currently exist that could bring together governments to consider climate policy as it relates to achieving Canada's 2020 target, these mechanisms have not met to tackle such policy coordination head on.

First, the Council of the Federation comprises the premiers of Canada's provinces and territories. This institution promotes interprovincial-territorial co-operation while fostering meaningful relations between governments in recognition of their diversities. The Council has worked on climate change initiatives since 2007, including those focused on climate change adaptation and energy efficiency.[45]

e Based on Wigle and Rivers 2012, available upon request.

Second, the Canadian Council of Ministers of the Environment (CCME) is made up of provincial, territorial, and federal environment ministers. It seeks to achieve positive results on national environmental issues in a collaborative manner. The CCME's past work on climate change includes a 2003 report on climate change trends in Canada and a 2011 report on the use of water monitoring networks for climate change adaptation.[46]

THE ROLE OF MUNICIPALITIES[47]

In addition to the policies being pursued at the provincial level, many municipalities are also engaging in emission-reduction activities. Canadian municipalities are engaging in mitigation measures through the Partners for Climate Protection (PCP) network coordinated by the Federation of Canadian Municipalities (FCM) and Local Governments for Sustainability (ICLEI). PCP includes 221 Canadian member municipalities. Since 2008, PCP has developed the *National PCP Measures Database* to track projects, and it currently contains more than 700 projects that represent over $(2012)1 billion in investments leading to GHG reductions in excess of 1.7 Mt CO_2e. Emission-reduction measures span large and small communities, residential and corporate sources, energy efficiency, waste diversion, fleet improvements, and renewable energy activities among others. To date, district energy systems and landfill gas capture and recovery systems have produced some of the largest sources of reductions. Many provinces have identified the need to work with municipalities in their climate plans, but municipal actions are not typically accounted for separately in provincial reporting of emission reductions. Rather, they are reported as a reduction in the context of a sector, such as landfills and waste or from public transit.

LOOKING FORWARD

Provincial governments continue to explore new GHG reduction measures as the economy changes, technologies advance, and gaps between GHG reduction targets and current emission trajectories emerge. Newfoundland and Labrador has indicated that it may introduce regulations to limit emissions from industrial sources.[48] Ontario, Manitoba, and British Columbia may follow Québec and introduce emissions trading as members of the Western Climate Initiative (see Text box 3).

TEXT BOX 3

WESTERN CLIMATE INITIATIVE

The Western Climate Initiative (WCI) was initially introduced in 2007 as an agreement between five U.S. state governors to work together to establish GHG reduction targets, measure emissions, and develop market-based schemes to achieve reduction targets that allowed for inter-regional trading of permits. The design of the program proposed by WCI is a cap on all major emissions sources, a consistent reporting methodology for regulatees, and support for compliance flexibility through a cap-and-trade system that allows for banking credits over time and for offsets.

The WCI points to several benefits to the proposed regional system including greater economic efficiency through compliance flexibility, reduced risk of "leakage" of emissions to areas that are not covered by a GHG reduction target, economies of scale in administrative and technical oversight, and enhanced capacity to support future national-level systems.

Membership has declined from a high of 11 members to five current members: California, British Columbia, Manitoba, Ontario and Québec. Québec has clarified plans to proceed to implementation in 2013 by formally adopting a WCI regulation putting this into effect, using 2012 as the transition year. The other three Canadian provinces are at varying degrees of readiness to proceed with the system, but their plans are unknown and timing is uncertain.

Members of WCI are collaborating with other states and provinces across North America through *North America 2050: A Partnership for Progress*. This partnership provides a forum for states and provinces to share information, coordinate efforts, advocate, and reduce GHG emissions.

Source: Western Climate Initiative 2008, 2012a, 2012b; North America 2050 ND; Finances Québec 2012

As provinces move forward in implementing their plans, they have the opportunity to learn from the experiences of others and borrow existing policy measures and tailor them to their own circumstances. In one example of this, Saskatchewan is currently developing a regulatory regime for industrial emitters that shares many common elements with Alberta's *Specified Gas Emitters Regulation*.[49]

3.3 LEADING PRACTICES

GHG reduction policies across the country are diverse and many of them are also highly innovative. This section describes examples of leading provincial practices. Other jurisdictions may look to include such actions in their own suite of measures to enhance climate policies in the future.

A CARBON-NEUTRAL GOVERNMENT IN BRITISH COLUMBIA[50]

A key component of British Columbia's 2007 *Greenhouse Gas Reduction Targets Act* was a commitment to achieve a carbon-neutral public sector by 2010. The province relies on an approach of measuring, reducing, offsetting, and finally reporting emissions from public sector sources. In the buildup to 2010 almost $75 million was spent to conserve energy in public buildings. To supplement internal reductions, the government also purchased 0.7 Mt CO_2e of offsets from the Pacific Carbon Trust — a provincial crown corporation that reviews and approves offset projects. To date, offsets have been generated through forest-based carbon sequestration, energy efficiency, and fuel switching across the province.

FUNDING TECHNOLOGY DEVELOPMENT IN ALBERTA[51]

Alberta's emissions-intensity-based regulatory system allows regulated entities to achieve compliance through several mechanisms including contributing to a technology fund at a rate of $15/tonne CO_2e. This fund — the Climate Change Emissions Management Fund — is administered by an arms-length not-for-profit corporation. The corporation's mandate is to use Fund revenues to support GHG reduction activities and climate change adaptation within the province. Funding is distributed using a portfolio approach focused primarily on green energy production, energy efficiency, and carbon capture and storage (CCS). As of September 2011, the fund had collected $257 million, with 27 projects representing $126 million in investment expected to produce annual GHG emission reductions (by their reckoning) of 2.3 Mt CO_2e, or 23 Mt CO_2e over 10 years.[52]

CARBON CAPTURE AND STORAGE IN SASKATCHEWAN[53]

In 2011 the Government of Saskatchewan announced the approval of the construction of the Boundary Dam Integrated Carbon Capture and Storage Demonstration Project, a $1.24 billion project aimed at capturing emissions from coal-fired electricity generation and using the CO2 in enhanced oil recovery. Construction is now underway and once operational in 2014, the project is expected to reduce GHG emissions by 1 Mt CO_2e per year. SaskPower, the provincial utility implementing this project, identified project goals including demonstrating an economic and technically feasible method by which to make coal-fired generation sustainable and influencing future industry-wide regulations and policies governing this emerging technology. Partners on the project include the provincial government, several private firms, and the Government of Canada, which has contributed $240 million toward the project.

EXPORTING CLEAN ELECTRICITY IN MANITOBA[54]

Hydro power is the main source of electricity in Manitoba and on an annual basis, Manitoba is a net power exporter. In 2010, non-emitting power exports reduced emissions outside the province by almost 7.2 Mt CO_2e — the equivalent of about one-third of Manitoba's expected 2010 emissions. Electricity is mainly transmitted via the north-south electricity grid from Manitoba to the United States.[55] As Manitoba Hydro continues to make investments in hydro capacity and wind power, the province should be in a position to continue contributing to emission reductions outside the province.

INCENTING SMALL-SCALE RENEWABLE ELECTRICITY PRODUCTION IN ONTARIO[56]

The Government of Ontario has developed a feed-in tariff (FIT) program to boost renewable energy use across the province. The Ontario Power Authority administers this program by entering into long-term purchasing agreements with renewable electricity producers working with bioenergy, solar photovoltaic, water, and wind. The program is designed to bring new electricity sources online in support of the coal-fired electricity phase-out, and support economic activity, new renewable electricity technologies, and growing employment in the industry. It is estimated that the FIT program will offset 8.4 Mt CO_2e that would otherwise be produced by natural gas facilities.[57]

ESTABLISHING AN EMISSIONS MARKET IN QUÉBEC[58]

In 2009, Québec tabled *Bill 42: An Act to amend the Environment Quality Act and other legislative provisions in relation to climate change* to allow it to establish a cap-and-trade system as part of its participation in the WCI. The province has since adopted a regulation in preparation for launching its provincial cap-and-trade system in 2013, following a year of transition. A second regulation will be required to link trading systems between jurisdictions. Participation will be voluntary in the first year, giving companies an opportunity to learn the system. As of 2013 roughly 75 operators — primarily from the industrial and electricity sectors — will be covered under the system and then in 2015 coverage will be expanded to fuel distributors and importers. The threshold that triggers participation is emissions of at least 25 kt CO_2e. Compliance permits will be distributed via free allocation, and/or auctioning and revenues from the scheme will be used to fund Québec's climate change plan for the period 2013–2020.

MAKING THE ENERGY-ENVIRONMENT CONNECTION IN NEW BRUNSWICK[59]

New Brunswick's 2011 *Energy Blueprint* identifies environmental responsibility as one of the province's key energy objectives. It recognizes that energy use is the source of 92% of GHG emissions and that the energy-intensive and export-oriented nature of its industries could be a liability if the environmental impact of energy is not lessened. The *Blueprint* identifies 20 government actions directed toward enhancing the energy sector including 13 actions that further the environmental responsibility objective. These actions include developing the province's 2012–2020 Climate Change Action Plan through cross-departmental participation, pursing regional electricity partnerships, and increasing the Renewable Portfolio Standard.

LEGISLATING A GREATER ROLE FOR RENEWABLE POWER IN NOVA SCOTIA[60]

The Government of Nova Scotia introduced a renewable energy plan for Nova Scotia in 2010, committing to source 25% of electricity from renewables by 2015 and setting a goal of 40% renewables by 2020. The 2015 target was put into law through the *Renewable Electricity Regulations* under the *Electricity Act*. When the targets were introduced in 2010, Nova Scotia sourced roughly 90% of the province's electricity from fossil fuels-based, principally coal. Recognizing that achieving the renewables targets will become increasingly difficult if energy demand rises, complementary energy efficiency measures are also planned.

BUILDING WIND ENERGY CAPACITY IN PRINCE EDWARD ISLAND[61]

Prince Edward Island has been committed to enhancing wind power capacity within the province since the development of the first utility-grade wind farm in 2001. In 2008, the Government of Prince Edward Island announced plans to generate an additional 500 megawatts of wind power by 2013. The province also supports wind energy R&D through collaboration with the Wind Energy Institute of Canada.

EXPANDING HYDROELECTRIC PRODUCTION IN NEWFOUNDLAND AND LABRADOR[62]

In 2010 the government of Newfoundland and Labrador announced plans to develop new large-scale hydroelectric generation on Labrador's Lower Churchill River. This project will commence with hydroelectric development at Muskrat Falls, and additional capacity is expected to be built at Gull Island further in the future. With this agreement, new transmission lines will allow for electricity to travel from Labrador to Newfoundland and from Newfoundland to Nova Scotia and create further potential for regional electricity exports. Once Muskrat Falls is operational, it is estimated that 98% of the province's energy supply will be non-emitting and that Newfoundland and Labrador's emissions will fall by 1.2 Mt CO_2e in 2020 (or 13% of the province's 2009 total emissions) as a result.

3.4
CLIMATE CHANGE PLANS IN THE TERRITORIES

Canada's three territories — Yukon, the Northwest Territories, and Nunavut — contributed 1.9 Mt CO_2e to Canada's total GHG emissions in 2009. The main emissions source in the territories is transportation (1.1 Mt CO_2e in 2009) with the largest sub-set of transportation emissions stemming from off-road diesel vehicles.[63] Transportation plays an integral role in socio-economic well-being in the territories. Even in Yukon where almost all communities are connected by roads, a large number of people still use off-road transportation to commute, receive provisions, and access health services.[64] Fuel content requirements may be considered to reduce emissions, but Arctic conditions need to be accounted for.[65]

Many isolated communities in the territories rely on diesel generators for electricity. Overall, hydro is the largest source of electricity generation for the North, but its distribution is very limited. Nunavut relies completely on diesel for electricity generation. Because of the heavy reliance on diesel, the desire to improve efficiency of diesel generators has increased in the territories, and is generally seen as a "reliable and least-cost, near-term solution."[66]

Yukon and the Northwest Territories have limited the application of GHG emission reductions targets to government operations.[67] Yukon seeks to cap GHG emissions from government operations in 2010, to achieve emission reductions of 20% below 2010 levels by 2015, and to be carbon neutral by 2020. The Northwest Territories has established a target to stabilize emissions from government operations at 2005 levels by 2015, to limit emissions increases to 66% above 2005 levels by 2020, and to return emissions to 2005 levels by 2030. Nunavut has no established target, but has committed to controlling and reducing GHG emissions between 2003 and 2013.

Each territory faces challenges on the horizon. Since 2009 there has been an increase in mining operations in Yukon with two new mines planned for the near future. The hydroelectricity grid has been maxed out in Yukon, and with additional mining activities, it will require more electricity. Rapid growth in the mining and natural gas sectors in the Northwest Territories could result in emissions increasing three-fold during the next two decades, with emissions from fossil fuels projected to reach 5,000 Kt by 2030.[68] Nunavut is focusing most of its efforts on adaptation, but mining growth in that territory may also create new pressures.

3.5
CONCLUSION

This chapter shows how without an agreed national policy approach, provincial climate policies in Canada have all developed individually. Nevertheless, even if divergent, these climate plans can still prove effective if they have the necessary common elements of targets and timelines, measures to drive emission reductions, and provisions to report and evaluate progress over time. The provinces have many crosscutting issues to consider when creating climate policies. These include ensuring that targets and timelines are ambitious yet realistic, balancing economic growth with emission reductions, and ultimately, determining how to tackle key emissions sources effectively to meet targets. Intergovernmental collaboration and regional efforts can prove instrumental in policy development. We have seen examples of this in Atlantic Canada and Québec as part of the Regional Greenhouse Gas Initiative (RGGI) with the New England states as well as the WCI. All provinces and territories should consider the effective and innovative reduction efforts of their counterparts when evaluating the effectiveness of their own measures and developing future policy choices.

As the levels of ambition in GHG reduction targets and the policy approaches to achieve them vary across provinces, so too will the environmental outcomes. The next chapter further investigates the GHG reductions expected from these plans.

4.0 TARGET 2020

IS CANADA ON TRACK TO MEET ITS 2020 GHG TARGETS WITH FEDERAL, PROVINCIAL, AND TERRITORIAL POLICIES THAT HAVE BEEN IMPLEMENTED AND PROPOSED TO DATE? IF NOT, HOW MUCH PROGRESS HAS THE COUNTRY MADE? WHICH SECTORS ARE RESPONSIBLE FOR DRIVING EMISSION REDUCTIONS? AND HOW MUCH ADDITIONAL EFFORT IS REQUIRED? THE NRT USED AN ECONOMIC MODELLING TOOL TO ANSWER THESE QUESTIONS. OUR ANALYSIS ASSESSES LIKELY CONTRIBUTIONS OF EXISTING AND PROPOSED FEDERAL, PROVINCIAL, AND TERRITORIAL CLIMATE CHANGE POLICES TOWARD ACHIEVING CANADA'S 2020 EMISSION-REDUCTION TARGETS.

This chapter provides an overview of our modelling approach and results. We begin by outlining the model itself and scenarios used to estimate emission reductions to 2020 from climate policies. Next, we present national forecast results and assess these likely reductions in the context of the federal 2020 target. We then provide a regional assessment, exploring the provincial distribution of forecasted emission reductions and progress toward each province's own targets as a continuation of our assessment of provincial plans from Chapter 3. Finally, we describe emission reductions from existing and proposed policies in terms of sector-level impacts. To offer a deeper picture of Canadian climate policy we also forecast emission reductions to 2030 and consider how far along Canada is to meeting another 2020 target it set for itself: non-emitting energy generation.

4.1 ANALYTICAL APPROACH

The NRT used the CIMS model to forecast the impacts of GHG mitigation policies to 2020. This section provides an overview of the modelling methodology and approach.[f]

STRENGTHS OF THE CIMS MODEL

CIMS is an economic modelling tool that simulates the evolution of the Canadian economy under a variety of energy and environmental policy regimes.

The model is based on detailed representation of technologies that use and produce energy. To generate a forecast, it simulates firm and household choices as these technological stocks are replaced over time. The model also includes equilibrium feedbacks, such that supply and demand for energy-intensive goods and services adjust in response to policy. Based on this representation of Canada's energy economy, CIMS can project the effects of government policies and programs on the energy-economy system, estimating how subsidies, regulations, and market-based policies influence technological development, firm and household decision making, demand for energy products, and resulting GHG emissions.

The model covers about 98% of Canadian GHG emissions apart from deforestation and land-use changes. It explicitly represents residential, commercial, personal, and freight transportation; industry; energy supply; agriculture; and waste sectors of the economy, with additional resolution for various sub-sectors. The model is disaggregated by province, although the Atlantic Provinces are grouped together. For this report, the NRT conducted supplementary

f The quantitative results in this report are drawn from the consulting analysis prepared for the NRT by Navius Research Inc. This report is available upon request (Navius Research Inc. 2012).

analysis to separate Atlantic forecasts by province based on supporting data from Environment Canada and assumptions about the electricity sectors in each province.[g] Emissions from the territories were not disaggregated explicitly in the modelling analysis because they are very small overall but are included in the national-level results. The regional and sector-level resolution allows for modelling a range of provincial/territorial as well as federal policies that apply either to specific sectors or to the economy as a whole.

Further, because the model is fully integrated, it also represents the interactions and overlaps between these different policies. Representing these interactions ensures that the model does not double-count emission reductions from different policies.

CIMS is a well-established modelling tool. It has been used by various provincial/territorial governments in Canada including British Columbia, Alberta, Saskatchewan, Ontario, the Northwest Territories, and Newfoundland and Labrador. It has also been used in a range of national-level analyses through organizations including Natural Resources Canada, the International Institute for Sustainable Development, and the NRT. As a result of these analyses, the model has continued to be improved through time. CIMS' track record for policy analysis in Canada establishes the model as a credible tool for analysis.

Finally, for the analysis in this report, the NRT applied CIMS using a transparent, credible modelling process. The baseline for the CIMS forecast was Environment Canada's assumptions for growth in each sector. Energy prices were drawn from the National Energy Board's 2011 *Energy Futures* report.[69] We presented the analysis to Environment Canada officials and also engaged with provincial and territorial government representatives on the modelling results at the NRT's Canadian Climate Policies Dialogue. Model results were also peer reviewed. The NRT adjusted and improved the forecasts throughout the modelling process in response to feedback.

LIMITATIONS OF ECONOMIC MODELLING

All model forecasts are inherently uncertain and should not be considered precise predictors of the future. The Canadian energy-economy system is complex, as are the effects of policy on this system. To simulate this system, the analysis depends on assumptions about technological and economic development, energy prices, and firm and consumer behaviour. The model uses credible sources to guide these inputs, but no amount of research allows perfect foresight into the future of the economy.

Yet uncertainty in the forecasts does not preclude the usefulness of models. Forecasts can provide a directional indication of the likely impacts of policy and can be very useful in comparing relative impacts of different policy tools. The goal of economic

g See Navius Research Inc. 2012 for more details.

modelling is not to produce a forecast for its own sake, but to draw insight and learning from forecasts and scenarios. This is the approach the NRT takes in this analysis. Overall, the NRT therefore remains confident in the modelling results presented here. The directional impacts of the modelling analysis in chapters 4-5 provide useful and important policy insight. To ensure the analysis is as useful as possible, we are transparent about the assumptions and limitations of the analysis. Appendix 7.2 provides additional detail on the CIMS model and the methodologies applied in this report.

DEFINING SCENARIOS

The scenarios modelled define the sets of federal, provincial, and territorial policies we explored within the modelling analysis. We assessed the likely impacts of three different sets of policies:

1. **Existing provincial and territorial policies** are measures to reduce GHG emissions that provincial or territorial governments implemented after 2005.
2. **Existing federal policies** are measures to reduce GHG emissions that the federal government implemented after 2005.
3. **Proposed federal, provincial, and territorial policies** are measures to reduce GHG emissions that have been proposed by any level of government for implementation by 2020 but have not yet been implemented. We included policies for which enough detail has been made public or available to us so that reasonable modelling assumptions could be made as to the nature of the measures.

We estimate the expected incremental emission reductions from each of these sets of policies to 2020 by layering the policies in sequential scenarios. The difference in forecasted GHGs between scenarios with and without a set of policies illustrates the incremental impact of that set of policies. To do this, we started with a *No Policy* case that assumes no new government measures had been implemented after 2005. This gives us a clear baseline upon which to measure the effectiveness to date and likely success of all federal and provincial/territorial policies implemented and proposed.

We then added to this scenario the *Existing Provincial and Territorial Policies* scenario to assess the incremental emission reductions expected from these policies. Next, the *Existing Federal Policies* scenario estimates the incremental emission reductions from federal policies implemented since 2005, in addition to existing provincial/territorial polices. Finally, the *Proposed Policies* scenario estimates the incremental emission reductions from policies from all levels of government — federal, provincial, and territorial — that have been announced but not yet implemented or legislated.

Table 6 provides an overview of federal, provincial, and territorial policies included in the modelling. For more details about specific policies included in the analysis, see Appendix 7.3.

TABLE 6: OVERVIEW OF EXISTING AND PROPOSED GHG MITIGATION POLICIES MODELLED

	Canada	BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL	TERR
Carbon Tax		●					●					
Cap and Trade (WCI)		○			○	○	○					
Coal Phase-Out					●	●						
Vehicle Emission Standards	● / ○	●				○	○	○	●	○		
Energy Efficiency Programs/DSM	●	●	●	●	●	●	●	●	●	●	●	●
Improved Building Codes		●			●	●					●	●
Renewable Portfolio Standards								○	●	●		
Renewable and/or Low-Carbon Fuel Standards	●	●	●			●	○	○				
Landfill Gas Regulation		●				●	●					
Regulated Emitters Legislation	●		●	○								
Technology Fund Expenditures			●	○								
Carbon Capture and Storage			○	●								
Feed-In Tariff for Renewable Electricity	●					●						

● = existing ○ = proposed

The NRT assessed all provincial, territorial, and federal policies and endeavoured to include as many individual policies as possible in the modelling analysis. We worked with representatives from the federal and provincial governments to ensure all major policies from each jurisdiction were included in the modelling. To manage the scope and complexity of the analysis, the NRT excluded some policies from the modelling based on qualitative assessment. Policies not modelled were either 1) likely to result in less than 1 Mt CO_2e of emission reductions annually or 2) had insufficient detail available to represent their likely impacts using CIMS.[h] In the case of the latter, some policies were still being defined by policy makers, while others are information-based or voluntary programs that do not translate well to the CIMS modelling framework. The NRT, however, qualitatively assessed the government measures not explicitly included in the modelling to assess how they might contribute additional emission reductions by 2020 to be as comprehensive as possible in our assessment (see Text Box 4).

Canada has a stated emission reductions target for 2020 of 17% below 2005 levels. To achieve this target, Canadian emissions must drop to 607 Mt CO_2e in 2020.

4.2 THE EMISSIONS GAP

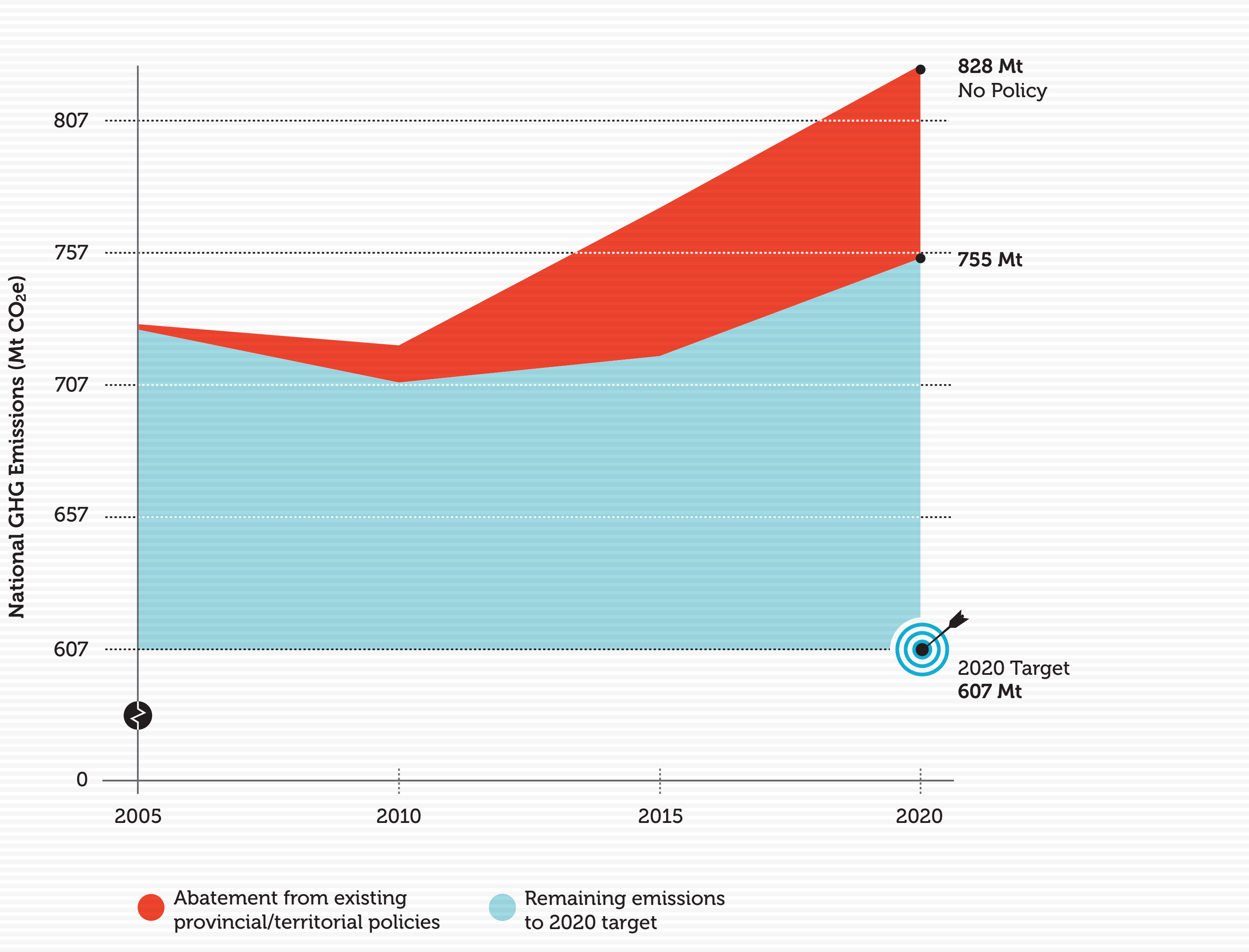
Canada has a stated emission reductions target for 2020 of 17% below 2005 levels. To achieve this target, Canadian emissions must drop to 607 Mt CO_2e in 2020. As seen in earlier chapters, the federal, provincial, and territorial governments have all implemented climate plans and policies to drive emission reductions in Canada. This section adds up the national emissions trajectory to 2020 based on these actions. It assesses how much progress Canada has made in meeting the 2020 target and how much of an emissions gap likely still remains.

EFFECTS OF EXISTING PROVINCIAL/TERRITORIAL POLICIES

To assess the impact of existing provincial and territorial policies, GHG forecasts are compared under two scenarios. The differences in emissions or abatement between the *No Policy* scenario — which includes no new policies since 2005 — and the *Existing Provincial and Territorial* scenario reflect the impact of this set of policies. Figure 8 below illustrates the forecasted emission reductions.

h The NRT has extensive experience in qualitatively assessing the likely impacts of policies through its annual assessment of government forecasts under the Kyoto Protocol Implementation Act.

FIGURE 8: EMISSION REDUCTIONS FROM EXISTING PROVINCIAL/TERRITORIAL POLICIES

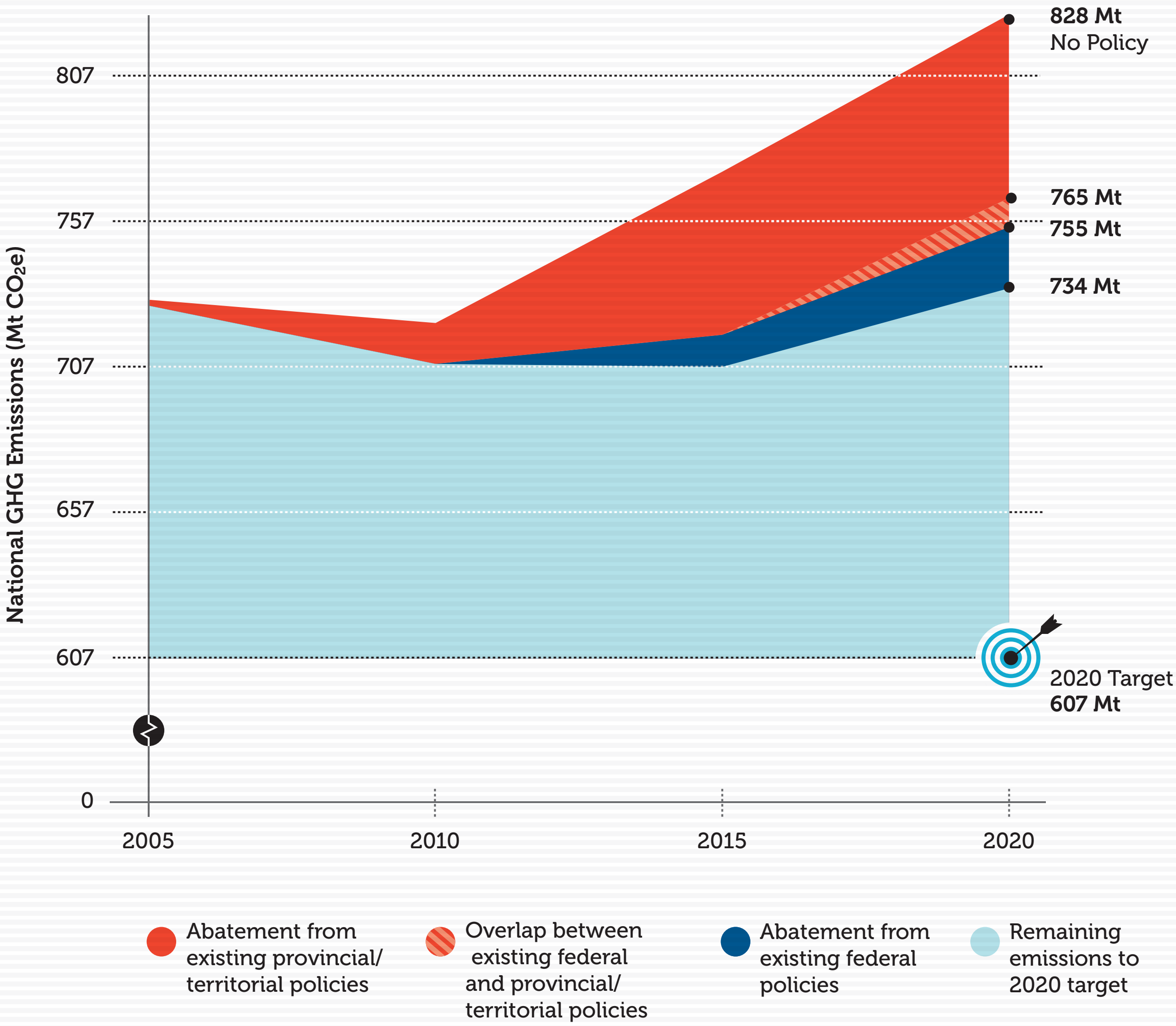


As illustrated in the figure, the *No Policy* scenario forecasts that Canada's emissions would have risen to 828 Mt CO_2e by 2020. This trend would have placed Canada about 221 Mt CO_2e above its target in 2020. Existing P/T policies implemented since 2005 put Canada on the path toward significant progress in closing the gap to the target, leading to an expected 73 Mt CO_2e of emission reductions in 2020.

EFFECTS OF EXISTING FEDERAL POLICIES

Now we present the effects of existing federal policies. Figure 9 illustrates the incremental abatement existing federal policies, notably including regulations for vehicles and coal-fired electricity, would add to reductions from existing P/T policies, by layering these additional policies onto the previous scenarios.

FIGURE 9: EMISSION REDUCTIONS FROM EXISTING PROVINCIAL/TERRITORIAL AND FEDERAL POLICIES



As illustrated, federal polices will result in 21 Mt CO_2e of incremental emission reductions by 2020, less than one-third of reductions compared to P/T policies. Together, however, emission reductions from both federal and P/T existing policies amount to 94 Mt CO_2e of expected emission reductions in 2020. Our forecast suggests an emissions gap to the Canadian target of about 127 Mt CO_2e based only on existing policies.

Emissions are not actually "federal" or "provincial." Some overlap between existing federal and existing P/T policies will exist as policies chase some of the same emissions.

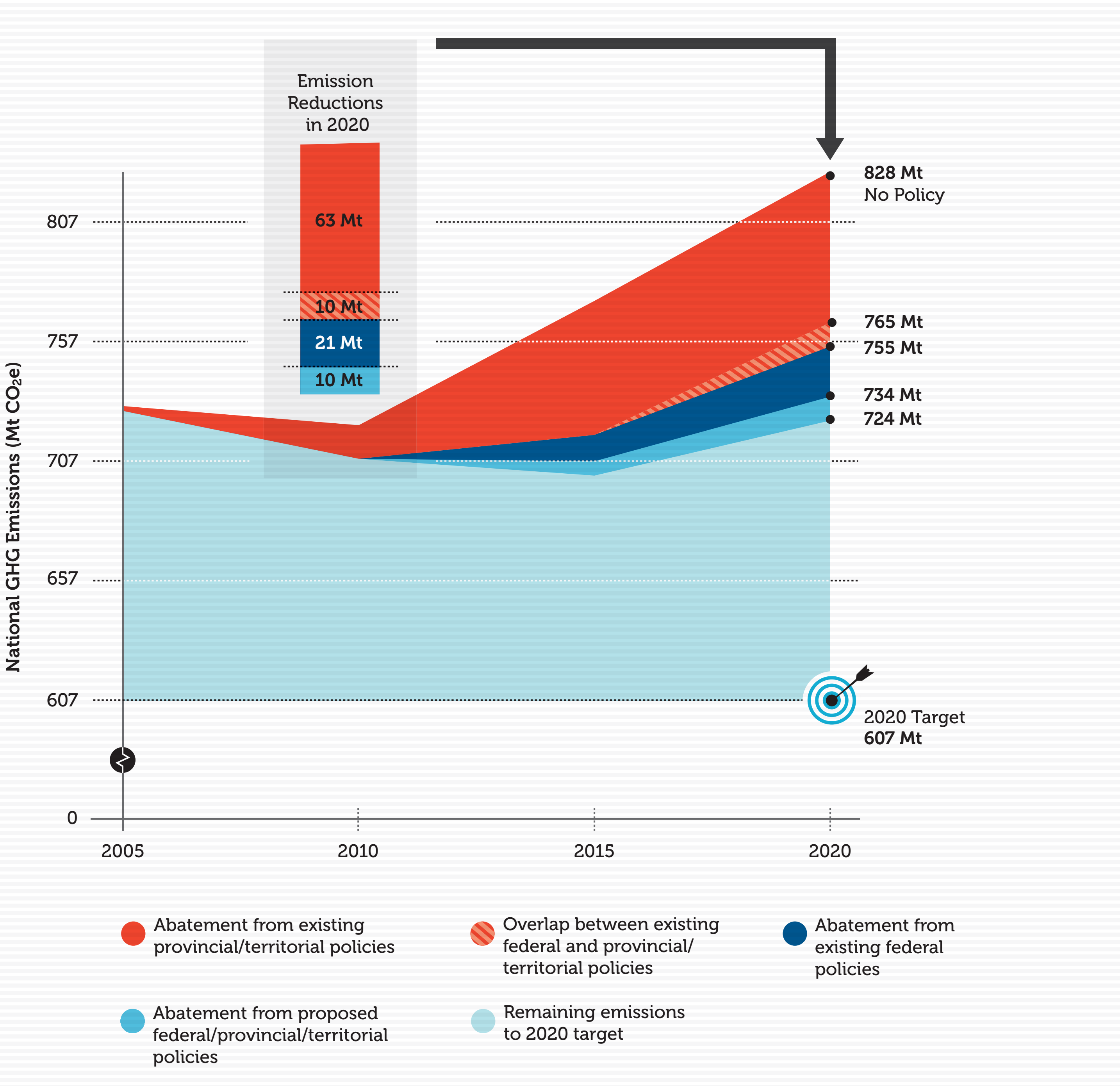
Emissions are not actually "federal" or "provincial." Some overlap between existing federal and existing P/T policies will exist as policies chase some of the same emissions. Policies with areas of overlap include the federal electricity regulations and the coal phase-out in Ontario as well as energy efficiency and demand-side programs for energy-use in buildings from both levels of government. To avoid double-counting of abatement, Figure 9 illustrates this overlap in efforts that amount to about 10 Mt CO_2e of emission reductions in 2020.

Existing federal policies layered on top of P/T policies achieve an *incremental* 21 Mt CO_2e of emission reductions. If existing federal policies were modelled on their own, they would achieve 31 Mt CO_2e of emission reductions in 2020. The NRT followed Environment Canada's standard modelling practice in how it conducted its scenario modelling to determine this.

EFFECTS OF PROPOSED FEDERAL AND PROVINCIAL/TERRITORIAL POLICIES

Both the federal and P/T governments have announced their intent to move forward with additional policies to reduce emissions. Our final scenario explores the potential impact of these proposed policies on GHGs to 2020 to determine if they could further close the emissions gap to the 2020 target. Even though these policies have not been implemented at the time of this report, governments have clearly stated their intention to move forward with them and have provided sufficient detail to define their nature. Figure 10 shows the incremental emission reductions from these proposed federal and P/T policies.

FIGURE 10: EMISSION REDUCTIONS UNDER EXISTING AND PROPOSED FEDERAL, PROVINCIAL, TERRITORIAL POLICIES



The proposed policies scenario would likely result in an additional 10 Mt CO_2e of reductions by 2020, about 10% more abatement than currently expected. These additional emission reductions are relatively small partly because existing policies have already driven substantial reductions and make up most of the effort by governments, but also because only a few policies likely to make a substantial impact have actually been proposed. Federal regulations for emissions on heavy vehicles will have an impact across the country. A proposed cap-and-trade policy under the Western Climate Initiative in British Columbia, Ontario, Manitoba, and Québec will also help reduce emissions, but the stringency of the cap is essentially the same as the existing carbon tax in British Columbia, so it has no incremental impact in British Columbia. Overall, the forecast suggests that together, the proposed policies will likely have only small impacts and will be insufficient to close the gap to the 2020 target. Should governments not go ahead and implement these policies then even fewer emission reductions will occur as can be seen below in our uncertainty analysis.

THE REMAINING GAP TO 2020

The NRT forecasts presented above suggest that existing and proposed federal, provincial, and territorial polices will together lead to substantial emission reductions of 104 Mt CO_2e in 2020. However, even considering all these policies, an additional 117 Mt CO_2e of emission reductions will be required by 2020 to achieve the target.

A key factor in the explaining this gap is the growth in emissions, largely resulting from growth in the Canadian economy, and in particular, in emissions-intensive sectors such as oil and gas. As Figure 10 shows, all sets of policies have an increasing impact through time — the coloured wedges of emission reductions grow wider and wider. Consequently, the gap to the target continually narrows to 2015, before again widening between 2015 and 2020, as growth in emissions from emissions-intensive sectors begins to again outpace emission reductions induced by policy. Still, existing and proposed policies provide a foundation for achieving Canada's 2020 emissions goal. Our analysis suggests that almost half the required reductions are likely to be achieved through existing and proposed government measures.

The NRT forecasts presented above suggest that existing and proposed federal, provincial, and territorial polices will together lead to substantial emission reductions of 104 Mt CO_2e in 2020. However, even considering all these policies, an additional 117 Mt CO_2e of emission reductions will be required by 2020 to achieve the target.

UNCERTAINTY IN THE REMAINING GAP

Exploring potential uncertainty in our assessment can be useful to illustrate how different assumptions can lead to different estimates for remaining emissions to the 2020 target. In the core analysis presented above, we have generally assumed that new policies will be implemented as stated and old policies remain in effect. We consider both an *optimistic* and a *pessimistic* scenario to better indicate the possible range of the size of the remaining gap.

TEXT BOX 4

GOVERNMENT POLICIES NOT REPRESENTED IN THE MODELLING

The NRT worked with representatives of provincial and territorial governments to ensure that the NRT's economic modelling includes the most significant programs and policies to reduce GHG emissions. However, while the modelling includes a large number of government measures, practical limitations prevented the NRT from including every single measure. As noted in this report, policies not modelled were either likely to result in less than 1 Mt CO_2e of emission reductions annually or had insufficient detail to quantitatively simulate their likely impacts. But what emission reductions might be expected collectively from the numerous smaller policies that were not modelled?

The NRT qualitatively assessed the remaining provincial, territorial, and federal policies to examine the likelihood for the un-modelled policies to provide emission reductions incremental to the policies that have been modelled. We consider policies solely by their potential to contribute to emissions abatement by 2020. To assess their potential, we applied three tests to filter the policies:

1. **Is the policy voluntary or mandatory?** We identify the type of each policy according to where it falls on the spectrum between completely voluntary (e.g., information programs) and absolutely coercive (e.g., command and control). To be considered, a policy has to be a financial disincentive or a regulation, i.e., "mandatory."
2. **Is there overlap with already modelled policies?** Our concurrent quantitative analysis suggests significant overlap exists among policies designed to reduce greenhouse gas emissions in Canada. For each policy, we identify whether we modelled another policy at the federal or provincial level that covers the same sector. To be considered to generate incremental abatement, a policy must not have significant overlap.
3. **Does the policy cover a significant portion of national emissions?** To be considered, a policy has to have reasonable potential to add a significant amount of emission reductions.

Based on these filters, several additional policies emerge as potentially important contributors to overall Canadian emission reductions, as illustrated in the table below. In most cases, the estimate is an upper bound estimate derived from government claims that have not been independently verified or assessed in context. Therefore we assume that these estimates present an optimistic assessment of emission-reduction potential. In total, we estimate incremental emissions abatement from these remaining quantifiable policies of up to 2.3 Mt CO_2e in 2020.

POLICY	JURISDICTION	SECTOR	EMISSIONS IN 2020 (Mt CO_2e)	MAXIMUM EXPECTED ABATEMENT IN 2020 (Mt CO_2e)
Provincial Transit Plan	BC	Transportation Personal	9.1	0.4
Green Trips	AB	Transportation Personal	9.7	Unknown
Sustainable Agricultural Practices	MB	Agriculture	7.1	0.4
Landfill Biogas Capture	MB	Waste	0.9	0.2
Public Transit Expansion	ON	Transportation Personal	30.1	0.3
Halocarbon Regulations	QC	Industry & Consumer Products	2.8	0.7
Voluntary Industry Agreements	QC	Metal Smelting	8.3	0.2
Landfill Gas	NL	Waste	0.7	0.1
Marine Shore Power Program	Canada	Transportation Freight — Marine	11.1	< 0.1
TOTAL				**2.3**

* *See, for example, Jaccard and Bataille 2004; Jaffe, Newell, and Stavins 1999; Khanna 2001.*

Our *optimistic* case includes some additional possible sources of emission reductions. First, as noted, the modelling analysis includes all major government policies and programs, but excludes government measures likely to have small impacts or that have insufficient detail available for modelling. The NRT's qualitative assessment of these policies, however, suggests that they could lead to up to 2.3 additional Mt CO_2e of emission reductions in 2020 (See Text Box 4 for details of this qualitative analysis). Second, the core analysis described above does not include the effects of investments under the *Climate Change and Emissions Management Corporation* (CCEMC) in Alberta. As discussed in Text Box 5, this mechanism could lead to up to an additional 6 Mt CO_2e of reductions in 2020. Under this *optimistic* scenario, the remaining gap in 2020 to the Canadian target would be 109 Mt CO_2e, rather than 117 Mt CO_2e; Canada would be slightly more than 50% of the way to achieving the target.

Yet proposed policies may not be implemented and existing policies may be weakened or cancelled. We considered a pessimistic case in which we assumed the following:

- All proposed policies (the Western Climate Initiative, CCS projects in Alberta,[i] proposed industrial regulations in Saskatchewan, federal heavy duty freight truck regulations) do not move forward;
- Federal Electricity Performance Standards, which are not yet finalized, are not implemented; and
- Ontario coal phase-out, which has been delayed in the past, does not proceed beyond what has already occurred to date.

Under this *pessimistic* scenario, national abatement would be reduced by about 32 Mt CO_2e in 2020, and the remaining gap in 2020 to the Canadian target would be 149 Mt CO_2e instead of 117 Mt CO_2e. Instead of being halfway to the target in 2020, Canada would be about one-third of the way there.

Many sources of uncertainty exist when forecasting future impacts of policies. The extent to which existing and proposed policies will close the gap to the 2020 target depends on factors such as economic and population growth, prices of natural gas and other energy sources, and technology deployment.

TABLE 7: EMISSIONS GAP TO 2020 TARGET BY SCENARIO MODELLED

SCENARIO	GAP (Mt CO_2e)
NRT Forecast	117 Mt
Optimistic Scenario	109 Mt
Pessimistic Scenario	149 Mt

i Carbon capture and storage is an example of a technology that may prove challenging to implement, as evidenced by TransAlta's recent cancellation of the $1.4 billion Pioneer carbon capture and storage project due to a low price on emissions (O'Meara 2012).

TEXT BOX 5

EMISSION REDUCTIONS FROM TECHNOLOGY FUND EXPENDITURES

A key element of Alberta's *Specified Gas Emitters* policy is the Technology Fund administered by the *Climate Change and Emissions Management Corporation* (CCEMC). One compliance option for industrial emitters is to contribute to this fund. The CCEMC then invests these funds in projects to reduce GHG emissions elsewhere in the province. Saskatchewan's proposed policy for industrial emitters will include a similar mechanism.

While the NRT's modelling does represent the incentive the Specified Gas Emitters policy provides for firms to reduce emissions (to avoid contributing to the technology fund), modelling the likely effects of CCEMC *expenditures* is challenging. The specific projects in which the CCEMC will invest is uncertain, as is the timing of these investments and the extent to which the funding from CCEMC is the key driver for the project. The CIMS model is not equipped to represent the possible effects of these expenditures on GHGs.

Consequently, the NRT implemented additional, complementary analysis to assess the likely reductions. We first drew on CIMS forecast data to identify the share of emitters' compliance achieved through offsets or direct emission reductions. We could then identify remaining compliance as contributions to the technology fund and so assess the revenue the CCEMC would be likely to generate from compliance payments by 2020. We then — drawing on assumptions generated from engagement with Alberta provincial government officials about the typical projects funded and typical project timelines — estimated the likely additional emissions by 2020. This analysis also accounted for *additionality* effects (i.e., the extent to which projects would have been developed even without CCEMC funding support). The analysis is likely optimistic, but does provide an assessment of additional potential emission reductions in Alberta.

This analysis suggests that CCEMC will receive around $1.8 billion between 2011 and 2020 through contributions to the technology fund, and this could lead to up to an additional 6 Mt CO_2e of reductions in 2020 in Alberta beyond the reductions shown in the figures in this chapter. This estimate is separate from the main analysis presented in this report because it is generated using a different methodology, and the sectors in which these reductions occur are not known. However, these reductions would further serve to reduce the expected emissions gap to the 2020 target.

Applying a similar analysis for the proposed Technology Fund in Saskatchewan indicates that no additional emissions would result because the Fund would not generate any revenue. Given that our forecast shows that Saskatchewan is likely to achieve its 2020 emission-reduction target, firms will not have significant compliance obligations under the policy, and so will not need to purchase credits from the Fund. If the Fund does not generate revenue, it cannot invest in low-carbon activities.

4.3 A REGIONAL PERSPECTIVE

Given the importance of provincial and territorial policies in driving Canada's emission reductions, what is the regional story behind 2020 emission reductions? To what extent are provinces likely to achieve their own targets? How are emission reductions from both provincial and federal policies distributed across Canada? This section explores these questions and builds upon our assessment of provincial plans from chapter 3.

The fact that no formal federal/provincial burden-sharing protocol on GHG emission reductions has ever been negotiated helps explain why Canada has difficulty assessing progress toward individual provincial targets and continues to have a 2020 gap.

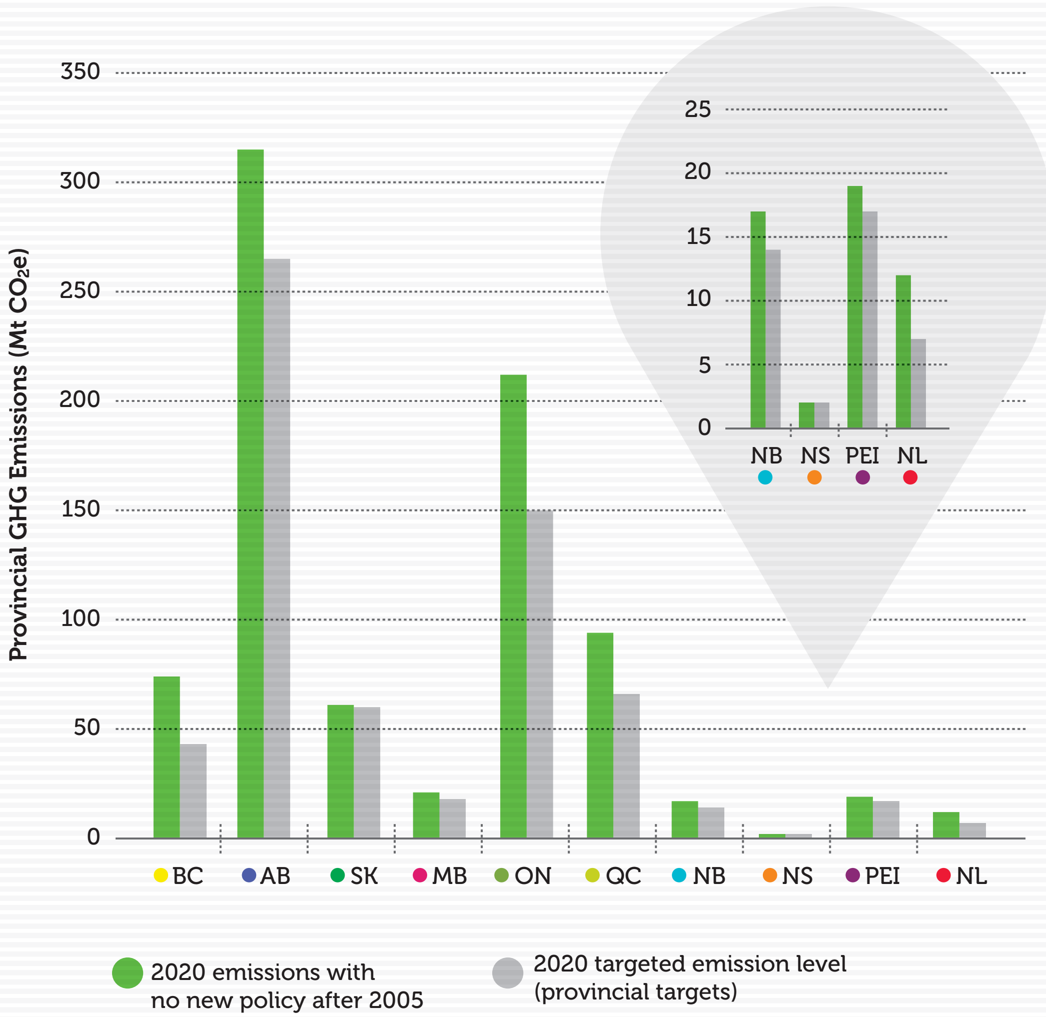
PROVINCIAL/TERRITORIAL TARGETS

As noted in Chapter 3, if all provinces and territories achieved their own 2020 targets, federal policies would only need to achieve about an additional 41 Mt CO_2e of emission reductions to reach the national 2020 target. The fact that no formal federal/provincial burden-sharing protocol on GHG emission reductions has ever been negotiated helps explain why Canada has difficulty assessing progress toward individual provincial targets and continues to have a 2020 gap.

Figure 11 situates the provincial targets with the model forecasts.[j] The figures shows 1) projected emissions in 2020 if no polices had been implemented after 2005, and 2) the targeted level of emissions under each provincial 2020 target.

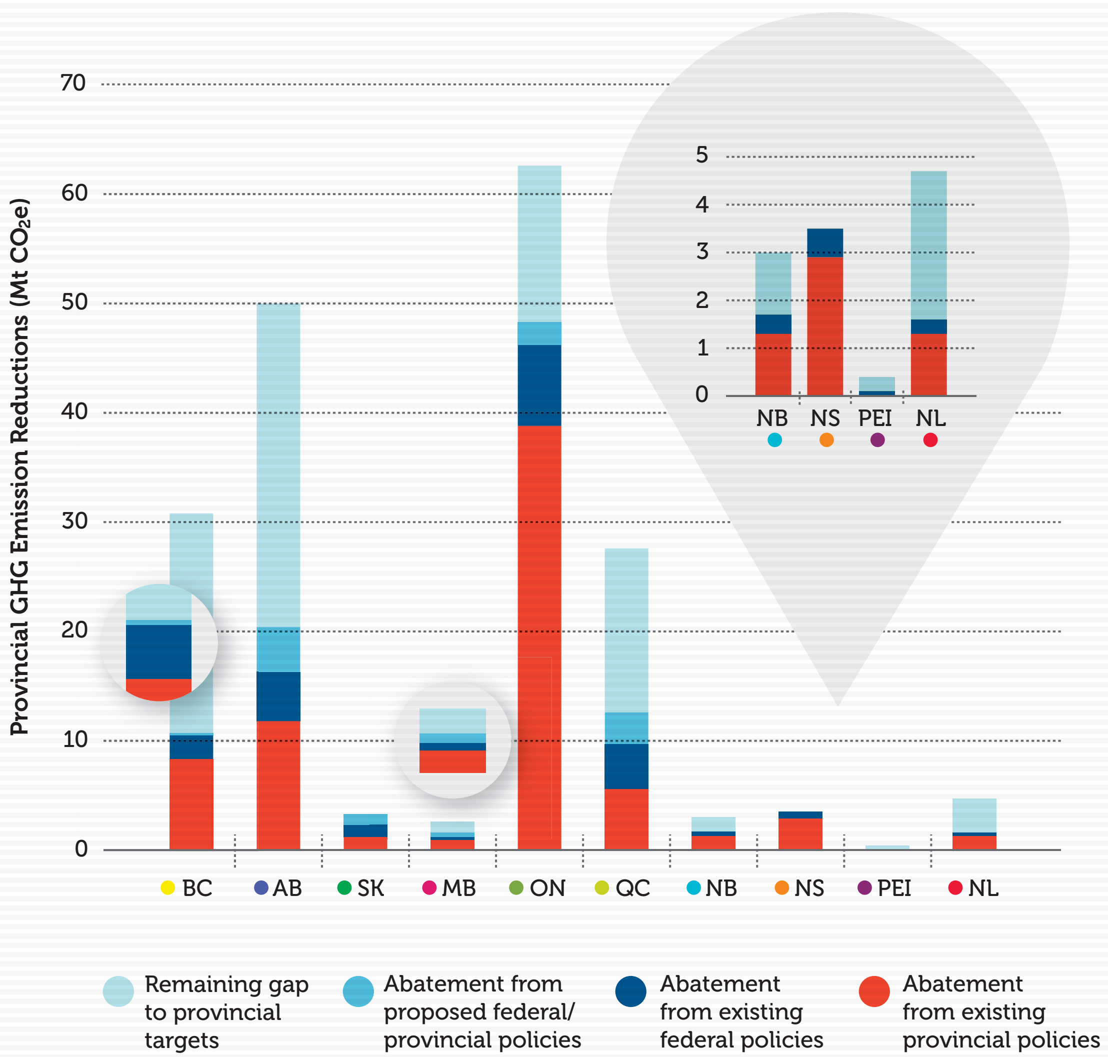
j Note that quantitative results for the territories are grouped with British Columbia in this report, but do not significantly affect British Columbia's results.

FIGURE 11: COMPARING 2020 PROVINCIAL EMISSIONS TARGETS



Note: Figure 12 explains the difference between 2020 provincial emissions and targets.

FIGURE 12: DETAILS ON 2020 EMISSION REDUCTIONS AND GAP TO TARGET



The figure highlights the challenge for each province in the context of both the magnitude of targets and the projected growth of emissions to 2020. Ontario and Québec have deep 2020 targets, for example, while according to the NRT forecast, Saskatchewan, Manitoba,[k] and Prince Edward Island would likely come close to achieving targets even without policy. On the other hand, even though Alberta's target actually allows for emission growth relative to 2005 levels, it faces a significant challenge in meeting its target as a result of sharply higher projected emissions growth.

PROVINCIAL EMISSION REDUCTIONS

The set of existing and proposed federal and provincial policies modelled by the NRT will likely have significant impacts on provincial emissions. Figure 12 illustrates the forecasted impacts for each province relative to the *No Policy* scenario and highlights remaining gaps to provincial targets. This figure illustrates how current and proposed policies reduce each province's emissions toward their provincial targets. As in our above modelling, the impacts of each policy scenario are incremental to the reductions from the previous scenario.[l]

As illustrated in the national forecast scenarios, *existing* provincial policies drive the largest share of expected emission reductions in each province. Policies like British Columbia's carbon tax, Alberta's Specified Gas Emitter program,[m] the coal-fired electricity phase-out in Ontario, and Nova Scotia's renewable electricity sector policies all help reduce emissions. The model allocates overlaps between existing federal policies and existing provincial policies to the provinces to avoid double counting. This means that existing federal policies like the coal-fired electricity standard have reduced incremental impact in the provincial results shown here given coal-focused policies by Ontario and Nova Scotia.

Expected abatement from proposed federal and provincial policies meanwhile is distributed across Canada but mostly in Alberta, Saskatchewan, Ontario, and Québec. The most substantial impact of proposed policies occurs in Alberta as a result of carbon capture and storage (CCS) project proposals. The forecast suggests these projects could lead to around 5 Mt CO_2e of reductions in 2020.

k The NRT's analysis of Manitoba assumes a 2020 target of 15% below 2005 levels by 2020, as per Environment Canada 2011a.

l To assess policy impacts in the Atlantic Provinces, we disaggregated individual provinces from an aggregate, regional representation in the CIMS model. This breakout was based on Environment Canada data and a detailed look at electricity systems in the four Atlantic Provinces.

m Additional reductions could also be expected from Alberta's Climate Change and Emissions Management Corporation, which is not included in the CIMS modelling shown here, but assessed separately in Box 4.2.

CHARACTERISTIC 4
ENVIRONMENTAL EFFECTIVENESS

As described in Chapter 3, our fourth key element of an effective provincial climate change plan is the inclusion of sufficient measures to achieve the GHG reduction targets established.

The NRT forecast illustrated in Figure 12 shows that Nova Scotia and Saskatchewan[n] are the only provinces expected to achieve their 2020 targets under the current set of existing and proposed policies. Existing and proposed policies for Ontario, Manitoba and New Brunswick are expected to bring these provinces more than 50% of the way to closing the gap and achieving targeted emission reductions in 2020. For the remaining provinces, existing and proposed policies are expected to make less than 50% of the progress necessary to close the gap and achieve targeted emission reductions by 2020.

It is important to emphasize that these conclusions are based on the forecast gap between 2020 emissions in the *No Policy* scenario and the 2020 emissions target (as set out in Figure 11) and the extent to which the policies modelled in the NRT analysis are expected to close that gap in 2020 (as set out in Figure 12). Table 8 situates progress for each province toward meeting its own GHG target based on this assessment.

TABLE 8: CONTRIBUTION OF EXISTING AND PROPOSED POLICIES TOWARD MEETING PROVINCIAL TARGET

BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL
35%	41%	100%	62%	77%	46%	56%	100%	30%	35%

n Representatives from the Government of Saskatchewan's Department of Environment have noted that, in their view, the NRT's forecast likely underestimates economic growth in Saskatchewan, and thus the extent to which emissions are likely to increase. This concern may be legitimate; recent trends in Saskatchewan have shown rapid growth in Saskatchewan in both population and economic activity. A recent short-term RBC forecast suggests that Saskatchewan could have the highest growth rates of all provinces by 2013 (RBC Economics 2012). However, we did not have alternative, long-term macro-economic assumptions that could be utilized for this modelling. Our forecast is rooted in consistent assumptions about regional and sector-level growth in production drawn from Environment Canada's modelling, which is in turn based on macro-economic forecasts from Informetrica.

4.4 A SECTOR-LEVEL PERSPECTIVE

Our sector-level story of emission reductions under proposed and existing policies further describes the nature of the impacts of federal and P/T policies. It not only illustrates the primary focus of emission reductions from government policies, but also highlights where additional emission reductions might be found.

SECTOR-LEVEL REDUCTIONS

The policies in the three scenarios modelled include measures that affect multiple sectors and those that affect emissions only in a single sector. Some provincial policies are more market-based like the British Columbia carbon tax, the proposed WCI cap-and-trade system, and to a lesser extent, the Québec gas levy. Others are regulatory in nature with compliance options and focused on large emitters, such as Alberta's existing and Saskatchewan's proposed industrial emitter regulations. Finally, some policies are more sector-based such as the federal light- and heavy-vehicle regulations and coal-fired electricity generation, or landfill gas regulations in Ontario, Québec, and British Columbia, and building codes in multiple provinces and territories.

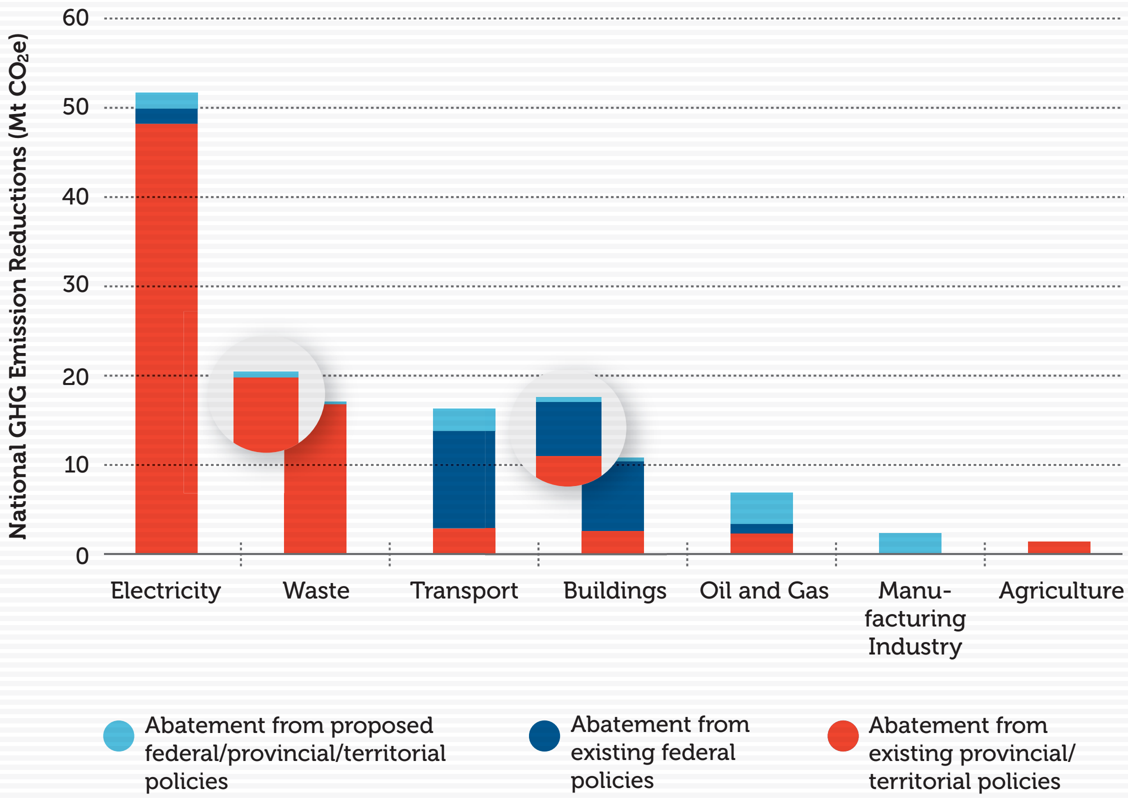
Figure 13 shows expected reductions from existing and proposed polices by sector.[o] It demonstrates that electricity generation is the largest source of emission reductions with 48 Mt CO_2e in 2020, principally because of existing provincial policies. Many provinces have targeted electricity generation directly as a key source of emissions: Ontario is phasing out coal plants, Prince Edward Island has a renewable portfolio standard and incentives for wind power, Nova Scotia has a cap on electricity-sector emissions, and British Columbia has a zero-emissions electricity objective. A focus on electricity makes sense since it is a high-emitting sector and reducing the carbon intensity of electricity supply can enable fuel switching to electricity to reduce emissions associated with consuming energy. Note that the overlap between federal and provincial policies is not illustrated here; overlap is allocated to provincial policies to avoid double-counting. Consequently, the *incremental* impacts of the federal coal-fired electricity standards are small because provincial policies such as the Ontario coal phase-out have already incented some of these emission reductions.

Waste is another sector that will see substantial expected emission reductions — about 17 Mt CO_2e in 2020 — as a result of provincial regulations and policies for landfill gas emissions. As we will explore in Chapter 5, capturing methane emissions is often a relatively low-cost source of emission reductions.

Finally, the forecast suggests that federal light-vehicle standards will have a substantial impact, with savings of close to 11 Mt CO_2e of emissions in 2020 in the transportation sector under existing policies. The proposed heavy-duty freight transport regulations have a relatively small forecasted impact of about 3 Mt CO_2e in 2020.

o Note that the sectoral breakdown provided here is a function of the CIMS structure and not entirely consistent with the activity-based breakdown used in Canada's *National Inventory Report*.

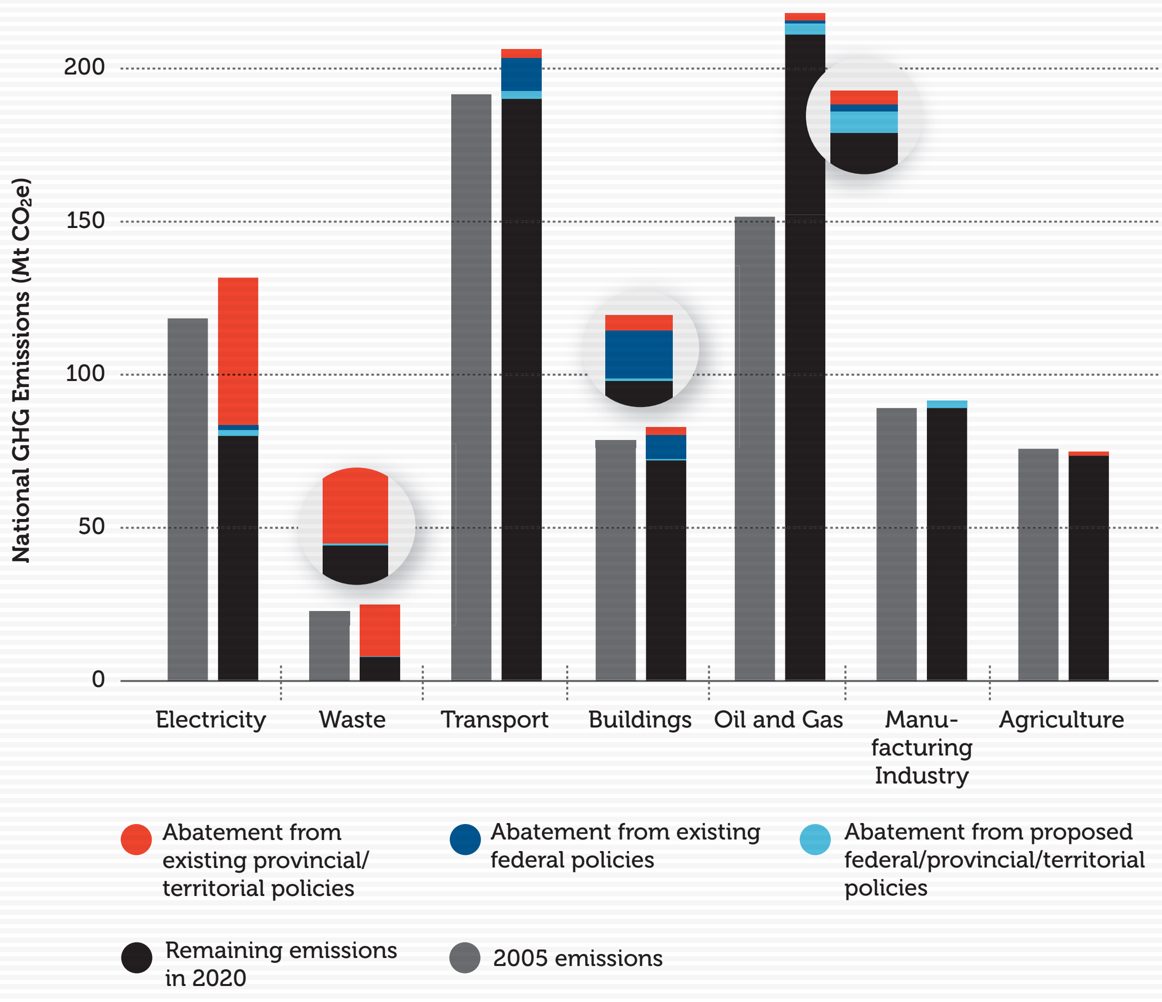
FIGURE 13: EMISSION REDUCTIONS FROM EXISTING AND PROPOSED POLICIES BY SECTOR IN 2020



KEY REMAINING SECTOR-LEVEL EMISSIONS

The emission reductions from the policies modelled also look quite different in the context of total emissions in the sector. Figure 14 stacks the estimated emission reductions from all existing and proposed policies set out in Figure 13 on top of all emissions from that sector, and compares them to 2005 emission levels. The figure therefore illustrates forecasted progress toward reducing emissions in each sector.

FIGURE 14: EMISSION REDUCTIONS FROM EXISTING AND PROPOSED POLICIES BY SECTOR IN 2020 AND REMAINING EMISSIONS

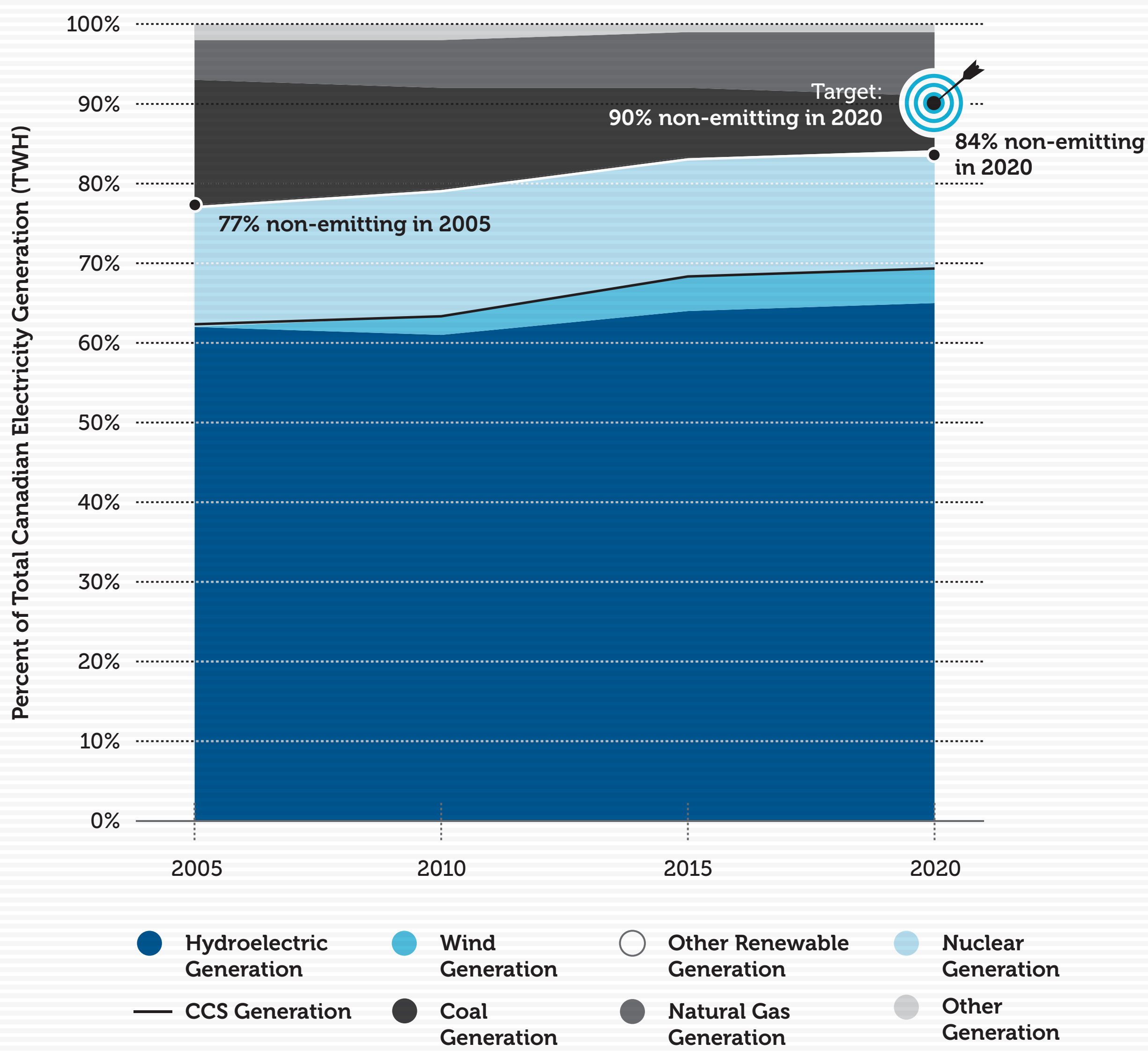


The forecast suggests that current and proposed policies will reduce emissions to 2005 levels or further in all sectors but oil and gas. This demonstrates the centrality of reducing emissions in this sector in order to achieve the 2020 target. Emissions in the waste sector are reduced by 66% from 2005 levels and electricity generation by 32%. While transportation policies are expected to drive some substantial emission reductions from forecasted growth, this same growth in the sector keeps overall emissions from dropping below 2005 levels. In Chapter 6, we will explore the costs of achieving further emission reductions in each sector.

CANADA'S TARGET FOR LOW-EMISSIONS ELECTRICITY GENERATION

The federal government also has a stated target of 90% of electricity generated from non-emitting sources by 2020.[70] The NRT's modelling assesses Canada's progress toward this goal. Figure 15 illustrates Canada's projected electricity mix under a scenario including all existing and proposed policies from federal, provincial, and territorial policies. It shows that the country will increase its non-emitting electricity share from 77% in 2005 to 84% in 2020. By 2020, hydroelectricity, wind, and other renewable generation are likely to make up about 69% of Canadian electricity generation. If nuclear generation and fossil-fuel-generated electricity equipped with CCS is included in this mix, Canada is projected to have about 84% carbon-emissions-free electricity by 2020. Canada is not on track to achieve this 90% target but is positioned to make progress.

FIGURE 15: ELECTRICITY GENERATION IN CANADA BY TYPE AND 2020 TARGET FOR NON-EMITTING SOURCES



4.5 EMISSION REDUCTIONS TO 2030

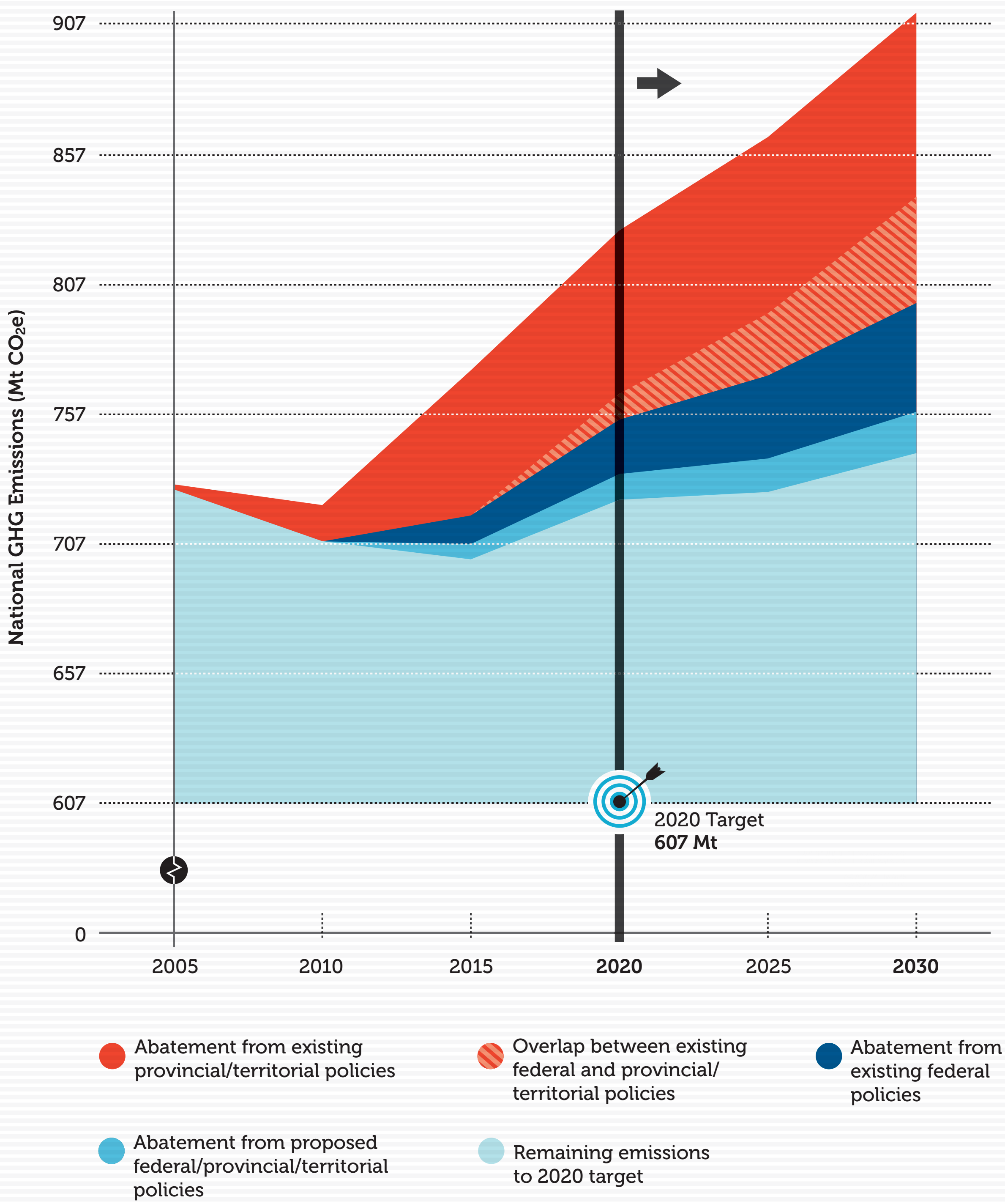
Even though the main focus of this report is on Canadian emissions to 2020, the longer-term story cannot be ignored. Cumulative GHG emissions matter for climate change. While short-term targets like 2020 are important in themselves, they are most significant as waypoints on a path toward long-term decarbonization. If Canada is not on a path for 2020, it will not be on path for 2030 or beyond. We therefore consider the likely impacts of existing and proposed policy in the longer term as well. Figure 16 shows the expected emission reductions under the different policy scenarios in our forecasts extended out to 2030.

Overall, the forecast indicates that all existing and proposed policies together will result in emission reductions of 169 Mt CO_2e in 2030. Despite this higher amount of reductions Canada is in fact further away from the 2020 target in 2030 due to increased overall growth in emissions.

The impacts of policies grow through time; by 2030, existing P/T policies are likely to lead to around 110 Mt CO_2e of reductions (including overlap with federal polices) from 2005 levels. Existing federal policies add an incremental 42 Mt CO_2e of emission reductions in 2030. Overall, the forecast indicates that all existing and proposed policies together will result in emission reductions of 169 Mt CO_2e in 2030. Despite this higher amount of reductions Canada is in fact further away from the 2020 target in 2030 due to increased overall growth in emissions.

Many of the policies modelled have greater impacts through time because they affect new investments. More time allows these policies to work with the pace of capital-stock turnover. For example, carbon pricing policies like British Columbia's carbon tax, Alberta's Specified Gas Emitter policy or the WCI primarily affect new investment decisions, incenting investment in lower-emissions equipment. Similarly, the federal coal-fired regulations have stronger impacts through time because they affect new plants coming on stream, not existing facilities. The federal vehicle standards also have growing impact as old vehicles are replaced, and only more efficient new vehicles are available in the market to replace them.

FIGURE 16: EMISSION REDUCTIONS FROM EXISTING AND PROPOSED POLICIES IN 2020 AND 2030



4.6 CONCLUSION

This chapter presents five key findings that are useful for informing future policy development:

- Based on existing and proposed federal and P/T policies, Canada is currently on track to achieve just under half of the emission reductions required to meet its 2020 target. A national emissions gap exists and additional policies will be required to drive further emission reduction in order to achieve the 2020 target.
- Existing and proposed measures by all governments will likely generate emission reductions of 104 Mt CO_2e in 2020. Provincial policies account for most of these emission reductions – 73 Mt CO_2e or approximately 75% of forecasted reductions in 2020.
- Most provinces are not currently in a position to achieve their provincial targets for 2020 based on existing and proposed provincial and federal policies. Our modelling suggests that only Nova Scotia and possibly Saskatchewan are on track to achieve their targets.
- Canada is positioned to partly close the gap on its target of 90% non-emitting electricity generation in 2020. The NRT's forecasts suggest that all current and proposed policies will lead to close to 84% of electricity coming from non-emitting sources in 2020 if nuclear and fossil-fuel facilities equipped with CCS are included.
- Reductions from electricity emissions account for most of all projected emission reductions by 2020, followed by waste emission reductions. Most of these reductions are, in turn, incented by provincial policies. Emission reductions incented by federal policies are concentrated in the transport and buildings sectors.
- Policies take time to have full impact. We expect the effects of existing federal and P/T policies to grow, driving 60% more emission reductions in 2030 than in 2020. Federal policies are more effective after 2020 because there is more time for the capital stock to transition to lower-emitting equipment.

5.0 COST-EFFECTIVE CLIMATE POLICY

WHEN IT COMES TO CLIMATE POLICY, COUNTRIES SEEK THE SAME THING: GETTING THE MOST GHG EMISSION REDUCTIONS AT THE LEAST ECONOMIC COST. HOW DOES CANADA FARE IN THIS CALCULUS?

This chapter ascertains just how cost-effective Canadian climate policies are today and the costs of additional policies needed to close the emissions gap. We begin by estimating the costs of emission reductions expected under existing and proposed measures by governments and then estimate the costs of additional measures that would be needed to close the gap to the 2020 target. To what extent is the existing combination of federal and P/T policies driving low-cost emission reductions? And perhaps more importantly, how can Canada most cost-effectively achieve the additional emission reductions required to close the gap to the 2020 target? By answering these questions, our analysis provides a foundation for advice for future climate policies, informing the Government of Canada's strategy of sector-by-sector regulations.

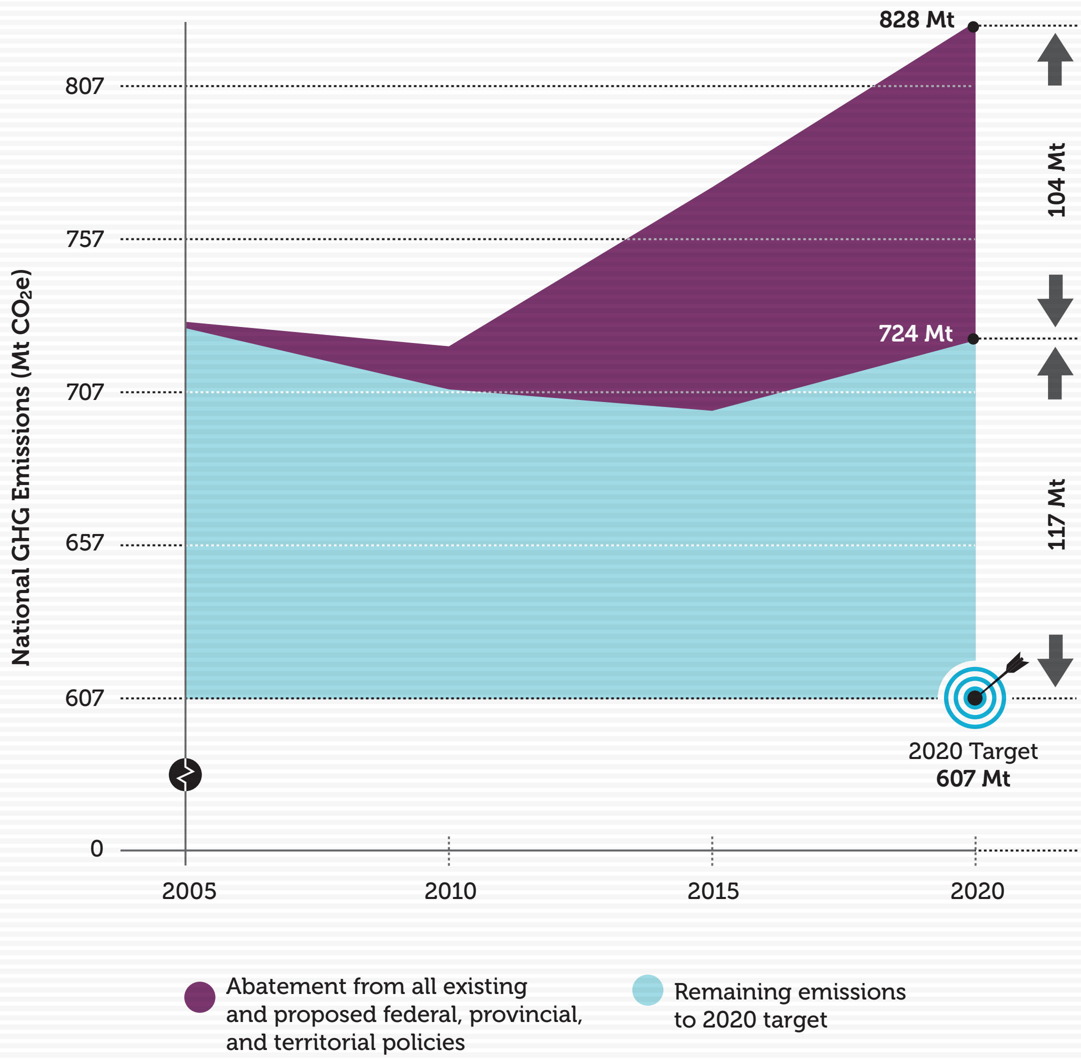
5.1 ECONOMIC ANALYSIS APPROACH

The economic analysis in this chapter builds on the previous chapter, which explored expected emission reductions from existing and proposed federal, provincial, and territorial policies and programs in 2020. Figure 17 simplifies the overall emissions forecast into two categories: the expected emission reductions from all existing and proposed federal and P/T policies (about 104 Mt CO_2e in 2020) and the additional emissions required to meet Canada's 2020 target (another 117 Mt CO_2e in 2020).

These two sets of 2020 emission reductions — the 104 Mt CO_2e Canada is currently positioned to achieve and the 117 additional Mt CO_2e required to meet the 2020 target — bookend the economic analysis in this chapter. We first explore the costs of expected emission reductions from existing and proposed policies (that is, the extent to which Canada is on track to achieve the 104 Mt CO_2e of emission reductions in 2020 at lowest cost). We then assess the potential for additional policies to meet the remaining 117 Mt CO_2e of emission reductions as cost-effectively as possible.

This chapter moves our assessment beyond the *environmental effectiveness* of existing and proposed policies — how much abatement they achieve — to their *cost-effectiveness*, or how much of that abatement is at what cost. To do so, we categorize expected emission reductions according to their *marginal cost of abatement*, or the incremental cost of achieving those additional reductions under the policy in dollars per tonne. See Appendix 7.2 for a short description of the technical modelling methodology used to categorize emission reductions by cost.

FIGURE 17: EMISSION REDUCTIONS FROM EXISTING AND PROPOSED POLICIES AND THE GAP TO CANADA'S 2020 TARGET



This analysis can provide useful insight for policy makers, but the findings must be applied while transparently recognizing its limitations:

- Cost-effectiveness is not the only important factor in policy design. Other key considerations could include co-benefits such as reduced air pollution, health, equity between regions or between households with different income levels, and longer-term transitional issues (i.e., emission reductions targeted in 2050). These other considerations are not the focus of the analysis in this chapter.
- It should be noted as well that the modelling does not provide a perfect representation of the economy. While models can be useful in identifying potential sources of cost-effective emission reductions, the findings presented here do have uncertainty. They are intended to help inform policy design but should not be interpreted as a definitive or prescriptive road map.

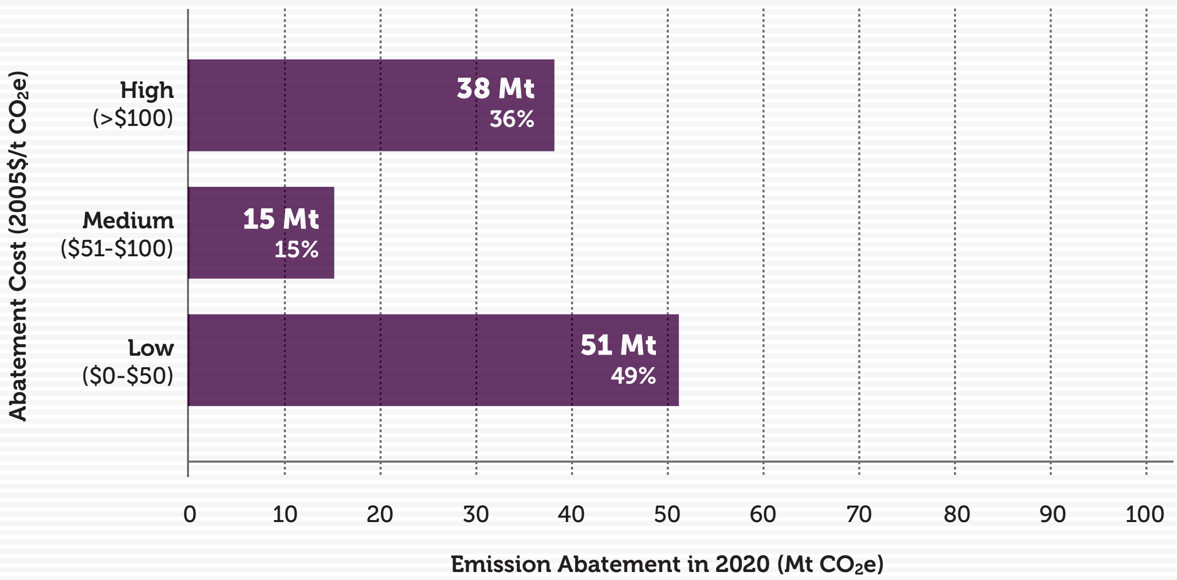
This chapter moves our assessment beyond the *environmental effectiveness* of existing and proposed policies — how much abatement they achieve — to their *cost-effectiveness*, or how much of that abatement is at what cost.

5.2 ABATEMENT COSTS FROM EXISTING AND PROPOSED POLICIES

Existing and proposed federal, provincial, and territorial policies have positioned Canada for significant emission reductions of 104 Mt CO_2e in 2020. But what are the costs of these expected emission reductions? Figure 18 provides an economic assessment that includes the expected 2020 emission reductions and categorizes them according to abatement cost. We categorize each Mt CO_2e of GHG emissions reduced in 2020 as a result of policy as *low cost* (i.e., less than $50/tonne), *medium cost* (i.e., between $50 and $100/tonne), or *high cost* (i.e., more than $100/tonne).[p] The lengths of each bar indicate the magnitude of emission reductions likely to be achieved in 2020 in each cost range. All the emission reductions shown in Figure 18 add up to the 104 Mt CO_2e of reductions from existing and proposed policies in our original analysis; we have simply disaggregated this 104 Mt CO_2e of emission reductions by abatement cost.

p All dollar values in this chapter are stated in 2005 Canadian dollars $ (2005).

FIGURE 18: EMISSION REDUCTIONS FROM EXISTING AND PROPOSED POLICIES IN 2020 BY ABATEMENT COST



CHARACTERISTIC 5
COST-EFFECTIVENESS

As described in Chapter 3, the final element in our assessment of provincial plans is cost-effectiveness. Cost-effectiveness considers both the emission reductions likely to result from a government measure and the cost of achieving these reductions. Therefore, an action is more cost-effective if it achieves emission reductions at a lower cost per tonne CO_2e than other actions.

First, as seen in Figure 18, almost half the expected emission reductions from existing and proposed policy in 2020 — 51 Mt CO_2e — are low-cost emission reductions. Market-based policies such as British Columbia's carbon tax, Alberta's specific gas emitter program and the Western Climate Initiative all generate low-cost-abatement. Policies based on market incentives are designed to simulate lowest-cost emission reductions. Similarly, electricity policies that are timed with the natural turnover of capital stock — such as the federal government's electricity performance standards and some portion of Ontario's coal phase-out — tend to generate low-cost abatement as well because they don't require capital investments to shut down before the end of their useful life. Policies in the waste sector (mainly provincial landfill gas regulations) and agriculture sector (included as offsets in Alberta's Specified Gas Emitter policy) also tend to access low-cost abatement opportunities.

Second, our analysis suggests about 15 Mt CO_2e of the reductions in 2020 are valued between $50 and $100 per tonne CO_2e, which we have classified as medium-cost reductions. Most medium-cost emission reductions come from the electricity sector and are weighted toward Ontario. The Ontario coal-fired electricity phase-out is therefore likely a significant driver of these reductions, as it accelerates the retirement of some plants ahead of their normal project life.

Finally, our analysis suggests that about 38 Mt CO_2e — or just over one-third — of emission reductions in 2020 from existing and proposed policies will be high cost at over $100 per tonne CO_2e. These higher cost emission reductions come from a range of sectors across all P/Ts, but have substantial contributions from transportation, building, electricity, and oil and gas sectors in particular. Emission reductions from vehicles — such as those induced by the federal vehicle standard — tend to have high marginal abatement costs overall, because individuals require strong incentives to switch to smaller, more fuel-efficient vehicles or vehicles that use alternative technologies like hybrid or electric engines. Emission reductions in commercial and residential buildings also tend to be largely high cost on a dollar per tonne basis, partly because buildings and appliances tend to become more efficient over time even in the absence of policies, thus reducing the incremental effect of policies implemented across all provinces to increase efficiency. Replacing more carbon-intensive electricity generation with low-carbon sources can have high costs as well, though as discussed below, electricity reductions are spread across all three cost levels. Finally, CCS projects in Alberta and Saskatchewan are estimated to drive both medium- and high-cost reductions, depending on the specific project.

Despite the concentration of low-cost reductions, the pursuit of some high-cost emission reductions suggests that governments have been willing — knowingly or not — in some cases to implement policies that tackle more than just the "low-hanging fruit."

5.3 ABATEMENT COSTS TO ACHIEVE 2020 TARGETS

As discussed in the previous chapter, existing and proposed policies are likely to lead to significant emission reductions, but will only achieve about half the emission reductions required to meet Canada's 2020 target. Additional government policies are required to induce the remaining 117 Mt CO_2e of emission reductions. This analysis assesses the cost implications of closing the gap. Figure 19 shows the costs of the *additional* 117 Mt CO_2e of emission reductions required to meet the 2020 target. Similar to the previous figure, it categorizes these additional emission reductions according to their economic cost of abatement. Our analysis suggests that *all* emission reductions available in Canada up to $150 per tonne must be achieved to meet the 2020 target.

FIGURE 19: POTENTIAL EMISSION REDUCTIONS REQUIRED TO CLOSE THE GAP TO CANADA'S 2020 TARGET BY ABATEMENT COST

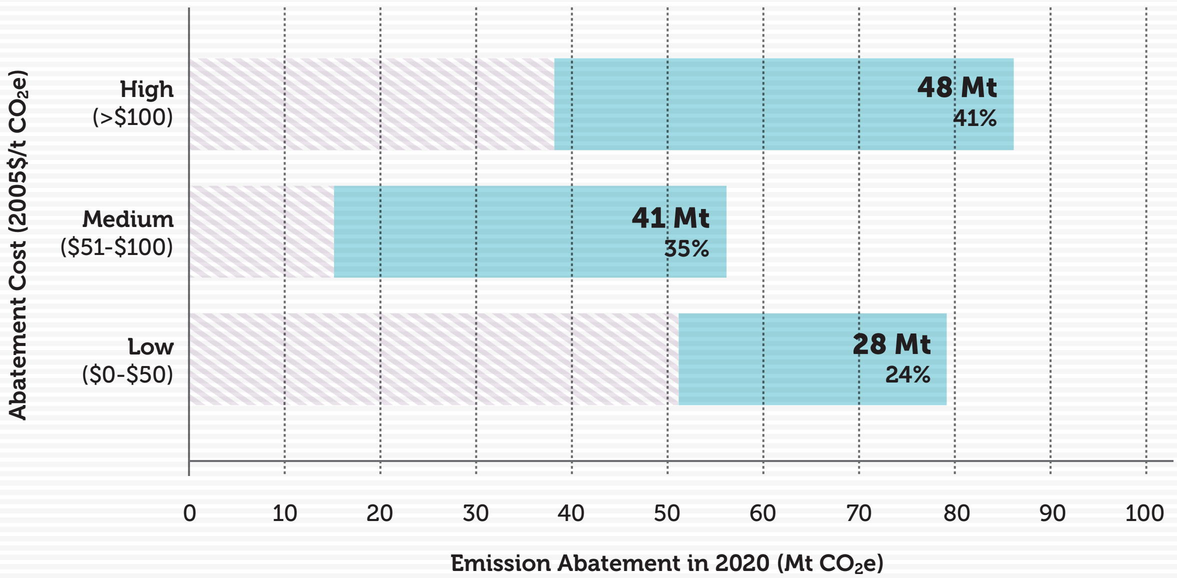
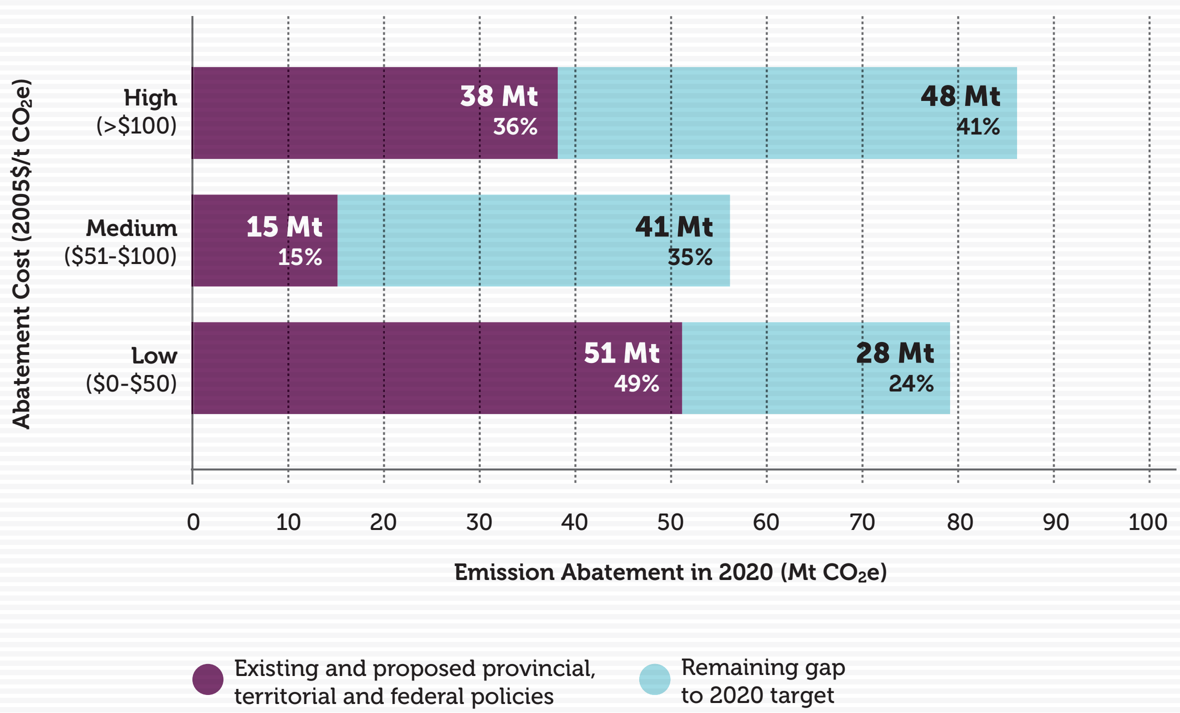


Figure 19 illustrates that about 75% of the gap between expected emissions in 2020 and the federal target for emission reductions can be closed only through medium- or high-cost emission reductions. These reductions are all cost-effective since they are the least expensive way to achieve the 2020 target. Almost 48 Mt CO_2e of reductions falls into the "high-cost" classification (which does not exceed $150 per tonne in this case), while about 41 Mt CO_2e of medium-cost reductions and 28 Mt CO_2e of low-cost reductions are available. The figure suggests that low-cost abatement opportunities are becoming limited in the context of the federal targets in 2020. Essentially, with only eight years to go until 2020, the opportunities for lower-cost abatement in the energy supply and industrial sectors are smaller because firms and households have already made investment decisions that have committed them to a certain level of emissions in 2020.

Figure 20 illustrates the cost profile of Canadian policies necessary to achieve the 2020 target. Essentially, the figure combines Figure 18 and Figure 19, stacking the required additional emission reductions to reach the 2020 target from Figure 19 onto the actual emission reductions expected to result from existing and proposed government polices as presented in Figure 18; again, these are classified as low, medium, or high cost.

FIGURE 20: EMISSION REDUCTIONS FROM EXISTING AND PROPOSED POLICIES IN 2020 AND POTENTIAL EMISSION REDUCTIONS TO CLOSE THE GAP TO CANADA'S 2020 TARGET BY ABATEMENT COST



In addition to the reductions expected from existing and proposed policies, *additional* policies are required to incent emission reductions equal to the remaining emissions gap. To meet Canada's 2020 target, *all* the emission reductions in the figure must be achieved. Our analysis shows that additional abatement is available at all cost levels. Though current and existing policies have targeted emissions across the cost spectrum, potential low- and medium-cost reductions still remain that are not yet targeted by any policy. Increasingly, however, Canadian climate policy will have to focus on medium- and high-cost emission reductions if Canada is to achieve its 2020 target.

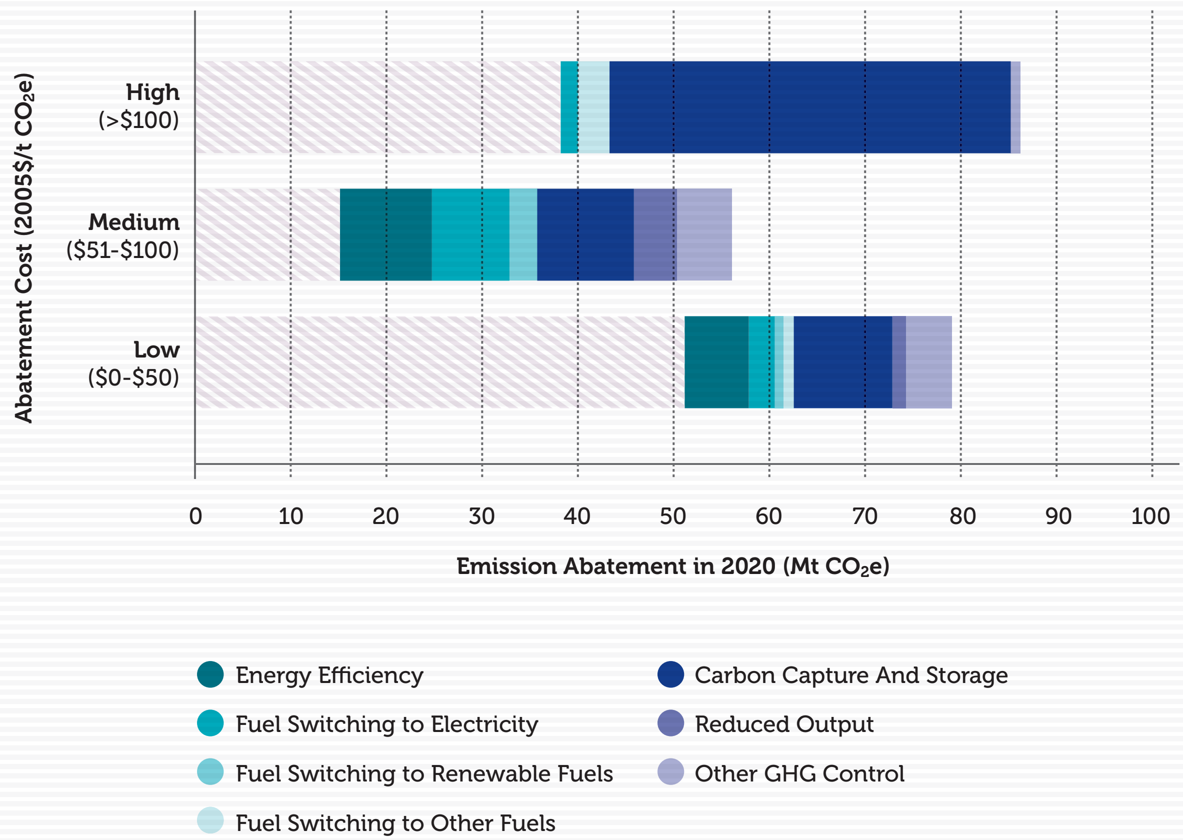
5.4 COST-EFFECTIVE EMISSION REDUCTIONS

How then should policy seek to achieve the additional cost-effective emission reductions required to meet the 2020 target? The high-, medium-, and low-cost reductions can now be disaggregated by the type of action that leads to reduced emissions by sector and by region to help inform the design of additional policies that federal and P/T governments could implement to incent these emission reductions. Note that the modelling analysis here does not make any assumptions about specific policies as drivers for the emission-reduction actions described. Governments could implement a range of possible policies to induce the cost-effective emission reductions described here. Of most interest is how the analysis could inform the federal government's sector-by-sector approach to regulation.

THE REMAINING EMISSIONS GAP DISAGGREGATED BY ACTION

Actions are the decisions that firms and households take to reduce emissions in response to government policy. For example, they can use energy more efficiently; use alternative fuels that produce fewer emissions (known as *fuel switching*); reduce production, producing less emissions but also less output; or implement CCS to capture and sequester CO_2 emissions. It is important to remember that all emission-reducing actions described here will occur only *in response to policy*. High-cost abatement actions will result from high-stringency policy by government. Figure 21 shows the low-, medium-, and high-cost components of the 117 Mt CO_2e emissions gap, disaggregated by action.

FIGURE 21: EMISSION REDUCTIONS TO CLOSE THE GAP TO CANADA'S 2020 TARGET BY ABATEMENT COST AND BY ACTION



The NRT analysis shows that CCS likely represents a key component of a cost-effective strategy to reduce emissions. In total, we show about 62 Mt CO_2e worth of carbon capture in 2020, representing more than 50% of additional emission reductions required, and while costs span a range of abatement costs, the emission reductions mostly occur at a marginal cost of greater than $100 per tonne CO_2e (though some lower-cost CCS is available where a pure stream of CO_2 can be captured). The CCS-intensive scenario shown here is credible given that in response to sufficiently strong policy signals (like a constant, steady carbon price of $100 to $150 per tonne CO_2e, for example) firms would quickly move to implement CCS. The very substantial investment in CCS projects required to achieve these reductions by 2020 would also require an accelerated permitting and construction environment enabled by government along with a clear policy signal about future carbon costs.[q]

The next most significant action is improving energy efficiency, which accounts for 16 Mt CO_2e of reductions in 2020. Potential energy efficiency improvements driving these reductions are concentrated in transport and buildings. However, gains in efficiency are partially offset by the increased energy demand coming from increased deployment of CCS.

Fuel switching to electricity accounts for about 13 Mt CO_2e of potential abatement in 2020. Electrification occurs in buildings and light industry at relatively low abatement cost. Some additional electrification is possible in transport, although its potential is constrained by the short time frame to 2020. Over the longer term, electrification is likely to play a much more significant role in cost-effective deep emissions abatement across the economy because equipment can be converted to electricity in pace with natural stock turnover, electric technologies such as heat pumps and batteries can be improved, and the electricity sector can fully decarbonize.

Remaining actions to close the gap include adopting other GHG control measures, fuel switching to renewable and other fuels, and reducing output. Collectively, these actions account for 26 Mt CO_2e of incremental abatement in 2020. Other GHG control measures include instituting changes to industrial processes and minimizing venting and flaring of emissions from the oil and gas sector. These actions are typically possible at low- and medium-cost thresholds.

Finally, we find that some abatement occurs in response to decreased industrial output of key energy-intensive products. Note that we assume that production of crude oil does not vary in response to climate policy. Though many facilities could potentially implement CCS and maintain production, as a result of this assumption the analysis likely underestimates the impacts of reduced output in contributing to a cost-effective approach to achieving 2020 targets.

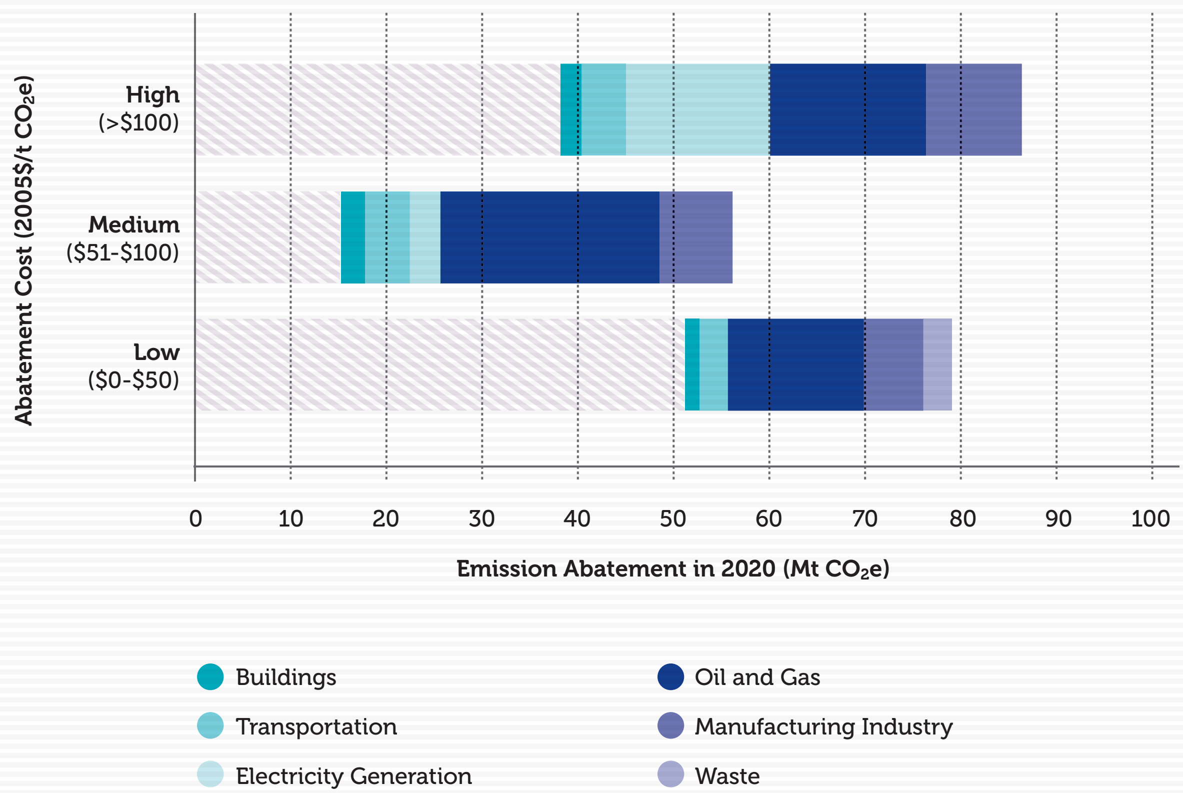
THE REMAINING EMISSIONS GAP DISAGGREGATED BY SECTOR

Exploring potential sector-level emission reductions is also illustrative, particularly given the federal government's stated intentions to move forward with sector-specific GHG regulations. Figure 22 breaks up the required emission reductions shown in Figure 19 by sector.[r] Again, the total emission reductions in the figure equal the 117 Mt CO_2e required to close the emissions gap. The figure therefore differentiates the low-, medium-, and high-cost emission reductions required to meet Canada's 2020 target in each sector of the economy.

q We also explored an alternative scenario that assumed CCS could not be broadly deployed by 2020. With less CCS, the gap to the 2020 target must be filled with much more high-cost abatement from energy efficiency improvements and reduced output. To achieve the 2020 target, abatement with costs up to $300 per tonne must be explored. The core scenario described above, however, with extensive CCS is consistent with Environment Canada's own modelling analysis of the potential for CCS, based on information exchanged with Environment Canada.

r Note that the sectoral breakdown provided here is a function of the CIMS structure and not entirely consistent with the activity-based breakdown used in Canada's National Inventory Report.

FIGURE 22: EMISSION REDUCTIONS TO CLOSE THE GAP TO CANADA'S 2020 TARGET BY ABATEMENT COST AND BY SECTOR



Sectors with larger potential reductions at lower costs should be prioritized, though to meet the 2020 target, all the additional emission reductions shown in Figure 22 must be incented by policy. A few notable findings emerge from the analysis:

This finding lends support to Environment Canada's consideration for oil and gas regulations as a next step in its sector-by-sector approach to emission reductions.

First, Figure 22 suggests that almost half the abatement required to close the gap could come from the oil and gas sector, and that most of this abatement could occur from this sector at relatively low and medium costs. This finding lends support to Environment Canada's consideration for oil and gas regulations as a next step in its sector-by-sector approach to emission reductions. It also makes sense that cost-effective reductions would exist in this sector: since it is poised to grow substantially, new production capacity can be built with lower emitting equipment if the correct policy incentives are in place. Lower-cost abatement actions in the oil and gas sector include energy efficiency improvements, fuel switching to electricity, and some CCS.

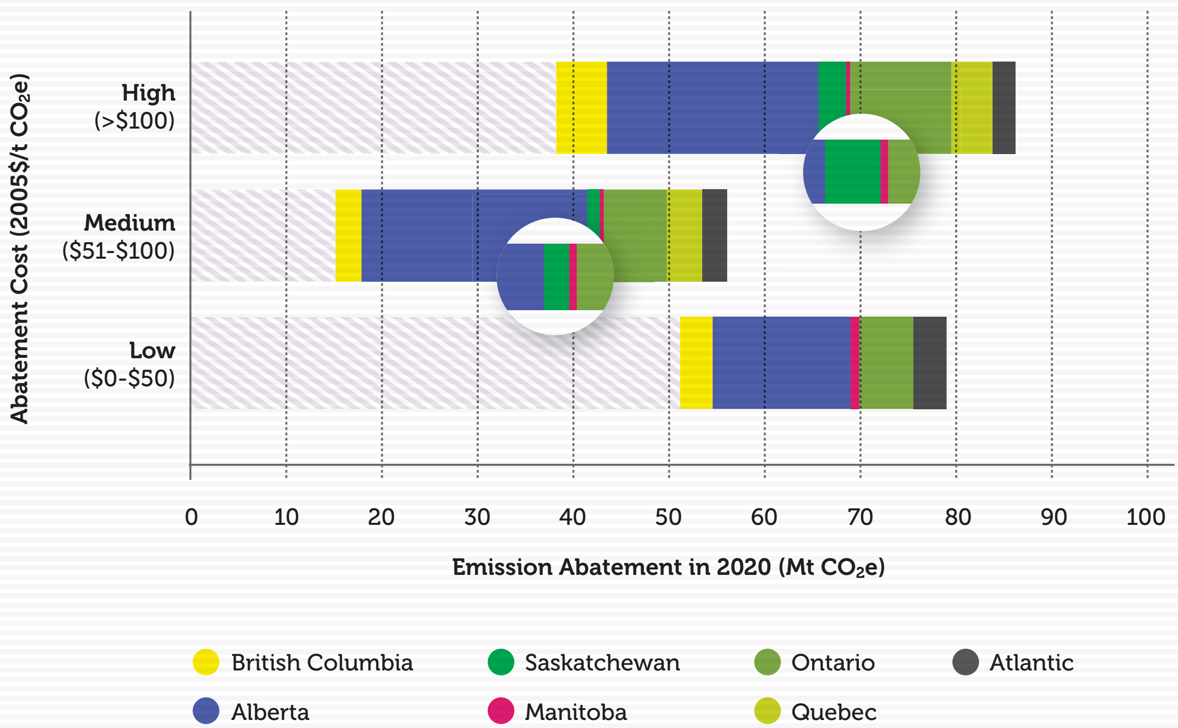
Second, some significant potential abatement from manufacturing sectors is likely available at low and medium cost. This potential for low-cost abatement likely exists because existing and proposed federal and P/T policies have not focused extensively on this sector.

Finally, additional potential abatement from electricity generation is also available in 2020 but is mostly high cost. This is due in part to the strong progress made to date in reducing emissions from this sector from low- and medium-cost measures, increasingly leaving higher cost emission reductions on the table. Additional reductions in the electricity sector largely come from retrofitting thermal coal facilities (with CCS mostly in Alberta and Saskatchewan), or shutting these facilities down and replacing them with less emitting sources including renewable energy. To meet the target, demand for electricity will likely increase further as a result of other policies that incent fuel switching away from oil and gas and toward electricity, making it more difficult for the electricity sector to abate over this time period.

THE REMAINING EMISSIONS GAP DISAGGREGATED BY REGION

Figure 23 illustrates that emission reductions are required across all regions and over a range of abatement costs in order to cost-effectively meet Canada's 2020 target.

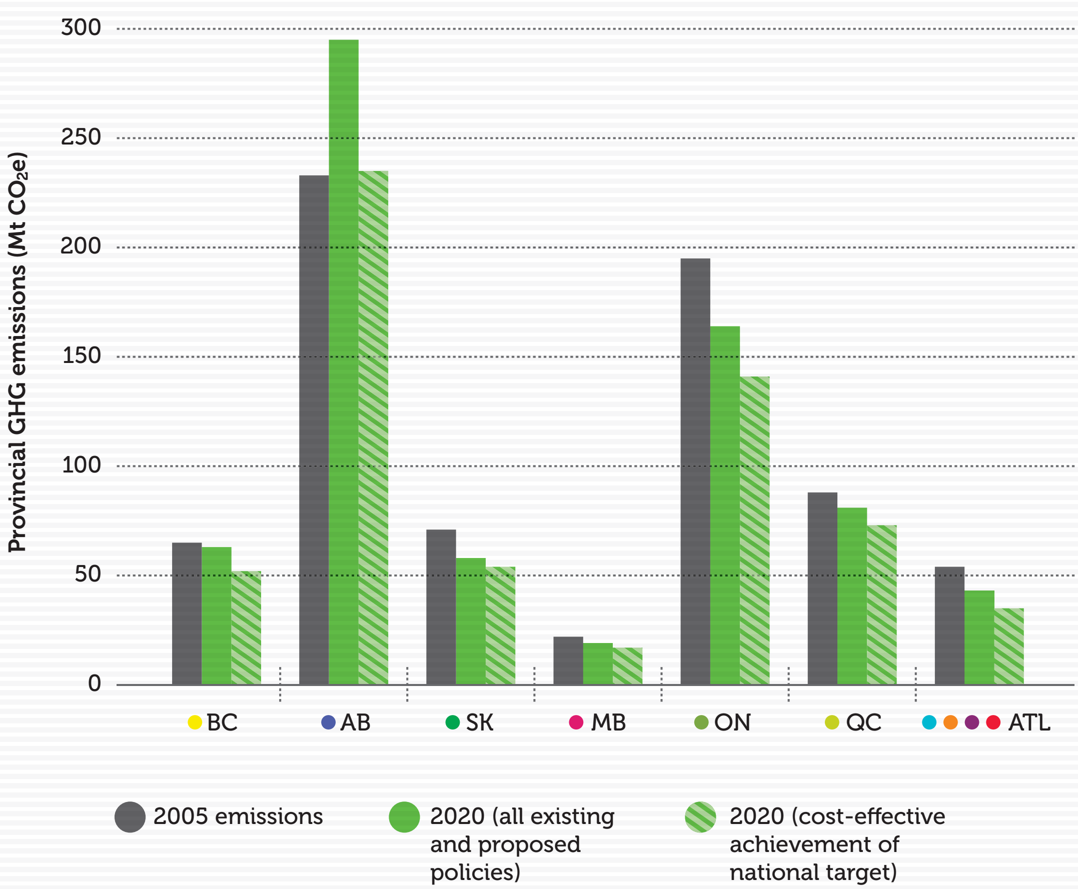
FIGURE 23: EMISSION REDUCTIONS TO CLOSE THE GAP TO CANADA'S 2020 TARGET BY ABATEMENT COST AND BY PROVINCE



A few specific results are notable. More cost-effective emission reductions are available in Alberta than in any other region, including about 22 Mt CO_2e of high-cost reductions, 24 Mt CO_2e of medium-cost reductions, and 15 Mt CO_2e of low-cost reductions. This finding matches the sector-level results discussed above, since many of the potential reductions in Alberta are in the oil and gas sector. Other provinces that require significant emission reductions are Ontario and British Columbia. British Columbia's low-cost reductions largely come from the natural gas sector. Ontario has about 6 Mt CO_2e of potential low-cost reductions — with a significant share in manufacturing sectors — and another 7 Mt CO_2e of potential medium-cost reductions. Almost all provinces have a share of required high-cost emission reductions; a large share of these high-cost potential reductions come from the transportation and building sectors, important in all regions of Canada. Overall, these findings reflect the challenge of the 2020 target: emission reductions must come from multiple sources across Canada, but most must occur in Alberta according to our analysis.

The results highlight the challenges of sharing the burden of national emission reductions across provinces. The distribution of potential emission reductions across Canada illustrated here is an economically efficient one. As noted earlier, to achieve the 2020 target cost-effectively, each province would need to achieve all emission reductions available that cost up to $150 per tonne CO_2e. Under this approach, the marginal cost of abatement is effectively equalized across the country with no emission reductions in any province costing more than $150 per tonne CO_2e. The total costs of abatement, however, will not be equalized given that provinces like Ontario and especially Alberta will contribute a large absolute share of emission reductions. This greater share of reductions is consistent with the larger total emissions and/or the faster emissions growth in these provinces. Figure 24 illustrates three snapshots of regional emissions. It shows actual emissions in 2005, emissions in 2020 accounting for all existing and proposed policies, and emissions in 2020 assuming that the remaining gap has been cost-effectively filled.

FIGURE 24: PROVINCIAL EMISSIONS IN 2020 AND COST-EFFECTIVE ACHIEVEMENT OF CANADA'S 2020 TARGET



Even though Alberta contributes the largest share of emission reductions in the cost-effective scenario, its emissions still grow by 1% from 2005 levels, whereas all other provinces see decreases between 17% and 36% relative to 2005 levels. Still, the distribution of reductions noted here is illustrative only. While it estimates the least-cost distribution of emission reductions across Canada, these results should not be interpreted as a fully prescriptive recommendation for policy. Burden sharing is complex and must reflect other factors in addition to economic efficiency, such as inter-regional equity considerations. GHG reductions in any one province are not just the responsibility of that province. But it paints the picture with which policy makers must grapple to make progress toward achieving any of our climate goals. Put succinctly, Canada's target cannot be achieved without emission reductions in Alberta, but Alberta alone cannot achieve Canada's target.

Put succinctly, Canada's target cannot be achieved without emission reductions in Alberta, but Alberta alone cannot achieve Canada's target.

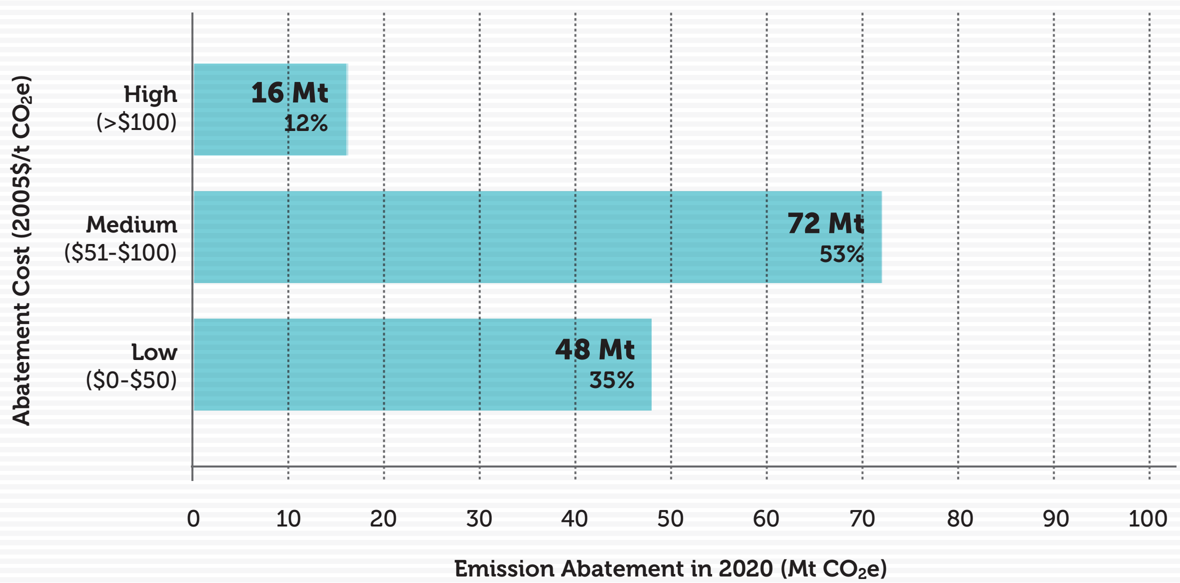
5.5 THE EMISSIONS GAP IN 2030

As noted, one of the main reasons Canada faces mostly high-cost potential abatement is the short period of time available between now and the 2020 target year. Limited time means limited opportunities to make emission reductions that coincide with normal capital stock turnover. Instead, the short time period requires a high level of emission reductions to be achieved by retrofitting or shutting down existing facilities or reducing output. These actions are more expensive than replacing old equipment as it is retired with lower-emitting options. To underline the importance of timing and delay, Figure 25 illustrates the low-, medium-, and high-cost potential emission reductions required for Canada to meet its 2020 target later, by 2030.

With a longer time period, the nature of the gap changes significantly. First, the overall size of the gap is larger (136 Mt CO_2e rather than 117 Mt CO_2e), given that emissions continue to grow between 2020 and 2030 even under all existing and proposed policies. Further, much more low- and medium-cost emission reductions are available because the longer time frame allows for reductions to take advantage of natural stock turnover as more emissions-intensive capital is retired and replaced with low-carbon alternatives.

The 2030 analysis has two main policy implications. First, it indicates that more lead time allows for emission reductions to match the normal speed of capital stock turnover, achieving reductions at lower cost. About 30 Mt CO_2e less high-cost reductions and about 20 Mt CO_2e more low-cost reductions are available to achieve the target over a longer time frame. Second, more time should not be considered a panacea for containing costs. High- and medium-cost reductions can still not be avoided. And delay, of course, results in more cumulative emissions being produced in the meantime. Less lead time to meet the target because of delays in policy action inevitably leads to increased costs of "catching up" to meet the target.

FIGURE 25: POTENTIAL EMISSION REDUCTIONS REQUIRED TO MEET CANADA'S 2020 TARGET IN 2030



5.6
CONCLUSION

These findings build on our previous assessment in Chapter 4 of likely emission reductions which concluded that Canada required additional climate action policies if it was to meet the federal 2020 target. This chapter provides insight as to how Canada might close the gap as cost-effectively as possible. It illustrates the sectors and regions in which opportunities for potentially low-cost emission reductions are likely available.
Here are the key findings:

- Most importantly, the analysis shows that Canada's 2020 target is a challenging goal that will require significant and more stringent policies to drive increasingly high cost reductions. A gradual process of trying to capture only the lowest cost emission reductions will not be successful. Yet the analysis also suggests that the target is not yet out of reach. Policies to incent reductions over the full spectrum of costs up to $150 per tonne over all regions and all major sectors could close the gap to 2020.
- A few key sectors, regions, and actions emerge as particularly important contributors to cost-effective emission reductions in 2020. The analysis clearly suggests the oil and gas sector, and Alberta in particular, have a significant role to play. This finding lends credence to Environment Canada's intention to regulate emissions in this sector. CCS shows as a key contributor to emission reductions in the sector.
- Yet the results also suggest that no one sector, region, or action is a silver bullet for achieving targets. A cost-effective approach to achieving targets requires emission reductions across all sectors and jurisdictions in Canada. This insight highlights a *policy gap* for Canada that parallels the *emissions gap*. To achieve all the required least-cost emission reductions, Canada therefore requires either 1) an economy-wide national policy approach or 2) coordination between different levels of government and among different policy mechanisms. Neither approach currently exists in Canada.
- Finally, the analysis also highlights that the short time frame to 2020 is a challenge for Canada. Because 2020 is only eight years away, many of the emission reductions required to meet the target are high-cost reductions. In the context of 2030, for example, substantially more low-cost reductions are available. This finding illustrates the challenge for Canada, but also an important lesson: delays to a coordinated approach with abatement coming from all provinces and all sectors, will only increase the final costs of achieving Canadian climate goals and targets.

6.0 GETTING TO 2020 – CONCLUSIONS AND ADVICE

CANADA STANDS AT A DECISION POINT FOR ACHIEVING ITS 2020 GREENHOUSE GAS REDUCTION TARGET. THE NRT'S ORIGINAL AND COMPREHENSIVE ANALYSIS DEMONSTRATES A LARGE GAP BETWEEN CANADA'S EMISSIONS TRAJECTORY AND THE FEDERAL GOVERNMENT'S TARGET OF 17 PER CENT BELOW 2005 LEVELS BY 2020. FURTHER, WE SHOW THAT THE COST OF ACHIEVING THE CANADIAN CLIMATE POLICY TARGET IS HIGH OWING TO THE SHORT TIME FRAME REMAINING TO MEET THE TARGET, A LACK OF COORDINATION BY GOVERNMENTS, AND THE GROWING EMISSIONS FROM SOME ECONOMIC ACTIVITIES. IT IS GETTING HARDER, NOT EASIER, TO ACHIEVE CANADA'S CLIMATE POLICY GOALS THE LONGER TIME GOES ON.

This chapter sets out the main conclusions from our qualitative assessment of provincial plans and our original modelling analysis of federal and provincial emission reductions measures. It provides advice and recommendations on steps that Canadian governments should take to put us on a realistic, achievable path to our 2020 target.

6.1 WHERE ARE WE?

ASSESSING THE GAP

CANADA IS MAKING PROGRESS TOWARD ITS 2020 TARGET BUT WILL NOT GET THERE WITH ONLY THE EXISTING AND PROPOSED MEASURES.

There is some good news in our analysis. Progress has been made and Canada will likely achieve almost half of its 2020 target, taking into account all existing and proposed emission-reduction measures. This is significantly better than previously projected by Environment Canada.[71] However, given that our full analysis includes all likely policy actions by governments — large and small — the NRT can also conclude that Canada will not achieve its 2020 GHG emission reductions target unless significant new, additional measures are taken. More will have to be done. No other conclusion is possible.

PROVINCIAL POLICIES ARE DRIVING THE LARGEST PORTION OF EMISSION REDUCTIONS TO DATE.

Climate policy actions by provincial governments account for almost three-quarters of estimated emission reductions in 2020, with only about one-quarter being derived from existing federal measures. This proportion changes somewhat leading to 2030 when existing federal measures are forecasted to account for about one-third of emission reductions.

THE PROVINCES ARE MAKING PROGRESS TOWARD THEIR OWN TARGETS BUT ALMOST ALL WILL NEED TO INTRODUCE ADDITIONAL MEASURES TO MEET THEM.

Despite significant progress overall, only Nova Scotia and Saskatchewan[s] are likely to achieve their targets as of now with Ontario coming close. Progress by provinces toward their own emission-reduction targets reinforces in part why Canadian progress overall is insufficient. Gaps provincially contribute to gaps nationally. This further reinforces the need for better coordination of emission-reduction actions by both levels of government since efforts by both have contributed to progress to date and will be needed to do more.

Canada will not achieve its 2020 GHG emission reductions target unless significant new, additional measures are taken. More will have to be done. No other conclusion is possible.

SOME PROPOSED FUTURE MEASURES HOLD POTENTIAL TO CLOSE PART OF THE GAP TO FEDERAL AND PROVINCIAL TARGETS.

The federal government has indicated an intention to develop regulatory measures to reduce emissions from the burgeoning oil and gas sector as part of its sector-by-sector regulatory approach and has begun consultations with industry. As the NRT analysis shows, this sector is an important source of emission-reductions opportunities, either in terms of slowing growth trends or driving absolute reductions at some point in the future. Indeed, our cost-effectiveness analysis shows that there are emission-reduction opportunities in this sector at low, medium, and high costs that could occur over the next eight years. Given that no details exist publicly on this possible measure from the federal government, it is impossible, however, to assess its effectiveness in reducing emissions from this sector by 2020. This will depend on when the regulations come into force and how stringent they are. No other sectors have been formally identified for regulatory action by the federal government as of 2012 so again, it is impossible to forecast a better outcome than we have currently modelled or to state with confidence that Canada will meet its 2020 target once other measures or actions are put in place.

Some provinces have indicated additional measures may be forthcoming from them. Next-generation climate policy plans will come forward from Québec for 2013 and possibly Manitoba and New Brunswick. But these actions alone will not bridge the national gap, however useful they are at the provincial level and in the longer run.

s Representatives from the Government of Saskatchewan's Department of Environment have noted that, in their view, the NRT's forecast likely underestimates economic growth in Saskatchewan, and thus the extent to which emissions are likely to increase. This concern may be legitimate; recent trends in Saskatchewan have shown rapid growth in both population and economic activity. A recent short-term RBC forecast suggests that Saskatchewan could have the highest growth rates of all provinces by 2013 (RBC Economics 2012). However, we did not have alternative, long-term macro-economic assumptions that could be used for this modelling. Our forecast is rooted in consistent assumptions about regional and sector-level growth in production drawn from Environment Canada's modelling, which is in turn based on macro-economic forecasts from Informetrica.

CLOSING THE GAP

THE FRAGMENTED NATIONAL AND PROVINCIAL APPROACH HAS CREATED LIMITED OVERLAP TO DATE BUT WILL LIKELY BE MORE PROBLEMATIC IN THE FUTURE.

Shifts in federal policy — first away from Kyoto to an industrial emitters' cap-and-trade program called *Turning the Corner*, then to the Copenhagen Accord and U.S. alignment, and now a regulatory sector-by-sector approach — have created uncertainty for provinces as to the national policy framework within which to undertake their own actions. Responding to their own perceived need and opportunity for actions, provinces have all established their own independent climate policy plans and goals. Inter-provincial coordination has occurred in Atlantic Canada on targets and with Ontario, Québec, British Columbia, and Manitoba on the Western Climate Initiative. Recent decisions by the federal government to accommodate provincial actions though equivalency agreements on the coal-fired electricity generation regulation[72] is another example of coordination, if after the fact.

Does this fragmented "go-it-alone" approach matter? Our conclusion: not that much so far, but a lot more in the years ahead. Our analysis shows a limited amount of duplication and overlap between federal and P/T actions in emission-reduction efforts to date. In 2020, this will amount to about 10 Mt CO_2e. Looking ahead, however, is a different story as this amount is expected to rise to 41 Mt CO_2e by 2030. Chasing the same emission reductions by both levels of government is both inefficient and ineffective; Canada will realize fewer reductions at potentially higher costs.

THE COST OF ADDITIONAL POLICIES TO CLOSE THE GAP WILL BE HIGHER ON AVERAGE THAN POLICIES PURSUED TO DATE.

Our analysis shows that while almost half the emission reductions to date from existing and proposed measures have been in the low-cost range of $50 per tonne and under, achieving our 2020 target will require an increasing share of emission reductions to come from medium- and high-cost measures. A clear consequence of failing to develop a coordinated economy-wide, pan-Canadian approach to climate change is that governments have for the most part focused on the least-cost emission reductions first. As the cheapest opportunities for emission reductions are exhausted, higher cost measures will be necessary for most of the emission reductions ahead if we are to meet our 2020 target.

The NRT analysis for Environment Canada reinforces a central conclusion of all our work and many other independent sources: delay is costly. Put directly, time is money. The closer the target date approaches, the higher the carbon prices will have to be to incent investment in capital stock turnover, develop and deploy and new technologies, and change firm and household energy-use behaviour. This was a conclusion we reached in our 2008 report for the Minister of the Environment at the time, called *Getting to 2050*, as well as our 2010 report *Achieving 2050: A Carbon Pricing Policy for Canada*. High projected carbon prices and resultant economic consequences played a key part in the federal government's decision not to meet Canada's Kyoto Protocol target and ultimately to announce withdrawal from the treaty. Now, several years later, high carbon prices needed to achieve the more modest but still stringent 2020 target may once again discourage governments from taking effective action.

ADDITIONAL CONSULTATION MECHANISMS ARE NEEDED.

The sole formal mechanism for intergovernmental collaboration on the environment is the Canadian Council for the Ministers of the Environment (CCME); however, similar intergovernmental fora relating to energy and transportation may also be a useful location to discuss sector-specific aspects of climate policy. Operating by consensus, the CCME has done useful work on technical and regulatory issues such as waste and wastewater (and possibly clean air, which it is now engaged in), but has not recently been used as a forum for either discussing or engaging in broader climate policy discussions. Participants at the NRT's Canadian Climate Policies Dialogue concluded that to date, no effective federal/provincial/territorial engagement exists for developing and implementing pan-Canadian climate policies. Concerns were raised that CCME may not be an effective vehicle to take on this role in part because of the prospect of a "joint decision trap" whereby collaboration and consensus leads to outcomes supporting the lowest common denominator. Provincial governments are concerned about the lack of provincial-federal coordination given the federal sector-by-sector regulatory approach to emission reductions. Two concerns were expressed: first, that sector-by-sector regulations would have an effect on provincial energy and climate policies already in place or underway and their regulated power utilities; and second, that the absence of any intergovernmental forum or mechanism meant that other, more effective policies such as carbon pricing were not being explored or were being effectively precluded. Bilateral equivalency agreements between the federal and provincial governments of Nova Scotia, British Columbia, and Saskatchewan (although details are lacking) may address some of these policy coordination issues.

Provinces echoed the desire for greater certainty in federal and, by extension, national policy approaches. Shifts in past federal policy, from Kyoto to *Turning the Corner* to Copenhagen, created a policy vacuum that provinces have partly filled within their jurisdictional competence. Complicating any cohesive national approach is provincial natural resource ownership and the provinces' right to determine exploitation and receive royalties from that development. With energy and emission patterns so different across the country, climate policy targets, timelines, and actions supporting emission reductions are as much a function of Canada's political economy as its is energy economy. Reducing emissions in every other province but Alberta, for example, given its growing oil and gas sector's contribution to forecasted emissions growth, will leave Canada short of achieving its stated target. So, what provinces do on their own matters. And, how the federal government either fills that gap with its own measures or seeks to coordinate climate policies across the country in some fashion definitely matters.

ALL GOVERNMENTS WILL NEED TO PARTICIPATE TO SUCCESSFULLY MEET THE 2020 TARGET.

The NRT analysis shows that in order for Canada to achieve its 2020 target as cost-effectively as possible, all governments, all provinces, and all sectors will need to contribute. No one sector and no one province can make up all the difference. This puts a premium on intergovernmental collaboration and coordination of measures. But our findings demonstrate that the most important sector to contribute in this period will be oil and gas with almost half the cost-effective abatement by 2020 coming from this sector alone. Therefore the most significant province for future emission reductions will be Alberta. But this will be insufficient by itself. Other sectors such as electricity generation, manufacturing, transportation, buildings, and waste will all need to reduce emissions. This means all other provinces, notably Ontario, British Columbia, Saskatchewan, and Québec, will need to contribute additional emission reductions.

6.2 HOW DO WE MOVE AHEAD?

KEY ELEMENTS

To achieve the 2020 target, Canada has a choice to make, a choice that principally lies with the federal government. That choice is either to "go it alone" or "work together." The choice is "more of the same" or "regulations plus." The federal government need not fundamentally alter its current regulatory, sector-by-sector approach. But it will need to accelerate and complement it. To be sure it meets the 2020 target it needs to supplement current policy with a more coordinated F/P/T approach to drive additional near-term reductions. It needs to consider how to achieve this with a more collaborative process with provinces to discuss — beginning soon and continuing regularly — how to avoid costly duplication and overlap, realize more efficient and cheaper emission reductions, and enable other tools, namely carbon pricing, to be used in conjunction with current and future policies by the federal government, a province, or a group of provinces under the framework of equivalency or memorandums of understanding.

The federal government need not fundamentally alter its current regulatory, sector-by-sector approach. But it will need to accelerate and complement it.

Let's look at each key element for developing additional policies.

Timing — The 2020 target is eight years away. This is long in terms of political cycles (two full electoral terms) but short in terms of investment and innovation cycles where capital stock can take decades to turn over. The sooner regulatory and market signals are available, the sooner the capital stock will transform to lower-emitting technologies and drive down GHG emissions. The sooner emissions begin to fall, the greater the contribution will be to limiting the cumulative stock of emissions in the atmosphere, which is better for both the environment and the economy.

Certainty — "Long, loud, and legal" is a term researchers in the United Kingdom have used to describe good climate policy signals.[73] Transparent and long-term rules and stringent and enforceable policy are all essential parts of developing policy certainty in our Canadian climate framework. Provinces stated this at the NRT dialogue session was a desirable and necessary condition to their own planning and actions (see Appendix 7.8).

Flexibility — Successful climate policy balances the need for long-term policy certainty with the need to be responsive to changing developments. As the NRT set out in *Achieving 2050: A Carbon Pricing Policy for Canada*, key sources of uncertainty include policies of Canada's trading partners, economic development, and distributional effects of policies.[74] Observing changes over time and adjusting policies in response will enhance the success of future policies.

Price — Given the remaining gap to achieving the 2020 target, there is strong interest in finding ways to achieve the best environmental outcomes at the least economic cost. Devising policies that are market-based, coincide with capital stock turnover cycles, and allow industry and others to innovate and invest in effective technologies rather than prescribing specific technological solutions are strategies to keep costs low. Finding the right price signal is key.

Burden — Climate policy, given its interconnections between energy, natural resource exploitation, and environment, is impossible to compartmentalize effectively in a federal state. Emissions are neither exclusively federal nor provincial. Yet the federal government is uniquely positioned to influence the actions of provinces, by acting or not acting itself, and by favouring some policy instruments over others. As we have seen, Canada's emissions profile is not an even one across the country. Sources of emissions vary with Alberta, Ontario, and Québec being the largest overall contributors, but Alberta, Saskatchewan, New Brunswick, and Nova Scotia being the largest per capita contributors. This uneven distribution of emissions makes our challenge not just a significant energy/emissions one, but also a significant political economy one. An equal reduction across all provinces at this stage would be neither fair nor effective. Yet, burden-sharing in Canada is a hallmark of our unique brand of federalism and suits this policy challenge well. It is clear that a lack of it will hinder effective progress on the file. In time, there is a risk that no further action will be taken individually, if not taken collectively. Similarly, the fiscal transfer prospect of reducing emissions in one province while seemingly distributing the benefits financially to another could be perceived as unfair and likely prevent progress from occurring.
Yet, jurisdictions that benefit from the exploitation of the natural resources in their jurisdiction have an obligation to contribute to addressing the environmental consequences of that exploitation. If Canada is to meet its 2020 target, then all Canadians must play their part.

Collaboration — Canada's 2020 target is a target on behalf of all Canadians. It has been committed to internationally. In theory, it can be achieved by the federal government acting alone or by the provinces and territories acting alone. In fact, this will never occur in our federation given the history of climate actions to date and the constitutional jurisdiction each level of government has in the areas of natural resources, energy, and environment. Both levels of government need to fully contribute because of the policy instruments each has and the different emission profiles across the country. Collaboration is essential going forward unless the federal government takes full and complete responsibility for all remaining emission reductions to get to the 2020 target. Its regulatory instrument can be effective in getting new emission reductions but it will have to extend its reach to include many sectors in a short time period.

Policy — While each province has a range of actions under its climate policy plans, a few key policies are driving the majority of actual emission reductions to date (e.g., phasing out coal-generated electricity plants in Ontario, a legislated renewables target in Nova Scotia, carbon tax in British Columbia). Provinces expressed the desire for more policy flexibility from the federal government in two areas: first, in terms of how its regulatory approach is being applied through better coordination via advance consultation and possible equivalency agreement; and second, in considering a modest but real national carbon pricing policy that would allow them to take more cost-effective actions in response.

Assessment — Knowing where Canada is at any one time and regularly forecasting ahead to estimate future progress is basic to any sound evaluation of climate policy effectiveness. Adapting policy actions in response to regular assessments is just common sense. The NRT was asked formally by the federal minister of the environment to conduct this analysis. It is the first such forecasting analysis done and released publicly. This should be normal not exceptional. Regular presentations, analysis, and forecasts of progress under various scenarios and policy actions are a key tool for decision makers.

Actions across each of these key elements are the best guarantee not just of achieving Canada's 2020 climate policy target but also of ensuring longer-term emission reductions after 2020, which remains a global imperative to limit the dangerous consequences of climate change.

We recommend that advances in future Canadian climate policy meet three tests: they should be collaborative, coherent, and considered. We call it *3C*.

6.3 NRT ADVICE

The NRT offers the following advice to the Minister of the Environment, the Government of Canada, and provincial and territorial governments. We recommend that advances in future Canadian climate policy meet three tests: they should be collaborative, coherent, and considered. We call it *3C*. **Collaborative** across governments by meeting regularly and specifically on climate policy; **Coherent** by acting together in a coordinated way to reinforce each other's policies and determine who is best positioned to act in one area over another; and **Considered** by undertaking regular progress reports and assessments of how well Canada is meeting targets and forecasting to help consider future actions.

COLLABORATIVE

Canada needs greater intergovernmental collaboration to make sustained progress toward its climate policy goals. There is a need for a regular forum for governments to engage together on developing and implementing climate policies and actions.

- To ensure ongoing political engagement across governments, establish a federal/provincial/territorial ministerial-level climate policy forum led by environment ministers, and joined by energy ministers, to meet annually to discuss trends and issues in Canadian and international climate policy development.
- To ensure ongoing technical engagement across government and support the work of ministers, establish a federal/provincial/territorial working group of climate policy officials to meet annually to discuss trends and issues in Canadian and international climate policy development.
- To foster greater interprovincial, regional, and provincial/state collaboration on climate change, the Council of the Federation should highlight and share success stories, lessons, and policy tools by governments and others.

COHERENT

Canada needs stronger coordination of climate policy measures between governments to choose a coherent and cost-effective means of achieving targets. This will foster more policy certainty, mutually reinforcing policies; reduced duplication and overlap in efforts; and consideration of alternative policy actions over time.

- To bring greater certainty to Canada's climate policy efforts, the federal government should release a plan detailing sectors and timing for future regulatory action under its sector-by-sector approach, setting out time frames, expected emission reductions and cost-benefit information and highlighting complementarity with current federal/provincial/territorial efforts.
- To encourage continued federal/provincial/territorial actions that avoid duplication and overlap of policies, the federal government should set out the principles and process for using equivalency agreements or other intergovernmental protocols such as MOUs, based on innovation, flexibility, and agreed emission-reduction outcomes and time frames.
- To complement the federal government's sector-by-sector regulatory approach and ensure the most effective and lowest cost emission reductions are sought to benefit the Canadian economy as a whole, a base-level carbon pricing regime should be considered upon which governments could add additional measures, with any and all revenue recycling being returned to the jurisdiction in question.

CONSIDERED

Canada needs better climate policy data, information, and forecasts for governments to use that allow for regular evaluation of progress toward its climate policy goals. Independent, transparent, and regular reporting of progress toward targets and goals, and effectiveness of policies and measures is a basic foundation of sound climate policy development that can adapt to changing circumstances.

- To ensure access to high-quality data for effective policy making, an independent federal/provincial/territorial climate and emissions information group should be established, funded equitably by all governments and managed collectively by governments, to ensure more regular and accurate inputs to both emissions reporting, modelling, and forecasting.
- To set the stage for regular reviews of climate progress by intergovernmental ministers and Parliament, Environment Canada should add a regular forecasting component based on results from either its own projections or from the independent intergovernmental climate information group to its annual Emissions Trends report detailing short-, medium-, and longer-term projections under various climate policy scenarios.
- To provide citizens, taxpayers, and policy makers with up-to-date progress on achieving climate policy targets and goals, governments should produce and publish a regular, independent assessment of progress and challenges within their jurisdiction and nationally for the country as a whole.

7.0 APPENDICES

7.1
MINISTERIAL REFERENCE LETTER

Minister of the Environment — Ministre de l'Environnement

Ottawa, Canada K1A 0H3

Mr. Robert Page
Chair
National Round Table on the Environment
and the Economy
344 Slater Street, Suite 200
Ottawa ON K1R 7Y3

Dear Mr. Page:

I am writing to request that the National Round Table on the Environment and the Economy (NRTEE) provide advice to the Government in support of its environmental agenda.

As an independent advisory agency which reports to Parliament through the Minister of the Environment, the NRTEE is in a unique position to advise the federal government on sustainable development solutions.

The Government of Canada has in the past asked the NRTEE to conduct research and provide advice on key and emerging issues, and today, I am seeking advice on two important issues that will help guide future federal government environmental policies.

1. Comprehensive Review of Provincial and Territorial Climate Change Plans and Policies

As you know, the Government of Canada has a plan to address climate change and meet its 2020 greenhouse gas (GHG) reduction target by pursuing a systematic approach of regulating GHG emissions sector by sector. Environment Canada recently released *Canada's Greenhouse Gas Target and Emissions Projections* indicating that federal government actions to date, combined with provincial and territorial government measures, are expected to result in 65 megatonnes of GHG emissions reductions by 2020, or roughly one quarter of the emissions reductions needed to achieve the 2020 target of 17 percent below 2005 emissions.

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Canada

In its recent report from the Climate Prosperity series, *Parallel Paths: Canada-U.S. Climate Policy Choices*, the NRTEE references Environment Canada's projections. While Environment Canada's emissions outlook projections have been reviewed by independent experts, I believe that there would be merit in in-depth analysis of provincial and territorial climate change plans, as well as the measures that provincial and territorial governments have taken and are preparing to take, and their expected contribution to the 2020 target of 17 percent below 2005 emissions.

Specifically, an analysis of the provincial plans to reduce emissions, progress to date in implementing their plans, and an estimate of the emissions reductions expected from current and future provincial and territorial climate change initiatives by 2020 would provide a better understanding of their likely contribution to the Government's 2020 emissions reduction target. Such an analysis would inform the Government's overall effort to achieve its 2020 target for GHG emissions through a sector-by-sector regulatory approach.

2. Assessment of Potential Life Cycle Approaches to Enhance Environmental Sustainability

Life cycle techniques have been utilized since the mid-1980s by the private sector to manage costs, including those of an environmental and social nature. The ability to analyze the costs of a product from design, production, distribution and finally, as a waste product, allows a firm to identify areas for cost reduction or for making productivity gains.

Life Cycle has not been as well integrated within the public sector despite the potential advantages afforded in developing environmental policy. The design of policy need not solely be based on reacting to, or regulating, an isolated negative environmental outcome that lies within a government's purview. Knowledge of the entire production chain from design to waste might allow government to step beyond its traditional role and to try to mitigate environmental impacts before they manifest in the form of a public/private partnership. For example, a simple intervention at the design phase of a product could yield positive environmental outcomes downstream, particularly at the waste and recycle stage.

In Europe, there have been several initiatives that attempt to effect change over the course of a product's or service's life cycle. One of the most notable, Extended Producer Responsibility, appears to have had much success, particularly in the automotive sector.

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What would the implications be of applying this kind of approach? Is the life cycle approach a useful technique for integrating economic and environmental costs so as to recognize the real value of environmental goods and services? Is there a way to advance a life cycle approach to environment stewardship in Canada that supports economic competitiveness?

I am requesting that this advice be provided to the Government no later than March 2012. I expect the process to be carried out within the current budget of the National Round Table.

Environment Canada and other departments and agencies of the Government are prepared to contribute to the work of the Round Table as required.

Thank you in advance for your members' commitment and their contribution to the environment, the Canadian economy, and the health of Canadians.

Sincerely,

Peter Kent

The Honourable Peter Kent, P.C., M.P.

7.2
CIMS MODEL

CIMS is an energy-economy model that is maintained by Navius Research, Inc. and the Energy and Materials Research Group at Simon Fraser University.[t] CIMS has a detailed representation of technologies that produce goods and services throughout the economy and attempts to simulate capital stock turnover and choice between these technologies realistically. It also includes a representation of equilibrium feedbacks, such that supply and demand for energy intensive goods and services adjusts to reflect policy.

CIMS simulations reflect the energy, economic and physical output, GHG emissions, and CAC emissions from its sub-models as shown in Table 9. CIMS does not include adipic and nitric acid, solvents or hydrofluorocarbon (HFC) emissions. CIMS covers nearly all CAC emissions except those from open sources (e.g., forest fires, soils, and road dust).

t For more information, please visit www.NaviusResearch.com

TABLE 9: SECTOR SUB-MODELS IN CIMS

SECTOR	BC	AB	SK	MB	ON	QC	ATLANTIC
Residential	✓	✓	✓	✓	✓	✓	✓
Commercial/ Institutional	✓	✓	✓	✓	✓	✓	✓
Personal Transportation	✓	✓	✓	✓	✓	✓	✓
Freight Transportation	✓	✓	✓	✓	✓	✓	✓
Industry							
Chemical Products	✓	✓	✓		✓	✓	
Industrial Minerals	✓	✓			✓	✓	✓
Iron and Steel			✓		✓	✓	
Non-Ferrous Metal Smelting*	✓			✓	✓	✓	✓
Metals & Mineral Mining	✓		✓	✓	✓	✓	✓
Other Manufacturing	✓	✓	✓	✓	✓	✓	✓
Pulp and Paper	✓	✓			✓	✓	✓
Energy Supply							
Coal Mining	✓	✓	✓				✓
Electricity Generation	✓	✓	✓	✓	✓	✓	✓
Natural Gas Extraction	✓	✓	✓	✓	✓	✓	✓
Pet. Crude Extraction	✓	✓	✓		✓		✓
Petroleum Refining	✓	✓	✓		✓	✓	✓
Agriculture & Waste	✓	✓	✓	✓	✓	✓	✓

** Metal smelting includes Aluminium.*

MODEL STRUCTURE AND SIMULATION OF CAPITAL STOCK TURNOVER

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

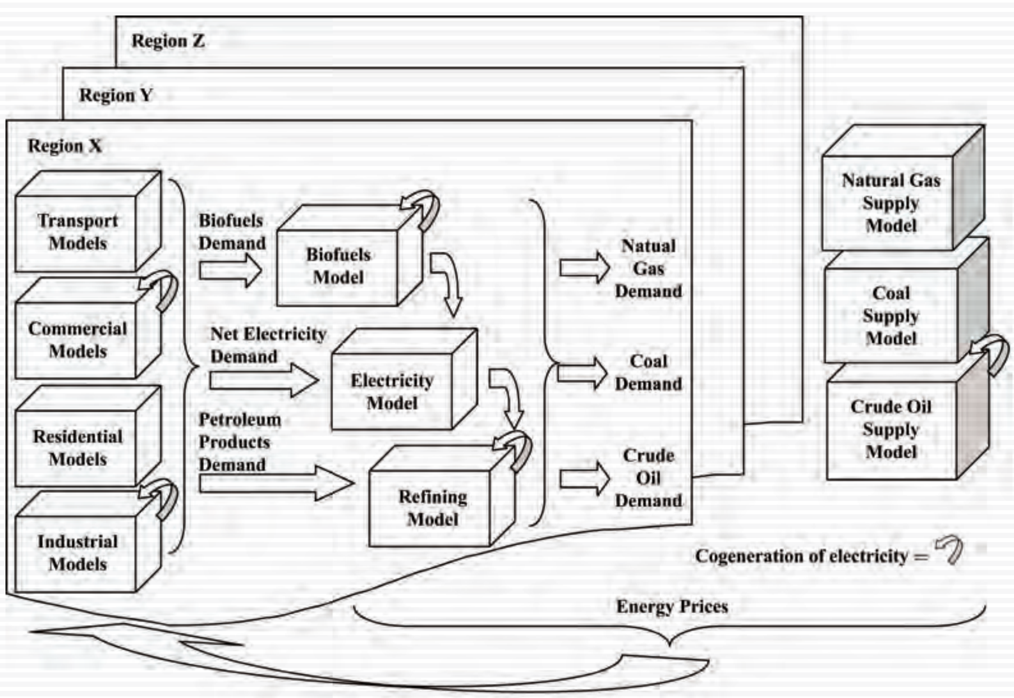
CIMS simulates the competition of technologies at each energy service node in the economy based on a comparison of their life cycle cost (LCC) and some technology-specific controls, such as a maximum market share limit in the cases where a technology is constrained by physical, technical or regulatory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

EQUILIBRIUM FEEDBACKS IN CIMS

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

CIMS estimates the effect of a policy by comparing a business-as-usual forecast to one where the policy is added to the simulation. The model solves for the policy effect in two phases in each run period. In the first phase, an energy policy (e.g., ranging from a national emissions price to a technology specific constraint or subsidy, or some combination thereof) is first applied to the final goods and services production side of the economy, where goods and services producers and consumers choose capital stocks based on CIMS' technological choice functions. Based on this initial run, the model then calculates the demand for electricity, refined petroleum products and primary energy commodities, and calculates their cost of production. If the price of any of these commodities has changed by a threshold amount from the business-as-usual case, then supply and demand are considered to be out of equilibrium, and the model is re-run based on prices calculated from the new costs of production. The model will re-run until a new equilibrium set of energy prices and demands is reached. Figure 26 provides a schematic of this process. For this project, while the quantities produced of all energy commodities were set endogenously using demand and supply balancing, endogenous pricing was used only for electricity and refined petroleum products; natural gas, crude oil and coal prices remained at exogenously forecast levels (described later in this section), since Canada is assumed to be a price-taker for these fuels.

FIGURE 26: CIMS ENERGY SUPPLY AND DEMAND FLOW MODEL



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

EMPIRICAL BASIS OF PARAMETER VALUES

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

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

u CIMS' Armington elasticities are econometrically estimated from 1960–1990 data. If price changes fall outside of these historic ranges, the elasticities offer less certainty.

v CIMS uses the 2001 100-year global warming potential estimates from Intergovernmental Panel on Climate Change, 2001, "Climate Change 2001: The Scientific Basis," Cambridge, UK, Cambridge University Press.

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

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

SIMULATING ENDOGENOUS TECHNOLOGICAL CHANGE WITH CIMS

CIMS includes two functions for simulating endogenous change in individual technologies' characteristics in response to policy: a declining capital cost function and a declining intangible cost function. The declining capital cost function links a technology's financial cost in future periods to its cumulative production, reflecting economies-of-learning and scale (e.g., the observed decline in the cost of wind turbines as their global cumulative production has risen). The declining capital cost function is composed of two additive components: one that captures Canadian cumulative production and one that captures global cumulative production. The declining intangible cost function links the intangible costs of a technology in a given period with its market share in the previous period, reflecting improved availability of information and decreased perceptions of risk as new technologies become increasingly integrated into the wider economy (e.g., the "champion effect" in markets for new technologies); if a popular and well respected community member adopts a new technology, the rest of the community becomes more likely to adopt the technology.

METHODOLOGY TO CATEGORIZE ABATEMENT COST OF EXISTING AND PROPOSED POLICIES

To categorize the abatement cost of existing and proposed policies, we compare their abatement in 2020 with that induced by carbon pricing. Using the method described below, we categorize abatement as occurring in one of three thresholds:

R_p^{low} = low cost reduction (\$0-50/t CO_2e)

R_p^{med} = medium cost reduction (\$51-100/t CO_2e)

R_p^{high} = high cost reduction (>\$100/t CO_2e)

Assuming the following simulations,

R_p = reductions in 2020 from all existing and proposed policies

R_{50} = reductions from \$50/t CO_2e alone (constant price from 2005)

R_{100} = reductions from \$100/t CO_2e alone (constant price from 2005)

R_{p+50} = reductions from all policies plus \$50/t CO_2e

R_{p+100} = reductions from all policies plus \$100/t CO_2e

Reductions from all policies are categorized as follows:

R_p^{low} = reductions from existing policy in low-cost category
$= R_p - (R_{p+50} - R_{50})$

R_p^{med} = reductions from existing policy in medium-cost category
$= R_p - (R_{p+100} - R_{100}) - R_p^{low}$

R_p^{high} = reductions from existing policy in high-cost category
$= R_{p+100} - R_{100}$

METHODOLOGY TO QUANTIFY ABATEMENT GAPS

A similar approach was taken to quantify the gap between expected emissions in 2020 and the federal target for emission reductions.

G_p^{low} = low cost gap (\$0-50/t CO_2e)

G_p^{med} = medium cost gap (\$51-100/t CO_2e)

G_p^{high} = high cost gap (\$101-150/t CO_2e)

Assuming the following simulations,

R_p = reductions in 2020 from all existing and proposed policies

$R_{p+50Gap}$ = reductions from all policies plus \$50/t CO_2e from 2015 to 2020

$R_{p+100Gap}$ = reductions from all policies plus \$100/t CO_2e from 2015 to 2020

$R_{p+150Gap}$ = reductions from all policies plus \$150/t CO_2e from 2015 to 2020, the price required to achieve 607 Mt CO_2e in 2020.

The gap is characterized as follows:

G_p^{low} = potential reductions to close gap in low-cost category
$= R_{p+50Gap} - R_p$

G_p^{med} = potential reductions to close gap in medium-cost category
$= R_{p+100Gap} - R_{p+50Gap} - R_p$

G_p^{high} = potential reductions to close gap in high-cost category
$= R_{p+150Gap} - R_{p+100Gap} - R_{p+50Gap} - R_p$

7.3 CLIMATE POLICIES ANALYZED

	EXISTING	PROPOSED	EXCLUDED FROM MODELLING BECAUSE UNDER 1 Mt CO_2e OR NOT POSSIBLE TO MODEL	EXCLUDED FROM MODELLING BECAUSE POLICY NOT DEFINED IN SUFFICIENT DETAIL
Federal	• ecoEnergy for Renewable Power • ecoEnergy for Buildings and Houses (subsidies only) • Renewable Fuels Content Regulation • Passenger Automobile and Light-Duty Truck Emissions Regulations • Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations • Strengthened Energy Efficiency Standards	• Heavy Duty Vehicle Emission Standards	• ecoEnergy for Industry • ecoFreight Program • Pulp and Paper Green Transformation Program • ecoEnergy for Fleets Program • Green Levy • ecoEnergy for Personal Vehicles Program • ecoTechnology for Vehicles Program • ecoMobility • ecoEnergy for Renewable Heat • Public Transit Tax Credit • ecoEnergy for Aboriginal and Northern Communities • ecoAUTO rebate Program • National Vehicle Scrappage Program • ecoEnergy Retrofit Initiative • Marine Shore Power Program • Renewable Fuels Development • ecoEnergy for Biofuels Initiative • ecoAgriculture Biofuels Capital Initiative • Technology Deveopment and Deployment • ecoEnergy Technology Initative	

	EXISTING	PROPOSED	EXCLUDED FROM MODELLING BECAUSE UNDER 1 Mt CO_2e OR NOT POSSIBLE TO MODEL	EXCLUDED FROM MODELLING BECAUSE POLICY NOT DEFINED IN SUFFICIENT DETAIL
BC	• Carbon Tax • Zero Emission Electricity • Green Building Code • Renewable and Low-Carbon Fuel Standard • Landfill Gas Regulation • Passenger Automobile and Light-Duty Truck Emissions Regulations • LiveSmart Efficiency Incentive Program	• WCI Cap and trade system (assuming permit price of 2007USD 33/t CO_2e as estimated by ICF).	• Provincial Transit Plan • Many Smaller Policies	
AB	• Specified Gas Emitters Regulation • Climate Change and Emissions Management Fund • Renewable Fuel Standard • Energy Efficiency Rebates	• Carbon Capture and Storage Projects, including: (1) Shell QUEST project (oil sands upgrader), (2) Swan Hills Synfuel Project (coal gasification) (3) Alberta Carbon Trunk Line (capture and a large-scale transport network to serve enhanced oil recovery) and (4) Project Pioneer (coal power plant CCS retrofit).	• One Simple Act • Biorefining Commercialization and Market Development Program and Bioenergy Infrastructure Development Program • Bioenergy Producer Credit Program • Green Trips • Government purchase of green power • Micro-generation regulation • On-farm energy management • Initiative for public buildings	• Energy Efficiency Act
SK	• Boundary Dam Integrated Carbon Capture and Storage Demonstration Project • Energy Efficiency Rebates	• Regulated Emitters and GHG Reduction Program (including Technology Fund)		• Landfill gas capture offset protocols

	EXISTING	PROPOSED	EXCLUDED FROM MODELLING BECAUSE UNDER 1 Mt CO_2e OR NOT POSSIBLE TO MODEL	EXCLUDED FROM MODELLING BECAUSE POLICY NOT DEFINED IN SUFFICIENT DETAIL
MB	• Biodiesel Tax Exemption • Green Building Policy • Furnace standards • Ethanol Sales Mandate • Biodiesel Sales Mandate • Regulation to restrict use of the coal-fired electrical generating station in Brandon • Coal reduction strategy and coal tax • Enhanced Incentives for geothermal heat pump installations	• WCI Cap and trade system (assuming permit price of 2007USD 33/t CO_2e as estimated by ICF).	• Manitoba Climate Investment Pilot Program • Power Smart Incentive Program • Biodiesel Production Credit • Landfill Biogas Capture • Provincial landfill gas (LFG) management • Hybrid Car Rebate • Enhanced Oil Recovery Demonstration Project • Ethanol Production Grant • Sustainable Agricultural Practices	
ON	• Coal Phase-Out • Feed-In-Tariff • Residential Building Code • Landfill gas capture regulation • Energy Efficiency Incentives • Renewable Fuels Standard	• WCI Cap and trade system (assuming permit price of 2007USD 33/t CO_2e as estimated by ICF). • Passenger Automobile and Light-Duty Truck Emissions Regulations	• Public Transit Expansion • Freight truck speed limiter regulation • Hybrid buses and Green Commercial Vehicle Program	• Natural gas utility conservation programs
QC	• Carbon Tax • Landfill gas capture regulation • Energy efficiency incentives	• WCI Cap and trade system (assuming permit price of 2007USD 33/t CO_2e as estimated by ICF). • Passenger Automobile and Light-Duty Truck Emissions Regulations • Ethanol Fuel Content	• Residual biomass • energy efficiency in the merchandise transportation sector • energy efficiency financing program • Voluntary industry agreements • Halocarbon regulations • Landfill and incineration regulations • Municipal program support • Mandatory speed limiting devices on trucks • improve energy efficiency of public buildings by 10% to 14% under the 2003 level • Building Code	

	EXISTING	PROPOSED	EXCLUDED FROM MODELLING BECAUSE UNDER 1 Mt CO_2e OR NOT POSSIBLE TO MODEL	EXCLUDED FROM MODELLING BECAUSE POLICY NOT DEFINED IN SUFFICIENT DETAIL
NB	• Efficiency NB	• Renewable Portfolio Standard • Renewable Fuel Standard • Passenger Automobile and Light-Duty Truck Emissions Regulations		
NS	• Cap on Electricity Sector Emissions • Passenger Automobile and Light-Duty Truck Emissions Regulations • Electricity Sector RPS • Energy Efficiency Incentives • eco Nova Scotia • Electricity Sector DSM programming			
NL	• Build Better Buildings Policy • Residential Energy Efficiency Program • Muskrat falls		• EnerGuide for Houses • 2011 plan • Green Fund • Landfill Gas	• GHG reduction framework for large industrial sector
PEI	• Renewable Portfolio Standard (Wind) • Other energy efficiency programs	• Passenger Automobile and Light-Duty Truck Emissions Regulations		• Renewable Fuel Standard • Low Carbon Fuel Standard
YK			• Investment in renewable electricity • A variety of actions listed in the action plan, including (many actions in preliminary form, i.e. commitment to investigate, etc.): • Targets for government operations (direct investment in buildings and transport) • Carbon offset policy • Building Codes • Biomass strategy	
NWT	• Building Codes • The Energy Efficiency Incentive Program			
NV	• None			

7.4
FEDERAL POLICY SUMMARY

The federal government is implementing a sector-by-sector regulatory approach to drive emission reductions through the establishment of sectoral emissions performance standards. In addition, the government is developing performance requirements for various products, which are referred to as product performance standards.

EMISSIONS PERFORMANCE STANDARDS

The first sector targeted under the current federal sector-by-sector regulatory approach is the electricity sector. The electricity sector contributed 120 Mt CO_2e to Canada's total emissions, or 16%, in 2008. Within that sector, coal-fired electricity generation was responsible for 93 Mt of GHG emissions, or over three quarters, of the emissions.[75] The Government of Canada is pursuing regulations for coal-fired electricity generation through the *Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations* (Coal-Fired Regulations).[76]

Under the proposed regulation, an emissions performance standard has been established for new coal-fired units and coal-fired units past the end of their "useful life." This standard is designed so that the emissions released are equivalent to those from high-efficiency natural gas electricity generation.[77] It is expected that the regulation will encourage a transition from current coal-fired electricity to more efficient and renewable sources. The final regulations are expected to come into effect in 2015. These regulations are expected to reduce 175 Mt CO_2e cumulatively between 2015 and 2030.[78] Annual reductions will ramp up over time.

The electricity mix varies significantly between provinces. These regulations will primarily impact Alberta, Saskatchewan, Nova Scotia and New Brunswick where coal is currently a major electricity source. In contrast, provinces which greatly rely on hydro power such as British Columbia, Manitoba, Québec and Newfoundland and Labrador will be virtually unaffected by the Coal-Fired Regulations. Ontario will also not be affected by these federal regulations because its coal phase-out is expected to have eradicated coal-fired electricity generation by 2014.[79]

Separate sector-specific regulations are anticipated for all other major emissions sources[80], including for the upstream oil and gas industry. The quantity of emissions being driven through the Coal-Fired Regulations suggest that planned reductions from other sector-specific regulations could also play an important role in driving future emission reductions in Canada.

PRODUCT PERFORMANCE STANDARDS

Vehicle emissions are a key source in Canada, with passenger cars and light trucks accounting for 12% of total emissions in 2007. The *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations* prescribe mandatory GHG emission standards for vehicles produced in 2011 and later years, with the stringency of the emission standards increasing over time. The regulations are designed to require manufacturers to meet a set emissions standard across the entire fleet, and they provide flexibility through banking and trading emission credits over time and across manufacturers. Environment Canada anticipates that as a result of these regulations, vehicles from model years 2011 to 2016 will, over their lifetime, yield 92 Mt of GHG reductions.[81]

Heavy-duty vehicles contributed just over 6% of Canada's GHG emissions in 2009.[82] The federal government is developing *Heavy Duty Vehicles Regulations* to regulate emissions from this source consistent with U.S. regulations. The proposed regulations would apply to vehicle manufacturers. A vehicle-based emission standard would incent emission reductions from engines and other components of the vehicle. As is the case with light-duty vehicles, emission standards would increase over time, starting with the model year 2014. Compliance flexibility could be offered through banking and trading emission credits. Examples of vehicles to be covered under these regulations include full-size pick-up trucks, tractor-trailers, cement trucks, and buses.[83]

The *Renewable Fuels Regulations* were established to mandate fuel producers and importers to ensure gasoline contain an average of at least 5% renewable fuels. The regulations provide compliance flexibility through trading credits across regulatees. The government anticipates that this regulation will drive an incremental GHG emission reductions of approximately 1 Mt per year. These regulations took effect on December 15, 2010.[84] A later amendment to these regulations requires 2% renewable content in diesel fuel and heating oil, coming into force on July 1, 2011.[85]

7.5 CLIMATE POLICY OVERLAP

CASE 1: A FEDERAL EMISSION PERFORMANCE STANDARD OVERLAPS WITH A PROVINCIAL QUANTITY MEASURE[w]

Overlap does not present any difficulty if the provincial regulation is stringent enough that the federal regulation is non-binding. However, if the federal regulation is binding, additional reductions required from covered firms will mean that other firms do not need to reduce as much as they would have done (instead, they would purchase additional credits from the firm subject to the overlapping regulation). Overall emissions in the regulated sectors are unchanged but the addition of the federal standard produces additional cost.

CASE 2: A FEDERAL EMISSION PERFORMANCE STANDARD OVERLAPS WITH A PROVINCIAL PRICE MEASURE[x]

In this case, overlap does not create problems. If the provincial regulation is stringent enough then the federal regulation is non-binding. If the federal standard is binding, total emissions in the province will fall.

CASE 3: A FEDERAL PRODUCT PERFORMANCE STANDARD OVERLAPS WITH ANY PROVINCIAL POLICY

Overlap does not present any difficulty if the federal regulation is stringent enough that the provincial regulation is non-binding. If the provincial policy is binding, it will cause increased emission reductions from regulated emitters but also yield unintended consequences that may be problematic. Regulated entities within the province will reduce their emissions, but others outside the province will be able to expand emissions in response (since the federal product performance standards allow credits to be traded between firms). Ultimately, overall emissions are unchanged, the burden of emission reductions is shifted to the regulating province, and overall costs of achieving emission reductions increase.

When there is a risk of running up against these unintended consequences of overlapping policies, three strategies can be employed to improve the outcome. First, make additional efforts to coordinate policies between levels of government. Second, rely on price-based policies. They achieve additional reductions even when several policies overlap since they do not result in the unintended consequences described above. Finally, if quantity-based targets are used, consider introducing mechanisms to ensure additionality of reductions when policies overlap.

Source: Wigle and Rivers 2012 (available upon request)

w i.e., a market-based measure that restricts total quantity of emissions such as a cap and trade system

x i.e., a market-based measure that imposes a financial penalty on emissions such as a carbon tax

7.6
PROVINCIAL SUMMARIES

The purpose of the following provincial summaries is to provide a snap-shot of current emissions profiles by activity, emissions trends over the past two decades, and key economy-wide and sector-specific emission reductions policies (both proposed and existing). It is not a comprehensive account of all provincial policies and measures.

BRITISH COLUMBIA

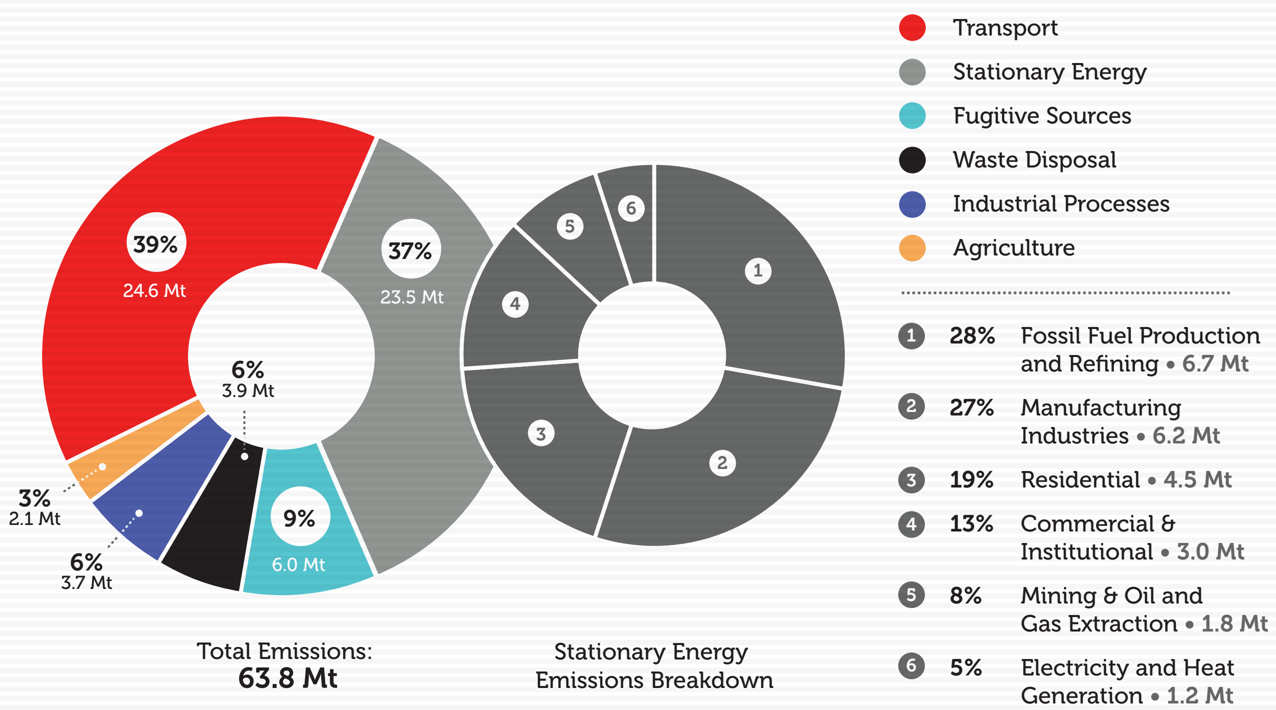
Climate Plan
British Columbia's Climate Change Action Plan (2008)

Governing Body
Ministry of Environment – Climate Action Secretariat

Interim Target:[86]	>>	6% below 2007 levels by 2012 18% below 2007 levels by 2016
2020 Target	>>	**33% below 2007 levels by 2020**
2050 Target	>>	80% below 1990 levels by 2050

- **5TH HIGHEST TOTAL EMISSIONS**
- **4TH LOWEST PER CAPITA EMISSIONS**
- **EXISTING AND PROPOSED POLICIES ARE EXPECTED TO CLOSE 35% OF THE GAP TO THE PROVINCE'S 2020 TARGET**

FIGURE 27: EMISSIONS SOURCES (2009)[87]



EMISSIONS PROFILE

In 2009 British Columbia (BC) emitted 63.8 Mt CO_2e, a 28% increase in emissions since 1990.[88] A breakdown of 2009 emission by source is provided in Figure 27.

ECONOMY-WIDE MEASURES

Chief among BC's emission reductions measures is the BC Carbon Tax, implemented in 2008 as a revenue-neutral carbon tax on fossil fuels.[y] The tax was introduced at $10/tonne CO_2e, and rises annually by $5 to reach $30/tonne by 2012. Revenues from the tax are recycled through tax reductions, credits or dividends with special provisions for low-income families.

BC has committed to make its government carbon neutral (discussed in more detail in Chapter 3). The province also sees potential in generating alternative energy and forest-based offsets to support global emission-reduction efforts.

EMISSION-REDUCTION MEASURES BY SOURCE

BC has implemented four main initiatives targeting transportation emissions. First, renewable fuels standards on diesel and gasoline have been put in place.[89] Second, in 2008, the province implemented a standard of 10% reduction in average carbon intensity of transportation fuels by 2020. Third, tailpipe emission standards exist to decrease GHG emissions. By 2016 the adoption of tailpipe emissions standards is expected to eliminate close to 1 Mt of GHGs annually and promote the development of more fuel-efficient vehicles. Fourth, there are public awareness campaigns and regulations for vehicle idling.

Measures to address stationary energy emissions are also in place. Within the electricity and heat generation sub-sector, emissions are only 1.2 Mt CO_2e due to the province's reliance on hydroelectricity.[90] The *Clean Energy Act* (2010) established a renewable energy requirement of a minimum of 93% total electricity generation.[91] As outlined in the *BC Energy Plan*, all new electricity generation projects were required to have zero net GHG emissions as of 2007. Existing thermal power plants are required to have zero net GHG emissions by 2016.[92]

Residential emissions are stable and relatively low due to the moderate climate in the Vancouver area where the largest population lives. The province has implemented various energy standards and conservation and efficiency plans that target the residential and commercial building sector. In 2008, BC put in place its *Green Building Code* that requires residential and commercial buildings to meet specific energy and water certification standards.

Fossil fuel production and refining accounts for 6.7 Mt of GHG emissions and stems mostly from natural gas production and processing.[93] BC set a target to reduce flaring of natural gas by 50% by 2011 - success can be assessed once 2011 data is available. Due to the small number and large size of natural gas plants in the province, CCS from a few key locations could yield significant reductions. The Fort Nelson processing plant could capture 1.3-1.6 Mt of CO_2 per year through CCS technology.[94]

Waste disposal in BC accounted for 3.9 Mt CO_2e in 2009.[95] In 2009, the province put in place landfill gas regulations that ensure that landfills producing more than 1000 tonnes of methane annually have landfill gas management facilities installed and operational in capturing and combusting methane emissions.[96]

PROVINCIAL EVALUATION OF EMISSION REDUCTIONS MEASURES

BC releases a bi-annual *GHG Inventory Report* using data from the NIR. The most recent inventory was released in 2010 detailing the province's 2008 GHG emissions. The Ministry of the Environment applies a quality assurance/quality control process to ensure that data presented is accurate and representative.[97]

BC has a reporting regulation that requires facilities emitting 10,000 tonnes or more of GHGs to report those emissions to the Ministry of the Environment.[98] This information is compiled in a provincial emissions inventory and used to support the development and implementation of climate action policies and programs such as the cap and trade program.

In addition to mandatory reporting requirements, voluntary emissions tracking and reporting can be done through the province's *Community Energy and Emissions Inventory* (CEEI).[99]

INTER-JURISDICTIONAL MEASURES

In 2009, BC approved the *Greenhouse Gas Reduction (Cap and Trade)* Act in support of its plans to implement a cap and trade system under the Western Climate Initiative (WCI) (see Chapter 3).[100]

In 2010, BC signed an Agreement in Principle on efforts to address climate change with the federal government to avoid regulatory overlap.[101]

y Information included in this appendix is sourced from Government of British Columbia 2008 unless otherwise indicated.

ALBERTA

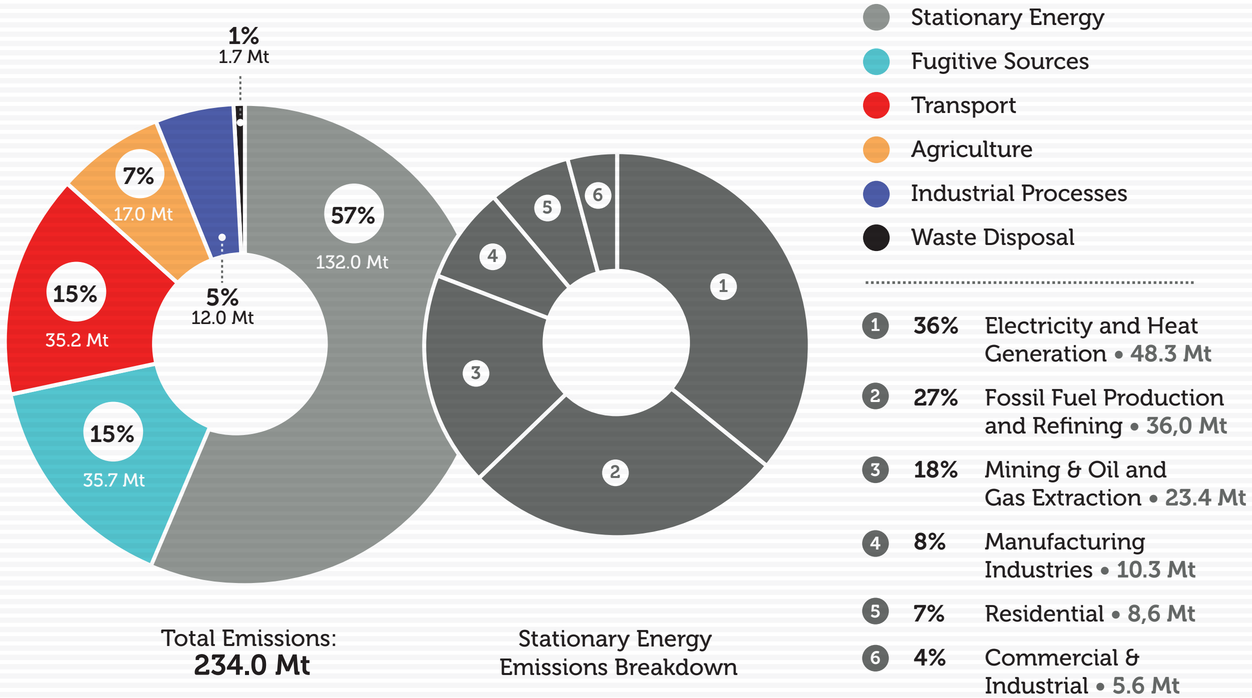
Climate Plan
Alberta's 2008 Climate Change Strategy responsibility/leadership/action.[102]

Governing Body
Department of Environment and Water - Climate Change Secretariat

Interim Target	>>	reduce 20 Mt of emissions by 2010
2020 Target	**>>**	**50 Mt below BAU by 2020**
2050 Target	>>	200 Mt below BAU by 2050

- **HIGHEST TOTAL EMISSIONS**
- **2ND HIGHEST PER CAPITA EMISSIONS**
- **EXISTING AND PROPOSED POLICIES ARE EXPECTED TO CLOSE 41% OF THE GAP TO THE PROVINCE'S 2020 TARGET**

FIGURE 28: EMISSIONS SOURCES (2009)[103]



EMISSIONS PROFILE

In 2009 Alberta emitted 234 Mt CO_2e, a 37% increase in emissions since 1990.[104] A breakdown of 2009 emission by source is provided in Figure 28.

ECONOMY-WIDE MEASURES

The three main approaches of Alberta's climate plan are: energy conservation and efficiency, CCS and greening energy production.[z]

Alberta's *Specified Gas Emitter Regulation* - the first legislation of its kind in Canada – limits the intensity of emissions in the province.[aa] Large final emitters[bb] were required to reduce combustion, venting and fugitive GHG intensities by 12% between 2003 and 2005. Facilities built after 2000 receive a three-year grace period after which they must reduce intensities by 2% annually until they reach the 12% reduction. *The Emissions Trading Regulation* provides compliance flexibility for the Specified Gas Regulations. Permits can be traded between firms and offsets can be purchased from sectors not covered by the regulation. Compliance credits can also be purchased from the Climate Change and Emissions Management Fund (CCEMF) (see Chapter 3). Under this regulation, in 2010, a reduction of 6.5 Mt of emissions was achieved from large facilities and over $70 million was contributed into the (CCEMF).[105]

EMISSION REDUCTIONS MEASURES BY SOURCE

Overall, total energy emissions have increased 37% since 1990; however, emissions have decreased 5% since 2007. This shift was caused by decreased use of coal in power generation, but also because of a slowdown in oil and gas activity due to the economic downturn.[106] Through conservation and energy efficiency, Alberta seeks to reduce emissions by 24 Mt by 2050. Increased energy efficiency incentive programs, efficiency standards, and an *Energy Efficiency Act* are all part of Alberta's efficiency strategy. CCS is expected to reduce emissions by 139 Mt by 2050. Finally, Alberta has a goal of reducing 37 Mt of GHG emissions by 2050 through greening energy production using clean burning coal technologies, wind energy projects and deep geothermal energy production.

Since 1990, transportation emissions have increased almost 60% in Alberta.[107] Renewable fuel standards in the province require a 2% renewable fuel content in diesel and 5% alcohol content in gasoline, with all renewable fuel emitting 25% less GHGs than equivalent petroleum fuel.[108]

Agriculture emissions in Alberta increased around 30% from 1990 to 2009 to reach 17 Mt CO_2e. Under Alberta's GHG Regulations, agriculture emission reductions are encouraged through carbon offsets.

PROVINCIAL EVALUATION OF EMISSION REDUCTIONS MEASURES

The Ministry of Environment conducts an annual report. In 2010-2011, the report included, an overview of annual efforts under the *Specified Gas Emitters Regulation* and a performance measure tracking the success in meeting the GHG emissions growth targets outlined in the Climate Change Strategy.[109]

Alberta's Auditor General evaluated the Climate Change Strategy in 2009 with a follow-up report in 2011. It was recommend that the Department of Environment and Water clarify the guidance it provides to facilities, verifiers, offset project developers and offset protocol developers, to ensure they consistently follow the requirements in place to achieve the Alberta government's emission reductions targets.[110]

z Information included in this appendix is sourced from Government of Alberta 2008 unless otherwise indicated.

aa Emissions intensity refers to the emissions relative to production or economic output such as GDP.

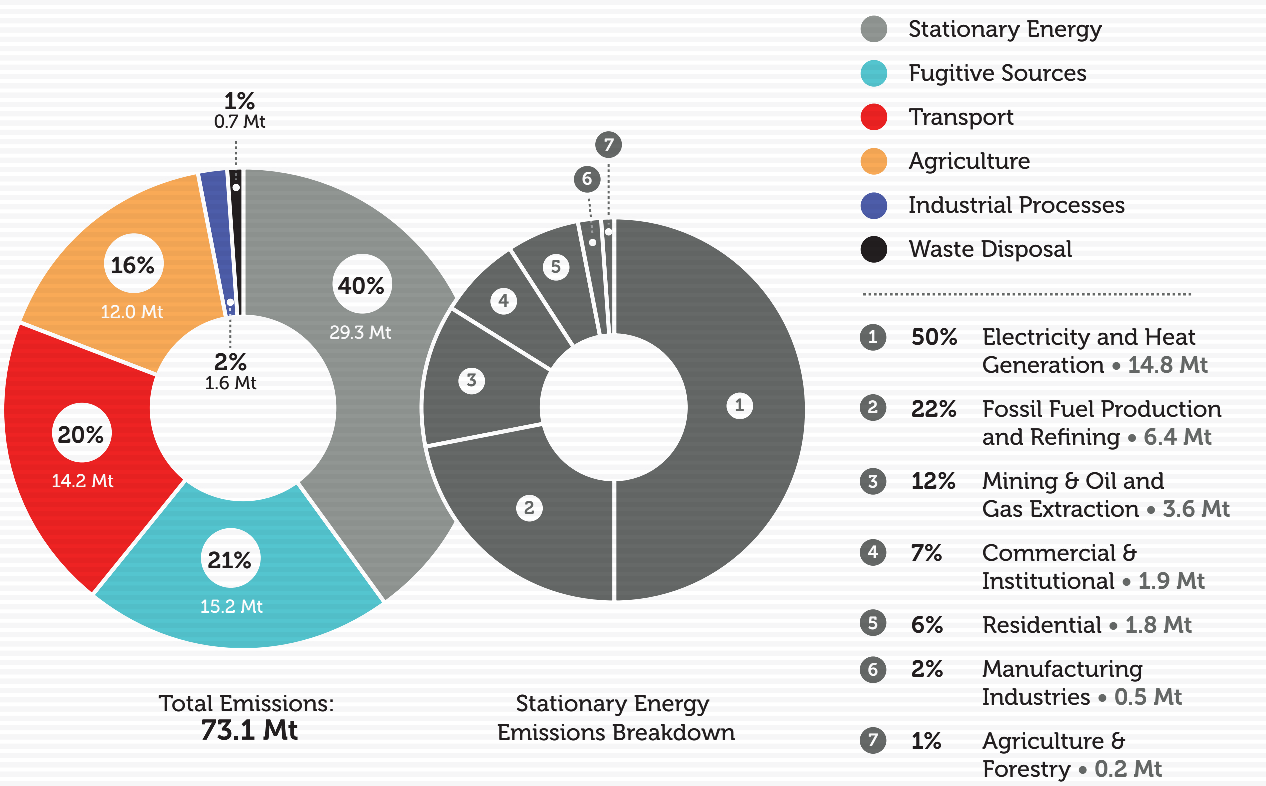
bb Those emitters producing 100,000 tonnes CO2e or more annually. Collectively, these facilities account for approximately half of the GHGs in Alberta.

SASKATCHEWAN

Climate Plan Energy and Climate Change Plan (2007)	
Governing Body Ministry of Environment - Office of Climate Change	
2020 Target:[111] >>	**20% below 2006 levels**

- **4TH HIGHEST TOTAL EMISSIONS**
- **HIGHEST PER CAPITA EMISSIONS**
- **EXISTING AND PROPOSED POLICIES ARE EXPECTED TO CLOSE THE GAP TO THE PROVINCE'S 2020 TARGET**

FIGURE 29: EMISSIONS SOURCES (2009)[112]



EMISSIONS PROFILE

In 2009, Saskatchewan emitted 73.1 Mt CO_2e, a 69% increase since 1990.[113] A breakdown of 2009 emission by source is provided in Figure 29.

ECONOMY-WIDE MEASURES

The major tool under development to address GHG emissions is *The Management and Reduction of Greenhouse Gases Act.*[cc] This act has received Royal Assent but has yet to be enacted as law. Under the act, regulated emitters[dd] are required to reduce emissions by 2% per year over the baseline level from 2010 to 2019 in order to achieve a net reduction of 20% below baseline levels by 2020.[114] There will be provisions for establishment of a carbon compliance price schedule; offsets and 'performance credits' earned when actual emissions are less than prescribed levels; and credit for early action. The act proposes the creation of a technology fund that will collect carbon compliance payments from large emitters to invest in low-emitting technologies and processes that reduce greenhouse gas emissions; and a Climate Change Foundation that promotes research and development of low-carbon technologies, promotes adaptation and fosters public education and awareness.[115]

CCS is seen as an important technical innovation to support GHG emission reductions. The Government of Saskatchewan approved construction of a CCS project at Boundary Dam that is expected to commence operation in 2014 and capture 1 million tonnes of CO_2 annually.[116] The Weyburn-Midale project is the largest CCS demonstration site in the world. Since 2002, it has stored approximately 20 million tonnes of CO_2.[117] (See Chapter 3).

EMISSION REDUCTIONS MEASURES BY SOURCE

The stationary energy and fugitive sources of GHG emissions in the province each increased by almost 10 Mt since 1990.[ee] While the economy-wide efforts outlined above will address these sources, more focused measures are also in place. Existing residential emission reductions programs include financial assistance for energy efficient retrofits (the *Saskatchewan Home Energy Improvement Program (SHEIP) for Low and Moderate-Income Homeowners*), an Energy Efficient Rebate for New Homes, a geothermal and self-generated renewable power loan program, and provincial sales tax exemptions on specified energy efficient appliances.[118]

GHG emission reductions in the commercial and institutional sectors are supported by several programs. This includes funding for solar water heating systems (*Solar Heating Initiative for Today* [*SHIFT*]) and rebates for geothermal system installations.[119] Through the *Commercial Boiler Program*, Saskatchewan also supports the use of high-efficiency natural gas hydronic space-heating systems in commercial new construction and retrofit applications.[120]

Saskatchewan has the 2nd highest agricultural emissions in Canada.[121] The Saskatchewan Biofuels Investments Opportunity Program (SaskBIO), a four year program which ended on March 31, 2012, encouraged farmers and communities to participate in biofuels production to lower transportation emissions.[122]

At 14.2 Mt CO_2e, transportation emissions represent 20% of Saskatchewan's emissions.[123] The province has implemented an *Idle Free Zone* programs and offers rebates to owners of hybrid and fuel-efficient vehicles.[124]

The Red Lily Wind Project is one of Saskatchewan's renewable energy measures. Wind power from the project is expected to contribute 8.5% to SaskPower's total generating capacity and wind power expansion will reduce the emissions by approximately 225,000 tonnes per year.[125]

PROVINCIAL EVALUATION OF EMISSION REDUCTIONS MEASURES

The province's *State of the Environment Annual Report* includes a brief review of climate change mitigation progress.

An *Environmental Code* to be completed in 2012 sets out requirements to be followed by those conducting activities regulated by *The Environmental Management and Protection Act*, (2010), *The Forest Resources Management Act*, and *The Management and Reduction of Greenhouse Gases Act*. These three acts and the recently revised *Environmental Assessment Act* are the initial building blocks for Saskatchewan's regulatory framework for environmental management and protection.[126] The *Code* will set out expectations for proponents and will make them accountable for achieving results set out in the legislation.

The Management and Reduction of Greenhouse Gases Act requires regulated emitters to obtain third party verification of their baseline emissions and the first year of their reported emissions.[127]

INTER-JURISDICTIONAL MEASURES

An *Agreement in Principle on Efforts to Address Climate Change* between the federal government and Saskatchewan was signed in May 2009 which would help to avoid any regulatory overlap.[128]

Saskatchewan has also taken on international partnerships. A Memorandum of Understanding between the province and the State of Victoria, Australia was signed to encourage collaboration and sharing of information on the research and development of new and emerging technologies related to climate change.[129] Also, a Memorandum of Understanding was signed between Saskatchewan and Montana in 2009 for the construction of CCS plant in Saskatchewan, a CO_2 storage facility in Montana, and a pipeline for transporting CO_2 between the projects.[130]

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cc Information included in this appendix is sourced from Government of Saskatchewan 2007 unless otherwise indicated.

dd Those with an emissions threshold of 50,000 tonnes of CO_2e in any year.

ee The largest percent change was in the industrial processes sector at 438%, but the absolute increase was only 1.3 Mt.

MANITOBA

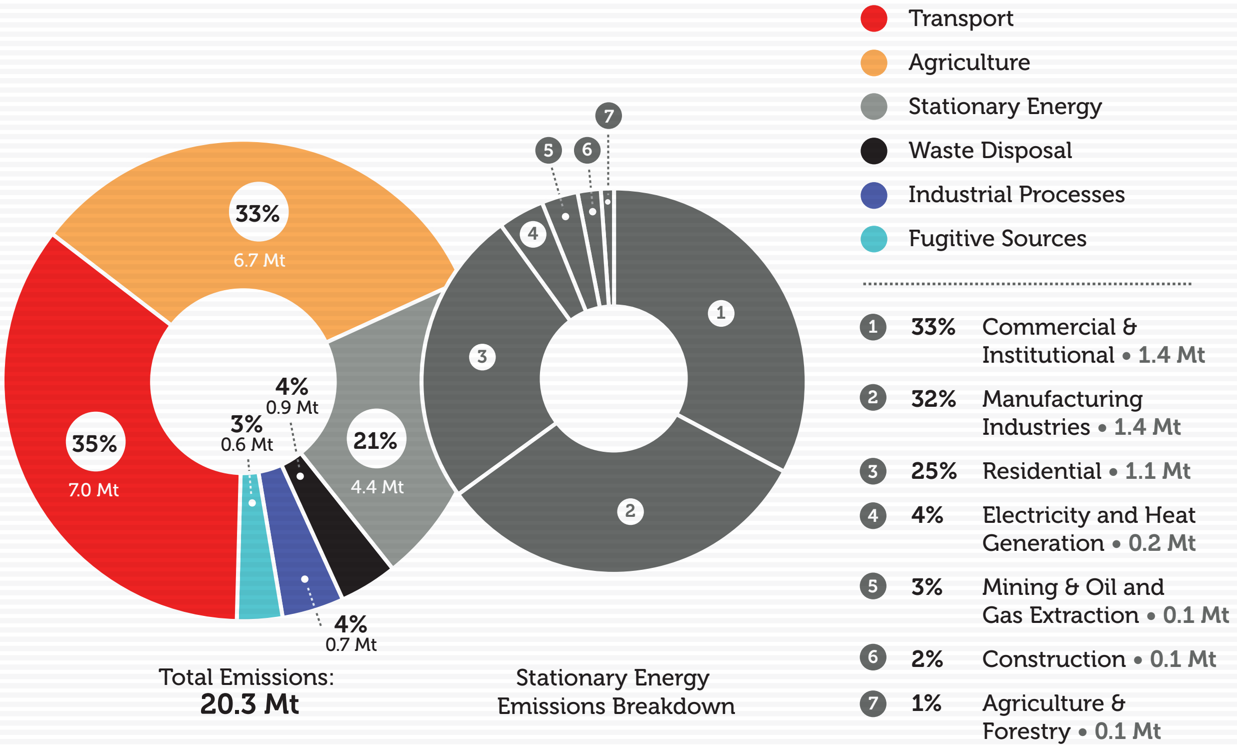
Climate Plan
Beyond Kyoto, Next Steps: Action on Climate Change, 2008

Governing Body
Manitoba Conservation - Climate and Green Initiatives Branch

Interim Target	>>	6% below 1990 by 2012
2020 Target	**>>**	**Under Development**

- **4TH LOWEST TOTAL EMISSIONS**
- **5TH LOWEST PER CAPITA EMISSIONS**
- **EXISTING AND PROPOSED POLICIES ARE EXPECTED TO CLOSE 62% OF THE GAP TO THE PROVINCE'S 2020 TARGET**

FIGURE 30: EMISSIONS SOURCES (2009)[131]



EMISSIONS PROFILE

In 2009 Manitoba emitted 20.3 Mt CO_2e, representing a 10% increase in emissions since 1990. A breakdown of 2009 emission by source is provided in Figure 1.

NRT
NATIONAL ROUND TABLE ON THE ENVIRONMENT AND THE ECONOMY

EMISSION REDUCTIONS MEASURES BY SOURCE

The majority of Manitoba's GHG emissions come from many smaller emitters in a wide range of sectors.[132]

Transportation is the largest emitting activity in Manitoba. In 2009 the GrEEEn (economically and environmentally efficient) Trucking Program came into effect.[ff] It provides incentives to Manitoba's commercial trucking industry for installing various emission-reduction technologies. Under the program, companies are eligible for rebates of up to 25 per cent, to a maximum of $2,500 per unit, per tractor or trailer. In 2010, GHG reductions from this program were estimated at 1.5 Kt.[133] There is also an ethanol sales mandate requiring gasoline to contain at least 8.5% ethanol, and a *Biodiesel Mandate Regulation* requiring an average of 2% biodiesel content in annual diesel fuel sales.[134] The Centre for Sustainable Transportation and The Vehicle Standards Advisory Board promote public awareness on transportation emissions and provide recommendations to help the province develop appropriate, vehicle-emission standards.

The percent of emissions from agriculture in the province is almost equal to that of transportation emissions, but emissions from agriculture have increased by 31% since 1990. In 2009, to address agricultural emissions, the Manitoba Sustainable Agriculture Practices Program came into effect. This program provided funding and technical assistance to carry out sustainable agriculture projects; however this funding ends after 2012.

The significant reliance on hydro for electricity generation in the province plays a large role in limiting stationary energy emissions both within the province and in jurisdictions that purchase power from Manitoba (see Chapter 3).

Electricity and heat generation only produces 0.2 Mt of GHG emissions in the province. Manitoba Hydro *Power Smart* programs are demand side management initiatives which help green public buildings through increased energy efficiency, improved energy performance, energy conservation and load management activities. *Power Smart* Programs saved an estimated 112 kt in 2010. In 2009, the province implemented the *Energy Efficiency Standards for Replacement Forced Air Gas Furnaces and Small Boilers Regulation* - the first regulation of its kind in Canada. The regulation sets minimum annual fuel use efficiency standards for replacement gas furnaces and small boilers. Also in 2009, Manitoba's *Coal-Fired Emergency Operations Regulation* came into effect under its *Climate Change and Emission Reductions Act*. This regulation restricts Manitoba Hydro's use of coal to generate power to emergency operations. Further, in 2012 a tax on coal is supposed to come into effect. The tax, based on the grade of coal, is imposed on those who purchase more than one tonne of coal per year for use in Manitoba.

Residential and commercial and institutional emissions contribute 2.5 Mt CO_2e in Manitoba. The province will adopt the 2011 *National Energy Code of Canada for Buildings* that will provide minimum requirements for the design and construction of energy-efficient buildings, and will apply to new buildings and substantial renovations to existing buildings. Energy efficiency programs exist for lower-income households and have been piloted for First Nations reserves.

Waste disposal is only 4% of the province's total GHG emissions, but under its *Climate Change and Emission Reductions Act*, Manitoba requires the submission of an assessment of prescribed landfills' potential for its emissions mitigation. A plan for monitoring, controlling, collecting or using GHG emissions before they are released must be considered as well.

The Manitoba government is also taking a leadership role in mitigating GHG emissions by measures focusing on public buildings and government fleet, and minimizing air and land travel.

PROVINCIAL EVALUATION OF EMISSION REDUCTIONS MEASURES

The Manitoba Report on Climate Change for 2010 was a requirement under *The Climate Change and Emission Reductions Act*. This 2010 Report included a description of the province's progress on emission reductions, its current measures, future emission reductions to 2025, and efforts to reduce emissions in other jurisdictions. Sixty action measures were outlined in the 2008 climate plan and the 2010 Report provides updates on these activities.

Manitoba's Green Registry exists so Manitobans can go online to get the necessary information to measure, reduce and report their emissions.

INTER-JURISDICTIONAL MEASURES

Manitoba has been a member of WCI since 2007. In 2009, Manitoba committed to legislation enabling the creation of a cap-and-trade system (see Chapter 3).

Because of Manitoba's wealth of renewable resources the province has taken to helping other jurisdictions reduce GHG emissions through energy transmission (see Chapter 3).

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ff Information included in this appendix is sourced from Government of Manitoba 2010 unless otherwise indicated.

ONTARIO

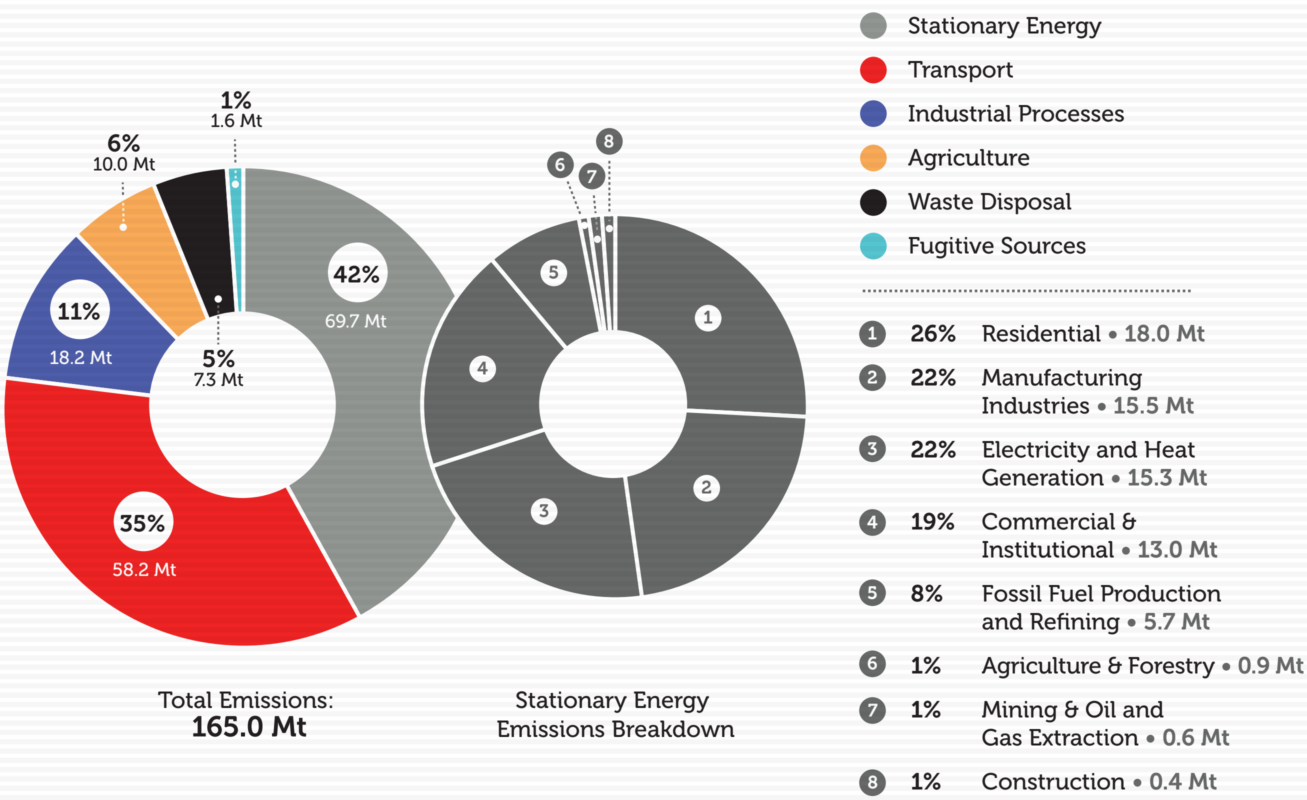
Climate Plan
Go Green – Ontario's Action Plan on Climate Change (2007)

Governing Body
Ministry of Environment – Climate Change Secretariat

Interim Target	>>	6% below 1990 by 2012
2020 Target	**>>**	**15% below 1990 levels by 2020**
2050 Target	>>	80% below 1990 levels by 2050

- 2ND HIGHEST TOTAL EMISSIONS
- 2ND LOWEST PER CAPITA EMISSIONS
- EXISTING AND PROPOSED POLICIES ARE EXPECTED TO CLOSE 77% OF THE GAP TO THE PROVINCE'S 2020 TARGET

FIGURE 31: EMISSIONS SOURCES (2009)[135]



EMISSIONS PROFILE

Ontario emitted 165 Mt CO_2e in 2009, almost 1/4 of Canada's total emissions.[136] Emissions have been reduced by over 6% since 1990 levels of 177 Mt, allowing the province to meet its interim 2014 target 5 years ahead of schedule.[99] A breakdown of 2009 emission by source is provided in Figure 1.

EMISSION REDUCTIONS MEASURES BY SOURCE

Almost half of Ontario's emissions come from stationary energy. Ontario developed a coal phase-out strategy to reduce coal-fired generation emissions to zero by the end of 2014. From 2008 to 2009 provincial emissions from electricity and heat generation decreased 44%.[137] Ontario aims to use clean energy to replace coal, increasing clean renewable electricity capacity by 50% by 2015.[hh] The Feed-in Tariff program for renewable sources of energy and the Renewable Energy Standard Offer Program are both incentives for renewable energy in the province (see Chapter 3).[138] The coal phase-out and related energy policies are expected to yield annual emission reductions of 29.1 Mt by 2020.

In addition to introducing new clean energy sources, the province is encouraging energy efficiency. It has created *The Green Energy and Green Economy Act* which seeks to bring more renewable energy sources to the province and to create of more energy efficiency measures to help conserve energy.[139] The province has also made revisions to the building code, used education programs to reduce energy use, and offered energy rebates. The provincial government is aiming to reduce its own electricity consumption by 10% to 2012. Ontario has estimated that Government leadership would account for 30,000 tonnes of GHG emission reductions to contribute to their 2020 goals.[140]

In 2009 emissions from manufacturing industries totalled 15.5 Mt CO_2e and 18.2 Mt CO_2e from industrial processes. But emissions from these sources have fallen substantially since 1990 – by 30% and 41%, respectively.[141] Ontario's Conservation Fund encourages energy conservation and efficiency within the industrial sector and supports clean technology development.[142]

In 2009, transportation emissions contributed 58.2 Mt CO_2e to Ontario's total emissions with 55% of those emissions coming from light-duty gasoline vehicles and trucks.[143] In the highly populated Greater Toronto and Hamilton Area a Regional Transit Plan – "The Big Move" - has been developed and implemented in conjunction with land-use planning policies aimed at decreasing vehicle kilometres travelled.[144] Speed limits have been placed on Heavy-Duty Trucks under the *Highway Traffic Act* and are projected to limit GHGs by 280,000 tonnes per year.[145] In addition, the province has a number of programs that address sustainable transportation relating to commuting. Federal and provincial initiatives including the Big Move, passenger vehicle efficiency regulation, truck speed limits, and a program to support hybrid buses and green commercial vehicles is expected to result in a 3.0 Mt total reduction in transportation emissions by 2020.[146]

Emissions resulting from waste in the province account for 7.3 Mt.[147] The province has introduced regulatory amendments to require the installation of methane capture in smaller capacity landfills and stated a preference for using landfill methane for energy production.[148]

PROVINCIAL EVALUATION OF EMISSION REDUCTIONS MEASURES

The Environmental Commissioner of Ontario (ECO) is responsible for reporting annually on the progress of the province's activities to reduce GHG emissions. The ECO reviews any annual report on GHG reductions or climate change published by the government.[149] The Ontario government used to release a CCAP Annual Report, with the last report being issued in December 2009.

The *Energy Efficiency Act* requires affected facilities to report GHG emissions, thereby facilitating monitoring and evaluation.

INTER-JURISDICTIONAL MEASURES

Ontario is a member of WCI and prepared for a cap-and-trade system under its *Environmental Protection Amendment Act* in 2009 (see Chapter 3).

gg According to ECO, with economic growth predicted to increase, the challenge of meeting Ontario's 2014 and 2020 targets will become more acute. Furthermore, GHG emissions are projected to rise between 2014 and 2020 because of a shift to natural gas when nuclear facilities are retired and measures have not been planned to address this (see Environmental Commissioner of Ontario 2011).

hh Information included in this appendix is sourced from Government of Ontario 2007 unless otherwise indicated.

QUÉBEC

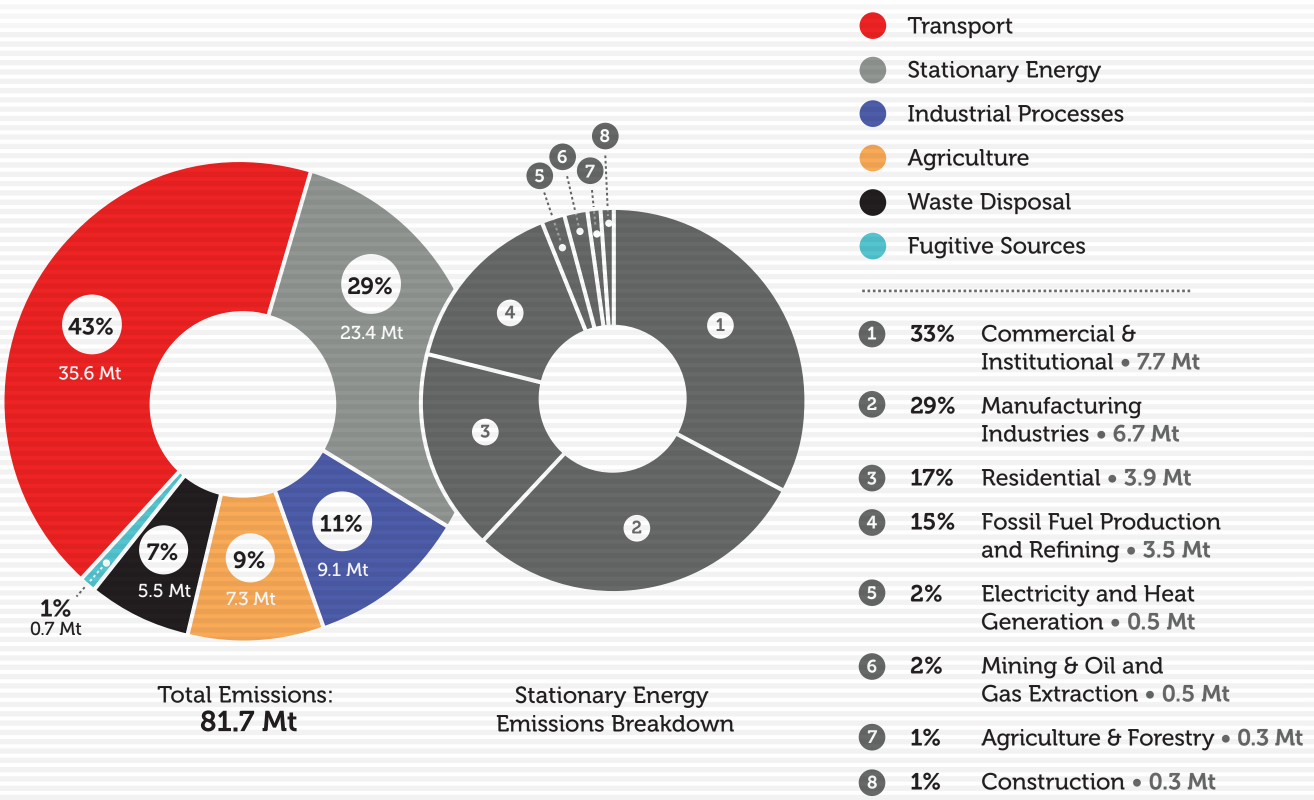
Climate Plan
Québec and Climate Change: A Challenge for the Future - 2006-2012 Action Plan

Governing Body
Ministry of Sustainable Development, Environment and Parks

Interim Target >>	6% below 1990 levels by 2012
2020 Target >>	**20% below 1990 levels by 2020**

- **3RD HIGHEST TOTAL EMISSIONS**
- **LOWEST PER CAPITA EMISSIONS**
- **EXISTING AND PROPOSED POLICIES ARE EXPECTED TO CLOSE 46% OF THE GAP TO THE PROVINCE'S 2020 TARGET**

FIGURE 32: EMISSIONS SOURCES (2009)[150]



EMISSIONS PROFILE

In 2009, Québec contributed roughly 12% of Canada's overall emissions (82 Mt CO_2e) - a 2% reduction in the province's emissions levels since 1990.[151] A breakdown of 2009 emissions by source is provided in Figure 32.

ECONOMY-WIDE MEASURES

Québec's GHG reduction policies over the last several years have been guided by the *2006-2012 Climate Change Action Plan*. The province is now transitioning to a *2013-2020 Action Plan*, which is expected to be released soon.[ii]

Since 2007, the provincial government has imposed a fuel duty on energy distributors that generates $200 million per year in funds that are directed back into GHG reduction measures.[152] In addition, beginning in 2013, the first phase of a cap and trade system will be implemented to limit emissions from the main sources in the province (see Chapter 3). The fuel duty will continue to apply until the end of 2014, but it will not be imposed on firms covered under the trading scheme.[153]

Québec's 2013-2020 climate plan will be financed using the $2.7 billion in revenues generated from the provincial cap and trade system and the existing fossil fuel duty to fund other emission-reduction measures and adaptation.[154]

EMISSION REDUCTIONS MEASURES BY SOURCE

Transportation is a growing emissions source for the province, having rose 28% since 1990.[155] Through Québec's *Policy Respecting Public Transit, the province* invested $4.5 billion in mass transit and alternative transportation between 2006 and 2012. Expenditures include the purchase of buses and trains and expansion of services.[156] Other measures targeting transportation included imposition of vehicle emissions standards on light-duty vehicles and 5% ethanol fuel content requirement. The 2013-2020 plan will dedicate two-thirds of the $2.7 billion in revenues expected from the fuel duty and emission allowances toward further actions to reduce emissions from transportation. $1.5 billion will be used to fund mass transit and alternative transportation. For freight vehicles, there will also be support for the conversion to other sources (e.g., electricity) and enhanced intermodal transportation alongside adoption of new vehicle emissions standards beyond 2017.[157]

Stationary energy emissions are already moving in the right direction, having fallen 21% since 1990.[158] These emissions are low relative to other provinces due in large part to a heavy reliance on non-emitting sources of electricity through hydropower. The province has pursued reductions in this sector through developing new hydroelectric and wind capacity and a strong focus on energy efficiency. Further measures are being developed through the 2013-2020 plan including programs to support energy efficiency and converting homes and businesses to rely more on renewable energy.[159]

Emissions from industrial processes are relatively small at 9.1 Mt and have fallen by 30% since 1990.[160] Large sources from this sector will be covered under the emissions trading scheme. The 2013-2020 Action Plan will support research and development into green technologies that may support emission reductions efforts in this sector.[161]

Agricultural emissions were 7.3 Mt in 2009, equivalent to a 1% increase since 1990.[162] The government has supported emission reductions efforts in this sector through funding for manure management and extracting energy from biomass. Going forward, there will be financial support for farmers to convert to more GHG efficient farming practices and further support for bioenergy sources.[163]

PROVINCIAL EVALUATION OF EMISSION REDUCTIONS MEASURES

Annual progress reports were issued on the 2006-2012 Action Plan. While details of the 2013-2020 plan are not yet available, there are plans to review progress at the mid-way point to ensure efficacy of measures and make sure funds are being used in the best way possible.[164]

INTER-JURISDICTIONAL MEASURES

Québec has been an active participant in the Western Climate Initiative (WCI) since joining in 2008 (see Chapter 3). The hallmark of this initiative has been the development of provincial and state-level emissions trading schemes that could eventually be interlinked to create a wider market, reduce leakage and drive costs down. Québec and California are both moving forward to implement trading schemes in the coming year.

Québec is also a member of the New England Governors/Eastern Canadian Premiers and has created its own targets that reach beyond the NEG/ECP Climate Change Action Plan 2001 target for regional GHG emissions of 1990 levels by 2010 and 10% below 1990 levels by 2020.

ii Information included in this appendix is sourced from Government of Québec 2008 (on measures to date) and Finances Québec 2012 (on future plans) unless otherwise indicated.

NEW BRUNSWICK

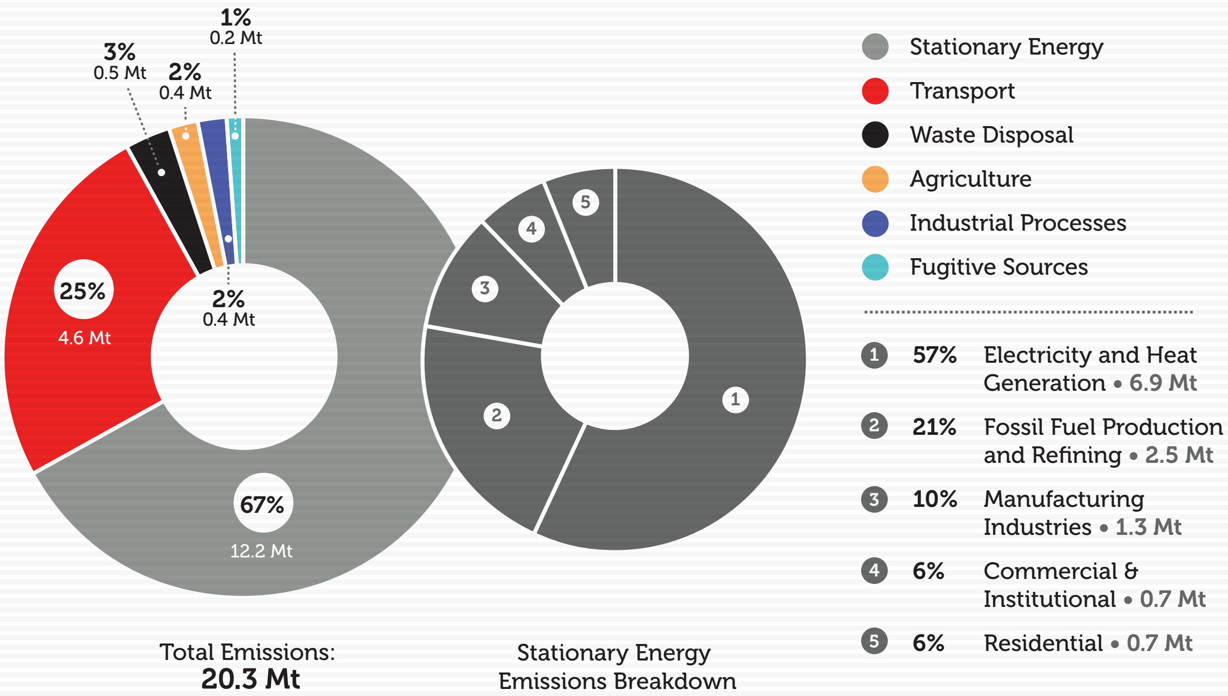
Climate Plan
Take Action - Climate Change Action Plan 2007-2012

Governing Body
Department of Environment – Climate Change Secretariat

Interim Target >>	Reach 1990 levels by 2010 5.5 Mt below 2007 levels in 2012
2020 Target >>	**10% below 1990 levels by 2020**

- **3RD LOWEST TOTAL EMISSIONS**
- **3RD HIGHEST PER CAPITA EMISSIONS**
- **EXISTING AND PROPOSED POLICIES ARE EXPECTED TO CLOSE 56% OF THE GAP TO THE PROVINCE'S 2020 TARGET**

FIGURE 33: EMISSIONS SOURCES (2009)[165]



EMISSIONS PROFILE

New Brunswick emitted 18.4 Mt CO_2e in 2009, a 15% increase since 1990. A breakdown of 2009 emission by source is provided in Figure 33.

NRT
NATIONAL ROUND TABLE ON THE ENVIRONMENT AND THE ECONOMY

EMISSION REDUCTIONS MEASURES BY SOURCE

Electricity generation is the largest emissions source, but lower energy demand, growth in wind energy, and electricity purchases from neighbouring utilities are all helping to reduce this emissions source.[166] The government created a renewable portfolio regulation in 2006 that identified a target of an additional 10% of electricity sold in the province by 2016 be generated from renewable sources.[jj] In 2009-2010 renewable sources contributed 20% of the total production in the province.[167] The province plans to support development of wood-based biomass resources (primarily pellets) through standards development, expanded use of biomass to heat government buildings, financial incentives and other measures.[168]

Energy efficiency and renewable energy measures implemented in its 2007–2012 climate plan have contributed to emission reductions from residential, and commercial and industrial activities.[169]

New Brunswick's transportation emissions represented a quarter of the province's total emissions in 2009. Speed limits for the trucking industry, incentives for fuel efficient vehicles, minimum emissions standards for vehicle registration, and anti-idling policies are all part of the government's transportation emission reductions strategy.

Waste disposal, at 3% of total emissions, is the third largest emitting activity in the province. Emissions from waste disposal have decreased 10% since 1990. In 2006, Fredericton began collecting and flaring landfill gas. The province aims to support further landfill gas capture where feasible.

Agricultural emissions accounted for 0.4 Mt CO_2e in New Brunswick in 2009. A farm energy efficiency program was put in place that supported several on-farm energy audits and funded a number of energy efficiency upgrades.[170]

The New Brunswick government is aiming to reduce emissions from public operations by 25% below 2001 levels by 2012. Specified procurement, low-emitting fleet, idling restrictions, sustainable building practices, and energy management and reporting all are intended to aid in reaching this target.

The New Brunswick climate plan addressed initiatives for 2007 to the current year. A new plan has not yet been put in place; however the province has stated that it will span to 2020 and that it will expand upon existing initiatives with new actions.[171] Similar to the 2007-2012 climate plan, the 2013-2020 climate plan is expected to address renewable energy and energy efficiency, transportation, waste reduction and diversion, industrial sources, government leading by example, adaptation, and partnerships and communication.[172]

PROVINCIAL EVALUATION OF EMISSION REDUCTIONS MEASURES

New Brunswick has released a Progress Report annually since 2007 detailing the progress of its climate plan each year. Initially, the province's focus was on the foundations laid for meeting the goals of the climate plan and has developed in nature to state the progress and results realized by the plan. The Department of Energy also has annual reports that include progress related to climate change concerns, energy efficiency, and renewables.[173]

The Department of Environment has monitored and measured various New Brunswick Climate Change Action Fund[kk] projects in support of public-sector, private-sector and not-for-profit initiatives which are expected to result in GHG reductions.[174]

Additionally, in order to track and report energy consumption and corresponding emissions the Department of Environment developed a model which will allow key departments to better manage their energy consumption, and will provide a baseline estimate of the province's emissions for future mitigation policies.

INTER-JURISDICTIONAL MEASURES

As a member of the New England Governors and Eastern Canadian Premiers (NEG/ECP), New Brunswick adopted the shared goal of stabilization of GHGs at 1990 levels by 2010 with additional reductions of 10% below 1990 levels by 2020.

Targeting electricity generated emissions is a key component of New Brunswick's climate plan. As a result, the interconnectivity of electricity transmission is also an important focus. The Atlantic Energy Gateway Initiative is one partnership that fosters this effort.

jj Information included in this appendix is sourced from Government of New Brunswick 2007 unless otherwise indicated.

kk This fund was announced in 2007 and provided $34 million in funding over three years to support emission reductions projects.

NOVA SCOTIA

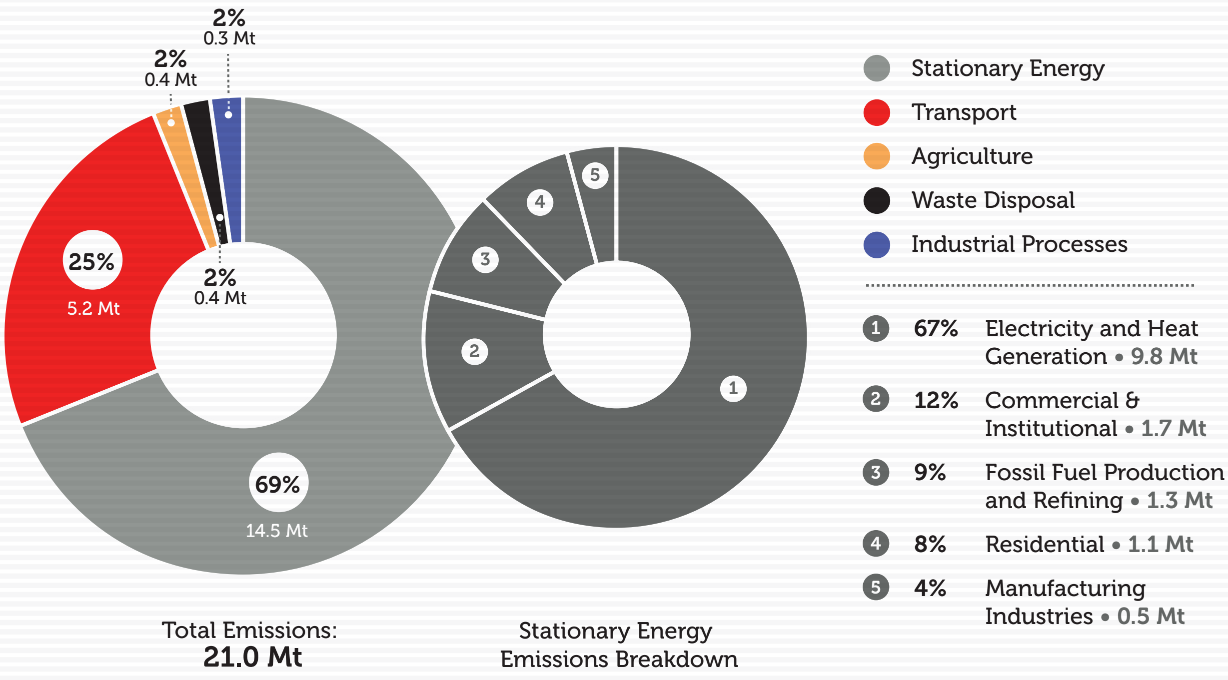
Climate Plan
Toward a Greener Future: Climate Change Action Plan

Governing Body
Department of Environment – Climate Change Directorate

Interim Target	>>	2.5 Mt below 2009 levels by 2015
2020 Target	**>>**	**10% below 1990 levels by 2020**
2050 Target	>>	up to 80% below 2009 levels by 2050

- **5TH LOWEST TOTAL EMISSIONS**
- **4TH HIGHEST PER CAPITA EMISSIONS**
- **EXISTING AND PROPOSED POLICIES ARE EXPECTED TO CLOSE THE GAP TO THE PROVINCE'S 2020 TARGET**

FIGURE 34: EMISSIONS SOURCES (2009)[175]



EMISSIONS PROFILE

In 2009, Nova Scotia contributed 21 Mt CO_2e to Canada's total emissions, an 11% increase in emissions since 1990. A breakdown of 2009 emissions by source is provided in Figure 34.

EMISSION REDUCTIONS MEASURES BY SOURCE

Stationary energy emissions contribute 69% of Nova Scotia's total emissions and within that, electricity and heat generation is responsible for two thirds of emissions. About 75% of electricity comes from burning coal. In 2009, Nova Scotia created legislation to regulate power generating facilities emitting 10,000 tonnes per year or higher.[||] Existing coal plants will have to be shut down at the end of their 40-year commercial lifespan unless they can be refitted with carbon-capture-and-storage equipment. Nova Scotia is the first province to put hard caps on GHG emissions for the electricity sector. A cap on total emissions from regulated facilities was imposed at 19.22 Mt through the province's *Greenhouse Gas Emissions Regulations*. Nova Scotia's Energy Strategy and its climate plan have a shared goal of reducing GHG emissions, and expect to drive about 5 Mt of emission reductions through initiatives such as energy efficiency and conservation, renewables and air quality, and future cleaner energy actions.

Nova Scotia's Renewable Electricity Plan proposes the use of 25% renewable electricity by 2015 and 40% renewable electricity by 2020 (see Chapter 3).[176] By 2020, the province is committed to increasing its energy efficiency by 20% from 2008 levels by giving people and businesses access to information, providing more money for energy efficiency and conservation, supporting more home energy audits, ensuring that more homes undergo efficiency upgrades, offering interest-free loans to increase the efficiency of existing housing, ensuring that new housing and buildings are more energy efficient, and providing incentives for more energy-efficient heating.[177]

Residential, and Commercial and Institutional emissions together contribute 2.8 Mt CO_2e. The *Nova Scotia Building Code Act* requires all buildings to meet certain energy efficiency standards. By 2020, all government-owned buildings constructed before 2001 are required to reduce energy consumption by 30%, and all new government-owned buildings are required to meet certain standards, including being carbon-neutral after 2020.

Transportation emissions constitute a quarter of Nova Scotia's total emissions, and efforts to reduce emissions include increasing vehicle efficiency, encouraging sustainable travel, and community land-use planning.

In 2010, the government passed a bill, entitled "An Act to Establish the Nova Scotia Voluntary Carbon Emissions Offset Fund" to support the development of offset projects within the province.[178]

PROVINCIAL EVALUATION OF EMISSION REDUCTIONS MEASURES

The Department of Environment produces an annual progress report of GHG emissions in the province as part of their *Environmental Goals and Sustainable Prosperity Act*. The effectiveness of measures to date in achieving the provincial 2020 target is to be assessed every five years through a public review by the Nova Scotia Round Table on Environment and Sustainable Prosperity.

The province monitors its emissions caps through an Emission reduction Schedule that requires five compliance periods from 2010 to 2020 under the regulations. If the electricity sector fails to meet the emissions cap for any individual compliance period, it is an offense punishable under the *Nova Scotia Environment Act*. Fines can be imposed by the Court for non-compliance of up to $500,000 daily, and are to be paid into the Nova Scotia Environmental Trust Fund.[179]

INTER-JURISDICTIONAL MEASURES

In 2010 Nova Scotia and the federal government signed an Agreement in Principle on efforts to address climate change. In March 2012, a commitment to an equivalency agreement was announced by the province and the federal government.[180] The equivalency agreement will avoid duplication of effort to control GHGs and ensure that industries do not face dual regulations. The federal regulations will stand down in favour of the provincial regulation, provided that the provincial regulations achieve equivalent outcomes. The federal regulations are to come into effect mid-2012, at which time the equivalency agreement can be finalized.

Nova Scotia is a member of the New England Governors and Eastern Canadian Premiers (NEG/ECP), and has adopted the shared goal of emission reductions of 10% below 1990 levels by 2020. It is also a member of the Atlantic Energy Gateway, a mechanism to foster the growth of clean and renewable energy supplies in Atlantic Canada and promoting this energy to new markets.[181]

|| Information included in this appendix is sourced from Government of Nova Scotia 2009 unless otherwise indicated.

PRINCE EDWARD ISLAND

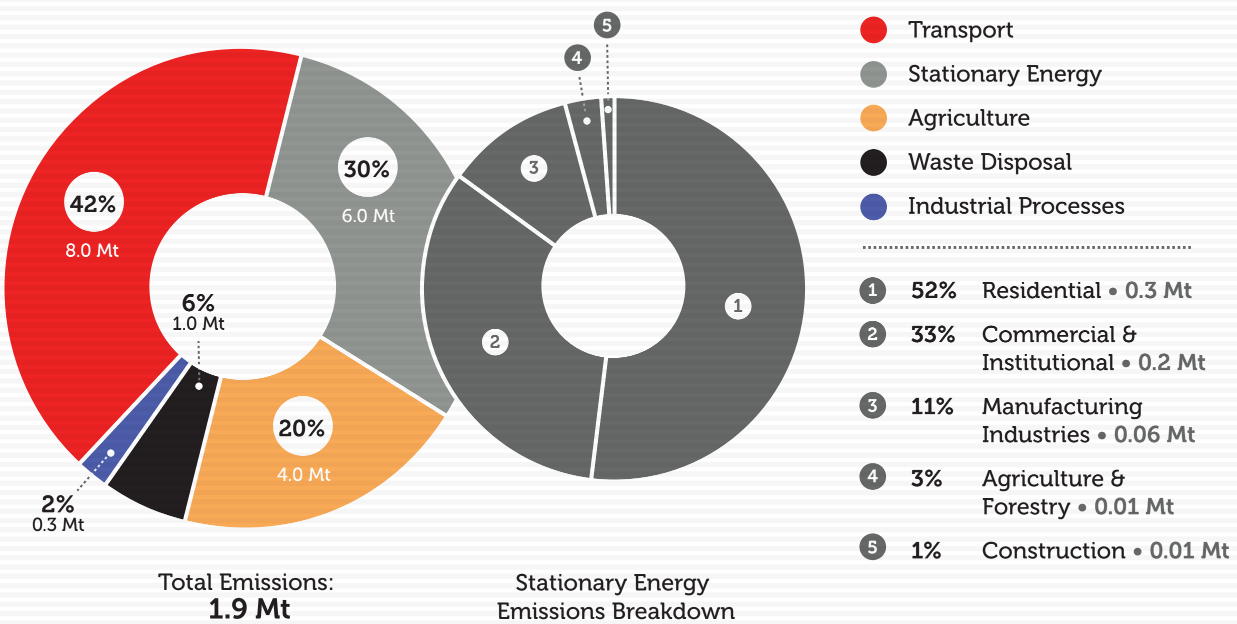
Climate Plan
Prince Edward Island and Climate Change: A Strategy for Reducing the Impacts of Global Warming

Governing Body
Department of Environment, Energy and Forestry

2020 Target >> **10% Below 1990 levels by 2020**

- **LOWEST TOTAL EMISSIONS**
- **3RD LOWEST PER CAPITA EMISSIONS**
- **EXISTING AND PROPOSED POLICIES ARE EXPECTED TO CLOSE 30% OF THE GAP TO THE PROVINCE'S 2020 TARGET**

FIGURE 35: EMISSIONS SOURCES (2009)[182]



EMISSIONS PROFILE

Prince Edward Island (PEI) has the lowest number of total emissions in Canada at 1.9 Mt CO_2e, and reduced its emissions by 4% from 1990 to 2009. A breakdown of 2009 emissions by source is provided in Figure 35.

ECONOMY-WIDE MEASURES

PEI has a three-pronged Environment and Energy Policy Series called "Securing Our Future" that includes a 10-point wind energy plan; an energy strategy focusing on conservation and renewables; and its climate plan focusing on reducing GHG emissions, enhancing carbon sinks, improving adaptation, and increasing public awareness.

EMISSION REDUCTIONS MEASURES BY SOURCE

Transportation is the largest emitting activity in PEI, contributing 42% to its total emissions, and having increased 14% since 1990. Over 80% of vehicles in PEI are classified as light-duty. PEI has acted to green its government fleet and has offered rebates for hybrid vehicles.[mm] Future planning is underway for technology funding, renewable fuel and vehicle efficiency standards, a public transit plan, and public education campaigns. PEI's Energy Strategy commits the province to introducing a renewable fuel content mandate by 2013 and engaging with neighbouring provinces and states to adopt low-carbon fuel standards.

PEI is committed to replacing thermal electricity that it imports to the province with wind power (see Chapter 3). Given the rural nature of much of the province, the PEI government is evaluating how best to facilitate the development of community-based renewable energy projects in PEI. Further efforts to reduce emissions from stationary energy are being planned through the implementation of new energy efficiency standards and building codes prior to 2018.

Agriculture emissions in the province represent 20% of its GHG emissions. Incentives are offered for the removal of marginal land from agricultural production if it is coupled with approved reforestation programs. The government has committed to promoting the use of reduce tillage management, cover crops, improved manure storage systems, and nutrient management systems to reduce GHGs. Moreover, biomass from agricultural sectors has been identified as available energy sources for biofuel development. The province intends to expand methane biogas capture and use it to generate heat for urban and local community district heating systems, thereby displacing fossil fuels.

PROVINCIAL EVALUATION OF EMISSION REDUCTIONS MEASURES

An annual climate change report is prepared that highlights progress on efforts to reduce GHG emissions provincially and in government operations.

INTER-JURISDICTIONAL MEASURES

Prince Edward Island is a member of the New England Governors and Eastern Canadian Premiers (NEG/ECP), and has adopted the shared goal of GHGs reductions of 10% below 1990 levels by 2020.

PEI is also a member of the Atlantic Energy Gateway that fosters the growth of clean and renewable energy supplies in Atlantic Canada and will promote this energy to new markets.[183]

mm Information included in this appendix is sourced from Prince Edward Island Department of Environment Energy and Forestry 2008 unless otherwise indicated.

NEWFOUNDLAND AND LABRADOR

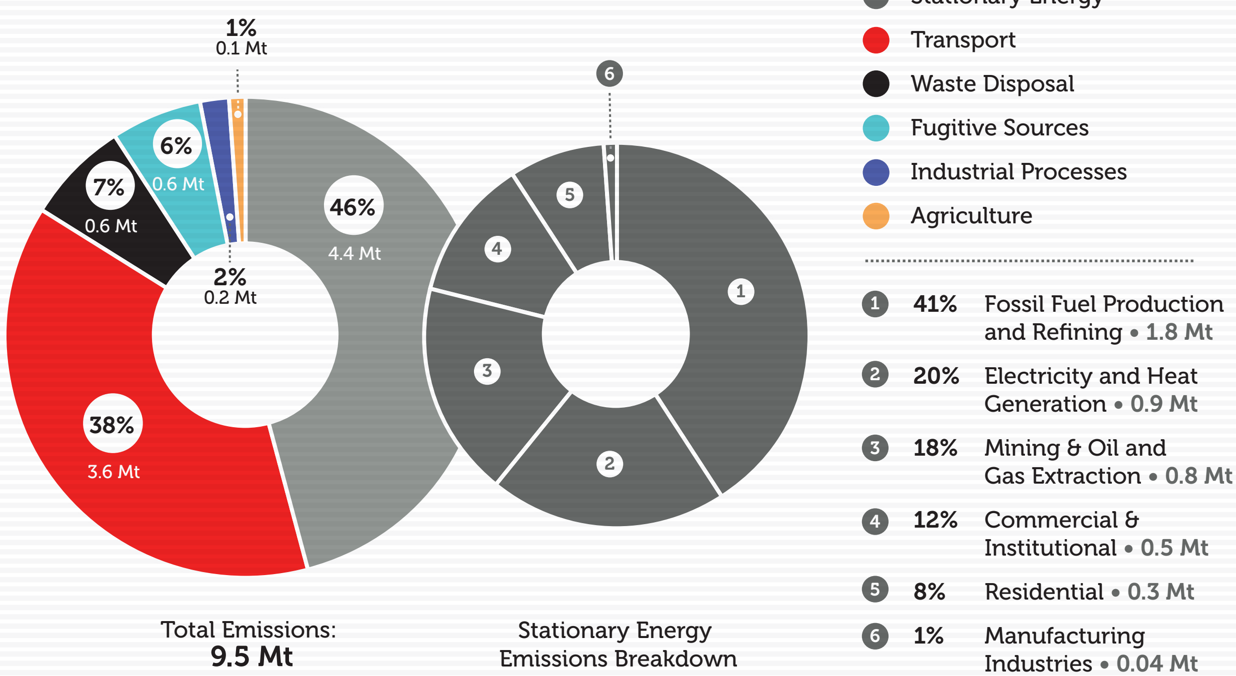
Climate Plan
Charting our Course: Climate Change Action Plan 2011

Governing Body
Office of Climate Change, Energy Efficiency and Emissions Trading

Interim Target	>>	reduce to 1990 levels by 2010
2020 Target	**>>**	**10% Below 1990 levels by 2020**
2050 Target	>>	75-80% below 2001 levels by 2050

- **2ND LOWEST TOTAL EMISSIONS**
- **5TH HIGHEST PER CAPITA EMISSIONS**
- **EXISTING AND PROPOSED POLICIES ARE EXPECTED TO CLOSE 35% OF THE GAP TO THE PROVINCE'S 2020 TARGET**

FIGURE 36: EMISSIONS SOURCES (2009) [62]



EMISSIONS PROFILE

Newfoundland and Labrador's GHG emissions have increased 3% since 1990 to a total emission level of 9.5 Mt CO_2e. A breakdown of 2009 emissions by source is provided in Figure 36.

NRT
NATIONAL ROUND TABLE ON THE ENVIRONMENT AND THE ECONOMY

EMISSION REDUCTIONS MEASURES BY SOURCE

Stationary energy in the province represents almost half of its GHG emissions. Currently approximately 85% of the electricity in Newfoundland and Labrador comes from clean energy, and the province is working to enhance that capacity. Developing the Muskrat Falls hydroelectric project will allow for a provincial electricity system that will be almost completely non-GHG-emitting. Muskrat Falls, would yield an estimated 1.2 Mt displacement of GHG emissions from the Holyrood oil-fired thermal generating station which currently emits over 10% of the province's GHG emissions (see Chapter 3).[nn] The province intends to use profits from investments in non-renewable resources, conventional light crude oil for example, to develop the renewable energy potential of the province. Oil-fired electricity from the Holyrood generating station also will be displaced by the two wind projects on the island that reduces GHG emissions by about 0.14 Mt annually. The province is also focusing on energy efficiency to simultaneously lower GHG emissions while supporting the economy.

Mining and oil and gas extraction is a large contributor to stationary energy. This is primarily because of offshore oil operations like Hibernia. The fugitive emissions in the province have increased exponentially from 0.04 Mt to 0.6 Mt per year since 1990 as a result of oil and natural gas. Hebron is another offshore oil operation that will come into operation over the next few years and is expected to raise the number of GHG emissions in the province. Newfoundland and Labrador plans to require the application of best available control technology requirements for new investments in the industrial sector to limit GHG emissions.

Emission reductions from the residential, and commercial and institutional sectors are encouraged through fuel switching and energy conservation. Efficiency programs exist for new buildings and retrofits, low-income residences, public buildings, and public housing. Specific focus has been placed on energy efficiency projects in coastal Labrador.

Transportation accounts for 38% of the province's emissions. An energy efficiency initiative for fishing vessels has been implemented in the province. Given the highly rural population distribution, mass transit alternatives are limited and reductions in this sector will be highly dependent on consumer-driven decisions.

Waste disposal contributes 0.6 Mt CO_2e to the province's total emissions. This number has increased 12% since 1990. The province's Solid Waste Management Strategy has attempted to divert landfill-bound materials, to reduce the number of waste disposal sites, and to eliminate open burning and phase out incinerators.

The provincial government intends to pursue its own reductions through procurement, energy audits, new government building and retrofit measures, and continuing to green government fleet.

PROVINCIAL EVALUATION OF EMISSION REDUCTIONS MEASURES

An Accountability Framework is being implemented by the Office of Climate Change, Energy Efficiency and Emissions Trading which establishes annual performance measures and targets, determines performance monitoring and reporting requirements, and assesses the need for program evaluations. The Premier will outline progress annually in the House of Assembly.

Regular monitoring and evaluation will document program impacts. A report will be released at the end of the plan and in 2.5 years (at the half-way mark) outlining progress on its commitments.

INTER-JURISDICTIONAL MEASURES

As a member of the New England Governors and Eastern Canadian Premiers (NEG/ECP), Newfoundland and Labrador adopted the shared goal of stabilization of GHGs at 1990 levels by 2010 with additional reductions of 10% below 1990 levels by 2020.

Newfoundland and Labrador is also a member of the Atlantic Energy Gateway, a mechanism to foster the growth of clean and renewable energy supplies in Atlantic Canada and to promote this energy to new markets.[185]

Collaboration with the federal government and other provinces and territories is an overarching theme of Newfoundland and Labrador's climate plan. The province intends to become an official observer of WCI to be involved with its emissions trading scheme without having to adopt the commitment of full membership status.

nn Information included in this appendix is sourced from Government of Newfoundland and Labrador 2011 unless otherwise indicated.

7.7 MEETINGS WITH PROVINCES AND TERRITORIES

PROVINCIAL/TERRITORIAL CONTACT LETTER

Dear…

I am writing to advise you that the National Round Table on the Environment and the Economy is conducting analysis on provincial / territorial climate change policies and plans in order to assess their likely contribution to Canada's 2020 greenhouse gas emission reductions target. We have been asked to do so by the federal Minister of Environment in order to better inform future federal regulatory policy actions on a sector-by-sector basis.

We would like you to participate directly in our consultation process to ensure we hear first-hand from the Government of (xxx) on progress and issues on your climate change plan and mitigation efforts. This will be of great value to us in our analysis and assessment so we can be sure of receiving all relevant information as well as direct feedback to inform our work. In turn, we will be seeking your suggestions and input on how federal/provincial/territorial climate policy efforts can be improved on a collaborative and coordinated basis so Canada achieves its 2020 GHG target in as effective a manner as possible.

Canada's 2020 GHG target is to reduce emissions by 17% below 2005 levels. As the attached backgrounder shows, forecasted federal and provincial/territorial measures together (based on Environment Canada data) should reduce domestic emissions by about 65 megatonnes in 2020, approximately one-quarter of the way towards the Canadian target (Figure 1). Analysis by the NRTEE shows that currently, this forecast results almost equally from both federal and provincial/territorial measures (Figure 2). As you can also see, forecasted emissions growth under baseline scenarios means additional measures are required to meet our 2020 target, less than ten years away (Figure 3). We are interested in receiving information on emission reductions achieved to date and forecasted from your respective plans and actions and to what extent they can be expected to contribute to Canada's 2020 target.

Provincial and territorial governments have been leading forces in developing and implementing novel and effective GHG reduction plans and measures. We wish to document this progress and learn from it. At the same time, federal and provincial/territorial efforts have, by choice and circumstance, resulted in a fragmented approach. Consideration of how more coordinated or collaborative efforts, where realistic and sensible, could jointly benefit jurisdictions in their own climate policy efforts and reduce duplication and overlap in policies and actions, could pay off for Canada as a whole in maximizing progress towards our 2020 domestic GHG reduction target.

The NRTEE has extensive experience in assessing and analyzing GHG emissions forecasts and policies. Over the past few years, we have issued detailed reports containing original modelling and policy recommendations on meeting both 2020 and 2050 national GHG reduction targets, harmonizing climate policy with the United States, carbon pricing, low-carbon performance, and best international practices in emissions forecasting. Our research and analysis has been relied upon and cited by numerous policy organizations, business and environmental groups, and government entities. We plan to be open and thorough as we undertake this new policy research project given its importance to you and the country's climate policy efforts.

As you may be aware, the NRTEE is an independent federal public policy advisory agency. We report to the Government of Canada and Parliament of Canada through the Minister of Environment. Our mission is to find sustainable pathways that advance integrated policy solutions benefitting both the environment and the economy. We do so by engaging governments, stakeholders, and experts in our independent and collaborative research and convening processes. Your direct participation in this important policy initiative will help make our analysis stronger and any advice we offer more relevant and useful to all.

Therefore, I am requesting the opportunity to meet bilaterally with you or designated officials in your government over the course of August, September and October to receive needed information that will assist us in our analysis and assessment. As series of questions to inform our conversation is contained in the attached backgrounder. We then plan to meet a second time bilaterally with officials to share and review our findings together and seek further input from you to ensure we have your full and considered information and comments before our work is completed. It is also our intention to commission independent academic and expert research from a national and intergovernmental perspective to assist us meeting our report goals. A stakeholder forum may take place early next year to offer further commentary and perspectives of value, to which you will be invited.

The attached backgrounder sets out specific questions and information requests needed to complete our task and to serve as a basis for our discussion. I hope you find it helpful.

My Executive Assistant, Ms. Helena Botelho, will be contacting you shortly to schedule a meeting.

I look forward to working with you on this initiative. In the meantime, please do not hesitate to contact me directly at any time.

Sincerely,

David McLaughlin
President and CEO

DATE	PROVINCE/TERRITORY	NAMES	
August 18, 2011	Prince Edward Island	John MacQuarrie, Erin Taylor, Jim Young,	DM Environment Climate Change Coordinator Director of Environment
August 23, 2011	New Brunswick	Perry Haines, Dean Mundee,	DM Environment Director of the Climate Change Secretariat
August 24, 2011	Nova Scotia	Jason Hollett, Lorrie Roberts,	Acting Director of Climate Change Director of Policy & Corporate Services
September 7, 2011	Manitoba	Fred Meier, Neil Cunningham,	DM Environment Acting Director of Climate Change and Green Strategy
September 20, 2011	Ontario	Gail Beggs, Jim Whitestone, Sarah Paul	DM Environment Director, Air Policy Instrument and Programs Design Branch Staff
September 21, 2011	Saskatchewan	Liz Quarshie, Donna Johnson, Ed Dean	DM Environment Acting Assistant DM Staff
September 22, 2011	Alberta	Jim Ellis, Ernie Hui, Bob Savage,	DM environment at that time ADM Environment at that time Acting Director, Climate Change Secretariat
September 23, 2011	British Colombia	Cairine MacDonald, James Mack, Jeremy Hewitt,	DM Environment Acting Head, Climate Action Secretariat Manager, Intergovernmental Relations
October 4, 2011	Québec	Diane Jean, Charles Larochelle, Genevieve Moisan,	DM Environment ADM Environment Director of Climate Change
October 27, 2011	Newfoundland and Labrador	Jackie Janes, Gerald Crane,	ADM / Senior Policy Advisor, Office of Climate Change, Energy Efficiency and Emissions Trading Director of Evidence
October 31, 2011	Yukon	Kelvin Leary, Eric Schroff, Harley Trudeau,	DM Environment Director Climate Change Yukon Government (Ottawa)

7.8 CANADIAN CLIMATE POLICIES DIALOGUE

On March 5–6, 2012, the NRT, in conjunction with the Queen's Institute of Intergovernmental Relations, held the Canadian Climate Policies Dialogue Session in Kingston, Ontario to present preliminary research, to receive feedback in response, and to engage participants in discussions on what this means to meeting Canada's 2020 target, with ideas and solutions for moving forward. The NRT chose to partner with the Queen's Institute because of its impeccable knowledge and credentials in working with governments, as well as academics and public policy experts, to host events and foster considered dialogue.

This invitation-only session was designed to offer a safe space for open discussion by governments. All provincial and territorial governments, the federal government, and noted climate and intergovernmental relations policy experts, including former senior officials, were invited to give their perspectives (see the Participants List in this Appendix).

This process allowed for our work to be well grounded in national, provincial, and regional realities, and it benefitted from top expert input and advice.

The dialogue session began with a reception and dinner on March 5th, with former Clerk of the Privy Council of Canada and Deputy Minister of Environment Canada, speaker Mel Cappe addressing the audience with a speech entitled "Federal/Provincial Relations and Climate Change: Change the Climate". On March 6th there were three facilitated roundtable discussions that focused on specific research topic areas allowing for a more detailed discussion on the subject matter. Topic areas included: NRT modelling analysis on Canadian emission reductions to 2020; climate policy experiences by provincial/territorial governments; and prospects and ideas for future climate policy approaches and steps.

Overall, the session confirmed some key conclusions:

- We have made progress as a country to achieve emission reductions but not enough based on existing and likely measures to close the gap.
- There is diversity in approaches by governments between federal and provincial governments and between provincial governments themselves. This is to be expected and has value. But it has also complicated efforts at a more pan-Canadian approach and created some duplication, overlap, and economic inefficiencies in the way climate actions have been implemented. Policy certainty from the federal government was strongly desired.

- Concerns exist about federal sectoral and regulatory approaches within some provinces; while the current federal approach has been accepted as inevitable, it meant national carbon pricing a more desirable approach for many provinces and experts, was not being considered.
- There has been emerging co-operation between levels of government on climate change policy action - namely, reviewing baseline numbers and having a single window approach for businesses to report to both levels of government.
- No effective mechanisms or processes for F/P/T collaboration exist to engage in policy development or dialogue to consider different approaches.
- Targets versus time frames came out as an important difference in detail. While all had targets and needed to move toward them, the time frames to do so was not always aligned. This disconnect was noted several times.
- All provincial representatives asserted a pretty clear determination to keep going with their climate plans. Links between climate policy and a transition to a low-carbon economy were noted by some.

AGENDA - CANADIAN CLIMATE POLICIES DIALOGUE SESSION

DONALD GORDON CONFERENCE CENTRE
421 UNION STREET - KINGSTON, ONTARIO
Conference Room B

Monday, March 5th, 2012

18:00 - 19:00	Reception – Cash Bar	*Coach House Pub At Donald Gordon Centre*
19:00 – 20:30	Dinner	*Conference Room B*
	Opening Remarks	*André Juneau David McLaughlin*
	Speaker	*Mel Cappe, Professor, School of Public Policy and Governance, University of Toronto*

Tuesday, March 6th, 2012

8:00 – 8:30	Continental Breakfast	
8:30 – 9:00	Opening Remarks	*André Juneau David McLaughlin*
9:00 – 9:15	Presentation	***Table 1: NRT Modelling Analysis on Canadian emission reductions to 2020***
9:15 – 10:15	Round Table Discussion	
10:15 – 10:30	Questions & Comments	
10:30 – 11:00	Break	
11:00 – 11:15	Presentation	***Table 2: Climate Policy Experiences by Provincial / Territorial Governments***
11:15 – 12:15	Provincial / Territorial representatives Discussion	
12:15 – 12:30	Questions & Comments	
12:30 – 13:30	Lunch	
13:30 – 13:45	Presentation	***Table 3: Prospects and Ideas for Future Climate Policy Approaches and Steps***
13:45 – 14:45	Round Table Discussion	
14:45 – 15:00	Questions & Comments	
15:00 – 15:15	Closing Remarks	*André Juneau David McLaughlin*

PARTICIPANTS

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Finance Canada

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Senior Managing Partner
Navius Research Inc.

Jonah Bernstein
Senior Policy Advisor,
Climate Change
Government of Nova Scotia

Dale Beugin
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SkyCurve Consulting

Douglas Brown
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Department of Political Science
St. Francis Xavier University

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University of Toronto

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Gerald Crane
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Scott Vaughan
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Randall Wigle
Professor
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ENDNOTES

1 *The Changing Atmosphere: Implications for Global Security - Conference Statement* 1988

2 Jaccard et al. 2006

3 Environment Canada 1990; as cited in Harrison 2012;

4 Harrison 2012; Liberal Party of Canada 1993

5 Environment Canada 1995

6 Jaccard et al. 2006

7 Environment Canada 2007

8 Environment Canada 2008

9 Environment Canada 2010a

10 Environment Canada 2007

11 Government of Canada 2000

12 Government of Canada 2002

13 Government of Canada 2005

14 Number 016, 1st Session, 39th Parliament, Thursday, October 5 2006

15 Environment Canada 2008

16 Environment Canada 2011b

17 Environment Canada 2010a

18 Environment Canada 2011b

19 Environment Canada NDa

20 Environment Canada 2011d

21 National Round Table on the Environment and the Economy 2011

22 Government of Canada 2009

23 Harrison 2012

24 Lucas and Yearsley 2011

25 Chalifour 2008

26 Chalifour 2008

27 Environment Canada 2011b

28 Environment Canada 2011b

29 Environment Canada 2011b

30 Environment Canada 2011b

31 Environment Canada 2011b

32 Environment Canada 2011b

33 Environment Canada 2011b

34 Environment Canada 2011b

35 Environment Canada 2011b

36 Environment Canada 2011a; Climate Change and Emissions Management Corporation ND

37 National Round Table on the Environment and the Economy 2009a

38 Intergovernmental Panel on Climate Change 2007

39 The Pembina Institute 2011

40 Environmental Commissioner of Ontario 2011

41 National Round Table on the Environment and the Economy 2007

42 Environment Canada 2011b

43 Environment Canada NDb

44 Government of Saskatchewan 2009b; *Specified Gas Emitters Regulation, Alta Reg 139/2007* 2007

45 Council of the Federation ND

46 Canadian Council of Ministers of the Environment ND

47 Federation of Canadian Municipalities 2012; Federation of Canadian Municipalities and Local Governments for Sustainability - ICLEI 2012

48 Government of Newfoundland and Labrador 2010b

49 Government of Saskatchewan 2010a

50 Live Smart British Columbia ND; Pacific Carbon Trust NDa, NDb

51 Climate Change and Emissions Management Corporation ND

52 Government of Alberta ND

53 Government of Sasktachewan 2011; SaskPower 2012a, 2012b

54 Government of Manitoba 2010

55 Government of Canada 2011

56 Ontario Power Authority 2010a, 2010b

57 Dachis and Carr 2011

58 Développement durable Environnement et Parcs ND; Government of Québec ND

59 New Brunswick Department of Energy 2011

60 Nova Scotia Department of Energy 2010; Province of Nova Scotia 2010

61 Prince Edward Island Department of Environment Energy and Forestry 2008

62 Government of Newfoundland and Labrador 2010a; Government of Newfoundland and Labrador 2011

63 Environment Canada 2011b

64 32nd Yukon Legislative Assembly 2011; National Round Table on the Environment and the Economy 2009b

65 Environment Canada 2012

66 National Energy Board 2011b

67 Department of Sustainable Development 2003; Northwest Territories Environment and Natural Resources 2011; Yukon Government 2009

68 Northwest Territories Environment and Natural Resources 2011

69 National Energy Board 2011a

70 Government of Canada 2008

71 Environment Canada 2011a

72 Canada NewsWire 2012

73 Grantham Research Institute on Climate Change and the Environment 2011

74 National Round Table on the Environment and the Economy 2009a

75 Canada Gazette 2011

76 Canada Gazette 2011

77 Environment Canada 2011c

78 Canada Gazette 2011

79 Government of Ontario 2010

80 Canada Gazette 2011

81 Canada Gazette 2010a

82 Environment Canada 2011b

83 Environment Canada 2010b

84 Canada Gazette 2010b

85 Environment Canada 2011e

86 Government of British Columbia 2010

87 Environment Canada 2011b

88 Environment Canada 2011b

89 British Columbia Ministry of Energy and Mines 2012

90 Environment Canada 2011b

91 Government of British Columbia 2010

92 Government of British Columbia ND

93 Environment Canada 2011b

94 Natural Resources Canada 2011

95 Environment Canada 2011b

96 British Columbia Ministry of Environment 2011

97 British Columbia Ministry of Environment 2010

98 British Columbia Ministry of Environment NDa

99 British Columbia Ministry of Environment NDb

100 British Columbia Ministry of Environment NDa

101 Government of British Columbia 2010

102 Government of Alberta 2008

103 Environment Canada 2011b

104 Environment Canada 2011b

105 Government of Alberta 2011

106 Government of Alberta 2011

107 Environment Canada 2011b

108 Government of Alberta 2010

109 Government of Alberta 2011

110 Auditor General of Alberta 2011

111 Government of Saskatchewan 2011b

112 Environment Canada 2011b

113 Environment Canada 2011b

114 Government of Saskatchewan 2009a

115 Government of Saskatchewan 2009b

116 SaskPower NDa

117 SaskPower NDb

118 Saskatchewan Housing Corporation ND; Government of Saskatchewan NDa; SaskEnergy NDa

119 Saskatchewan Ministry of Environment ND; Government of Saskatchewan 2009b

120 SaskEnergy NDb

121 Environment Canada 2011b

122 Government of Saskatchewan NDb

123 Environment Canada 2011b

124 Government of Saskatchewan NDc

125 Government of Saskatchewan 2011a

126 Saskatchewan Ministry of Environment 2012

127 Government of Saskatchewan 2009b

128 Government of Saskatchewan 2010b

129 Government of Saskatchewan NDd

130 Government of Saskatchewan 2009a

131 Environment Canada 2011b

132 Government of Manitoba ND

133 Government of Manitoba 2010

134 Government of Manitoba 2010

135 Environment Canada 2011b

136 Environment Canada 2011b

137 Environment Canada 2011b

138 Ontario Power Authority 2010

139 Legislative Assembly of Ontario 2009

140 Government of Ontario 2009

141 Environment Canada 2011b

142 Ontario Power Authority ND

143 Environment Canada 2011b

144 Environmental Commissioner of Ontario 2011

145 Environmental Commissioner of Ontario 2011

146 Environmental Commissioner of Ontario 2011

147 Environment Canada 2011b

148 Environmental Commissioner of Ontario 2011

149 Environmental Commissioner of Ontario 2011

150 Environment Canada 2011b

151 Environment Canada 2011b

152 Government of Québec 2010

153 Finances Québec 2012

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155 Environment Canada 2011b

156 Government of Québec 2010

157 Finances Québec 2012

158 Environment Canada 2011b

159 Finances Québec 2012

160 Environment Canada 2011b

161 Finances Québec 2012

162 Environment Canada 2011b

163 Finances Québec 2012

164 Finances Québec 2012

165 Environment Canada 2011b

166 New Brunswick Department of Energy 2011

167 New Brunswick Energy Commission 2011

168 New Brunswick Department of Energy 2011

169 Government of New Brunswick 2011

170 Government of New Brunswick 2011

171 Government of New Brunswick 2011

172 New Brunswick Department of Energy 2011

173 Government of New Brunswick 2011

174 Government of New Brunswick 2011

175 Environment Canada 2011b

176 Nova Scotia Department of Energy 2010

177 Nova Scotia Department of Energy 2009

178 Government of Nova Scotia 2010

179 Nova Scotia Department of Environment 2009

180 Canada NewsWire 2012

181 Atlantic Canada Opportunities Agency 2009

182 Environment Canada 2011b

183 Atlantic Canada Opportunities Agency 2009

184 Environment Canada 2011b

185 Atlantic Canada Opportunities Agency 2009

REFERENCES

32nd Yukon Legislative Assembly. 2011. Report of the Select Committee on the Safe Operation and Use of Off-road Vehicles.

Atlantic Canada Opportunities Agency. *The Atlantic Energy Gateway - Making Atlantic Canada a Leader in Clean and Renewable Energy* 2009. Available from http://www.acoa-apeca.gc.ca/eng/Agency/mediaroom/NewsReleases/Pages/2559.aspx#mainContent.

Auditor General of Alberta. 2011. Report of the Auditor General of Alberta - November 2011.

British Columbia Ministry of Energy and Mines. 2012. Renewable and Low Carbon Fuel Requirements Regulation.

British Columbia Ministry of Environment. 2010. British Columbia Greenhouse Gas Inventory Report 2008.

British Columbia Ministry of Environment. 2011. Landfill Gas Management Regulation.

British Columbia Ministry of Environment. *Reporting Regulation – Greenhouse Gas Reduction (Cap and Trade) Act* NDa. Available from http://www.env.gov.bc.ca/cas/mitigation/ggrcta/reporting-regulation/.

British Columbia Ministry of Environment. *Community Energy and Emissions Inventory* NDb. Available from http://www.env.gov.bc.ca/cas/mitigation/ceei/index.html.

Canada Gazette. 2010a. Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations (Regulatory Impact Analysis Statement).

Canada Gazette. 2010b. Renewable Fuels Regulations (Regulatory Impact Analysis Statement).

Canada Gazette. 2011. Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations (Regulatory Impact Analysis Statement).

Canada NewsWire. 2012. Canada and Nova Scotia working together to reduce greenhouse gas emissions. http://www.digitaljournal.com/pr/628925.

Canadian Council of Ministers of the Environment. *About CCME* ND. Available from http://www.ccme.ca/about/.

Chalifour, N. 2008. Making Federalism Work for Climate Change: Canada's Division of Powers over Carbon Taxes. *National Journal of Constitutional Law* 22 (2):119-214.

The Changing Atmosphere: Implications for Global Security - Conference Statement. 1988. Available from http://www.cmos.ca/ChangingAtmosphere1988e.pdf.

Climate Change and Emissions Management Corporation. ND. 2010-2013 Business Plan.

Council of the Federation. *About the Council* ND. Available from http://www.councilofthe-federation.ca/aboutcouncil/aboutcouncil.html.

Dachis, B, and J Carr. 2011. Zapped: The High Cost of Ontario's Renewable Electricity Subsidies. C.D. Howe Institute.

Department of Sustainable Development. 2003. Nunavut Climate Change Strategy.

Développement durable Environnement et Parcs. *Cap and trade system for greenhouse gas emission allowances* ND. Available from http://www.mddep.gouv.qc.ca/changements/carbone/Systeme-plafonnement-droits-GES-en.htm.

Environment Canada. 1990. Canada's Green Plan: Canada's Green Plan for a Healthy Environment.

Environment Canada. 1995. National Action Program on Climate Change.

Environment Canada. 1999. Canada's Greenhouse Gas Inventory 1997: Emissions and Removals with Trends.

Environment Canada. 2007. A Climate Change Plan for the Purposes of the Kyoto Protocol Implementation Act.

Environment Canada. 2008. Turning the Corner: Regulatory Framework for Industrial Greenhouse Gas Emissions.

Environment Canada. 2010a. News Release: Canada Announces a New Federal Sustainable Development Strategy.

Environment Canada. *Regulatory Framework Consultation Document describing key elements being considered for future regulations to limit greenhouse gas emissions from new on-road heavy-duty vehicles and engines of the 2014 and later model years* 2010b. Available from http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=D8A56F71-1.

Environment Canada. 2011a. Canada's Emissions Trends.

Environment Canada. 2011b. National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2009.

Environment Canada. *Backgrounder: Reducing Greenhouse Gas Emissions from the Electricity Sector* 2011c. Available from http://www.ec.gc.ca/default.asp?lang=En&n=2D1D6FA7-1&news=E9162F74-3B55-49AE-BCDA-2D4A83331591.

Environment Canada. *Statement by Minister Kent* 2011d. Available from http://www.ec.gc.ca/default.asp?lang=En&n=FFE36B6D-1&news=6B04014B-54FC-4739-B22C-F9CD9A840800.

Environment Canada. *Current Regulation: Regulations Amending the Renewable Fuels Regulations* 2011e. Available from http://www.ec.gc.ca/lcpe-cepa/eng/Regulations/DetailReg.cfm?intReg=202.

Environment Canada. *Gazette I Publication of the Proposed Sulphur in Diesel Fuel Regulations* 2012. Available from http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=01D4A774&offset=4&toc=show

Environment Canada. *Canada's Domestic Action* NDa. Available from http://www.climatechange.gc.ca/default.asp?lang=En&n=4FE85A4C-1

Environment Canada. *Backgrounder: Regulating On-Road GHG Emissions* NDb. Available from http://www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=0F384925-9836-4936-B20F-A551607EEC95.

Environmental Commissioner of Ontario. 2011. Meeting Responsibilities: Creating Opportunities - Annual Greenhouse Gas Progress Report 2011.

Federation of Canadian Municipalities. *Partners for Climate Protection Members* 2012. Available from http://fcm.ca/home/programs/partners-for-climate-protection/members.htm.

Federation of Canadian Municipalities, and Local Governments for Sustainability - ICLEI. 2012. Outcomes from the 2011 National PCP Measures Report. In *Sustainable Communities Conference and Trade Show.*

Finances Québec. 2012. Budget 2012-2013 Québec and Climate Change: A Greener Environment.

Friends of the Oldman River Society v. Canada (Minister of Transport). 1992. In 1 S.C.R. 3 at para. 85.

Government of Alberta. 2008. Alberta's 2008 Climate Change Strategy: Responsibility / Leadership / Action.

Government of Alberta. 2010. Talk About BioEnergy.

Government of Alberta. 2011. Environment: Annual Report 2010-2011.

Government of Alberta. *Climate Change and Emissions Management Fund* ND. Available from http://environment.alberta.ca/02486.html.

Government of British Columbia. 2008. British Columbia's Climate Change Action Plan.

Government of British Columbia. 2010. British Columbia: Climate Action for the 21st Century.

Government of British Columbia. ND. The BC Energy Plan: A Vision for Clean Energy Leadership.

Government of Canada. 2000. Government of Canada Action Plan 2000 on Climate Change.

Government of Canada. 2002. Climate Change Achieving Our Commitments Together: Climate Change Plan for Canada.

Government of Canada. 2005. Project Green: Moving Forward on Climate Change: A Plan for Honouring our Kyoto Commitment.

Government of Canada. 2008. 2008 Speech from the Throne.

Government of Canada. *News Releases: Canada and the U.S. work together on Clean Energy Dialogue* 2009. Available from http://www.ecoaction.gc.ca/news-nouvelles/20090630-eng.cfm.

Government of Canada. 2011. A Strong Partnership: Energy Relationship between Canada and the United States.

Government of Manitoba. 2010. Manitoba's Report on Climate Change: Progress Update on Manitoba's Emission Reductions.

Government of Manitoba. ND. Public Consultation on a Proposed Cap and Trade System for Manitoba.

Government of New Brunswick. 2007. Take Action: Climate Change Action Plan 2007-2012.

Government of New Brunswick. 2011. New Brunswick and Climate Change: On Track to 2012 - 2010-2011 Progress Report Summary.

Government of Newfoundland and Labrador. *Lower Churchill Project - News Release* 2010a. Available from http://www.gov.nl.ca/lower-churchillproject/release.htm.

Government of Newfoundland and Labrador. 2010b. Responding to Climate Change in Newfoundland and Labrador Public Discussion Document.

Government of Newfoundland and Labrador. 2011. Charting Our Course: Climate Change Action Plan 2011.

Government of Nova Scotia. 2009. Toward a Greener Future: Nova Scotia's Climate Change Action Plan.

Government of Nova Scotia. 2010. Voluntary Carbon Emissions Offset Fund Act.

Government of Ontario. 2007. Go Green: Ontario's Action Plan on Climate Change.

Government of Ontario. 2009. Climate Change Action Plan: Annual Report 2008-09.

Government of Ontario. *Phasing Out Coal Power in Ontario* 2010. Available from http://news.ontario.ca/mei/en/2010/10/phasing-out-coal-power-in-ontario.html.

Government of Québec. 2008. Québec and Climate Change: A Challenge for the Future.

Government of Québec. 2010. 2006-2012 Climate Change Action Plan Fourth Annual Report: Blending the Environment with the Economy.

Government of Québec. ND. Regulation Respecting a Cap-and-Trade System for Greenhouse Gas Emission Allowances.

Government of Saskatchewan. 2007. Saskatchewan Energy and Climate Change Plan 2007.

Government of Saskatchewan. *Saskatchewan and Montana Join Forces on Carbon Capture and Storage* 2009a. Available from http://www.gov.sk.ca/news?newsId=c06068a6-59d6-40ba-a2f7-43d07b24441c.

Government of Saskatchewan. 2009b. Bill N°. 126: An Act Respecting the Management and Reduction of Greenhouse Gases and Adaptation to Climate Change.

Government of Saskatchewan. 2010a. An Act Respecting the Management and Reduction of Greenhouse Gases and Adaptation to Climate Change.

Government of Saskatchewan. 2010b. Saskatchewan Climate Change Plan. Presentation at the Canadian Energy Forum, February 9, 2010.

Government of Saskatchewan. 2011a. Saskatchewan's 2011 State of the Environment Report.

Government of Saskatchewan. 2011b. Saskatchewan's 2011 State of the Environment Report.

Government of Saskatchewan. NDa. Go Green: Programs for Homeowners / Residential Users.

Government of Saskatchewan. NDb. Saskatchewan Biofuels Investments Opportunity Program (SaskBio): Media Backgrounder.

Government of Saskatchewan. NDc. Go Green: Transportation.

Government of Saskatchewan. NDd. Backgrounder: Memorandum of Understanding Between the Province of Saskatchewan and the State of Victoria.

Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science. 2011. Green Economy.

Harrison, K. 2012. Intergovernmental Relations and Climate Policy: Lessons from Comparitive Federalism, report commissioned by the National Round Table on the Environment and the Economy.

Intergovernmental Panel on Climate Change. 2007. IPCC Fourth Assessment Report: Climate Change 2007.

Jaccard, M, and C. Bataille. 2004. If Sustainability is Expensive, What Roles for Business and Government? A Case Study of Greenhouse Gas Reduction Policy in Canada. *Journal of Business Administration and Policy Analysis* 30-31:149-183.

Jaccard, M, N Rivers, C Bataille, R Murphy, J Nyboer, and B Sadownik. 2006. Burning Our Money to Warm the Planet: Canada's Ineffective Efforts to Reduce Greenhouse Gas Emissions.

Jaffe, A, R Newell, and R Stavins. 1999. Energy efficient technologies and climate change policies. In *Climate Issue Brief No. 19*: Resources for the Future.

Khanna, M. 2001. Non-mandatory Approaches to Environmental Protection. *Journal of Economic Surveys* 15 (3):291-324.

Legislative Assembly of Ontario. 2009. Bill 150: Green Energy and Green Economy Act, 2009.

Liberal Party of Canada. 1993. Red Book: Creating Opportunity - The Liberal Plan for Canada.

Live Smart British Columbia. ND. Carbon Neutral B.C.: Transforming B.C.'s Public Sector.

Lucas, A R, and J Yearsley. 2011. The Constitutionality of Federal Climate Change Legislation. *University of Calgary School of Public Policy Research Papers* 4 (15).

May, E. 2002. From Montreal to Kyoto, How we got from here to there - or not. *Policy Options.*

National Energy Board. 2011a. Canada's Energy Future: Energy Supply and Demand Projections to 2035.

National Energy Board. 2011b. Energy Use in Canada's North: An Overview of Yukon, Northwest Territories, and Nunavut - Energy Facts.

National Round Table on the Environment and the Economy. 2007. Getting to 2050: Canada's Transition to a Low-Emission Future: Advice for Long-Term Reductions of Greenhouse Gases and Air Pollutants.

National Round Table on the Environment and the Economy. 2009a. Achieving 2050: A Carbon Pricing Policy for Canada.

National Round Table on the Environment and the Economy. 2009b. True North: Adapting Infrastructure to Climate Change in Northern Canada.

National Round Table on the Environment and the Economy. 2011. Response of the National Round Table on the Environment and the Economy to its Obligations under the Kyoto Protocol Implementation Act.

Natural Resources Canada. 2011. ecoENERGY Technology Initiative.

Navius Research Inc. 2012. Economic Modelling of Provincial, Territorial and Federal Climate Change Policies, report commissioned by the National Round Table on the Environment and the Economy.

New Brunswick Department of Energy. 2011. The New Brunswick Energy Blueprint.

New Brunswick Energy Commission. 2011. Final Report 2010-2011.

North America 2050. *North America 2050: A Partnership for Progress* ND. Available from http://www.oregon.gov/ENERGY/GBLWRM/docs/NA2050_Fact_Sheet.pdf?ga=t.

Northwest Territories Environment and Natural Resources. 2011. A Greenhouse Gas Strategy for the Northwest Territories 2011 - 2015.

Nova Scotia Department of Energy. 2009. Toward a Greener Future: Nova Scotia's 2009 Energy Strategy.

Nova Scotia Department of Energy. 2010. Renewable Electricity Plan.

Nova Scotia Department of Environment. 2009. An Approach to Regulating Electricity Sector Greenhouse Gas and AIr Pollutant Emissions in Nova Scotia: A Discussion Paper.

2006. Standing Committee on Environment and Sustainable Development. *Number 016, 1st Session, 39th Parliament, Thursday, October 5.*

O'Meara, D. 2012. Cancellation of major Alberta carbon capture project 'a big setback'. *Calgary Herald*, April 27.

Ontario Power Authority. 2010. Feed-in Tariff Program: Program Overview.

Ontario Power Authority. *Conservation Fund* ND. Available from http://www.powerauthority.on.ca/cfund.

Pacific Carbon Trust. *Who We Are* NDa. Available from http://www.pacificcarbontrust.com/who-we-are/.

Pacific Carbon Trust. *Offset Showcase* NDb. Available from http://www.pacificcarbontrust.com/our-projects/offset-showcase/.

Prince Edward Island Department of Environment Energy and Forestry. 2008. Prince Edward Island and Climate Change: A Strategy for Reducing the Impacts of Global Warming.

Province of Nova Scotia. 2010. Renewable Electricity Regulations made under Section 5 of the Electricity Act.

Rabe, B. 2012. The Evolving American Approach to Climate Change: Consequences for Canada, report commissioned by the National Round Table on the Environment and the Economy.

RBC Economics. 2012. Provincial Outlook March 2012.

Saskatchewan Housing Corporation. ND. Know the Facts: Saskatchewan Home Energy Improvement Program (SHEIP) For Low and Moderate-Income Homeowners.

Saskatchewan Ministry of Environment. 2012. Exploring the New Saskatchewan Environmental Code: A Framework for Effective Environmental Protection through Innovation.

Saskatchewan Ministry of Environment. *Solar Heating Initiative for Today* ND. Available from http://www.environment.gov.sk.ca/adx/aspx/adxGetMedia.aspx?DocID=e020e04b-4817-439f-ad15-55708da35d32&MediaID=4005&Filename=SHIFT.pdf&l=English.

SaskEnergy. *Energy Efficiency Programs* NDa. Available from http://www.saskenergy.com/saving_energy/specialoffers.asp.

SaskEnergy. *Commercial Boiler Program* NDb. Available from http://www.saskenergy.com/business/commercialboiler.asp.

SaskPower. *Boundary Dam Integrated Carbon Capture and Storage Project* NDa. Available from http://www.saskpowercarboncapture.com/projects/boundary_dam.

SaskPower. *CCS in Saskatchewan* NDb. Available from http://www.saskpowercarboncapture.com/what-is-ccs/ccs_in_sask.

Specified Gas Emitters Regulation, Alta Reg 139/2007.

Statistics Canada. ND. GDP - Table 384-0002 - Expenditure based annual, chained.

The Pembina Institute. 2011. Responsible Action? An Assessment of Alberta's Greenhouse Gas Policies.

Western Climate Initiative. 2008. Design Recommendations for the WCI Regional Cap-and-Trade Program.

Western Climate Initiative. *Frequently Asked Questions* 2012a. Available from http://www.westernclimateinitiative.org/the-wci-cap-and-trade-program/faq.

Western Climate Initiative. *History* 2012b. Available from http://www.westernclimateinitiative.org/history.

Wigle, R, and N Rivers. 2012. Overlapping Federal-Provincial Climate Policies, report commissioned by the National Round Table on the Environment and the Economy.

Yukon Government. 2009. Yukon Government Climate Change Action Plan.

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