Economic Modeling of NWT Greenhouse Gas Emissions - FINAL REPORT

Analysis of carbon pricing policy options

This report was prepared for information only for the Department of Environment and Natural Resources in 2016. It predates the development of the Pan-Canadian Framework on Clean Growth and Climate Change as well as the Government of Canada's federal carbon pricing benchmark.

SUBMITTED TO

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About Us

Navius Research Inc. ("Navius") is a private consulting firm in Vancouver. Our consultants specialize in analyzing government and corporate policies designed to meet environmental goals, with a focus on energy and greenhouse gas emission policy. We also assist clients with stakeholder consultation and engagement processes, and with the development of clear and effective communication strategies and materials. This combination of quantitative forecasting expertise and communication and engagement capabilities allows Navius to provide a complete and integrated solution to clients working on climate change and energy planning

Our consultants have been active in the energy and climate change field since 1996, and are recognized as some of Canada's leading experts in modeling the environmental and economic impacts of energy and climate policy initiatives. Navius is uniquely qualified to provide insightful and relevant analysis in this field because:

- We have a broad understanding of energy and environmental issues both within and outside of Canada.
- We use unique in-house models of the energy-economy system as principal analysis tools
- We have significant experience developing and implementing communication and engagement strategies on energy, climate change, and environmental topics.
- We have a strong network of experts in related fields with whom we work to produce detailed and integrated climate and energy analyses.
- We have gained national and international credibility for producing sound, unbiased analyses for clients from every sector, including all levels of government, industry, labour, the non-profit sector, and academia.

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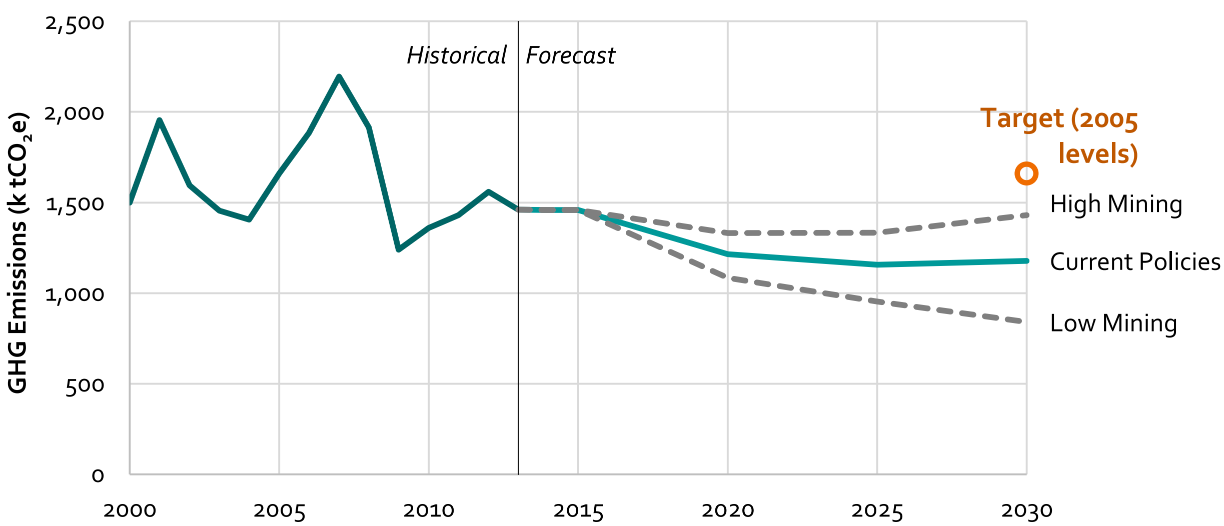
Executive Summary

The NWT Department of Environment and Natural Resources (ENR) is evaluating new policies to limit territorial greenhouse gas (GHG) emissions. To inform these efforts, ENR contracted Navius Research to project GHG trends in response to different climate policy options in the NWT.

How are emissions likely to evolve in response to current policies?

The NWT's GHG emissions reach 1,179 kt CO_2e by 2030 in the reference case. This level corresponds to a 19% decrease relative to 2013 (the most recent year of historical data), as shown in Figure 1. The implication of this forecast is that the NWT is likely to meet and surpass its emission target in 2030. This conclusion holds for both higher and lower bounds of projected mining activity, within the ranges considered.

Figure 1 NWT reference case emissions forecast to 2030



Note that the model used to create the forecast solves in five and six-year increments, allowing it to better capture long-term trends rather than factors which influence inter-annual variations such as weather and business cycles. For example, peaks in freight activity associated with mining construction are not captured, such that the resulting forecast is "smoothed" relative to historical variations.

This forecast is based on numerous assumptions about sector activity, energy prices and the effectiveness of current federal and territorial policies, all of which are detailed in this report. The forecast is lower than the reference case prepared for ENR in 2011 due to (1) the impact of new territorial and federal policies to reduce emissions, such as the NWT Biomass Strategy and Canadian vehicle emission standards, and (2) lower anticipated activity in the mining sector.

What policy options are available to reduce GHGs in the NWT?

To further reduce emissions from those anticipated in response to current policies, the government of the NWT can implement new climate mitigation policies. The ideal choice of policy option depends on territorial goals for abatement (e.g. stringency of desired emissions abatement) as well as other government objectives (e.g. minimizing cost of living impacts).

The report describes design considerations associated with implementing a carbon pricing policy. Carbon pricing is a policy that imposes a price on GHG emissions, thereby encouraging households and firms to avoid this additional cost by taking actions to reduce their emissions. It is an important policy option because it can induce cost-effective abatement in all sectors of the economy.

The primary objective of the quantitative analysis is to provide insight into the impact of different carbon tax design options on territorial GHG emissions and financial costs. Four carbon tax policies are simulated as shown in Table 1. The policies vary in terms of stringency (i.e., emissions price) and sector coverage in order to isolate the impact of these design mechanisms on policy outcomes.

Table 1 Summary of carbon tax policy scenarios

Policy	Stringency (2015$/t CO_2e)	Coverage
1. Petition Proposal	3.5	All sectors
2. Economy-Wide Carbon Tax	20	All sectors
3. Economy-Wide Carbon Tax	30	All sectors
4. Heavy Emitters Tax	20	Mining Oil and gas extraction

How much revenue would be raised by a carbon tax?

A carbon tax could raise between $4 and $35 million annually in the NWT depending on its stringency and coverage. These bounds are based on a carbon price of $3.50/t and $30/t, applied to all sectors of the territorial economy.

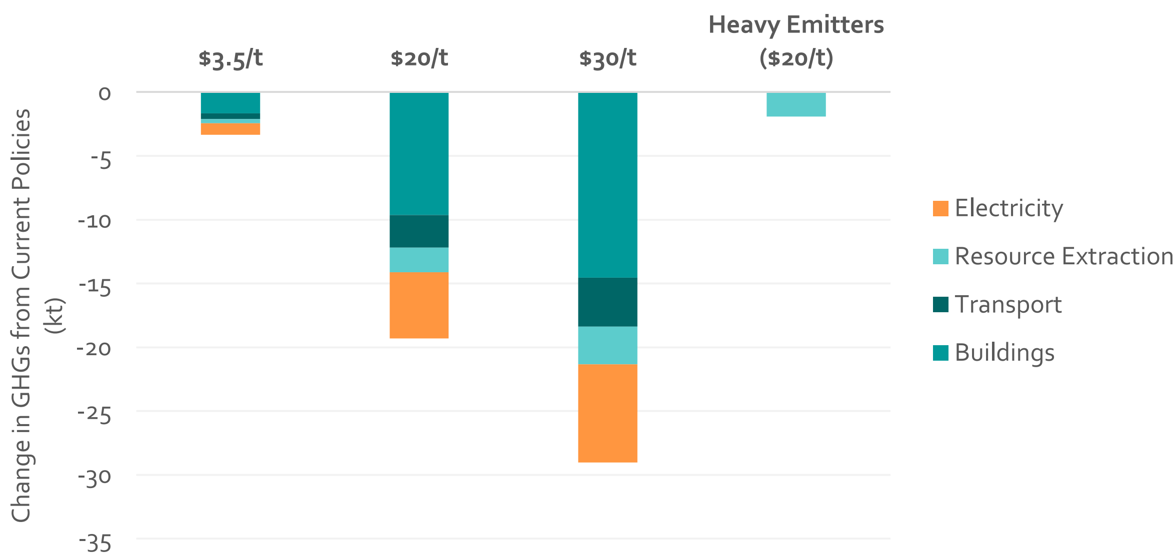
A price of $20/t applied to all sectors of the economy would raise $23 million annually. If this price were applied to heavy emitters only, it would raise $6 million annually. Different levels of economic activity could influence these values significantly.

What is the impact of carbon tax policy options on GHG reductions?

Higher levels of carbon tax generate greater emissions reductions. The carbon tax policies reduce NWT emissions by between 3 kt ($3.5/t) and 29 kt ($30/t) below the Current Policy forecast in 2030, as shown in Figure 2.

A carbon tax will achieve greater emission reductions if it is applied to all sectors of the NWT economy. An economy-wide carbon tax of $20/t reduces emissions by 19 kt in 2030. By contrast, the same carbon price applied solely to resource extraction sectors reduces emissions by 2 kt.

Figure 2 Emissions abatement in 2030 in response to different levels of carbon tax



Investing carbon revenue in low emissions technologies can achieve additional abatement. Our analysis shows that that investing in energy efficiency and renewable technologies can generate an additional 7 kt to 66 kt of additional abatement in 2030. However, tradeoffs exist among different revenue recycling options as discussed below.

Could clean electricity policies complement a carbon tax?

A policy to develop low and zero emissions sources of electricity can be combined with a carbon tax policy to achieve greater reductions in emissions. We examine the impact of a policy to boost electricity supply from low and zero emission sources. This policy includes grid expansion from the Taltson and Snare hydro systems as well as the development of small hydro, wind and natural gas generation in communities currently reliant on diesel.

These supply options result in 13 kt of abatement in 2030, as shown in Figure 3. When combined with a carbon tax (of $20/t), the electricity and carbon tax policies result in greater abatement than either policy does on its own (31 kt).

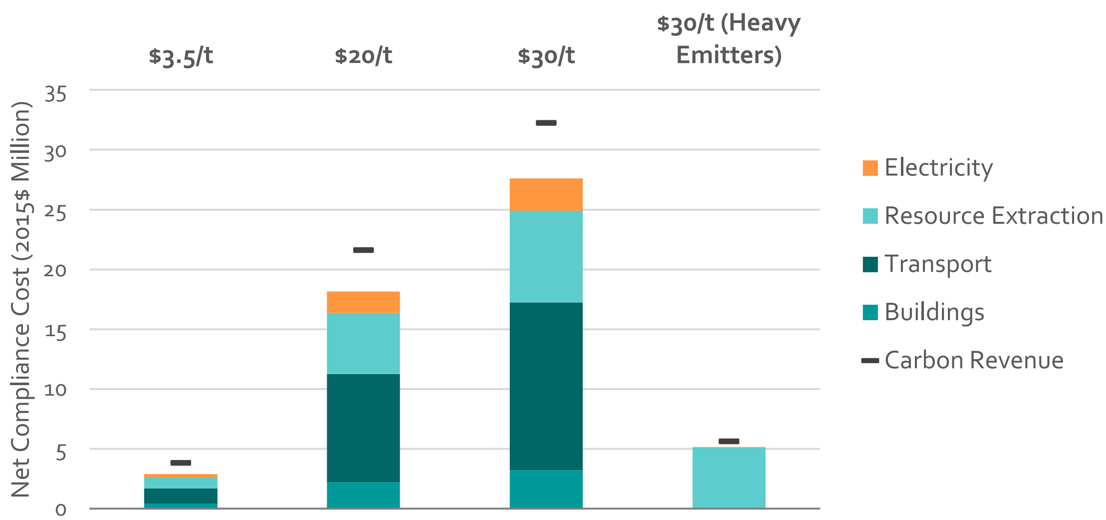
Figure 3 Impact of carbon pricing and electricity policies on GHG abatement in 2030

What is the financial impact of a carbon tax?

A carbon tax imposes a net financial cost on firms and consumers in the NWT, but some of this cost is offset by lower energy expenditures. Direct financial costs include carbon tax payments and capital investment in low emission technologies. These costs are partially offset by savings on energy expenditures due to improved energy efficiency and fuel switching to lower cost biomass energy sources.

Revenue raised from the carbon tax can be used to compensate firms and households for their compliance costs. As shown in Figure 4, carbon revenue exceeds total compliance costs for all of the carbon tax policy options explored. This revenue can be used to achieve the NWT's environmental, economic and other objectives–including compensating firms and households for all or some portion of their compliance costs–although we did not explicitly simulate these revenue recycling options for this project.

Figure 4 Average annual compliance costs by sector, 2017-2030



How can carbon tax revenue be used to achieve NWT's objectives?

Although a carbon tax imposes a cost on any unabated GHGs, this cost is a "transfer" because revenues raised by the tax must be allocated somewhere (i.e., it is cost neutral for the NWT as a whole). This revenue can be used to achieve the NWT's environmental, economic and other objectives.

For example, carbon revenue can be:

- Used to reduce other taxes, such as those on personal or corporate income.
- Returned to households as a direct transfer, for example to ensure low income households are not made worse off.
- Invested in GHG reduction activities to further reduce emissions and/or subsidize the cost of reducing emissions.
- Used to compensate sectors at risk of competitiveness pressures.
- Combined with general government revenue and used for any other government priority, such as the NWT Heritage Fund.
- Any combination of the above.

Tradeoffs exist among these revenue recycling options, with the ideal choice of recycling method dependent on the NWT's GHG, economic and other objectives. Table 2 identifies the objectives for which particular revenue recycling methods are best suited.

Table 2 Ranking of revenue recycling method according to potential government objectives

	Maximize GHG reductions	Maximize economic activity	Mitigate concern about sectors at risk of competitiveness impacts (e.g. mining)	Ensure households are not adversely affected	Raise revenue for other purposes (e.g. adaptation)
Reduce corporate income tax		✓			
Reduce personal income tax				✓	
Direct transfer (i.e., cheque in the mail)				✓	
Invest in low emissions technologies	✓				
Output rebates		✓	✓		
Other government priorities					✓

A general equilibrium model can quantitatively assess the impacts of all revenue recycling options on the NWT economy.

This study relies on a partial equilibrium model that is well suited for exploring the emissions abatement that may occur in response to different types of energy and climate policies. However, exploring the full impacts of different revenue recycling options on financial flows in the NWT requires a general equilibrium model. Navius' GEEM macroeconomic model could be applied for this purpose in the NWT.

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1. Introduction

The GNWT has committed to working with federal and provincial governments to reduce Canada's emissions. The first step toward this commitment was the release of the original NWT Greenhouse Gas Strategy in 2001. Each successive Strategy has built on the previous, identifying actions that the GNWT, industry and communities can take to make an appropriate contribution to global reductions of greenhouse gas emissions during the coming decades.

In its most recent Greenhouse Gas Strategy, the NWT set several territorial targets for GHGs over different time frames:

- Stabilize emissions at 2005 levels (1,500 Kt CO_2e) by 2015.
- Limit emissions increases to 66% above 2005 levels by 2020.
- Return emissions to 2005 levels by 2030.[1]

Against this backdrop, the NWT Department of Environment and Natural Resources (ENR) is evaluating new policies to limit greenhouse gas (GHG) emissions. To inform these efforts, Navius Research has been contracted to provide an updated analysis of GHG trends and climate mitigation policies in the NWT. This analysis builds on previous work conducted for ENR in 2011, which is generally referred to as the "previous analysis" in this report.[2]

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[1] NWT Environment and Natural Resources. A Greenhouse Gas Strategy for the Northwest Territories: 2011-2015. http://www.enr.gov.nt.ca/sites/default/files/strategies/ghg_strategy_2011-2015.pdf

[2] MKJA. 2011. An Exploration into the Impact of Carbon Pricing in the Northwest Territories: Revised Reference Case & Quantitative Policy Analysis. http://www.enr.gov.nt.ca/sites/default/files/reports/an_exploration_into_impact_of_carbon_pricing_in_the_nwt.pdf

1.1. Analytical Approach

This analysis employs the CIMS technology simulation model. CIMS simulates how different policies affect the stock of technologies (such as buildings, vehicles, and energy supply infrastructure) over time, taking into account stock turnover rates and consumer and business preferences. Additionally, the model ensures that the energy supply matches energy demand (equilibrium conditions) by adjusting the price for energy. In other words, if the demand for electricity exceeds generation at a particular price, electricity prices move higher to curtail demand and increase supply. This integrated approach can identify the full impact of policies across the economy, including interactive effects among policies.

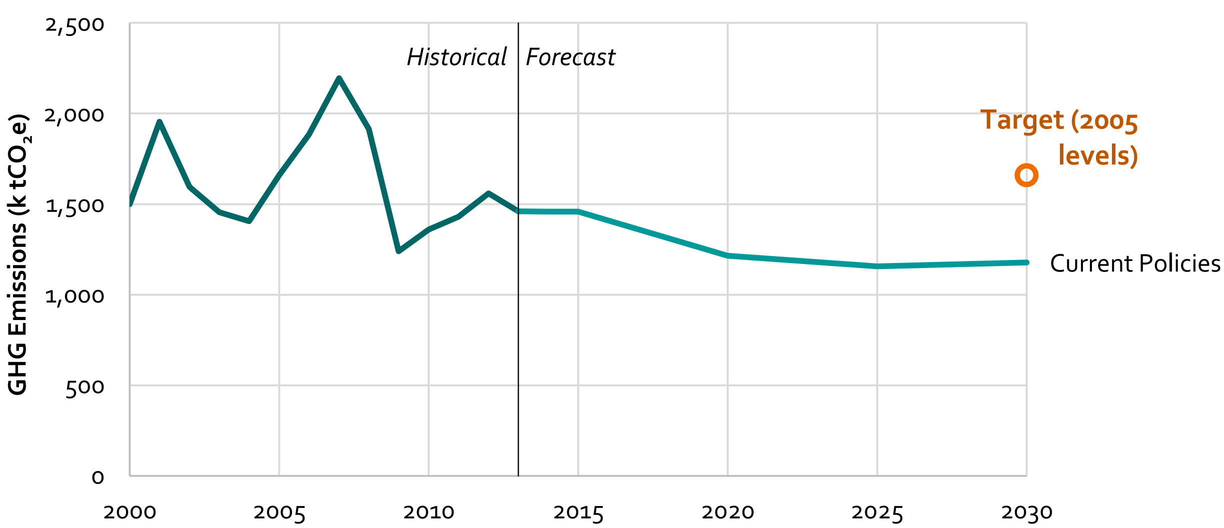
Using external forecasts of baseline energy prices and economic growth (detailed in Appendix A), CIMS produces a reference forecast of the capital stock used to provide goods and services. Based on this forecast, it calculates the resulting GHG emissions and energy consumption. Alternative scenarios that include different market and policy conditions can then be modeled to demonstrate the impact of these changes on energy consumption, air emissions, and financial costs relative to this reference forecast. For a more detailed description of CIMS, refer to Appendix B.

2. How are NWT emissions likely to change in response to current policies?

The reference case describes how energy consumption and GHG emissions are expected to change in response to current policies. These policies include both territorial policies (e.g. the Biomass Strategy) as well as federal policies that will impact emissions in the NWT (e.g. vehicle emission standards). Taking these policies into account, as well as projected levels of economic activity and energy prices, we use CIMS to develop a reference case forecast for energy consumption and GHG emissions. **The reference case assumptions are summarized in Appendix A: Reference Case Assumptions.**

Historical and forecast reference emissions are shown in Figure 5. In 2013, the most recent year for which historical data are available, emissions in the NWT are estimated to be 1,460 kt. Emissions are forecasted to decline in the reference case, reaching 1,179 kt in 2030. The implication of this forecast is that the NWT surpasses its emission targets by about 480 kt in 2030.

Figure 5 Reference case emissions forecast to 2030



Note that the model used to create the forecast solves in five and six-year increments, allowing it to better capture long-term trends rather than factors which influence inter-annual variations such as weather and business cycles. For example, peaks in freight activity associated with mining construction are not captured, such that the resulting forecast is "smoothed" relative to historical variations.

2.1. How do different sectors contribute to territorial emissions?

Emissions decline across most sectors of the territorial economy, as shown in Table 3. The key trends are discussed below. Sector-specific assumptions are also summarized in detail in Appendix A: Reference Case Assumptions.

Table 3 Reference case emissions forecast by sector (kt CO_2e)

	2015	2020	2025	2030	AAGR[1]
Energy Demand Sectors					
Residential	95	91	82	71	-1.9%
Commercial and Institutional	138	134	124	123	-0.8%
Personal Transport	311	310	308	320	0.2%
Freight Transport[2]	426	311	279	289	-2.5%
Mineral Mining	300	214	236	263	-0.9%
Total Demand Sectors	1,269	1,060	1,029	1,066	-1.2%
Energy Supply Sectors					
Utility Electricity[3]	68	62	65	77	0.8%
Petroleum Crude Extraction	105	77	49	36	-6.9%
Natural Gas Extraction	16	15	14	0	-100.0%
Total Supply Sectors	189	154	128	113	-3.4%
Total NWT	**1,458**	**1,214**	**1,157**	**1,179**	**-1.4%**

[1] Average Annual Growth Rate.
[2] Freight transport includes off-road activity associated with mining.
[3] Industry electricity generation is accounted for in the corresponding industrial sector (e.g., mining).

Buildings

Emissions from buildings decline from about 230 kt in 2015 to 193 kt in 2030. This decline occurs despite growth in the number of buildings, because buildings become less emissions intensive over time.

Buildings become less emissions intensive for two reasons:

- **Biomass accounts for an increasing share of building space heating energy requirements.** A key driver of this shift is the NWT Biomass Strategy. As described in Appendix A: Reference Case Assumptions, we assume that biomass accounts for about one third of all space heating by 2030. If biomass achieves a lower penetration over this period, emissions will be higher than forecasted.

- **Buildings become more energy efficient.** Over time, buildings install more efficient space and water heating equipment. Shell efficiency also increases because new buildings are built to higher standards and a portion of existing buildings engage in shell retrofits. These energy efficiency improvements result from the natural turnover of equipment, as well as regulations such as the Yellowknife Building Code and federal minimum energy performance standards.

Transport

The emissions intensity of vehicles improves substantially over the forecast period. These improvements are driven to a large extent by federal regulations governing the emissions intensity of new vehicles sold in Canada. The Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations set fleet targets for passenger cars at 98 g/km in 2025. This emissions intensity is lower than that of a Toyota Prius V. Likewise, regulations for heavy duty vehicles require that the GHG emissions intensity be improved by about 23% in 2018.

The trend in total emissions differs between personal and freight transport. Personal transport emissions are largely flat (between about 310 and 320 kt) because the increase in demand for transport is offset by the adoption of more efficient vehicles. By contrast, total emissions from freight transport decrease from 426 kt to 289 kt. This drop is due to a decline in freight activity associated with less mining activity, coupled with emissions intensity improvements.

Mining

Emissions from mineral mining decline from 300 kt in 2015 to 263 kt in 2030. This decline is due to a decrease in mining activity, from about 8.4 to 7.8 million tonnes. The level of mining activity is based on anticipated mining projects as reported by the Northern Projects Management Office and detailed in Appendix A: Reference Case Assumptions. The impact of alternative levels of mining activity on NWT emissions is explored in the sensitivity analysis beginning on page 36.

Note that the mining sector includes emissions generated at mine sites, including those associated with diesel combustion for heat and power. It does not include emissions associated with vehicles (road or off road), which are included in freight transport sector.

Utility Electricity Generation

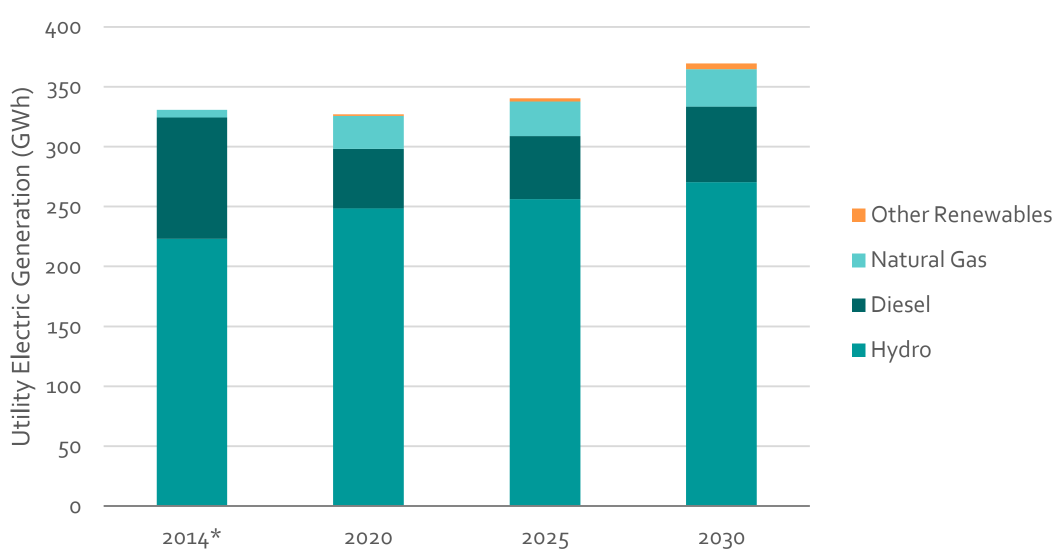
A growing number of households and commercial buildings is expected to increase demand for electricity. As a result, utility electricity generation increases from 331 GWh in 2014 to 367 GWh in 2030.

Utility electricity is generated from the following sources in the reference case, as shown in Figure 6:

- **Hydro.** Upgrades to existing hydro capacity increase generation by 27 GWh between 2015 and 2030.
- **Solar PV.** Following the target laid out within the Solar Energy Strategy, solar power displaces 2% of the average annual generation in thermal communities (about 1 GWh) by 2017.
- **Natural gas.** Natural gas is used to generate electricity in Inuvik and Norman Wells.
- **Diesel.** Diesel is used to meet most remaining incremental electricity demand.

Emissions from electricity generation decrease in the short term (2020) because diesel generation is displaced by hydro. Emissions increase over the longer term (2030) because a portion of new demand is met by diesel generation.

Figure 6 Utility electricity generation



*CANSIM Table 127-0002. Electric power generation, by class of electricity producer.

Oil and Gas

Emissions from oil and gas decline from 121 kt in 2015 to 36 kt in 2030. This decline is due to a drop in oil and gas extraction, based on Environment Canada's most recent forecasts and summarized in Appendix A: Reference Case Assumptions. If activity turns out to be greater than that assumed, emissions will be higher.

2.2. How do these projections compare with the previous forecast?

This emissions forecast is significantly lower than the previous projection prepared for ENR, which reached 2,587 kt in 2030. The current forecast is lower because:

- **The number of planned mining projects has decreased.** Anticipated mining activity is significantly lower (7.8 million tonnes of ore in 2030 compared with 29 million tonnes as previously forecast). This factor accounts for about two thirds of the difference between forecasts.
- **Various territorial and federal policies have been implemented to reduce emissions in the NWT.** These include territorial policies such as the Biomass Strategy as well as federal policies such as regulations for the emissions intensity of new light and heavy duty vehicles. A complete list of policies included in the reference case is provided in Appendix A.

3. What new policy options are available to reduce GHGs in the NWT?

To further reduce emissions from those anticipated in response to current policies, the government of the NWT can implement new climate mitigation policies. The options for new policies are varied, ranging from regulations and standards (that require a specific mitigation action be taken) to carbon pricing (that provides a financial incentive to reduce emissions but allows flexibility in how that abatement is achieved) to subsidies and voluntary policies (such as informational campaigns).

The ideal choice among policy options depends on territorial goals for abatement (e.g. stringency of desired emissions abatement) as well as other government objectives. Other objectives might include things like maintaining a low cost of living and ensuring a robust population and level of economic activity. Climate policy can be designed to align with both emissions abatement and other objectives.

The discussion below focuses first on design considerations associated with implementing a carbon pricing policy. Carbon pricing is an important policy option because it can induce cost-effective abatement in all sectors of the economy. The second part of the discussion describes other policies that could complement (or not) carbon pricing.

3.1. Carbon Pricing Design Considerations

Carbon pricing is a policy that imposes a price on GHG emissions, thereby encouraging households and firms to avoid this additional cost by taking actions to reduce their emissions. Several carbon pricing options exist, which can be roughly categorized as either carbon tax or cap-and-trade approaches. Implementing a carbon pricing policy requires consideration of numerous design options, as summarized in Table 4. These considerations are discussed below.

Table 4 Checklist for implementing carbon pricing

Criteria	Question	Considerations
Objectives	What are the government's objectives?	Carbon abatement and other government objectives can guide choice among policy options, particularly revenue recycling.
Policy type	Carbon Price or Cap and Trade?	A carbon tax may have lower administrative costs. Due to uncertainty in future NWT emissions, a cap and trade may result in allowance price volatility unless flexibility mechanisms are adopted.
Stringency	In the case of a carbon tax, what is the $/t price and how will it change over time? In the case of a cap-and-trade, what is the cap (either absolute or emissions intensity based)?	The stringency can be informed by the reference case projection and subsequent analysis of policy impacts. Providing adequate notice to firms and consumers of carbon pricing gives them time to adjust. Implementing a price that doesn't greatly exceed that in other jurisdictions reduces competitiveness concerns.
Coverage	What types of emissions in what sectors will be covered?	Greater coverage reduces the average cost of reducing GHGs.
Revenue recycling and allowance allocation	How will revenue be recycled? In the case of a cap and trade system, how will allowances be allocated?	Revenue recycling is one of the best opportunities for government to pursue its additional objectives with carbon pricing. Depending on these objectives, revenue can 1) reduce other taxes, 2) be returned to households, 3) subsidize abatement, 4) support sectors at risk of competitiveness, and/or 5) be combined with general government revenue.
Linkages with other jurisdictions	In the case of a cap and trade, will the NWT link its system with others?	Joining another system may reduce allowance price volatility and the overall cost of abatement from all jurisdictions. The NWT would have less control over policy design if it joins another system. It will also open the possibility of financial transfers to or from the NWT.
Flexibility mechanisms	What flexibility mechanisms are desired in a cap-and-trade system?	Offsets from sectors or regions not covered by the policy can lower abatement cost. Setting a price floor or ceiling can help control allowance price volatility.

Carbon Tax versus Cap-and-Trade

A carbon tax is achieved by placing a surcharge on carbon-based emissions. By contrast, a cap-and-trade system puts a limit, or cap, on the total amount of GHGs that can be emitted from covered sources. Emissions allowances (or permits) totaling this amount are auctioned or distributed for free to emitters. Emitters can then trade their emission allowances with other firms. This flexibility means that firms with a higher cost of abatement can purchase allowances from firms that have lower abatement costs. Thus, while government sets the cap, the market determines the ultimate price on emissions.

The key difference between a carbon tax and a cap-and-trade program is that a carbon tax provides certainty with respect to the price, but not with respect to the quantity of emissions. The price remains fixed at the level of the tax, while households and firms can decide the economically optimal level of emissions at that price level.

On the other hand, a cap-and-trade program provides certainty with respect to the quantity of emissions, but not with respect to the price. Using this policy option, the price will adjust to ensure that the environmental objective is achieved.

The choice between these two options for carbon pricing may be influenced by:

- **Administrative costs.** Carbon taxes and cap-and-trade programs are likely to have different costs of administration. Based on our experience in Canada, carbon taxes appear to have been implemented and administered at lower costs relative to cap-and-trade programs.

- **Uncertainty in future emissions.** In a small jurisdiction like the NWT, emissions may vary significantly on an annual basis or depending on whether a single mining project proceeds. A carbon tax may therefore result in significantly different levels of emissions depending on future developments such as those in the mining sector. By contrast, such developments may lead a cap-and-trade program to experience volatile prices. The price uncertainty in a cap-and-trade program can be managed with various design options, as discussed in the sections "Linkages with Other Jurisdictions" and "Flexibility Mechanisms" on page 14.

Stringency

The level of stringency of a carbon tax is simply the price for emissions (e.g., $ per tonne of carbon dioxide or equivalent). The stringency under a cap-and-trade program is determined by the desired level of GHG reductions. When determining the desired stringency of the policy, a number of factors may be considered:

- **Policy notice and certainty.** Providing adequate notice to firms and consumers of carbon pricing gives them time to adjust. For example, policy stringency can be set at a relatively low level but with a clear schedule for how that stringency will be increased over time.
- **The time period over which abatement is desired.** A more stringent policy is required to achieve the same level of abatement over a shorter period. This dynamic occurs because the longer a policy is in effect, the greater the number of investment decisions it can influence.
- **The carbon price in other jurisdictions.** Implementing a price that doesn't greatly exceed that in other jurisdictions reduces concerns that industry might choose to invest in regions other than the NWT as a result of the policy.

Coverage

The coverage of carbon pricing within a jurisdiction can vary in terms of sectors and sources of emissions. First, carbon pricing can be economy-wide (applied to all sectors) or focused on select sectors (e.g. large final emitters). Second, carbon pricing can apply to all anthropogenic GHGs or to a subset of these emissions (e.g., exclusively combustion emissions). In general, the cost of the policy per level of abatement achieved will be lower if coverage of the policy is greater because it ensures that no abatement opportunities are missed.

Revenue Recycling and Allowance Allocation

Carbon pricing raises revenue or generates "value" which can be used to achieve various objectives. In the case of a carbon tax, the revenue raised is simply equal to the carbon price multiplied by the amount of covered emissions. In the case of a cap-and-trade system, revenue may be raised directly if allowances are auctioned. By contrast, if allowances are allocated for free, these allowances have "value". As discussed below, the impact of allocating allowances for free is analogous to recycling revenue.

Carbon revenue can be recycled in various ways, as shown in Table 5:

- First, revenue can be used to **reduce other taxes**, such as personal income, corporate income or sales tax. This "tax shifting" can have the effect of discouraging carbon pollution while at the same time encouraging some other activity (i.e., creation of income or consumption of goods and services). Using carbon revenue to reduce other taxes therefore tends to have the most positive economic impact of all of the revenue recycling options.
- Second, revenue can be **returned to households as a direct transfer** (i.e., a "cheque in the mail"). Revenue can be distributed equally among households, or alternatively it can be targeted at specific households such as those that are low-income or otherwise likely to be most adversely impacted by carbon pricing. This method of recycling revenue can be a means of mitigating concerns about the economic impact of carbon pricing on specific groups.
- Third, revenue can be used to **subsidize abatement** or otherwise invest in abatement activities. For example, revenue could be used to reduce the cost of less emissions intensive equipment for firms and consumers. It could also be invested directly in mitigation activities, such as the provision of low or zero emission electricity generation. This method of revenue recycling can help to achieve GHG reductions above the stringency of the carbon price.
- Fourth, revenue can be used to provide **output rebates** to sectors at risk of competitiveness pressures. This method of revenue recycling is most commonly implemented in cap-and-trade programs via a free allocation of allowances. However, policies that generate revenue for government can also provide output rebates. These rebates are most commonly allocated to sectors at risk of competitiveness and in proportion to a benchmark for their GHG intensity. In other words, sectors deemed at risk of competitiveness pressure receive an output rebate or a free allocation of allowances in proportion to some measure of their GHG intensity (e.g., historic GHG intensity or the GHG intensity of the "best in class" in their sector).
- Finally, revenue can be **combined with general government revenue** and used for any other government priority (e.g. the NWT Heritage Fund).

Ideally, the method chosen should align with both emissions abatement and other government objectives. Additionally, the revenue recycling options are not mutually exclusive. For example, revenue collected under BC's Carbon Tax is used to reduce personal and corporate income tax rates (to maximize overall economic impacts) as well as distributed directly to low-income and rural households (which are more likely to be negatively impacted by the tax).

Revenue recycling is more intuitive when considering carbon pricing that generates revenue for government (i.e., carbon tax or a cap-and-trade program in which allowances are auctioned). However, the objectives of revenue recycling can also be achieved by allocating allowances for free, with varying levels of difficulty. Revenue recycling to corporate income taxes can be mimicked by allocating allowances for free to sectors in proportion to their corporate income. Likewise, allowances can be given to households to mimic direct transfers to households. Finally, allowances can be allocated for free based on a benchmark of GHG intensity to mimic output rebates.

Table 5 Carbon revenue recycling options

Option	Advantages	Disadvantages
Reduce other taxes	-Tends to have the best economic outcome (especially if revenues are used to reduce corporate income taxes)	-Reduction in other taxes is unrelated to goal of carbon abatement
Direct transfers	-Mitigates concerns about policy cost for vulnerable (e.g. low-income) households -Based on discussions with ENR, this option may be popular among recipients of transfers	-Tends to have greater economic cost relative to other recycling options
Subsidize abatement	-Reduces the cost of abatement and may achieve greater levels of GHG reductions -Funds are seen to be used for objective that aligns with that of climate mitigation	-Tends to have greater economic cost than reducing other taxes
Output rebates	-Mitigates concerns about sectors at risk of competitiveness impacts	-Emissions abatement may be reduced
General government revenue	-Can be used for any government priority unrelated to carbon abatement	-Tends to have greater economic cost than reducing other taxes

Linkages with Other Jurisdictions

As discussed in the section "Carbon Tax versus Cap-and-Trade" on page 10, one of the challenges with a cap-and-trade program in NWT is that there would be relatively few participants in the program. Therefore, the addition or removal of a single participant (such as a new mine) may have a significant impact on the price for allowances. Additionally, emissions in NWT have historically been highly volatile, such that a fixed cap on emissions would likely lead to a volatile price.

One option for addressing concerns about price volatility would be to link a cap-and-trade program with another jurisdiction. In Canada, Québec has joined (and Ontario and Manitoba are planning to join) the Western Climate Initiative cap-and-trade program. Likewise, NWT may have the option of joining this program.

The implications of joining this system include:

- Accept the general framework for the policy established in other jurisdictions. The framework for the WCI cap-and-trade program has largely been set by California. NWT would have limited ability to pursue its own designs if it chooses to participate in this program.
- Accept the volatility in price from other jurisdictions. Although linking a cap-and-trade program with other jurisdictions would likely reduce the volatility in price, some volatility would remain as the demand for allowances adjusts to a fixed supply.
- Possibility of interregional transfers. The trade of allowances between NWT and other participants in the cap-and-trade would lead to transfers among regions. The NWT could be a net recipient of transfers if the abatement costs to its target are lower relative to other jurisdictions, but it could also experience an outflow of transfers.

Flexibility Mechanisms

In addition to linkages with other jurisdictions, volatility in cap-and-trade systems can be managed through various flexibility mechanisms, including:

- **Offsets.** Offsets represent abatement undertaken by sectors or regions that are not covered by the policy.
- **Price floor or ceiling.** To manage volatility in price, the government of the NWT could establish a price "ceiling" or "floor". The ceiling would ensure the price does not

exceed a specific level. This would be achieved through a government guarantee that it will see an additional amount of allowances at a set price. Therefore, if the price for allowances exceeds the set price, firms and households are likely to purchase these additional allowances. Similarly, government could establish a price floor by guaranteeing that it will buy allowances if the price falls below a set level.

Experience with Carbon Pricing in Other Jurisdictions

Various forms of carbon pricing have been adopted by jurisdictions across Canada, including BC's carbon tax, Alberta's Specified Gas Emitters Regulation and the Western Climate Initiative. Key aspects of these policies are summarized in Table 6.

Note that Alberta's Specified Gas Emitters Regulation is neither a carbon tax or a cap-and-trade program. Rather, it is defined as a "tradable performance standard". These policies establish targets for emissions intensity, and allow participants to trade compliance obligations.

Additionally, in November of 2015 Alberta announced that it would adopt a carbon tax. This tax is set to begin at $20/t in 2017 rising to $30/t in 2018, and then at inflation plus 2% annually thereafter.

Table 6 Carbon pricing schemes in Canadian jurisdictions

	BC's Carbon Tax	Alberta's Specified Gas Emitters Regulation	Western Climate Initiative (California & Québec)[1]
Policy Type	Carbon tax	Tradable performance standard	Cap and trade
Start Date	2008	2007	2013
Stringency	$30/t CO_2e	12% reduction in emissions intensity from historical levels, capped at $15/t CO2e	Each region may allocate allowances in proportion to their caps (Québec's cap is 20% below 1990 levels by 2020)
Coverage	All fossil fuel combustion	Large emitters (>100 kt/year)	All sources of emissions from industrial, electricity and fossil fuel distribution (facilities >25 kt/year)
Allowance Allocation	N/A	Free allocation based on GHG intensity	Auction, with free allocation to emissions intensive and trade exposed sectors
Revenue Recycling	Personal and corporate income tax cuts Transfers to low income and rural households	Proceeds from technology fund (see Flexibility mechanisms below) are re-invested in emissions reducing technologies	Auctioned revenues are used to invest in abatement. However, we understand that each jurisdiction would have leeway to pursue its own objectives for revenue recycling.
Flexibility Mechanisms	N/A	Offsets from uncovered sectors Price ceiling: Technology fund caps the price of allowances at $30/t	Offsets from uncovered sectors Price floor: The price for allowances may not go below a value, which appreciates with inflation and adjusts based on the Canada-USA exchange rate

[1] Ontario and Manitoba have also announced they will join the WCI.

3.2. Complementary (or not) Policies

If policies are combined with carbon pricing, will they have an incremental impact?

A carbon pricing policy can be combined with other climate mitigation policies. These policies may complement the carbon pricing policy if they achieve additional abatement. However, in some cases the objectives of these policies overlap such that incremental abatement is small.

Policies may complement carbon pricing if they:

- Apply to emissions that are not covered by the carbon pricing policy (e.g. a venting regulation combined with a carbon price that is not applied to non-combustion emissions).
- Achieve abatement that is otherwise difficult to achieve through a carbon price (e.g. reducing the upstream emissions intensity of refined petroleum products imported to a jurisdiction).
- Ensure abatement options are available to firms and consumers that otherwise would not be (e.g. the development of low-carbon electricity generation).

What policy options are available in addition to carbon pricing?

Despite overlapping objectives between carbon pricing and many regulatory policies, a number of jurisdictions have pursued other policy options in addition to carbon pricing. These other policies provide an opportunity to target a particular set of emissions (e.g., buildings or transportation) more directly or because of constraints on implementing aggressive carbon pricing. These policies include, but are not limited to:

- **Development of clean electricity.** Low or zero emissions electricity can be developed through various policy mechanisms, including a renewable portfolio standard, feed-in-tariff or direct government investment in capacity. Boosting generation from low emission sources such as hydro or wind can achieve significant abatement by displacing generation from fossil fuel combustion. Additionally, a source of low carbon electricity could potentially allow firms and consumers to reduce their direct emissions by electrifying end-use consumption (e.g. switching from oil to electric heating).

- **Energy efficiency standards for buildings.** Strengthened building codes can reduce demand for space heating, which is often provided by oil-fired furnaces in the NWT. Strengthened appliance standards (some of which are already set federally) can reduce demand for electricity. If the electricity is generated from emissions-intensive sources, these standards can also reduce emissions.
- **Vehicle emissions standards.** The NWT will benefit from federal policies that require significant improvements to the emissions intensity of light and heavy duty vehicles sold in Canada. Such policies are very likely to have an incremental impact in the NWT because their stringency (in $/t terms) is high.
- **Landfill gas and/or organic waste diversion.** Such a policy could complement a carbon pricing scheme that applied solely to combustion emissions.
- **Low carbon fuel standard.** A low carbon fuel standard requires improvements to the upstream emissions intensity of fuel imported to a jurisdiction.

If non-carbon pricing policies target the same sources of emissions as carbon pricing, what is the benefit of carbon pricing?

Carbon pricing offers two important advantages over regulatory approaches. First, carbon pricing ensures that a given level of GHG reduction is achieved at the lowest cost to households and firms. The carbon price effectively "caps" the cost of abatement. Any level of abatement that costs in excess of the carbon price is not undertaken. On the other hand, a regulatory approach requires that abatement be undertaken irrespective of the cost. Because the cost of abatement is inherently uncertain, the cost of the regulatory policy is uncertain.

To illustrate the difference between the two approaches, consider two (almost) identical mines that use diesel fuel to meet their electric needs. Mine A has the option to meet 50% load with wind power at a cost of $25/t CO_2e, while Mine B can meet the same portion of its load with wind at a cost of $100/t CO_2e.

Two policies can be implemented that achieve the same level of GHG reductions, but that have significantly different costs:

- A carbon price at $50 per/t CO_2e, and
- A regulation that requires each facility to achieve 25% its load with wind power.

Under the carbon price, Mine A can avoid the $50/t CO_2e carbon price by meeting 50% of its load with wind at $25/t CO_2e. However, Mine B avoids the cost of abatement at $100/t CO_2e by paying the carbon price. Under the regulation, both firms would achieve 25% of their load, but at a higher average cost than the carbon price. Overall then, carbon pricing encourages households and firms with lower costs of abatement to undertake more abatement.

The second benefit of carbon pricing over non-carbon pricing is that pricing can be implemented more broadly. GHG emissions occur from many energy end-uses (e.g., cooking, space heating, water heating, industrial heat, etc). It is difficult to implement regulations for each of these sources, but relatively simple to implement a carbon price.

4. What is the impact of new policies to reduce NWT GHGs?

This section describes the impact of new policies to reduce the NWT's GHG emissions. The primary objective is to provide insight into the impact of different carbon tax design options on territorial GHG emissions and financial costs. In particular, different sections focus on answering the following questions:

- What is the impact of carbon tax policy options on GHG emissions?
- What is the impact of carbon tax policy options on financial costs?
- How can carbon revenue be used to achieve the NWT's GHG, economic and other objectives?

4.1. Overview of Policy Scenarios

Carbon Tax Policies

Four carbon tax policies are simulated as shown in Table 7. The policies vary in terms of stringency (i.e., emissions price) and sector coverage in order to isolate the impact of these design mechanisms on policy outcomes.

All of the carbon tax options are applied to (1) combustion emissions and (2) fugitive emissions in oil and gas extraction. The tax is implemented in 2017 and takes two years to rise to its full value.

Another key design consideration is how the revenue raised by the carbon tax is to be "recycled" back to the economy. Using the modeling tool for this project, we quantify GHG reductions if this revenue is re-invested in emissions reducing technologies. We also qualitatively discuss tradeoffs associated with other revenue recycling options.

Table 7 Summary of carbon tax policy scenarios

Policy	Stringency (2015$/t CO2e)	Coverage
1. Petition Proposal	3.5	All sectors
2. Economy-Wide Carbon Tax	20	All sectors
3. Economy-Wide Carbon Tax	30	All sectors
4. Heavy Emitters Tax	20	Mining Oil and gas extraction

Price is constant in real dollars (i.e., it increases in nominal terms at the rate of inflation).

Complementary Electricity Supply Policies

We also examine the impact of a policy to boost electricity supply from low and zero emission sources. This policy includes the following projects:

1. **Grid expansion.** This policy allows excess hydroelectric power from the Taltson hydro plant to displace diesel generation in Kakiska and Fort Providence by 2020. It also allows excess hydroelectric power from the Snare system to displace diesel generation in Whatì by the same date.
2. **Small hydro.** This policy develops small hydro capacity to displace diesel generation in Lutsel K'e and Deline by 2025.
3. **Wind generation.** This policy develops wind capacity to meet 20% of annual load in Inuvik by 2020, displacing generation from natural gas. Wind power also meets 20% of annual load in Sachs Harbour and Paulatuk by 2025, displacing diesel generation.
4. **Natural gas.** This policy develops liquefied natural gas-fired capacity to displace diesel generation in Fort Liard, Fort Simpson and Tuktoyaktuk by 2020.

These complementary electricity policies are simulated with and without a carbon tax, to explore the interactive effects between these policy options.

4.2. What is the impact of new policies on GHG reductions?

How does carbon tax stringency affect GHG reductions?

Higher levels of carbon tax generate greater emissions reductions. The carbon tax policies reduce NWT emissions by between 3 kt (0.3%) and 29 kt (2.5%) below the Current Policy forecast in 2030, as shown in Figure 7. A higher carbon tax achieves greater reductions because it creates a greater financial incentive for firms and consumers to switch to lower emissions technologies. The revenue collected from a carbon tax can also be used to achieve additional abatement, as discussed on page 25.

Figure 7 Impact of carbon pricing stringency on GHG abatement in 2030 (before revenue recycling)

What emissions abatement actions can be induced by a carbon tax?

A carbon tax will induce a variety of actions to reduce emissions across all sectors of the NWT's economy. Figure 8 disaggregates emissions abatement by sector.

About half of abatement occurs in the **buildings** sector. Several actions contribute to this abatement, including the adoption of more efficient building shells and equipment, as well as greater use of biomass for heating. These actions reduce emissions by up to 15 kt in 2030. Current policies already require significant adoption of biomass, with uncertain additional adoption due to consumer preferences related to biomass heating (e.g. work associated with refueling, space required for fuel storage) and financial costs (e.g. retrofit costs).

The carbon tax policies also encourage the adoption of more efficient vehicles beyond that required by federal regulations, including hybrid-electric vehicles. These actions reduce **transport** emissions by up to 4 kt in 2030. Electricity prices in the NWT are likely too high for substantial adoption of plug-in electric vehicles at the level of policy stringency examined here.

Figure 8 Impact of carbon pricing stringency on GHG abatement in 2030 by sector

In the **electricity** sector, the carbon tax policies encourage the adoption of renewable generation technologies that displace generation from diesel. These technologies generate electricity from hydro, biomass, wind and solar energy. Greater adoption of renewable generation reduces emissions by up to 8 kt in 2030 (beyond that which occurs in response to Current Policies). The cost of deploying these technologies in different regions of the NWT is uncertain. Therefore, the actual abatement in response to a carbon tax could be higher or lower than that shown.[3]

The **resource extraction** sector includes mining and oil and gas extraction. The carbon tax policies induce some adoption of more efficient equipment and renewable electricity technologies in these sectors. Most of this abatement is concentrated in the mining sector. In the oil and gas sector, declining production levels in the Current Policies scenario is associated with a lack of investment. Due to this decline, a carbon tax has a limited opportunity to influence investment decisions and hence achieve GHG reductions.

Significant uncertainty exists about the impact of a carbon tax on abatement in the resource extraction sector. In particular, the analysis is based on detailed data at the sector level. However, GHG emissions in this sector are associated with a relatively small number of facilities. It is therefore challenging to anticipate which technologies these facilities will adopt.

How does sector coverage affect GHG reductions?

A carbon tax will achieve greater emission reductions if it is applied to all sectors of the NWT economy. Figure 9 compares the abatement achieved by:

- A $20/t carbon tax that is applied to all sectors of the NWT economy, with
- A $20/t carbon tax that is applied solely to resource extraction sectors.

The economy-wide carbon tax reduces emissions by 19 kt. By contrast, the same carbon price applied solely to resource extraction sectors reduces emissions by 2 kt. This difference occurs because mining, oil and gas account for about one quarter of total NWT emissions over the forecast period. The implication of not applying a carbon tax to the rest of the economy is that abatement opportunities associated with the remaining three quarters of emissions are missed.

[3] This analysis is based on estimated renewable supply costs provided by GNWT Public Works and Services, Energy Division.

Figure 9 Impact of carbon pricing coverage on GHG abatement in 2030 ($20/t)

Can revenue raised by the carbon tax be used to achieve additional abatement?

Investing carbon revenue in low emissions technologies will achieve additional abatement. However, tradeoffs exist among different revenue recycling options. To illustrate the range of potential abatement if carbon revenue is invested in low emissions technologies, we evaluate the following two policy options:

- A carbon tax of $3.5/t, with half of revenue raised by non-oil and gas extraction sectors invested in low emissions technologies. This option aligns with the petition proposal and results in an annual average of $1.9 million invested in low emission technologies between 2020 and 2030.
- A carbon tax of $30/t, with all revenue raised (an annual average of $33 million between 2020 and 2030) invested in low emission technologies.

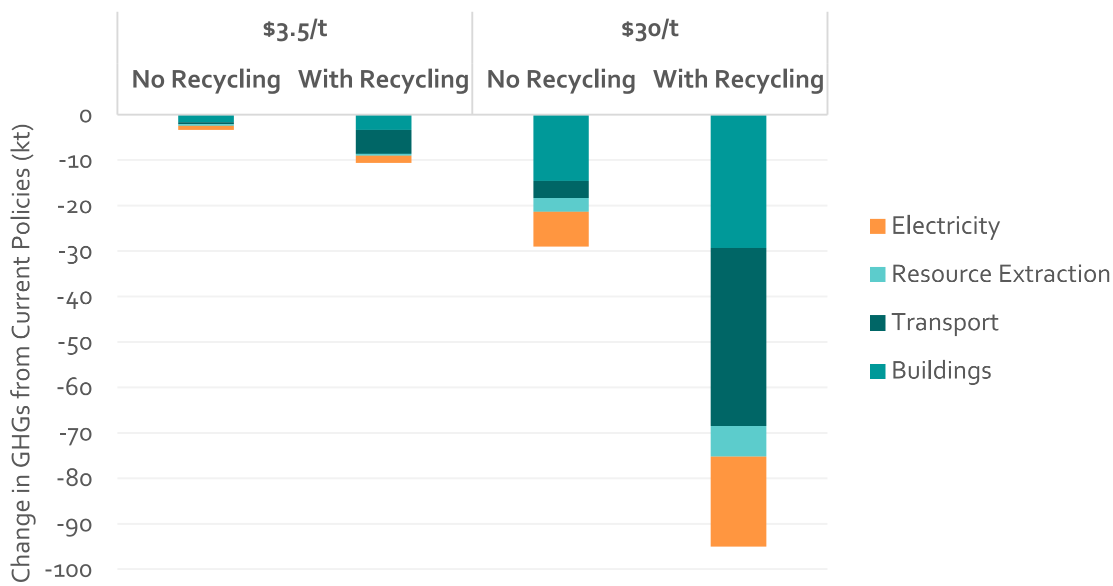
The results show that investing in the following low emissions technologies can generate an additional 7 kt to 66 kt of additional abatement in 2030 (see Figure 10):

- High efficiency space and water heating for residential and commercial buildings.
- Biomass heating for residential and commercial buildings.

- Electricity generation from hydro, wind, solar and biomass.
- High efficiency passenger and freight vehicles, including those with hybrid-electric drive trains.

However, tradeoffs exist among revenue recycling options. Essentially, investing carbon revenue in low emissions technologies means that revenue is not available for other government priorities, for example ensuring households are not adversely affected by the policy or stimulating economic activity. These tradeoffs are discussed beginning on Page 33.

Figure 10 Impact of revenue recycling to low emission technologies on GHG abatement in 2030



How do electricity supply policies interact with a carbon tax?

The electricity policies result in 14 GWh of renewable and natural gas generation replacing diesel as shown in Figure 11. This generation exceeds that adopted in response to a $20/t carbon tax. The electricity policies therefore achieve greater abatement from the electricity sector as shown in Figure 12. However, the carbon tax policy achieves greater total abatement because it encourages emissions reducing actions across all sectors of the economy.

When combined, the electricity and carbon tax policies result in greater abatement than either policy does on its own. This dynamic occurs because the implied carbon price of the electricity policies is generally higher than $30/t (i.e., there is little policy overlap).

Changes in the cost of electricity production are assumed to not be passed on to consumers. Therefore, the electricity policies do not result in a net change in electricity supply. By contrast, the carbon tax imposes a cost on the use of fossil fuels for heating, making electricity consumption relatively more attractive and having a slight impact on net generation.

Figure 11 Change in utility electricity generation in 2030

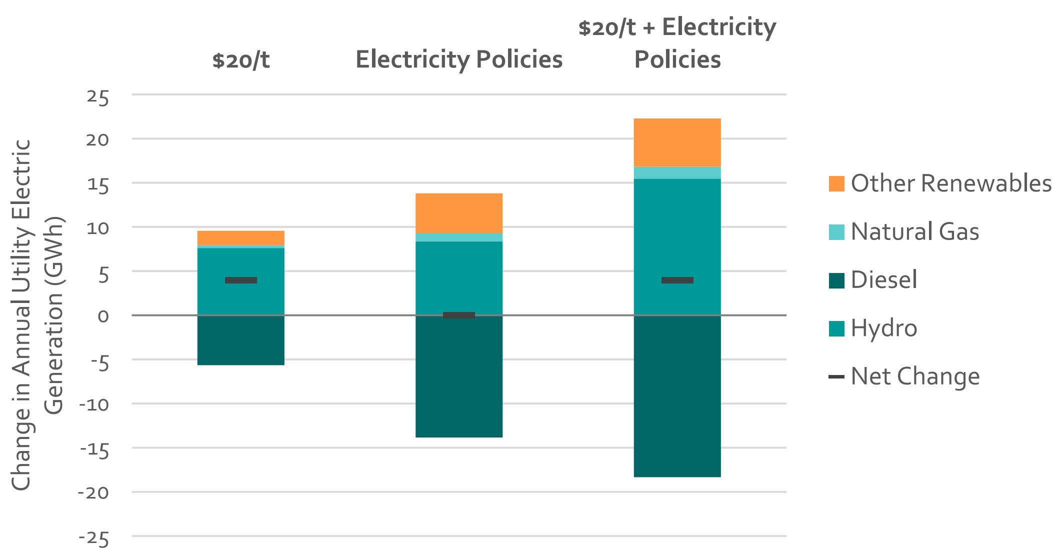


Figure 12 Impact of carbon pricing and electricity policies on GHG abatement in 2030

4.3. What are the financial impacts of a carbon tax?

A carbon tax will have a variety of financial impacts on firms and consumers in the NWT. In particular, it will:

- Impose net financial costs (i.e., compliance costs) on firms and consumers.
- Raise sufficient government revenue to alleviate these costs or achieve other government objectives.

What is the direct financial impact of the carbon tax on NWT consumers and firms?

A carbon tax will impact the financial expenditures of consumers and firms in the NWT in the following ways:

- **Carbon tax payments.** The most obvious effect of a carbon tax is to raise the price for refined petroleum products, which are used for personal transportation and household heating. For example, a carbon tax of $30/t raises the price for gasoline by 6.7¢ per litre.

- **Household decisions to reduce greenhouse gas emissions.** A central objective of a carbon tax is to encourage households and firms to reduce emissions, which can alter their investments in **capital** and expenditures on **energy**. For example, if a household chooses to purchase a hybrid-electric vehicle as opposed to a conventional vehicle, their carbon tax payments would decline. These household decisions result in additional benefits associated with improving energy efficiency (the hybrid vehicle consumes less fuel) as well as additional costs (a hybrid vehicle is more costly to purchase than a conventional vehicle).
- **Revenue recycling.** Although a carbon tax imposes a cost on any unabated GHGs, this cost is a "transfer" because revenues raised by the tax must be allocated somewhere (i.e., it is cost neutral for the NWT as a whole). Depending on how this revenue is returned to the economy, it will have various benefits for firms and consumers. For example, households could benefit directly if the revenue is returned to them via a direct transfer.

A carbon tax imposes a direct financial cost on firms and consumers in the NWT, although some of this cost is offset by lower energy expenditures as shown in Figure 13. The main component of these costs is carbon tax payments, which increase with rising policy stringency. Capital investment costs represent a fraction of carbon tax payments, while energy costs decline. Energy costs decline for two reasons. First, firms and consumers invest in more energy efficient technologies in response to the carbon tax. Second, the carbon tax encourages fuel switching to renewable fuels that are typically cheaper than fossil fuels.

Figure 13 Average annual compliance costs, 2017-2030 (before revenue recycling)

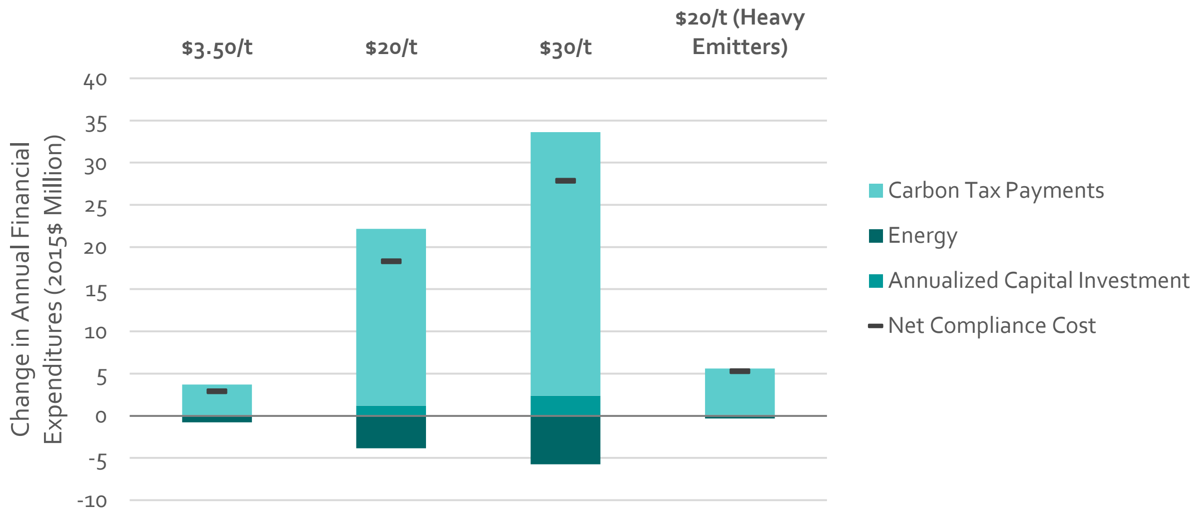


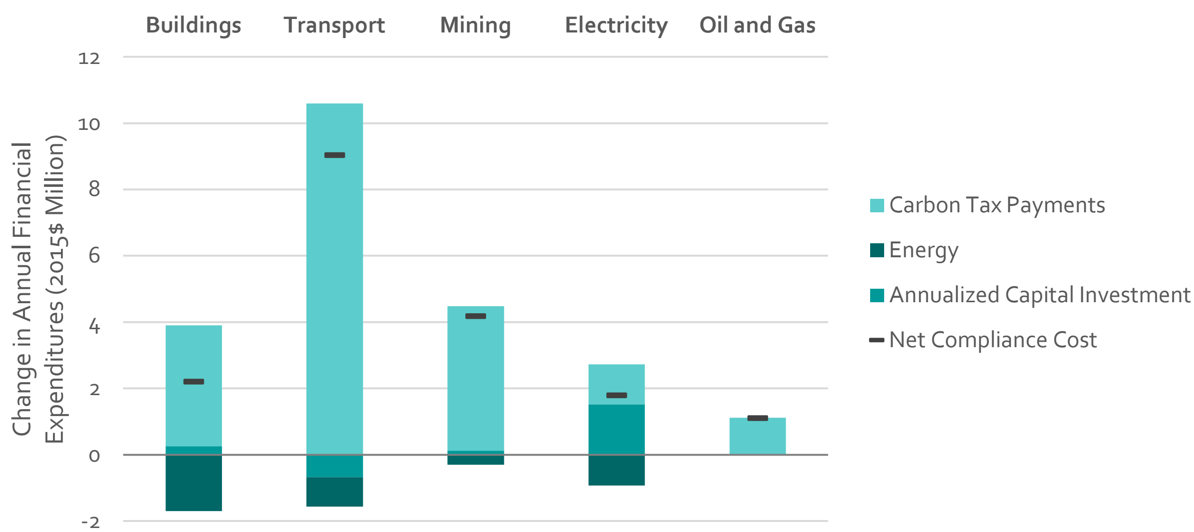
Figure 14 disaggregates compliance costs by sector for the $20/t carbon tax scenario. These costs represent average annual costs between 2017 and 2030, and are relative to the reference case:

- **Buildings.** Net compliance costs average $2.2 million annually for the buildings sector. Carbon tax payments and investment in less emissions intensive equipment are partially offset by lower energy costs. Energy costs for buildings decline for three reasons: (1) improved building envelopes which require less space heating, (2) the adoption of more energy efficient space and water heating equipment and (3) fuel switching from oil to biomass heating.
- **Transport.** The transport sector has the highest compliance cost ($9.0 million annually) because it accounts for about half of territorial emissions over the forecast period. Energy costs decline because firms and consumers purchase more energy efficient vehicles than they otherwise would have. Capital costs are likely to decline because consumers spend less on vehicles. First, energy efficient vehicles are often smaller and less costly than larger vehicles. Second, vehicle occupancy increases, driving a small decline in the rate of vehicle utilization. A carbon tax is also likely to exert a downward pressure on the demand for vehicle travel. If this dynamic was included in the analysis, capital and energy cost savings would be greater.
- **Mining.** Compliance costs in the mining sector average $4.2 million over the forecast period. Investment in more efficient equipment results in some energy cost savings. Our findings generally show that the stringency of carbon price modeled is insufficient to induce greater adoption of renewable electricity generation options by industry.

However as mentioned earlier, significant uncertainty exists about the equipment that is likely to be installed at specific facilities in the future.

- **Electricity.** The utility electricity sector accounts for the bulk of the capital investment requirements ($1.5 million annually). This investment is associated with the development of various renewable generation options to displace generation from diesel. It also results in energy cost savings because renewable fuels are cheaper than diesel.
- **Oil and gas.** Compliance costs in the oil and gas sector average $0.9 million. As mentioned earlier, declining production from oil and gas is associated with a lack of investment in the sector. Due to this decline, a carbon tax has a limited opportunity to influence investment decisions and hence achieve GHG reductions.

Figure 14 Average annual compliance costs by sector, 2017-2030 ($20/t carbon tax, before revenue recycling)



How much revenue would be raised by carbon pricing?

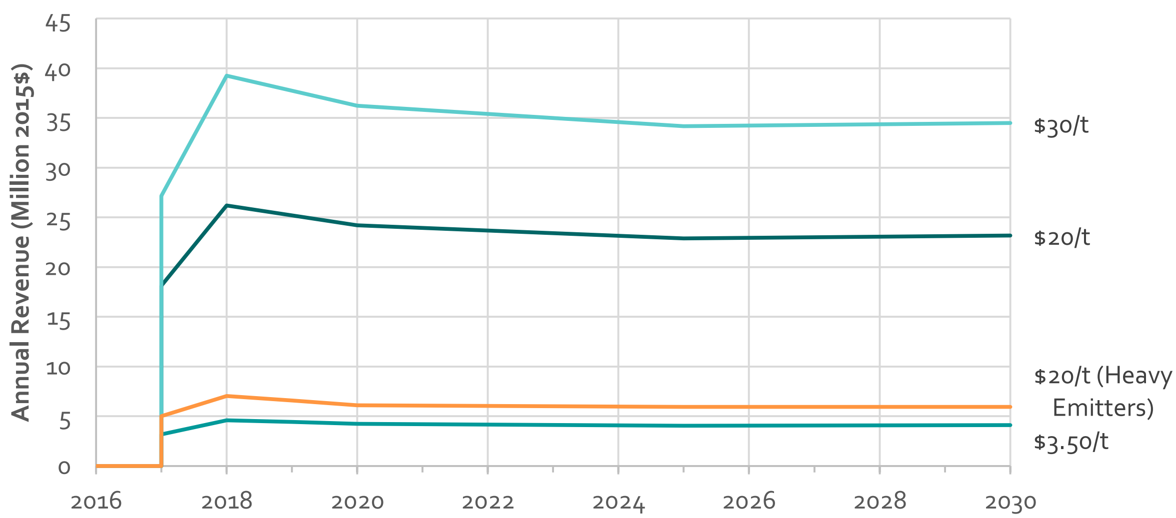
A carbon tax could raise between $4 and $35 million annually in the NWT depending on its stringency and coverage. Figure 15 shows the annual revenue raised by different carbon tax policies. For all policy options, revenue increases between 2017 and 2018 as the carbon price is raised to its maximum value. It then decreases because territorial emissions decrease.

A price of $30/t applied to all sectors of the economy would raise an average of about $35 million annually between 2017 and 2030, as shown in Figure 15. A lower price of $3.50/t would raise an average of about $4 million annually. Likewise, $20/t would raise $23 million annually if applied to all sectors of the economy, but only $6 million if applied to heavy emitters only.

Several other factors influence the amount of revenue raised:

- The choice of revenue recycling. For example, if revenue is invested in technologies to reduce emissions, carbon revenue will be lower in subsequent years.
- Different trends in sector activity (e.g. an increase in mining activity) or the emissions intensity of sector activity.

Figure 15 Annual carbon pricing revenue (before revenue recycling)

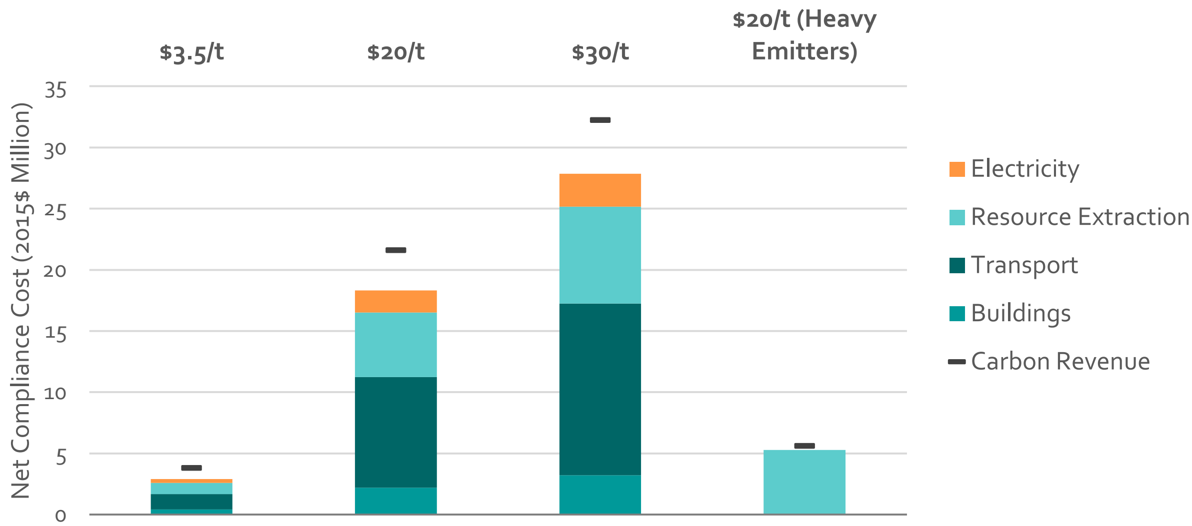


Note: Carbon price is assumed constant in real terms. In other words, it will increase with rate of inflation. By contrast, if revenue was constant in nominal terms, real value would erode and revenues would be lower.

Revenue raised from the carbon tax can be used to compensate firms and households for their compliance costs. Compliance costs only provide a partial picture of the financial impact of a carbon tax in the NWT. In particular, a carbon tax is not a pure cost on the NWT's economy because the revenue raised must be allocated somewhere.

As shown in Figure 16, carbon revenue exceeds total compliance costs for all of the carbon tax policy options. This revenue can be used to achieve the NWT’s environmental, economic and other objectives–including compensating firms and households for all or some portion of their compliance costs.

Figure 16 Average annual compliance costs by sector, 2017-2030



4.4. How can carbon tax revenue be used to achieve the NWT's environmental and economic objectives?

As emphasized above, a carbon tax is not a pure cost on the NWT economy because the revenue raised must be allocated somewhere. This revenue can be used to achieve the NWT's environmental, economic and other objectives. For example, carbon revenue can be:

- Used to reduce other taxes, such as those on personal or corporate income.
- Returned to households as a direct transfer, for example to ensure low income households are not made worse off.
- Invested in GHG reduction activities to further reduce emissions and/or subsidize the cost of reducing emissions.
- Used to compensate sectors at risk of competitiveness pressures through output rebates.
- Combined with general government revenue and used for any other government priority, such as the NWT Heritage Fund.
- Any combination of the above.

Tradeoffs exist among these revenue recycling options, with the ideal choice of recycling method dependent on the NWT's climate mitigation, economic and other objectives. These options are discussed in the section "Revenue Recycling and Allowance Allocation" starting on page 11.

Below, we summarize key tradeoffs among these options. This summary is qualitative, drawing on recent analyses conducted for other jurisdictions. Notably, we draw on an analysis conducted by Navius Research for the Ecofiscal Commission which explores how carbon pricing in Canada can be used to achieve both environmental and economic objectives.[4]

Table 8 ranks each revenue recycling option against potential government objectives:

- **Reducing corporate income taxes** tends to yield the greatest economic benefits. Most taxes are "distortionary", meaning they lead to economically inefficient outcomes. Since there are few limits on where investors can allocate capital, any tax discouraging capital investment, such as a corporate income tax, will effectively be dampening a powerful tool of economic efficiency. Using carbon tax revenue to reduce taxes with the greatest distortionary effects leads to greater economic benefits.

- **Investing in low emission technologies** tends to achieve the greatest GHG abatement. In terms of economic performance, it is likely to have a more moderate effect relative to cutting corporate income taxes. Most abatement technologies are capital intensive, so investing in technology acts as a reduced capital tax for a small portion of capital.

- Recycling carbon revenue through **transfers to households** or **lower personal income taxes tends** to have the least benefits for economic activity. This dynamic occurs because labor is less mobile and less sensitive to income taxes relative to capital. Nevertheless, these mechanisms can be helpful for ensuring that households are not made worse off by the policy.

- Providing **output rebates** to industry has a similar but more moderate effect as cutting corporate income taxes. As mentioned above, most abatement technologies are capital intensive, so investing in technology acts as a reduced capital tax for a small portion of capital. Similarly, output rebates are allocated to industry that is

[4] This report is not yet public. Related information can be found at http://ecofiscal.ca/reports/provincial-carbon-pricing-competitiveness-pressures/.

typically more capital intensive and also face the greatest carbon competitiveness pressure. This option would therefore maintain capital investment in the NWT for relatively emissions intensive industries (i.e., mining, oil and gas).

Table 8 Ranking of revenue recycling method according to potential government objectives

	Maximize GHG reductions	Maximize economic activity	Mitigate concern about sectors at risk of competitiveness impacts (e.g. mining)	Ensure households are not adversely affected	Raise revenue for other purposes (e.g. adaptation)
Reduce corporate income tax		✓			
Reduce personal income tax				✓	
Direct transfer (i.e., cheque in the mail)				✓	
Invest in low emissions technologies	✓	✓			
Output rebates		✓	✓		
Other government priorities					✓

5. What is the impact of uncertainty in the forecast?

The future evolution of the NWT's economy and GHG emissions is highly uncertain. Resource extraction and GHG emissions are influenced by many factors such as global commodity prices which are outside of the NWT's control. One of the key uncertainties identified for this project is the future level of mining activity in the NWT.

Overview of assumptions

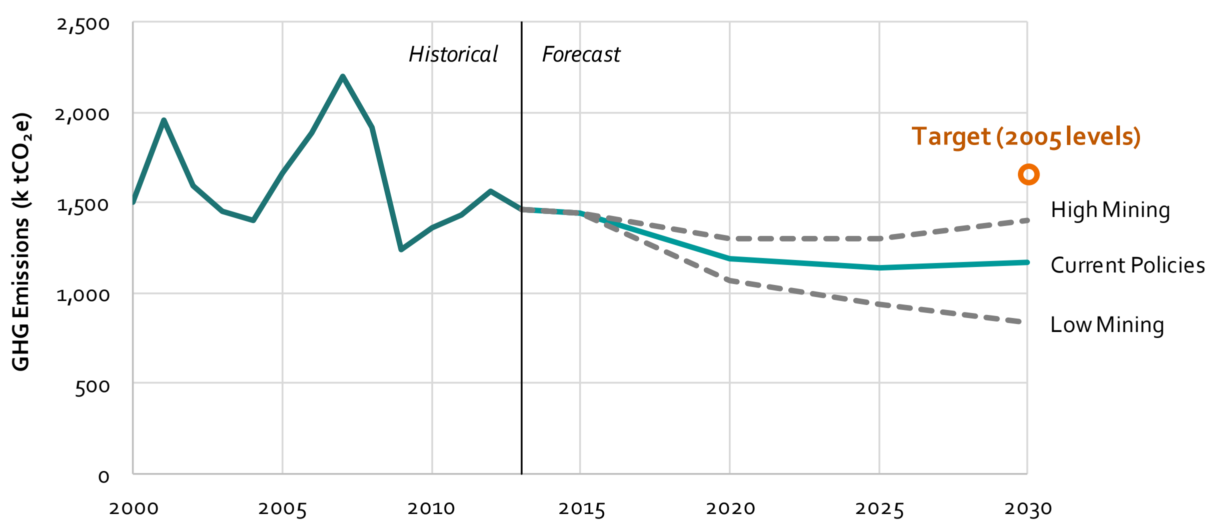
Mining activity accounts for a large share of emissions in the NWT (around one fifth of emissions plus a significant share of transport emissions). Therefore, changes in mining activity can have a large impact on territorial emissions.

In the base case, future mining activity was estimated from current and planned mining projects. The resulting forecast saw mining activity decrease from about 8.4 million tonnes of ore in 2015 to 7.8 million tonnes in 2030 (as described in Appendix A: Reference Case Assumptions). The sensitivity analysis examines the impact of mining activity being 75% higher and 75% lower in 2030.

Are GHG emissions under current policy affected by uncertainty in mining activity?

Mining activity has a significant impact on the NWT's emissions under a Current Policy scenario. The high mining assumption increases emissions by 252 kt in 2030 (21%) while the low mining activity assumption decreases emissions by 338 kt (29%), as shown in Figure 17. While most of the change in emissions is associated with the mining sector itself, freight transport emissions are also affected because of the close relationship between freight and mining activity.

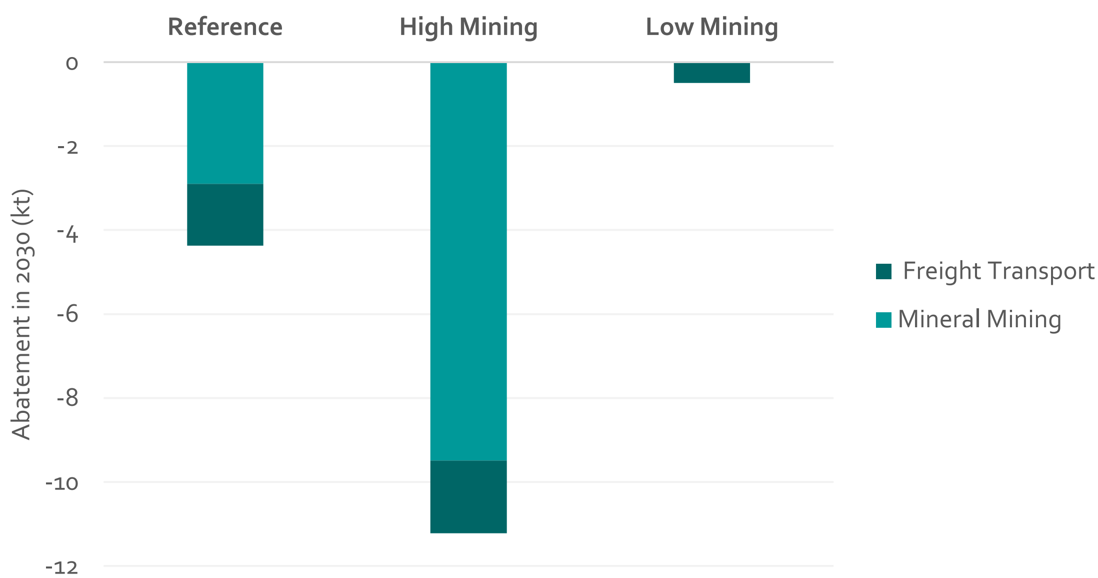
Figure 17 Impact of uncertainty in mining activity on reference forecast



Do different levels of mining activity affect emissions reduced by carbon pricing?

Although higher levels of mining activity imply higher levels of emissions in the NWT, they also offer a greater opportunity for policy to reduce emissions relative to these trends. In response to a carbon tax of $30/t, abatement from mining and freight transport reach about 4 kt in 2030 under the reference activity levels. In a scenario of high mining activity, abatement reaches 11 kt, as shown in Figure 18. This dynamic occurs because if the sector is growing, the carbon tax influences a greater number of investment decisions. By contrast, lower levels of mining activity reduce the abatement potential of a carbon tax.

Figure 18 Abatement from mining and freight transport in response to $30/t carbon tax



Appendix A: Reference Case Assumptions

This appendix summarizes key data sources and assumptions that are used to construct the reference case forecast of energy consumption and greenhouse gas emissions in the NWT. This forecast serves as a benchmark against which the impact of new climate policies is measured.

The forecast relies on a variety of data sources and assumptions that describe:

- Economic activity by sector.
- Energy prices.
- Existing NWT and federal policies.

Each of these variables is discussed below.

Sector Activity

Activity forecasts by sector (e.g. number of households, tonnes of mined ore) serve as a starting point for determining demand of energy services (e.g. space heating, freight transport) and hence GHG emissions in the NWT. These forecasts are summarized in Table 9. The footnotes below the table explain how the forecasts were derived. Where possible, we have relied on Environment Canada (EC) forecasts provided by ENR.

The forecasts are generally similar to those used in the previous analysis, with the following exceptions:

- Mining activity is significantly lower than the previous forecast (by about 70% in 2030). Information from the Northern Projects Management Office shows that a number of projects included in the previous analysis are no longer being considered (see Table 10 for additional information). A sensitivity analysis is conducted to determine the impact of higher or lower levels of mining activity on model results.
- Natural gas production ceases by 2030. This assumption is based on EC's forecast.

Table 9 Reference case output forecasts

	Units	2015	2020	2025	2030	AAGR
Demand Sectors						
Residential	*thousand households*	15.9	16.3	16.7	17.1	0.5%
Commercial	*Growth in floor space (%)*	0.4%	1.7%	1.1%	1.0%	1.0%
Transportation						
Passenger	*billion pkt*	2.5	2.7	3.0	3.3	1.7%
Freight	*billion tkt*	1.3	1.0	1.1	1.2	-0.5%
Mineral Mining	*million tonnes ore*	8.4	6.2	7.0	7.8	-0.5%
Supply Sectors						
Utility Electricity	*GWh*	300	298	310	337	0.8%
Petroleum Extraction	*thousand barrels per day*	10.0	8.0	6.0	5.0	-4.5%
Natural Gas Extraction	*million cubic feet per day*	10.9	5.5	2.7	0.0	-100.0%

Notes:

1. The number of households in 2030 is equal to that forecasted by EC. This projection aligns with the NWT Bureau of Statistics' most recent population forecast, which reaches 47,163 in 2031.
2. Growth in commercial floor space is based on (1) EC's GDP forecast and (2) the historical relationship between GDP and floor space growth in Canada.
3. Passenger-kilometers are driven by population and increasing demand for transport by person.
4. Demand for freight transport tracks mining activity.
5. Mining activity assumptions are described below.
6. Electricity generation is endogenously determined.
7. Oil and gas production is based on that forecasted by EC.

Table 10 provides additional information about how the mining activity forecast is derived. Mining activity from 2015 to 2020 is taken as the sum of (1) operational mines and (2) "advanced stage territorial projects" as reported by the Northern Projects Management Office. Activity is then linearly extrapolated from 2020 to 2030 based on trends from 2000 to 2020.

Table 10 Mining output forecast (million tonnes ore per year)

	2015	2020	2025	2030
Forecast	**8.4**	**6.2**	**7.0**	**7.8**
Average annual growth rate	0.4%	-5.8%	2.4%	2.2%
Operational				
Ekati	5.3	1.9	-	-
Diavik	1.6	1.6	-	-
Snap Lake	1.1	-	-	-
Cantung	0.4	-	-	-
Total Operational	**8.4**	**3.5**	**-**	**-**
Permitting or Construction				
NICO	-	0.9	1.5	1.5
Gahcho Kué	-	1.2	2.0	2.0
Prairie Creek	-	0.4	0.4	0.4
Nechalacho	-	0.3	0.7	0.7
Total Permitting or Construction	**-**	**2.7**	**4.6**	**4.6**
New				
Other assumed growth[1]	**-**	**-**	**2.4**	**3.2**

[1] Represents potential new output from projects not individually identified.

Energy Prices

Energy price forecasts are summarized in Table 11.

- The price of **refined petroleum products** (heating oil, propane, gasoline and diesel) is based on EC forecasts for crude oil, adjusted to average NWT retail prices based on historic refining margins. Relative to the previous analysis, the price for refined petroleum products is lower due to the recent decline in crude oil prices.
- **Electricity** prices are assumed to remain constant (in real terms) over the forecast period. Prices in the residential sector reflect the GNWT's Territorial Power Support Program.[5]
- Prices for **biomass** (wood and wood pellets) are based on the Arctic Energy Alliance's Fuel Cost Library and are assumed to remain constant over time (in real terms). The price for wood pellets is differentiated for residential and commercial customers.

[5] NWT Power Corporation. 2014. Zone Rate System. https://www.ntpc.com/our-community/zone-rate-system

Table 11 Energy price forecasts

	2015	2020	2025	2030	AAGR
Refined Petroleum Products (2015$/l)					
Gasoline	1.20	1.21	1.25	1.29	0.5%
Diesel	1.19	1.17	1.21	1.25	0.3%
Heating Oil	1.17	1.13	1.18	1.22	0.3%
Propane	0.84	0.96	1.12	1.28	2.9%
Biomass (2015$/GJ)					
Wood	16.5	16.5	16.5	16.5	0.0%
Pellets					
Residential	15.2	15.2	15.2	15.2	0.0%
Commercial	14.3	14.3	14.3	14.3	0.0%
Electricity (2015$/kWh)					
Residential					
Up to 700 kWh	0.29	0.29	0.29	0.29	0.0%
Over 700 kWh	0.40	0.40	0.40	0.40	0.0%
Commercial	0.33	0.33	0.33	0.33	0.0%

Notes:

1. Energy prices can vary significantly among communities of the NWT. The price forecasts are averaged by population and sales data.
2. Prices are in real 2015$ (i.e., net of inflation).

Current Policies

Below are key territorial and federal policies that are included in the reference case.

Territorial Policies

- **Biomass Energy Strategy.** The GNWT has taken a number of actions to increase the use of biomass and displace fossil fuel consumption, including installing wood pellet boilers in public buildings, working with communities and businesses to promote the installation of commercial or institutional biomass heating systems and providing rebates to consumers and firms that adopt the technology.[6] Following from the NWT Greenhouse Gas Strategy goals, it is assumed that biomass will make up 30% of all space heating capacity in NWT by 2030.

[6] NWT. ENR. http://www.nwtclimatechange.ca/content/biomass

- **Solar Energy Strategy.** As part of overall actions outlined in the NWT Energy Plan, the Solar Energy Strategy aims to develop policies and guidelines that assist utilities in providing solar power in both diesel and off-the-grid communities. Following the target laid out within the Solar Energy Strategy, it is assumed that by 2017 solar power will displace 2% of the average annual generation in diesel communities.[7]

- **Alternative Energy Technologies Program.** This program provides subsidies for the installation of alternative energy systems, as well as upgrades of existing energy systems to higher efficiency. There are three categories of funding: Community (CREF), Medium (MREF) and Small (SREF).[8]

    - CREF provides up to half the cost of large-scale emissions reducing energy technologies, with an annual maximum of $50,000, allocated to communities, boards, agencies and Aboriginal communities. Eligible technologies include solar water heating panels, wind turbines and ground source heat pumps.

    - MREF provides up to one third the cost of emissions reducing energy technologies, with an annual maximum of $15,000, allocated to NWT businesses, including off-grid camps and lodges. Eligible technologies include photovoltaics and wood pellet furnaces.

    - SREF provides up to one third the cost of emissions reducing energy technologies, with an annual maximum of $5,000, allocated to NWT residents. All installation costs associated with the implementation of residential alternative energy systems are eligible for funding.

- **Commercial Energy Conservation and Efficiency Program.** This program provides rebates to businesses located, or with assets in, Northwest Territories, for the purchase of energy and/or water use reducing technology. The maximum single rebate is $15,000 with multiple rebates possible per year.[9]

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[7] NWT. ENR. http://www.nwtclimatechange.ca/sites/default/files/Solar_Energy_Strategy_2012-2017_0.pdf

[8] NWT ENR. 2011. Application Guidelines for Alternative Energy Technologies Program. http://www.enr.gov.nt.ca/sites/default/files/brochures/aetp_application_guidelines.pdf

[9] NWT ENR. 2014. Application Guidelines for Commercial Energy Conservation and Efficiency Program. http://www.enr.gov.nt.ca/sites/default/files/cecep_guidelines_2014.pdf

- **Energy Efficiency Incentive Program.** This program provides rebates ranging from $50 to $1,500, for residential appliance efficiency upgrades.[10]

- **Yellowknife Building Code.** Effective 2009, new commercial buildings must exceed that National Model Energy Code of Canada for Buildings 1997 by 25%. Effective 2011, new residential buildings must meet EnerGuide 80 standards.[11]

Federal Policies

- **Minimum performance standards.** New standards have been developed for household appliances, including in particular those related to water heaters[12] and light bulbs.[13]

- **Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations.**[14] New passenger vehicles and light-commercial vehicles/light trucks sold in Canada must meet fleet-wide GHG emission standards between 2012 and 2016, and between 2017 and 2025. Fleet targets for passenger cars are 135g/km in 2016 and 98 g/km in 2025.

- **Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations.**[15] New heavy-duty vehicles sold in Canada must meet GHG emissions standards between 2014 and 2018. These regulations will require that GHG emissions from 2018 model-year heavy-duty vehicles will be reduced by up to 23%.

[10] Arctic Energy Alliance. 2014. Application Guidelines for the Energy Efficiency Incentive Program. http://www.enr.gov.nt.ca/sites/default/files/eeip-application-guidelines.pdf

[11] The City of Yellowknife. Building By-Law No. 4469. Adopted January 28, 2008.

[12] Natural Resources Canada. June 2010. *Higher Efficiency Requirements for Water Heaters Bulletin on Developing and Amending Standards.* http://oee.nrcan.gc.ca/regulations/bulletin/water-heaters-june-2010.cfm?attr=0

[13] Natural Resources Canada. January 2014. *Amendment to Canada's Energy Efficiency Regulations for Lighting Products*. https://www.nrcan.gc.ca/energy/regulations-codes-standards/12342

[14] SOR/2010-201 (2012-2016) http://gazette.gc.ca/rp-pr/p2/2010/2010-10-13/html/sor-dors201-eng.html; SOR/2014-207 (2017-2025) http://canadagazette.gc.ca/rp-pr/p2/2014/2014-10-08/pdf/g2-14821.pdf

[15] SOR/2013-24 (2014-2018), http://canadagazette.gc.ca/rp-pr/p2/2013/2013-03-13/html/sor-dors24-eng.html

Appendix B: The CIMS Model

The CIMS energy-economy model is used to estimate the impacts of policy on energy consumption, air emissions, and capital, operating, and energy costs. The CIMS model is a technologically explicit energy-economy model that captures equilibrium feedbacks for the supply and demand of energy and energy intensive goods and services. CIMS requires external inputs – forecasted demand for products, services and energy prices. These drivers determine the processes, technologies and energy required to meet demand, enabling CIMS to produce regional and sector emissions forecasts.

The CIMS model is based on a disaggregated sector structure and technologically explicit framework, which allow it to simulate both price policies (e.g. British Columbia's Carbon Tax) and technology regulation (e.g. the federal transport emissions intensity regulations). CIMS models all the major energy supply and demand sectors in the economy as well as the main processes within those sectors (where demand for each process is satisfied by current and emerging technologies). The model captures most emissions, energy consumption and energy production in the economy; thus, it is well positioned to provide a realistic forecast of abatement opportunities in the NWT.[16]

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.

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

[16] This excludes non-vehicle energy consumption and emissions in the construction, forestry and aspects of the agriculture sector as well as energy commodities used as refinery or chemical feedstock.

(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.

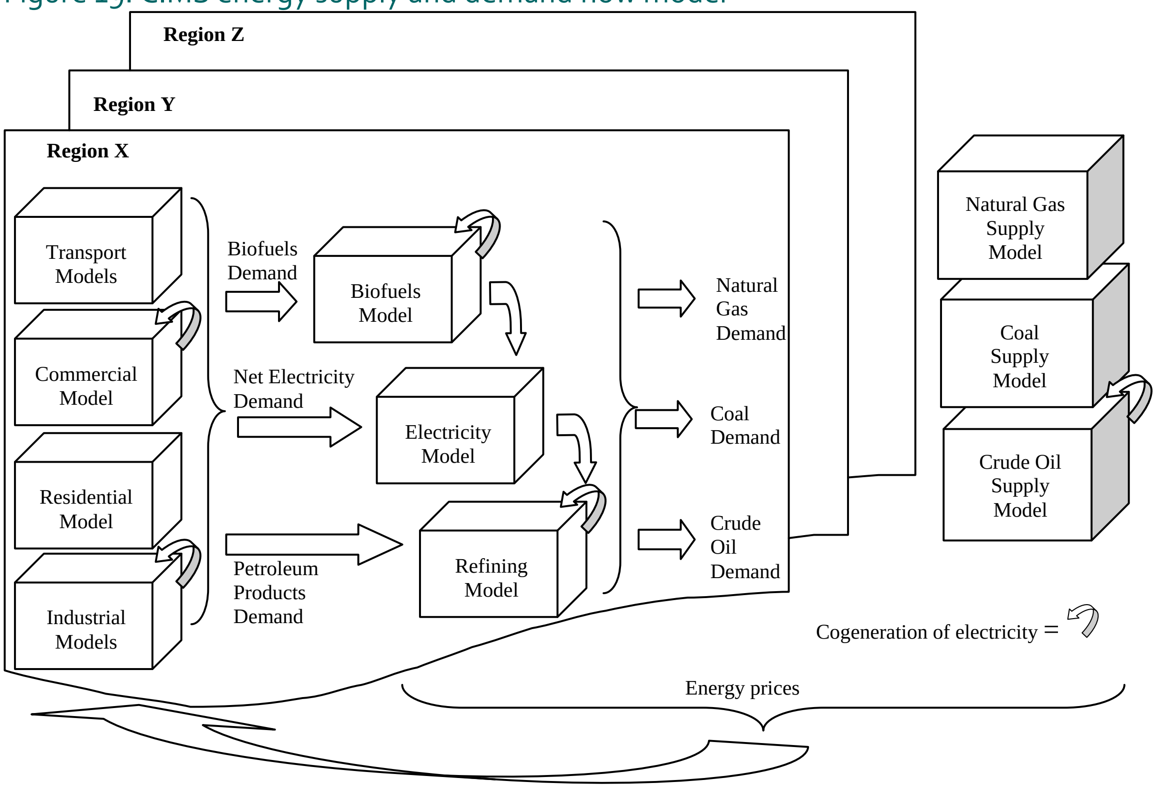
CIMS simulates the competition of technologies at each energy service node in the economy based on a comparison of their life cycle cost (LCC) and some technology-specific controls, such as a maximum market share limit in the cases where a technology is constrained by physical, technical or regulatory 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 19 provides a schematic of this process. For most projects, while the quantities energy commodities produced are set endogenously using demand and supply balancing, endogenous pricing is used only for electricity and refined petroleum products; natural gas, crude oil and coal prices remain at exogenously forecast levels, since Canada is assumed to be a price-taker for these fuels.

Figure 19: 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).[17] 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

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

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.[18]

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 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

[18] 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.

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.

In summary, the main advantages of CIMS are:

- **CIMS accounts for non-linearities in emissions abatement.** Many models simulate abatement using elasticities of substitution or linear functions that represent how firms can change their inputs while maintaining a given level of production. For example, computable general equilibrium models use elasticities to show how firms may switch from refined petroleum products to electricity, or how they can increase capital consumption to reduce energy consumption. The result is that the abatement from these models is relatively linear as a function of an emissions price. Rather than using elasticities or linear functions to represent abatement, CIMS simulates a competition between technologies (e.g., an oil furnace vs. a ground source heat pump) that provide the same service (i.e., space heating). The result is that some abatement technologies may be uncompetitive until an emissions price reaches a specific threshold (e.g., plug-in electric vehicles), at which point the sector undertakes a significant amount of abatement.
- **CIMS is technologically detailed.** Every sector requires several services and processes to function. For example, natural gas extraction requires a combination of drilling, extraction, and processing services to produce natural gas. For each service and process required, CIMS allows a suite of technologies to compete to fulfil the particular service or process needs of the sector. For example, low efficiency diesel, high efficiency diesel and biodiesel trucks may compete to provide freight trucking services to the freight transportation sector. CIMS represents each of the major processes/services and associated technologies, whereas the other modelling approaches represent the sector as a single production unit.

- **CIMS reports detailed policy impacts.** Because of the level of detail in the CIMS model it is possible to separate the impacts of policies on each sector. For example, CIMS describes the changes in energy intensity of space heating in the commercial sector (GJ / m^2 floor space), or the changes in average vehicle fuel price (2005¢ / L gasoline eq.) that are produced when policies are implemented.

The limitations of CIMS are:

- **CIMS does not account for economic activity unrelated to energy consumption or greenhouse gas emissions.** The CIMS model accounts for the energy and emissions intensive portion of the economy, but does not account for other economic activity. For example, the CIMS model accounts for a household's costs related to energy consumption (e.g., light bulbs), but does not account for other household expenses. Therefore, CIMS does not estimate how a change in expenditures on energy or capital related to energy consumption might affect other household expenditures. However, supplemental analysis with our in-house general equilibrium model, GEEM, provides an estimate of policy impacts on these broader economic structures.
- **CIMS is not a general equilibrium model, and does not account for some markets likely to be affected by the implementation of climate policy.** The CIMS model also does not account for key markets such as capital or labour, and cannot simulate how increased capital expenditures to abate emissions might affect interest or wage rates. Additionally, while CIMS does balance supply and demand of key energy commodities, such as electricity and refined petroleum products, it does not ensure this balance for commodities such as iron or newsprint. The result of these omissions is that CIMS cannot be used to estimate a policy's impact on gross domestic product.

Select CIMS References

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Appendix C: Data Tables

Greenhouse Gas Emissions

Table 12 Petition proposal, $3.5/t (kt CO_2e)

	2015	2020	2025	2030	AAGR
Energy Demand Sectors					
Residential	95	91	82	70	-2.0%
Commercial and Institutional	138	134	123	122	-0.8%
Personal Transport	311	310	308	320	0.2%
Freight Transport	426	311	278	289	-2.6%
Mineral Mining	300	214	236	262	-0.9%
Total Demand Sectors	1,269	1,059	1,027	1,063	-1.2%
Energy Supply Sectors					
Utility Electricity	68	62	65	76	0.7%
Petroleum Crude Extraction	105	77	49	36	-7.1%
Natural Gas Extraction	16	15	14	0	-100.0%
Total Supply Sectors	189	154	128	112	-3.5%
Total NWT	**1,458**	**1,214**	**1,155**	**1,175**	**-1.4%**

Table 13 Economy-wide carbon tax, $20/t (kt CO_2e)

	2015	2020	2025	2030	AAGR
Energy Demand Sectors					
Residential	95	90	79	66	-2.4%
Commercial and Institutional	138	132	120	118	-1.0%
Personal Transport	311	310	307	319	0.2%
Freight Transport	426	311	278	288	-2.6%
Mineral Mining	300	214	235	261	-0.9%
Total Demand Sectors	1,269	1,057	1,019	1,052	-1.3%
Energy Supply Sectors					
Utility Electricity	68	61	63	72	0.3%
Petroleum Crude Extraction	105	77	49	36	-7.1%
Natural Gas Extraction	16	15	14	0	-100.0%
Total Supply Sectors	189	153	126	108	-3.7%
Total NWT	**1,458**	**1,210**	**1,145**	**1,159**	**-1.5%**

Table 14 Economy-wide carbon tax, $30/t (kt CO_2e)

	2015	2020	2025	2030	AAGR
Energy Demand Sectors					
Residential	95	89	78	64	-2.7%
Commercial and Institutional	138	131	119	115	-1.2%
Personal Transport	311	310	307	318	0.2%
Freight Transport	426	311	278	288	-2.6%
Mineral Mining	300	214	234	260	-1.0%
Total Demand Sectors	1,269	1,055	1,015	1,044	-1.3%
Energy Supply Sectors					
Utility Electricity	68	61	62	69	0.1%
Petroleum Crude Extraction	105	77	49	36	-7.1%
Natural Gas Extraction	16	15	14	0	-100.0%
Total Supply Sectors	189	153	124	105	-3.9%
Total NWT	**1,458**	**1,208**	**1,139**	**1,150**	**-1.6%**

Table 15 Heavy-emitters tax, $20/t (kt CO_2e)

	2015	2020	2025	2030	AAGR
Energy Demand Sectors					
Residential	95	91	82	71	-1.9%
Commercial and Institutional	138	134	124	123	-0.8%
Personal Transport	311	310	308	320	0.2%
Freight Transport	426	311	279	289	-2.6%
Mineral Mining	300	214	235	261	-0.9%
Total Demand Sectors	1,269	1,060	1,028	1,064	-1.2%
Energy Supply Sectors					
Utility Electricity	68	62	65	77	0.8%
Petroleum Crude Extraction	105	77	49	36	-7.1%
Natural Gas Extraction	16	15	14	0	-100.0%
Total Supply Sectors	189	154	128	113	-3.4%
Total NWT	**1,458**	**1,214**	**1,156**	**1,177**	**-1.4%**

Utility Electricity Generation

Table 16 Utility electricity generation by source and policy in 2030 (GWh)

	Current Policies	Carbon Tax $20/t	Electricity Policy	Electricity Policy with $20/t Carbon Tax
Hydro	270	278	279	286
Diesel	63	57	49	45
Natural Gas	31	31	32	32
Wind	1	1	6	7
Biomass	3	4	2	3
Solar PV	1	1	1	1
Total NWT	**369**	**373**	**369**	**373**

Carbon Revenue

Table 17 Annual carbon revenue before revenue recycling (2015$ million)

	2017	*2018*	*2019*	*2020*	*2021-2025*	*2026-2030*
$3.50/t	3.2	4.6	4.4	4.2	4.0	4.1
$20/t	18.1	26.2	25.2	24.2	22.9	23.2
$30/t	27.2	39.2	37.7	36.2	34.2	34.5
$20/t (Heavy Emitters)	5.0	7.0	6.6	6.1	6.0	5.9

Financial Costs

Table 18 Change in average annual financial costs relative to reference case, $3.5/t (2015$ million)

	Capital Investment	Energy	Carbon Tax Payments	Net Compliance Cost
Buildings	0.04	-0.29	0.66	0.41
Transport	-0.44	-0.16	1.86	1.27
Mining	0.02	-0.05	0.77	0.74
Electricity	0.26	-0.16	0.22	0.31
Oil and Gas	0.00	0.00	0.19	0.19
Total	**-0.12**	**-0.67**	**3.69**	**2.91**

Table 19 Change in average annual financial costs relative to reference case, $20/t (2015$ million)

	Capital Investment	Energy	Carbon Tax Payments	Net Compliance Cost
Buildings	0.25	-1.70	3.65	2.20
Transport	-0.68	-0.88	10.60	9.04
Mining	0.12	-0.30	4.36	4.18
Electricity	1.52	-0.93	1.20	1.79
Oil and Gas	0.00	-0.01	1.11	1.10
Total	**1.22**	**-3.83**	**20.93**	**18.32**

Table 20 Change in average annual financial costs relative to reference case, $30/t (2015$ million)

	Capital Investment	Energy	Carbon Tax Payments	Net Compliance Cost
Buildings	0.38	-2.56	5.38	3.20
Transport	-0.53	-1.31	15.88	14.04
Mining	0.19	-0.46	6.53	6.26
Electricity	2.33	-1.39	1.76	2.70
Oil and Gas	0.00	-0.02	1.67	1.65
Total	**2.37**	**-5.74**	**31.23**	**27.86**

Table 21 Change in average annual financial costs relative to reference case, $20/t heavy emitters tax (2015$ million)

	Capital Investment	Energy	Carbon Tax Payments	Net Compliance Cost
Buildings	0.00	0.00	0.00	0.00
Transport	0.00	0.00	0.00	0.00
Mining	0.12	-0.30	4.36	4.18
Electricity	0.00	0.00	0.00	0.01
Oil and Gas	0.00	-0.01	1.11	1.10
Total	**0.13**	**-0.31**	**5.48**	**5.29**

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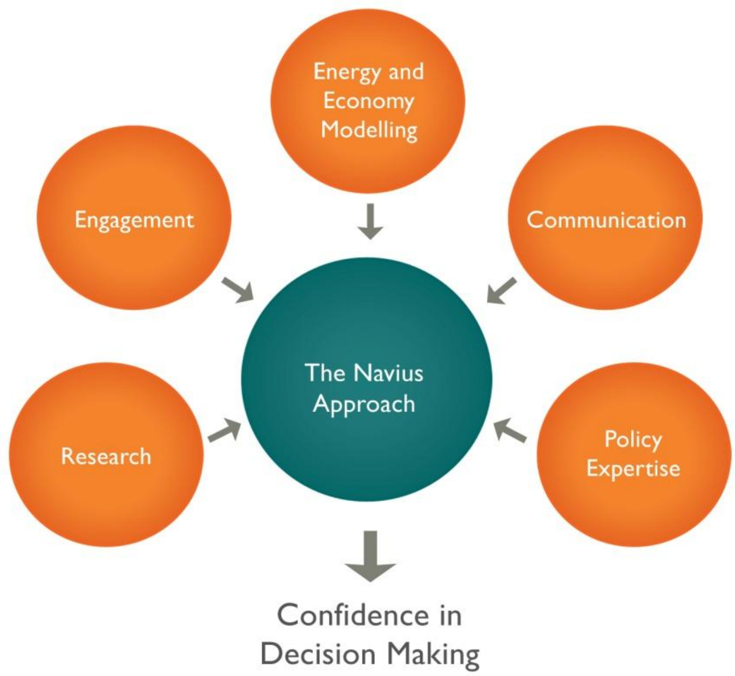

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