Carbon Pricing in Nunavut – Potential Impact Analysis

This document provides data on potential estimated impacts of carbon pricing in Nunavut. It is important to note that the results provide an estimated order of magnitude based on modeling and available data rather than a precise assessment of specific impacts. The economic costs and benefits of carbon pricing depend on the design of the system and how jurisdictions use the resulting revenue. Costs will also vary across the country, according to the degree of fossil fuel use for electricity generation, the types of fuels used for heating, and the mix of economic activity, and costs will vary across households and businesses reflecting these and consumption differences.

There are significant limitations and caveats to the modeling and related estimates, noted below.

Caveats related to the modeling results

Fully assessing the economic impacts of carbon pricing is complicated. In addition to estimating the costs that pricing will impose on various parts of the economy, it is important to account for the benefits of reducing GHG emissions (including the avoided costs of climate change), certainty of cost of emission for consumers planning investment, long-term financial benefits of transitioning to a cleaner economy, and the potential benefits that may flow from innovations driven by carbon pricing.

Modelling projections always have a degree of uncertainty, but they can provide helpful information about the potential range and magnitude of impacts. Model-based estimates depend on a wide range of assumptions, including a projection of the future economy. Thus, to the extent that underlying assumptions are uncertain or future economic performance differs from the projections embedded in the models, the actual impacts will differ from the estimates presented below.

Recognizing the uncertainty associated with some of these key underlying assumptions, it is important to note that the estimated impacts identified in this report are much less than the average revision to GDP growth year over year or the potential effect of fluctuations in world oil prices.

Overall, the expected economic impacts are likely an overestimate because computable general equilibrium models of climate change policies, such as EC-PRO, do not capture the full range of benefits including direct benefits from public infrastructure investments, the development of new technologies and market opportunities, improved health, and contributions to the avoided costs of climate change. As a result, carbon pricing is expected to have various benefits that have not been captured by the model. Further, the modeling used to support this report does not account for possible technological breakthroughs. As new technologies become available, their cost will likely fall and their overall effectiveness will improve. As well, carbon pricing will provide business certainty and help create and attract investment opportunities in Canada and enable export growth of clean tech and services solutions. These positive impacts are not addressed in the modeling.

The impacts of carbon pricing will also depend heavily on the way in which carbon pricing revenue is used. Revenue can be recycled back into the economy in various ways, for example to reduce distortionary taxes and make the economy more efficient, to minimize impacts on vulnerable groups such as low-income households, or to support businesses that innovate, are more efficient, contribute

to a clean economy, and create good jobs for the future. Governments can also invest carbon revenues in specific mitigation initiatives, like energy efficiency programs.

Notably, these estimates also do not consider the cost of global inaction on climate change. The impacts of a changing climate are already being felt, and the costs of inaction are much greater than the costs of addressing climate change. In its 2011 "Paying the Price" report, the National Round Table on the Environment and the Economy concluded that the costs of climate change could represent about $5 billion per year by 2020 in Canada, and "could range from $21 billion to $43 billion per year by 2050, equivalent to 0.8% to 1% of GDP, depending upon what future global emissions occur and how Canada grows in the meantime."[1]

EC-PRO Model

The estimated macro-economic impacts have been analyzed using Environment and Climate Change Canada's (ECCC's) peer reviewed, multi-region, multi-sector, provincial-territorial based computable general equilibrium (CGE) model, named EC-PRO.

The EC-PRO model is a small open-economy recursive-dynamic CGE model of the Canadian economy. It captures characteristics of production and consumption patterns through a detailed input-output table and links provinces via bilateral trade. Each province and territory is explicitly represented as a region. The representation of the rest of the world is reduced to imports and export flows to Canadian provinces which are assumed to be price takers in international markets. To accommodate analysis of energy and climate policies, the model incorporates information on energy use and GHG emissions related to the combustion of fossil fuels. It also tracks non-energy-related GHG emissions. The EC-PRO model, being a CGE model, is an appropriate tool for modelling carbon pricing scenarios, since it allows the entire economy to respond as relative prices change throughout the economy. **However, some significant caveats should be noted**:

- Results from CGE models should always be interpreted as based on a certain set of assumptions. These assumptions typically vary from model to model, which can lead to different models producing differing results. Model results are therefore most useful when interpreted in relation to other scenarios of the same model, rather than as predictions on an absolute basis.

- As noted above, CGE models do not typically capture the full range of positive impacts of climate change policies. These might include: the development of new green technology sectors; direct benefits on public expenditure, such as those resulting from improved health; or the reductions of societal costs associated with GHG emissions, which are estimated to be $41 per tonne CO2e on a global basis in 2016 by ECCC[2]. In cost-benefit analyses, these positive societal impacts would offset some of the negative economic impacts typically predicted by CGE models.

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[1] National Round Table on the Environment and the Economy: *Paying the Price: The Economic Impacts of Climate Change for Canada*, 2011. http://nrt-trn.ca/climate/climate-prosperity/the-economic-impacts-of-climate-change-for-canada

[2] Estimate from Figure 6 of the "Technical Update to Environment and Climate Change Canada's Social Cost of Greenhouse Gas Estimates", March 2016. For more information, see: http://ec.gc.ca/cc/default.asp?lang=En&n=BE705779-1

- Calibrating the model to match the unique characteristics of each province and territory is a major endeavour and federal-provincial-territorial collaboration on modelling approaches is ongoing.

- The EC-PRO model does not attempt to predict which new technological breakthroughs will materialize in the future. As these new technologies become available, their cost will likely fall and their overall effectiveness improve, thereby leading to more emissions reductions at lower carbon prices than predicted by these models. While the available technologies in the model are limited to those that currently exist, associated performance characteristics (e.g., level of energy efficiency, operating costs and up-front capital costs) improve over the projection period.

- Global commodity prices and carbon policies are assumed to be static. This results in increased carbon leakage and reduced positive technology spillover relative to a global increase in climate policy ambition.

Environment Sales Tax Input-Output Model

With respect to the modeling of household-level impacts, a further limitation of the estimates presented in this document is that data for the territories are difficult to collect because of their small populations and large geographic size.

It should be noted that the modeling used for this report also likely over estimates[3] the impacts of carbon pricing on households. The reasons for this inflation include:

- The number of households used as a divisor in deriving average household impacts reflects the recently-released Census 2016 data, whereas the number of households in the territories is growing, so the actual costs per household will likely be lower than the estimates in this analysis.

- The income data used to estimate impacts as a share of average household income, across thirds of the income distribution, are from the 2012 Survey of Household Spending, although the impacts in the numerator remain estimated nominal impacts for 2018. Household incomes have grown since then, meaning that carbon pricing costs will be a lower share of household income than shown in this analysis.

- The estimates include carbon pricing on fuels used for all transportation. However, under the current provincial systems and proposed backstop systems, carbon pricing does not apply to inter-jurisdictional sea or air transportation.

- The estimates include the impact on Nunavut households of carbon pricing in the provinces. Given that carbon pricing is already in place in BC, Alberta, Ontario and Quebec, many of these costs are already borne by households in Nunavut.[4]

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[3] Data were chosen to maximize the quality of the estimates while minimizing the likelihood of underestimating the impacts on households.

4 Current pricing for BC reflects the pricing in place at the time of estimation (namely $30/tonne), and the federal backstop prices of $40 and $50 in 2021 and 2022, respectively.

Carbon pricing

Overall, economic analysis and growing international experience indicate that carbon pricing is the most efficient measure to achieve reductions. Carbon pricing provides an incentive for firms and consumers to take advantage of their own least-cost abatement options first and to continue to reduce emissions in all circumstances where it is cost-effective to do so. By creating incentives for consumers to shift their purchases towards less carbon-intensive goods, carbon pricing further reduces emissions and provides industry with an incentive to innovate and respond to the growing demand for low-carbon products.

Macro-economic analysis scenarios

This report presents economic impacts estimated using ECCC's computable general equilibrium (CGE) model, EC-PRO. Modelling projections always have a degree of uncertainty, but they provide helpful information about the potential range and magnitude of impacts. For the purpose of this analysis, ECCC used EC-PRO to model the application of a carbon levy in which a direct carbon price is applied to emissions from fossil fuels starting at $10 per tonne in 2018 and increasing annually $10 per year until it reaches $50 per tonne in 2022. A carbon levy + output-based pricing system (OBPS) scenario was also modeled, whereby, as of 2019, industries emitting at or above 50,000 tonnes of CO2e per year pay the carbon price on a portion of their emissions (for the purpose of the modelling in this study, this is assumed to be 20%).[5]

The results are presented relative to changes from a "business-as-usual" baseline, which is based on Canada's 2016 greenhouse gas emissions Reference Case[6] and adjusted to reflect territory-specific data and considerations.

Household-level analysis approach

The analysis of impacts of carbon pricing on consumers in this report are shown as impacts on households. This type of analysis is typically conducted on a household basis given that many consumer goods and services are consumed at the household level and there are economies of scale in consumption when individuals live together. For example, each individual in a multi-person household does not pay for home heating separately, but rather home heating is typically paid for at the household level. Analysis presented in this report also provides averages across groups of households, which on average contain multiple people. This means that the analysis contained in this report must be compared to other data collected at the household level, such as household income data, and cannot be compared directly to individual-level income data.[7]

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[5] The choice of 20% is for illustrative purposes only.

[6] For more information, see: https://www.canada.ca/en/environment-climate-change/services/climate-change/publications/2016-greenhouse-gas-emissions-case.html

[7] All income data used in the household analysis in this report reflect Statistics Canada's definition of total household income, which includes not only total income for tax purposes but all income (including all income from government sources). Median income represents the income of the household(s) at the middle or 50th percentile of the income distribution.

According to Census 2016, there were 9,820 private households in Nunavut in 2016, with an average household size of 3.6 people. Estimated median total household income among these households was $97,441 in 2015.[8]

The household-level estimates provided show both direct and indirect costs of carbon pricing on households in each jurisdiction. Direct impacts represent the additional cost of carbon pricing on the purchase of fossil fuels by households, while indirect impacts reflect the costs embedded in commodities consumed by households. For example, increases in the price of gasoline used for households' personal vehicles reflect direct impacts, whereas increases in the cost to households of fossil fuel-generated electricity attributable to carbon pricing are indirect expenses borne by households. While the former can only arise from purchases within the territory, the latter can also arise outside the jurisdiction.[9]

Household impacts were estimated using output from ECCC's EC-PRO model and data from the National Inventory Report. These data are parameters used in the Environment Sales Tax Input-Output Model (ESTIOM) to emulate the transmission of direct and indirect carbon prices to household consumption in the territory. Aggregate estimates of the impacts on households in Nunavut therefore capture the transmission of the levy through both direct consumption and through trade, as reflected in the Supply Use Tables of the National Accounts and territory-specific data and analysis.[10] The household analysis for 2018 is based solely on the carbon levy, applied for the full year; for subsequent years, the levy is modeled in conjunction with the output-based pricing system (OBPS). All results presented in the household impacts sections reflect nominal dollar impacts in the year in question (e.g., 2018, 2022).

Estimated impacts of carbon pricing in Nunavut

Projected Impact on GHG Emissions

As shown in Figure 1, both carbon pricing scenarios (levy and levy + OBPS) generate modest reductions in Nunavut. A carbon levy scenario results in GHG emission reductions of 11.3 kilotonnes (Kt) in 2018 or 0.9% below the projected business-as-usual baseline level, increasing to 40.1Kt (2.7%) in 2020 and 67.5Kt (4.5%) by 2022. The application of the carbon levy + OBPS results in reductions of 11.3Kt (0.9%) below the baseline level in 2018, increasing to 29.6Kt (2.0%) in 2020 and 50.7Kt (3.4%) by 2022.

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[8] Statistics Canada, Census Profile, Census 2016, Nunavut. Median total household income in Canada was $70,336 in 2015, with an average household size of 2.4 people.

[9] Indirect impacts embedded in goods produced outside the territory will be borne by households consuming the goods regardless of jurisdiction (e.g., the pricing embedded in maple syrup produced in Quebec will be the same for Ontarians as for those living in the territory). However, the costs of shipping the goods to the territory, to the extent that fuels used to ship the goods bear carbon pricing, would be additional indirect costs for households. Carbon pricing on fuels used for intra-territorial transport would also represent indirect costs to households.

[10] While the estimates of total impacts on households in Nunavut reflect outputs of ESTIOM, to provide some insight into how impacts might vary across the income distribution, these estimates were distributed using detailed household consumption data at different levels of income, as available for Nunavut in Statistics Canada's Survey of Household Spending 2012 data. The use of these data permitted the inclusion of Figures 6 and 7 in this report, as illustrations of potential variation in impacts across households of different income levels.

Figure 1: **Estimated Emissions Impacts in Nunavut**

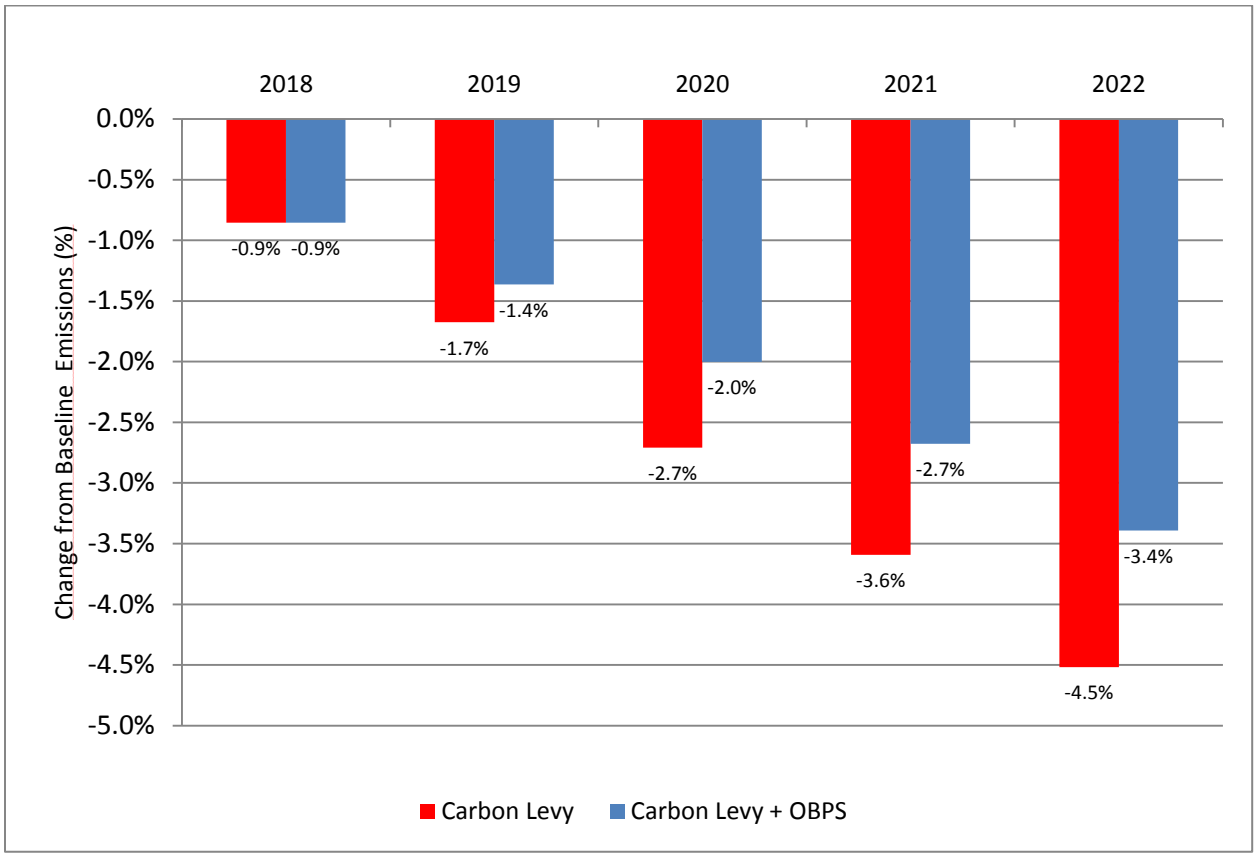
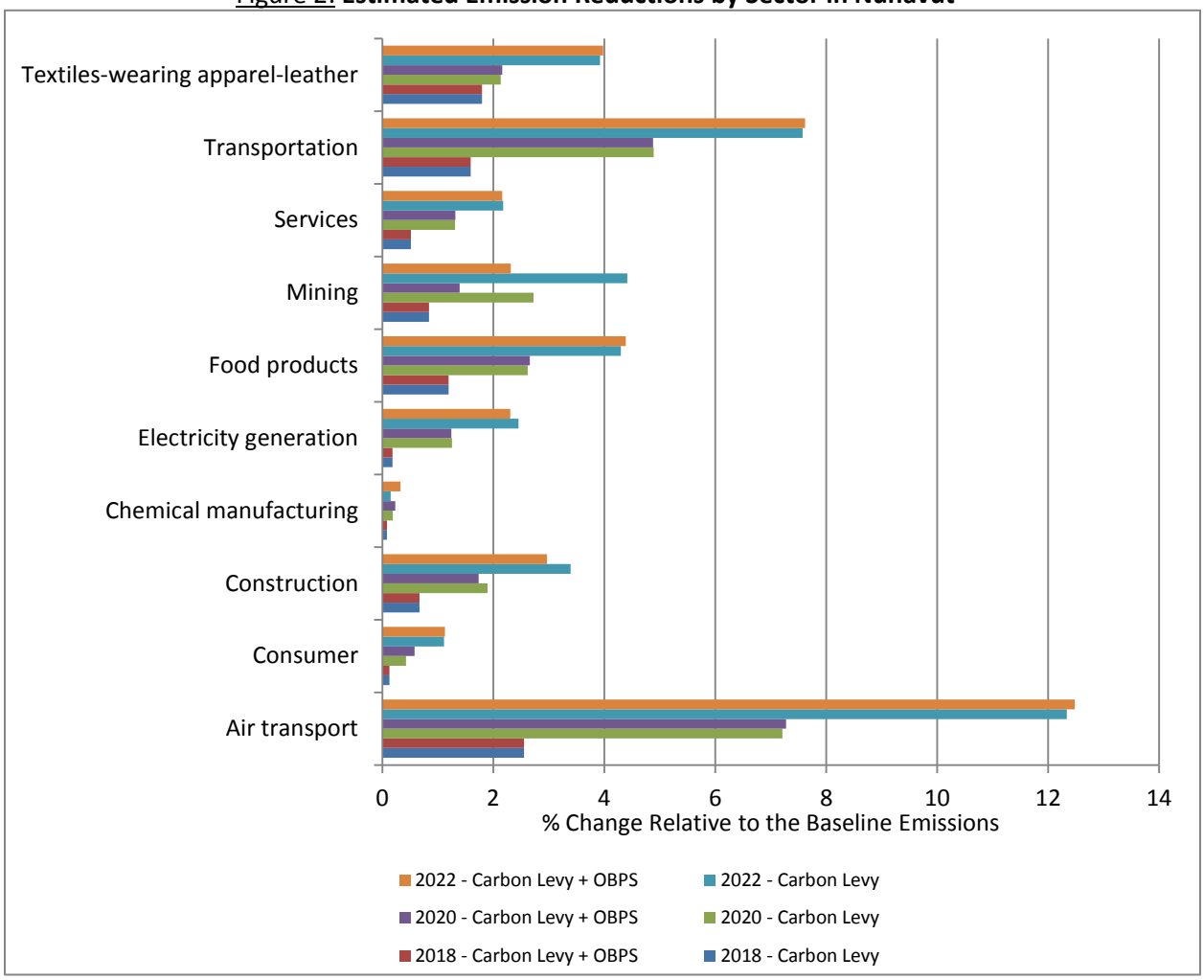


Figure 2 shows the estimated impacts of both carbon pricing scenarios (levy and levy + OBPS) on GHG emissions by sector. In 2022, the largest reductions below projected business-as-usual levels occur in the air transportation sector followed by the transportation sector (freight, railways, pipelines, etc.) and the food products sector. The air transportation sector is estimated to see reductions of about 12% (17.9Kt) while the transportation sector is estimated to see a reduction of almost 8% (4.0Kt) in 2022.

Figure 2: **Estimated Emission Reductions by Sector in Nunavut***



* Details on the activities included in each sector are provided in the Annex.

Estimated Economic Impacts of Carbon Pricing

Figure 3 shows GDP impacts associated with both carbon pricing scenarios. Relative to the baseline scenario, the carbon levy results in a slight decline in GDP of 0.04% ($0.96 million (in $2011)) in 2018, increasing slightly to 0.19% in 2020 ($4.53 million) and 0.54% ($13.45 million) in 2022. The levy + OBPS scenario generates a slightly less impact on GDP in 2022 — an estimated decline of 0.48% ($11.95 million).

These estimates do not account for the full range of positive impacts of climate change policies, such as: GDP and job growth in low carbon sectors; direct benefits on public expenditure, such as those resulting from improved health; or the reductions of societal costs associated with carbon-intensive activities, which are estimated to be $41/tonne CO2e in 2016 by ECCC.

These estimates include impacts from prices imposed on Nunavut due to carbon pricing in other regions.

Figure 3: **Estimated Economic Impacts in Nunavut (Real GDP)**

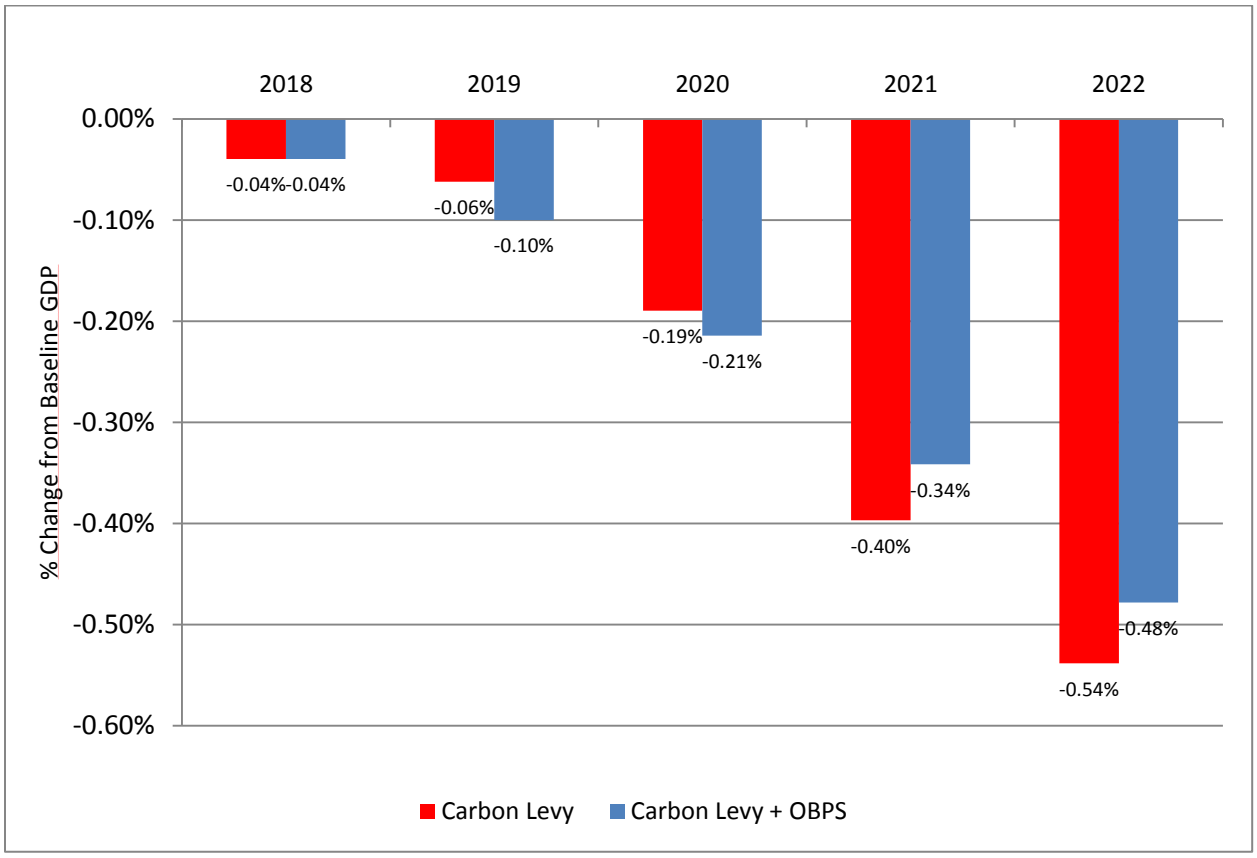
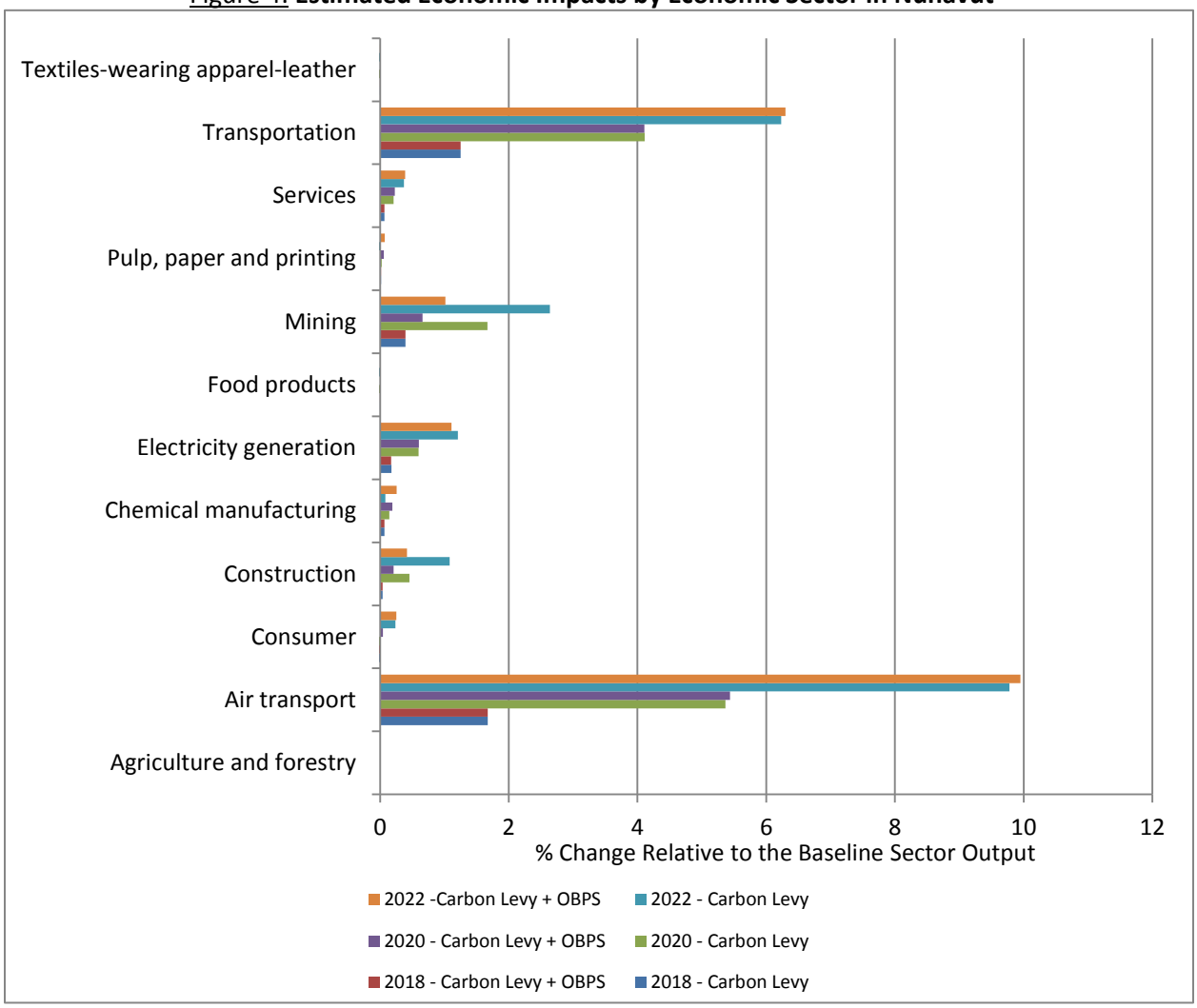


Figure 4 shows the sector-specific economic impacts associated with the implementation of the two carbon pricing scenarios. The mining sector has the highest relative impact in terms of total economic value, estimated to have an impact of $3.7 million (0.4%) in 2018, increasing to $27.2 million (2.6%) in 2022 under the carbon levy scenario, and of $3.7 million (0.4%) in 2018, increasing to $10.5 million (1.0%) under the levy + OBPS scenario. The next highest impact in terms of economic value is in the services sector; the estimated impact to this sector increases from $1.9 million (0.1%) in 2018 to $10.5 million (0.4%) in 2022 under the levy scenario, and of $1.9 million (0.1%) in 2018 increasing to $11.1 million (0.4%) in 2022 under the levy + OBPS scenario.

With respect to proportionate impacts (percentage), the air transport sector has the highest impacts. This sector is estimated to see impacts increasing from 1.7% ($1.5 million) in 2018 to 9.8% ($7.3 million) in 2022 under the carbon levy scenario, and impacts of 1.7% ($1.5 million) in 2018 increasing to 10.0% ($7.4 million) in 2022 under the levy + OBPS scenario. The transportation sector (e.g., freight, railways, pipelines, etc.) has the second highest impacts, estimated at 1.3% ($0.7 million) in 2018 increasing to 6.2% ($3.7 million) in 2022 under the carbon levy scenario, and 1.3% ($0.7 million) in 2018 increasing to 6.3% ($3.7 million) in 2022 under the levy + OBPS scenario. Light manufacturing sectors (e.g., chemical manufacturing, food products, textiles-wearing apparel-leather, etc.), agriculture and forestry, and electricity generation see few impacts — 1% or less, and at or below $1 million in 2022.

Figure 4: **Estimated Economic Impacts by Economic Sector in Nunavut***



* Details on the activities included in each sector are provided in the Annex.

Estimated Revenues Generated by Carbon Pricing

As illustrated in Figure 5, the carbon levy scenario generates estimated revenues of $12.9 million in 2018, increasing to $42.6 million in 2020 and $70.3 million in 2022. The levy + OBPS scenario generates estimated revenues of $12.9 million in 2018 (noting the model scenario assumed levy in 2018, with OBPS coming into effect in 2019), increasing to $24.0 million in 2020 and $39.9 million in 2022. **These estimates** assume that carbon pricing is in place for the full year of 2018.

Figure 5**: Estimated Revenues Generated in Nunavut (in $ Millions)**

	2018	2019	2020	2021	2022
Levy Scenario	12.9	24.6	42.6	56.4	70.3
Levy + OBPS Scenario	12.9	15.1	24.0	31.9	39.9

Household Impacts

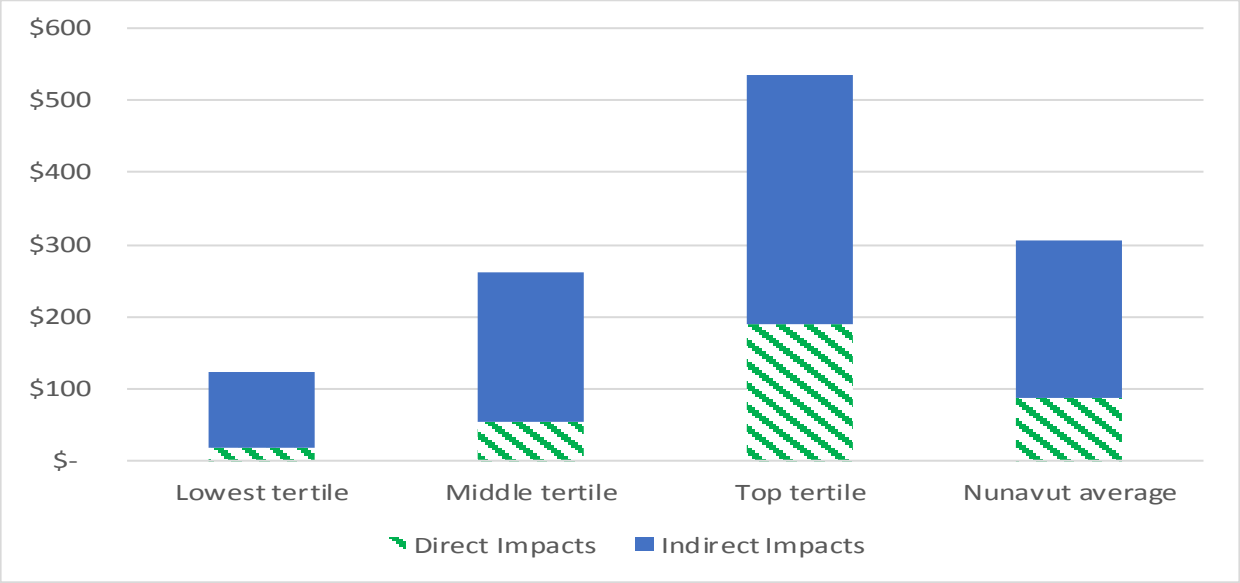
Figure 6 shows estimated average direct and indirect impacts on households, by household income tertile (third of the household income distribution) in 2018. These impacts reflect the imposition of a $10/ tonne carbon levy in the territory and in other jurisdictions currently without carbon pricing, as well as impacts associated with the carbon pricing from jurisdictions with regimes in place. The cost of embedded carbon pricing (indirect cost) accounts for more than 70% of the estimated average impact in the territory. This is in part attributable to the importance of imports in consumption by households in Nunavut.

The estimated household impacts are likely biased upwards. While the impacts shown reflect 2018 nominal costs, the number of households used to derive average household impacts reflects Census 2016 data. In addition, the income data used to estimate impacts as a share of average household income are from the 2012 Survey of Household Spending, to maintain consistency with the groupings used to provide the distribution in Figure 6. Household incomes have grown since then, meaning that carbon pricing costs will be a lower share of household total income than shown here.

Annual impacts range from an average of about $120 per household for those in the lowest third of the household income distribution, to about $260 in the middle third of the household income distribution, to a high of about $535 in the top third of the household income distribution, with a territorial average of about $305 per household. [11] Higher average impacts on higher-income households simply reflect the fact that higher-income households spend more on average, both on carbon-based fossil fuels and on goods and services with embedded carbon pricing, than do those with lower incomes. The average impacts on households in Nunavut for 2022 are expected to be somewhat more than three times the estimated impacts for 2018. This result is explained further in the discussion below, pertaining to Figure 9.

[11] The territorial average impact per household of $305 was derived by dividing total estimated impacts on Nunavut households of about $3.0 million in 2018 by the Census 2016 estimate of 9,820 households in Nunavut.

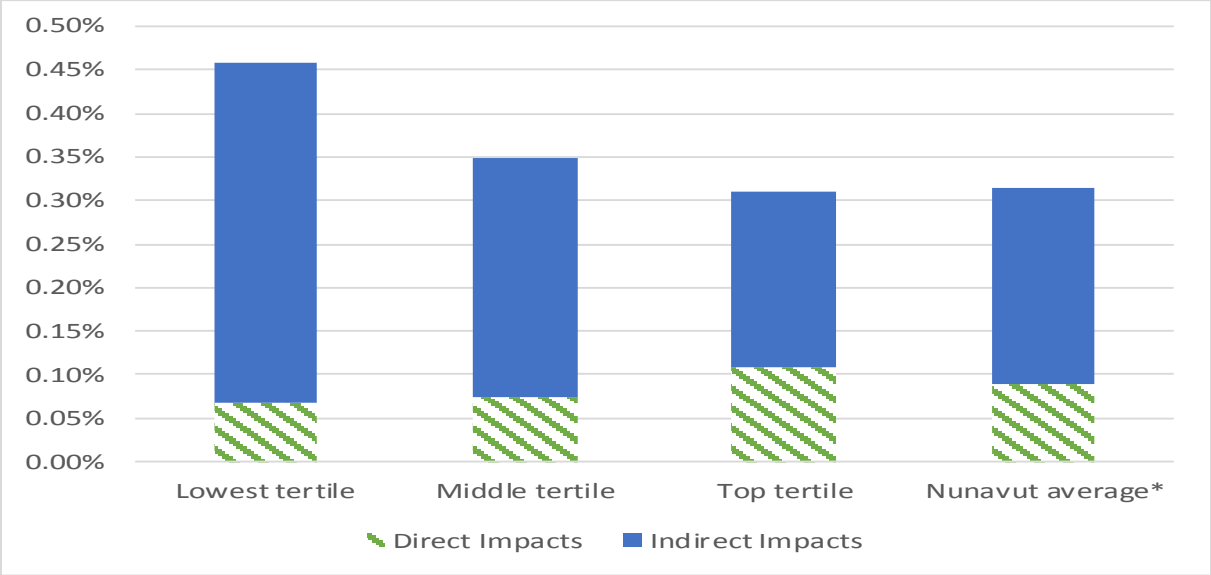
Figure 6: **Average per Household Impacts in 2018, by Tertile of Nunavut Household Income Distribution ($)***



* Estimates reflect the impact on all consumption by households in Nunavut impacted by carbon pricing. Detailed consumption data in the Survey of Household Spending (SHS) 2012, by household income group, permit this illustration of how impacts might differ on average for households with different levels of income. The SHS data is used only as a frame to create a distribution; the overall impacts underlying this figure reflect estimated consumption of fuels that release GHGs in 2018 and outputs of ESTIOM.

Conversely, when expressed as a share of income, Figure 7 shows that average impacts are strongest at the bottom of the income distribution and fall with income. These impacts were calculated by expressing the figures in Figure 6 as a share of estimated average household income in each of the three income groups separately. The territorial average annual household impact of $305 is expressed as a share of median total household income in 2015 (Census 2016).

Figure 7: **Impacts in 2018 as a Share of Average Income, by Tertile of Nunavut Household Income Distribution (%)***



*Note that for consistency with the sample data used to prepare the distribution, incomes used to calculate impacts as a share of income for households in the lowest, middle and top thirds of the household income distribution reflect average incomes for these groups in the SHS 2012. The Nunavut average impact per household, however, is expressed as a percentage of total median household income in the territory in 2015 (Census 2016).

These impacts amount to less than one half of one percent for those in the lowest tertile, compared to about one third of one percent for those in the middle tertile and slightly less than one third of one percent for those in the highest tertile income group. The territorial average household impact of $305 as a share of median total household income in Nunavut in 2015 ($97,441), as reported in Census 2016, is about 0.3% of income.

About 80% of the estimated carbon pricing impacts on households in Nunavut in 2018 are attributable to seven commodities (see Annex for a definition of commodity categories). The impacts of carbon pricing on households in Nunavut are estimated to be, on average:

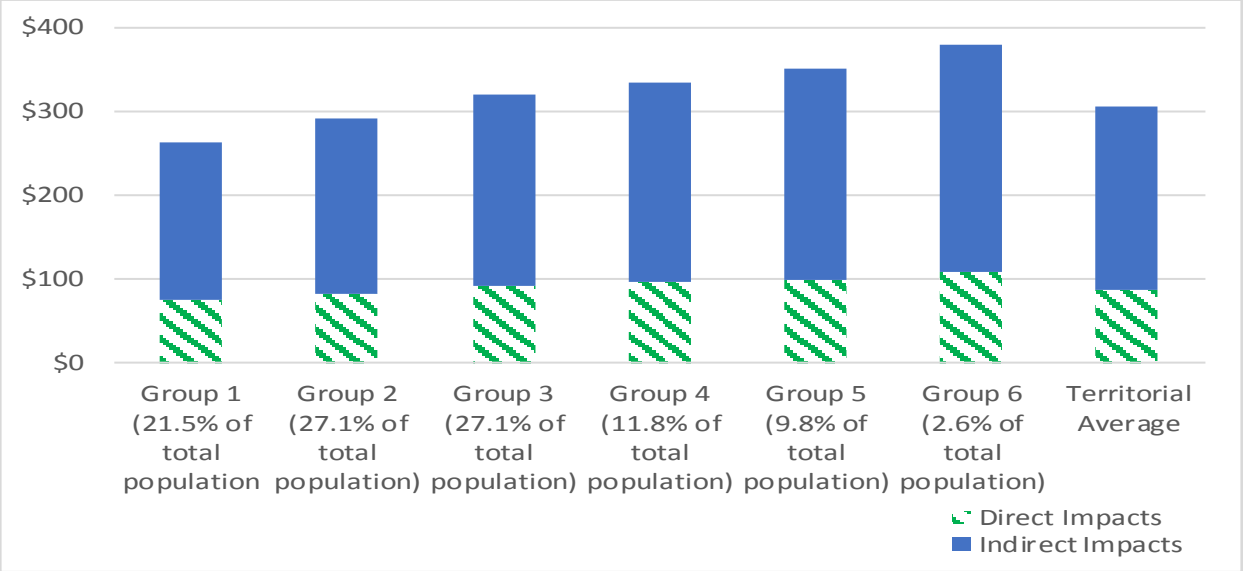
- $70 for gasoline and other fuels for vehicles and tools;
- $51 for electricity costs;
- $41 for food purchased from stores;
- $29 for rented living quarters;
- $27 for home heating fuel;
- $18 for air transport; and
- $14 for “other” transportation.

Impacts from most commodity groups generally fall into one specific category – direct or indirect. For example, home heating fuel impacts are generally direct impacts, while impacts from carbon pricing embedded in food purchased from stores are indirect impacts. In the gasoline and other fuels for vehicles and tools category, a small share of impacts represents indirect impacts, while the remainder reflects direct impacts on households purchasing these fuels. Detailed descriptions of commodities

included in some categories of spending, as reflected in the National Accounts, are provided in the Annex.

The impact of carbon pricing on households across the territory is expected to range across communities. As Figure 8 demonstrates, assuming average spending patterns for an illustrative household, carbon pricing is likely to have a larger impact on those living in communities outside of Iqaluit (where slightly less than 30% of the population resides), given higher transportation costs, apart from in one region (Group 1).[12] To the extent that average incomes may be lower outside of Iqaluit, however, which means that spending by households may be lower, the level impacts shown in Figure 8 may be overestimates of the true impacts on residents in those communities and underestimates of the impacts in the capital. That said, given similar spending patterns by two households in different regions, both direct and indirect impacts are expected to be larger in the remote community, as both will be impacted by intra-territorial transportation. Additionally, differences in the composition of spending will matter. Households in remote regions may be less impacted by indirect impacts on some goods and services, which are consumed to a lesser extent in their communities, but more impacted on average by carbon pricing on some carbon emissions-intensive commodities, should they consume these more heavily. The grouping of communities used for this chart is provided in the Annex.

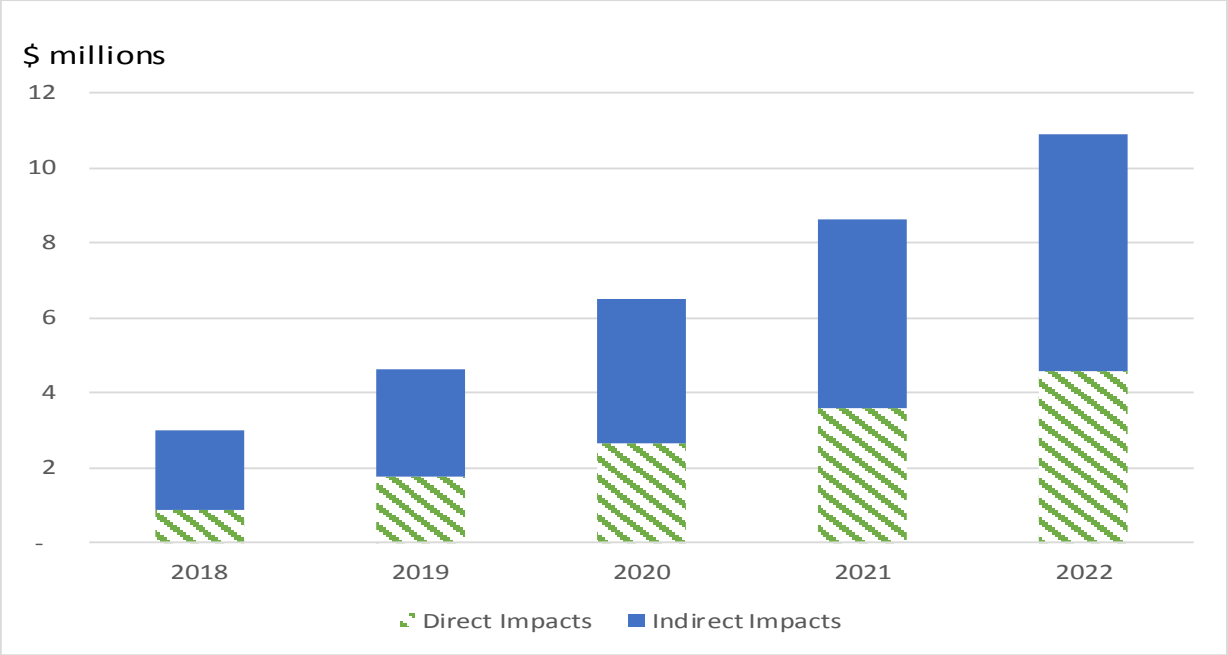
Figure 8: **Illustration of Potential Differences in Average Household Impacts in 2018, by Nunavut Community Groupings ($ per Household)**



12 To provide an illustration of how impacts may vary, food price index variation across regions, relative to Iqaluit, was used as a proxy for differences in living costs that reflect differences in the cost of intra-territorial transportation. Average impacts across all households in the territory, grouped into communities with similar cost differences, were rescaled using these scaling factors and population estimates to provide this illustration. Bracketed numbers reflect the approximate share of population in each group, with Group 2 including the Iqaluit area. Importantly, although differences in spending that reflect differences in incomes and in the composition of consumption by households across communities are implicitly captured in the modeled impacts for the territory as a whole, the data are not sufficient for a detailed parsing of these factors to be completed on a community by community or region by region basis. Group 1 represents a group where costs appear to be marginally lower than in Iqaluit.

Figure 9 provides estimates of the total direct and indirect pricing impacts on households. These are expected to range from about $3 million in 2018 to just under $11 million in 2022. These estimates include the impact of the output-based pricing system, modelled as implemented as of 2019. Overall cost impacts on all territorial households are estimated to be somewhat more than three times in 2022 what they are estimated to be for 2018. The total indirect impact on all Nunavut households is estimated to be about three times its 2018 level for 2022. This in part reflects the fact that carbon pricing at higher levels than $10/tonne is already in place in some provinces as of 2018.

Figure 9: **Total Estimated Impact on Households in Nunavut ($ Millions)**



ANNEX: Methodology & Approach

EC-PRO Model - – Context and Caveats

The EC-PRO model is a useful tool for modelling carbon pricing scenarios since it allows the entire economy to respond as relative prices change throughout the economy. However, some significant caveats should be noted:

- Results from CGE models should always be interpreted as based on a certain set of assumptions. These assumptions typically vary from model to model, which can lead to different models producing differing results. Model results are therefore most useful when interpreted in relation to other scenarios of the same model, rather than predictions on an absolute basis.
- Calibrating the model to match the unique characteristics of each province and territory is a major endeavour and federal-provincial-territorial government collaboration on modelling approaches is ongoing. Modelling exercises undertaken by individual provinces and territories can focus specifically on these unique characteristics of its energy economy and may provide more robust results for individual regions. The EC-PRO model, on the other hand, has the advantage of explicitly modelling interactions between regions which provides a pan-Canadian perspective. This likely explains many of the differences regarding GHG inventories, projections and impacts which exist when comparing modelling analysis published by federal, provincial, territorial and non-governmental institutions.
- CGE models do not capture the full range of positive impacts of climate change policies. These might include the development of new green technology sectors; direct benefits on public expenditure, such as those resulting from improved health; or the reductions of societal costs associated with GHG emissions.
- The EC-PRO model does not attempt to predict which new technological breakthroughs will materialize in the future. As these new technologies become available, their cost will likely fall and their overall effectiveness improve, thereby leading to more emissions reductions at lower carbon prices than predicted by these models.
- The model assumes that global commodity prices and carbon policies are static. This results in increased carbon leakage and reduced positive technology spillover relative to what will happen if other countries increase their climate policy ambition.

EC-PRO Model – Description and Methodology

EC-PRO is a small open-economy recursive-dynamic computable general equilibrium (CGE) model of the Canadian economy. It captures characteristics of provincial production and consumption patterns through a detailed input-output table and links provinces via bilateral trade. Each province and territory is explicitly represented as a region. The representation of the rest of the world is reduced to imports and export flows to Canadian provinces which are assumed to be price takers in international markets. To accommodate analysis of energy and climate policies, the model incorporates information on energy use and greenhouse gas emissions related to the combustion of fossil fuels. It also tracks non-energy-related GHG emissions.

The estimates provided are based on two scenarios:

(1) Application of a carbon levy where all non-exempt combustion-related GHG emissions face a carbon price starting at $10/tonne and increase annually at $10 increments to $50/tonne in 2022. The carbon price is applied to all emissions from the combustion of fossil fuels and emissions from industrial processes.[13] The emissions not covered include fugitive emissions and agricultural emissions (e.g., gasoline and diesel fuel used by registered farmers in certain farming activities, and from livestock, manure management and soils) and waste (e.g., landfills).

(2) Application of a carbon levy, as described above, plus an output-based pricing system , whereby, as of 2019, industries emitting at or above 50,000 tonnes of CO_2e per year pay the carbon price on a portion of their emissions (for the purpose of the modelling in this study, this is assumed to be 20% for illustrative purposes only).

The model assumes all revenues generated by the carbon price are returned by direct transfer to the household sector in the province or territory where the carbon price was paid. It is recognized that there many potential policy priorities that could be pursued in recycling carbon revenues (e.g., using the revenues to decrease income or corporate taxes; to fund programs, measures and infrastructure projects; etc.), all of which would have different emissions and economic impacts across sectors and territories.

All results are presented relative to the baseline projection rather than the economy as it exists today.

Baseline – EC-PRO Basis

The EC-PRO model was initially calibrated to create a baseline consistent with Canada's 2016 greenhouse gas emissions Reference Case. This Reference Case presents the future impacts of policies and measures taken by federal, provincial and territorial governments as of November 1, 2016. It is aligned with Canada's historical emissions from 1990 to 2014 as presented in National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada (NIR). The Reference Case does not take into account the impact of broader strategies or future measures within existing plans where significant details are still under development. Policies still under development will be included in subsequent reference cases as their details become finalized.

Historical data on key macro-economic variables, such as GDP, population, and consumer price indices are obtained from Statistics Canada. Statistics Canada also produces the historical energy data used in the model in the Report on Energy Supply and Demand. The latest historical GHG emissions are obtained from the 2016 NIR.

In the forecast, key macro-economic variables in the model such as GDP, the exchange rate, and inflation are aligned to Finance Canada's projections. The economic projections to the year 2021 are calibrated to Finance Canada's Fall Economic Statement 2016. The outer years (2022-2030) are based on Finance Canada's 2014 Update of Long-Term Economic and Fiscal Projections. Population growth projections are obtained from Statistics Canada. Forecasts of oil and natural gas price and production are taken from the National Energy Board's Canada's Energy Future.

[13] Emissions from industrial processes are covered to be consistent with the proposed federal backstop and with the approaches being taken by current provincial carbon pricing policies.

As Nunavut Government officials expressed concerns that the Statistics Canada's data on energy supply and demand do not capture all energy consumed in Nunavut, and thereby underestimates GHG emissions, an alternative baseline was created. Emissions and macro-economic analysis are reported relative to the alternative baseline.

Baseline – Adjustment based on Nunavut Government Information

EC-PRO's business-as- usual (BaU), or baseline projection, is developed using Statistics Canada's Supply and Use (IO) tables and ECCC's Energy, Emissions and Economy model for Canada (E3MC). E3MC emissions align to the historic values provided in the National Inventory Report (NIR). Both EC-Pro and E3MC also rely on data and projections from CANSIM, the National Energy Board (NEB), and Finance Canada. EC-PRO's current BaU is based on Canada's 2016 Greenhouse Gas Emissions Reference Case and the 2011 IO tables. The emissions projections are mapped to EC-PRO's sector disaggregation, which is derived from the IO tables.

All inputs and outputs in the model are expressed in real 2011 dollars. Energy values in the model are aggregated as natural gas, oil, coal, and electricity. When creating the augmented baseline, emissions levels are targeted first and foremost. When EC-PRO applies a carbon price it imposes the price per tonne directly on the covered emissions. While the emissions and associated fuel are modeled as perfect compliments, the model does not explicitly assign emissions intensities to fuels. Since the price and composition of the aggregate fuel can vary significantly by sector and region, the intensity measurements endogenous to the model do not provide a reliable method for calculating emissions or imposing a carbon price. It is also unclear if the values of energy corresponding to the missing emissions are also missing from the IO table. As such, the augmented baseline was created by: building a calibration model to balance supply and demand; assigning new BaU emissions levels by pollutant, sector and fuel; assigning new target values of demand, production, imports, exports, and margins; and iteratively solving the calibration model and adjusting its objective function and target values.

Calibration Model

EC-PRO requires a fully balanced representation of the economy, requiring that all production and use correspond to a specified sink and source. This can be seen in the IO tables where the sum of a row or column in the Supply sheet must be equal to its sum in the Use sheet, and the interprovincial imports of a row in one table correspond to the exports in another.

The calibration model operates by defining critical formulae which must hold for the model to balance, and defining an objective function. The objective function is comprised of the weighted sum of squared deviations from targets. Thus, the model attempts to minimize the absolute deviations between specified variables and their target values. The objective function includes a value to target intermediate demands, value-added share of production, the share of each intermediate demand in production, and the emission intensity per dollar of input. Each sum of squared deviations is given a coefficient to specify relative importance, and the territories are given the largest weight.

BaU Emissions Estimates

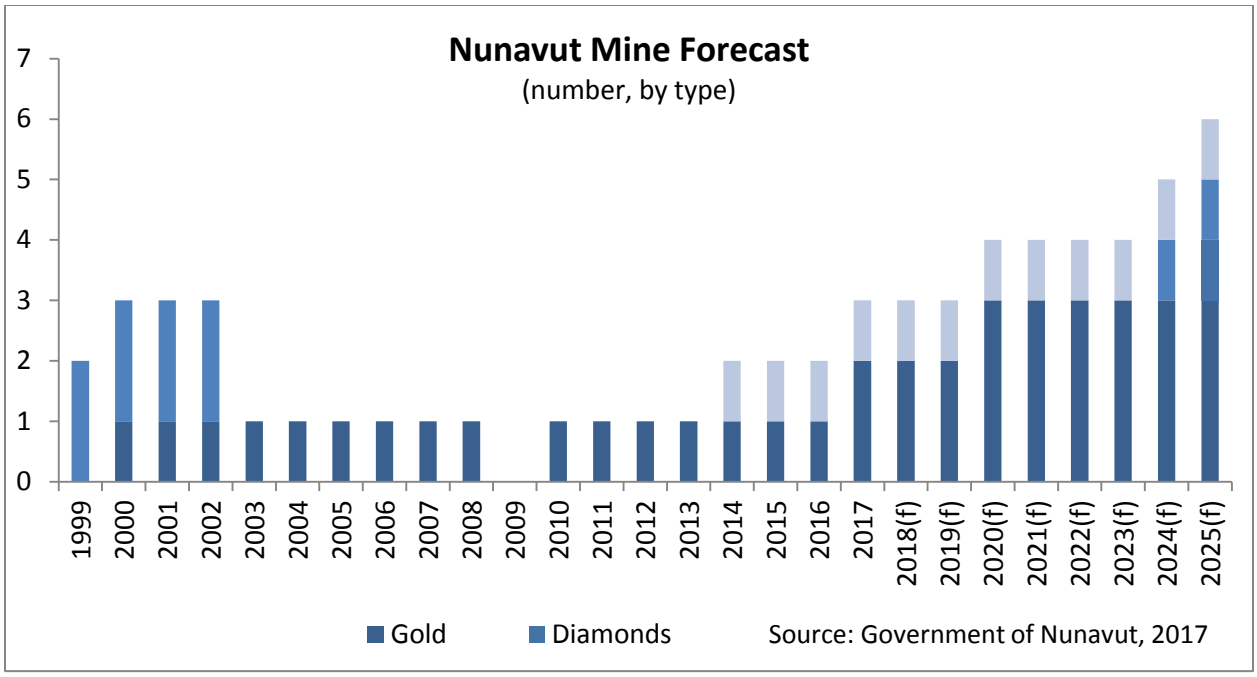
The emissions estimates for the augmented baseline are listed in the below table, provided by Nunavut Department of Finance.

Nunavut GHG Emissions (Mt CO2e) – Source: Government of Nunavut, 2017					
Sector	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Electricity generation	0.120	0.123	0.126	0.129	0.132
Heating	0.172	0.176	0.181	0.185	0.190
Government	0.083	0.085	0.087	0.089	0.092
Transportation	0.174	0.178	0.183	0.187	0.192
Commercial enterprises	0.064	0.066	0.068	0.069	0.071
Meadowbank mine	0.196	0.200	0.205	0.211	0.216
Baffinland estimates	-	-	0.200	0.205	0.210
Nunavut Total	0.8089	0.829123	1.049851	1.076097	1.102999
Canada	726.7	727.7	730	735.4	740
Nunavut National Share	0.11%	0.11%	0.14%	0.15%	0.15%

As government, transportation, and mining sector emissions are provided separately, they are targeted directly. This is also true for electricity generation; however, electricity generation emissions are higher in the reference case beginning in 2015 and are therefore not adjusted. All targeted emission increases are assumed to be the result of oil combustion.

Commercial and heating emission increases are applied to relevant sectors (e.g., services, households, and manufacturing) according to their share of oil demand in the reference case. Matching the government and transportation emissions is simply a matter of adding the difference between the above and the reference case, shared out across pollutants following the national average for oil. Transportation above is assumed to include air transport as well as freight.

Matching the mining emissions required significant increases. 200Kt were added to mining in 2011, 2014, 2017, 2020, 2024 and 2025. The increases in 2017 and beyond assume that each new mine shown in the figure below (provided by the Nunavut Department of Finance) will contribute an equivalent increase in emissions as Meadowbank and Baffinland estimates above.



Assigning Target Economic Values

The calibration model takes the above emissions as given, but the economic values associated with the increases are endogenous. Using the new emissions levels, intermediate demand for oil is increased. It is assumed that the additional emissions are produced via the national emission per dollar intensity of oil for each sector. The choice to use the national average value was made due to the presumed accuracy gains. The margins are similarly increased to maintain the margin rate on intermediate demands.

Labour and capital inputs are assumed to increase in each sector by the same percentage that total demand increased due to the additional oil demand. The additional supply of oil is assumed to be provided from international and interprovincial sources in the same ratio as the reference case. The additional output by each sector which remains in Nunavut, is exported internationally, or exported inter-jurisdictionally is assumed to increase according to the percentage increase in total demand by that sector.

These manually-increased economic values are the first-order and second-order effects of targeting higher emissions. Additional interaction effects, particularly with other provinces and territories, are determined within the calibration model. These increased values serve as targets in the calibration model and the values to be used are endogenous. It is thus critical to impose appropriate target values as well as a well-specified objective function so that one can be confident in the calibration model's output values. For this reason, the weights in the objective function are highest for the territories.

Iteratively Improving the Calibration Model

For the reasons discussed above, it is critical to review the calibration model output and compare it with both real-world values and the reference BaU. As the majority of variables taken from the model are endogenous, many iterations are required to achieve the targeted emissions levels with intensities, demands, and production values which are neither an issue for EC-PRO to handle, nor visibly erroneous. Further improvement will depend on feedback from the Government of Nunavut, Finance Canada, and ECCC.

Household Impacts - Community Groupings

Details on the community groupings for Figure 8: Illustration of Potential Differences in Average Household Impacts in 2018, by Nunavut Community Groupings are as follows. Note: Some communities may not appear in the table because of missing data.

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Rankin Inlet	Hall Beach	Igloolik	Pangnirtuung	Cape Dorset	Kugaaruk
Arviat	Chesterfield Inlet	Kimmirut	Resolute	Taoyoak	
Baker Lake	Iqaluit	Pond Inlet	Grise Fiord	Clyde River	
Whale Cove	Naujaat	Cambridge Bay	Arctic Bay		
		Kugluktuk	Gjoa Haven		
		Coral Harbour			
		Qikqtarjuaq			
		Sanikluaq			

Communities were grouped using food price survey information provided by the territory, in the absence of detailed data describing consumption in each community. The intention of the scaling using these community groupings is to illustrate how intra-territorial transportation differences might be reflected in differential impacts of carbon pricing across the territory.

Category Details in the Survey of Household Spending

The assessment of impacts on households is estimated by using the provincial and territorial consumption patterns from the Survey of Household Spending. The following provides descriptions of commodities included in some categories of spending, as reflected in the Survey of Household Spending and the National Accounts.

Category in the Survey of Household Spending	Subcategories (from the National Accounts)
Food purchased from stores	• Food • Non-alcoholic beverages
Household operations	• Materials for the maintenance and repair of the dwelling • Services for the maintenance and repair of the dwelling • Other services related to the dwelling and property • Telecommunication equipment • Telecommunication services • Information processing equipment • Property insurance • Child care services outside the home

	• Child care services in the home • Other social services
Household furnishing and equipment	• Furniture and furnishings • Carpets and other floor coverings • Household textiles • Major household appliances • Small electric household appliances • Major tools and equipment • Small tools and miscellaneous accessories • Other semi-durable household goods • Other non-durable household goods • Repair of personal and household goods except vehicles • Renting and leasing of personal and household goods except passenger vehicles
Clothing and accessories	• Garments • Cleaning of clothing • Clothing materials, other articles of clothing and clothing accessories • Footwear • Jewellery, clocks and watches • Other personal effects
Automobile, purchase, rent, lease and parts	• New passenger cars • New trucks, vans and sport utility vehicles • Used motor vehicles • Other vehicles • Spare parts and accessories for vehicles
Services related to automobile transportation	• Maintenance and repair of vehicles • Parking • Passenger vehicle renting • Other services related to the operation of transport equipment • Insurance related to transport
Other public transportation (referred to as “other” transportation in the text)	• Railway transport • Urban transit • Interurban bus • Taxi and limousine • Water transport • Other transport services (includes moving and storage) • Postal services
Health care	• Therapeutic appliances and equipment • Pharmaceutical products and other medical products • Out-patient services • Hospital services
Personal care	• Personal grooming services • Electrical appliances for personal care • Other appliances, articles and products for personal care

Recreation	• Recording media • Audio-visual and photographic equipment • Major durables for outdoor recreation • Musical instruments and major durables for indoor recreation • Games, toys and hobbies • Equipment for sport, camping and open-air recreation • Garden products, plants and flowers • Veterinary and other services for pets • Pets and pet food • Recreational and sporting services • Cable, satellite and other program distribution services • Cinemas • Photographic services • Other cultural services
Education	• Books • Newspaper and periodicals • Miscellaneous printed matter and stationery and drawing materials • University education • Other education
Tobacco products and alcoholic beverages	• Alcoholic beverages • Tobacco • Alcoholic beverage services
Miscellaneous expenditures	• Life insurance • Health insurance • Implicit loan charges • Implicit deposit charges • Stock and bond commissions • Other actual financial charges • Trusteed pension funds • Mutual funds • Undertaking and other funeral services • Legal and other services

EC-PRO Sector Details related to North American Industry Classification System (NAICS)

Details on the activities included in the EC-PRO model sectors are as follows.

EC-PRO Sector	**NAICS Categories and Code Legend**
Crude oil	BS21100* - Oil and gas extraction
Other mining	BS21220 - Metal ore mining BS21230 - Non-metallic mineral mining and quarrying BS21300 - Support activities for mining and oil and gas extraction
Natural gas	BS21100* - Oil and gas extraction

Electric power generation, transmission and distribution	BS22110 - Electric power generation, transmission and distribution
Agricultural and forestry	BS11A00 - Crop and animal production BS11300 - Forestry and logging BS11400- Fishing, hunting and trapping BS11500 - Support activities for agriculture and forestry
Construction	BS23A00 - Residential building construction BS23B00 - Non-residential building construction BS23C00 - Engineering construction BS23D00 - Repair construction BS23E00 - Other activities of the construction industry
Petroleum and coal products manufacturing	BS32400 - Petroleum and coal product manufacturing
Pulp and paper mills and printing	BS32210 - Pulp, paper and paperboard mills BS32220- Converted paper product manufacturing BS32300 - Printing and related support activities
Primary metal manufacturing	BS33100 - Primary metal manufacturing
Chemical manufacturing	BS32510 - Basic chemical manufacturing BS32530 - Pesticide, fertilizer and other agricultural chemical manufacturing BS32540 - Pharmaceutical and medicine manufacturing BS325C0 - Miscellaneous chemical product manufacturing BS32610 - Plastic product manufacturing BS32620 - Rubber product manufacturing
Cement	BS32731 - Cement manufacturing BS32732 - Ready-mix concrete manufacturing
Wood and wood products	BS32100 - Wood product manufacturing
Non-metallic minerals	BS327A0 - Non-metallic mineral product manufacturing (except cement and concrete products)
Transport equipment (TRANSEQ)	BS33610 - Motor vehicle manufacturing BS33620 - Motor vehicle body and trailer manufacturing BS33630 - Motor vehicle parts manufacturing BS33640 - Aerospace product and parts manufacturing BS33650 - Railroad rolling stock manufacturing BS33660 - Ship and boat building BS33690 - Other transportation equipment manufacturing
Food products	BS31110 - Animal food manufacturing BS31130 - Sugar and confectionery product manufacturing BS31140 - Fruit and vegetable preserving and specialty food manufacturing

	BS31150 - Dairy product manufacturing BS31160 - Meat product manufacturing BS31170 - Seafood product preparation and packaging BS311A0 - Miscellaneous food manufacturing BS31211 - Soft drink and ice manufacturing BS31212 - Breweries BS3121A - Wineries and distilleries BS31220 - Tobacco manufacturing
Textiles-wearing apparel-leather	BS31A00 - Textile and textile product mills BS31B00 - Clothing and leather and allied product manufacturing
Other manufacturing	BS33200 - Fabricated metal product manufacturing BS33300 - Machinery manufacturing BS33410- Computer and peripheral equipment manufacturing BS334B0 - Electronic product manufacturing BS335A0 - Electrical equipment and component manufacturing BS33520 - Household appliance manufacturing BS33700- Furniture and related product manufacturing BS33900 - Miscellaneous manufacturing BS32733 - Concrete pipe, brick and block manufacturing BS32739 - Other concrete product manufacturing
Transportation and warehousing	BS48200 - Rail transportation BS48300 - Water transportation BS48400 - Truck transportation BS48B00 - Transit, ground passenger and scenic and sightseeing transportation, taxi and limousine service and support activities for transportation BS48600 - Pipeline transportation GS91400 - Other aboriginal government services
Air transport	BS48100 - Air transportation
Services	BS4A000 - Retail trade BS51510 - Radio and television broadcasting BS51B00 - Publishing, pay/specialty services, telecommunications and other information services BS52B00 - Depository credit intermediation and monetary authorities BS52410 - Insurance carriers BS53110 - Lessors of real estate BS5311A - Owner-occupied dwellings BS53B00 - Rental and leasing services and lessors of non-financial intangible assets (except copyrighted works) BS5A000 - Other finance, insurance and real estate services and management of companies and enterprises

	BS541C0 - Legal, accounting and architectural, engineering and related services BS541D0 - Computer systems design and other professional, scientific and technical services BS54180 - Advertising, public relations, and related services BS56100 - Administrative and support services BS56200 - Waste management and remediation services BS61000 - Educational services BS62000 - Health care and social assistance BS71000 - Arts, entertainment and recreation BS72000 - Accommodation and food services BS81100 - Repair and maintenance BS81A00 - Personal services and private households BS81300 - Professional and similar organizations NP61000 - Educational services NP62400 - Social assistance NP71000 - Arts, entertainment and recreation NP81310 - Religious organizations NPA0000 - Miscellaneous non-profit institutions serving households GS611B0 - Educational services (except universities) GS61130 – Universities GS62200 – Hospitals GS62300 - Nursing and residential care facilities GS91100 - Other federal government services GS91200 - Other provincial and territorial government services GS91300 - Other municipal government services BS221A0 - Natural gas distribution, water, sewage and other systems BS49A00 - Postal service, couriers and messengers BS49300 - Warehousing and storage
Consumer	PEC01100 - Food PEC01200 - Non-alcoholic beverages PEC02100 - Alcoholic beverages PEC02200 - Tobacco PEC03120 - Garments PEC03140 - Cleaning of clothing PEC031A0 - Clothing materials, other articles of clothing and clothing accessories PEC03200 - Footwear PEC04100 - Paid rental fees for housing PEC04200 - Imputed rental fees for housing PEC04310 - Materials for the maintenance and repair of the dwelling

	PEC04320 - Services for the maintenance and repair of the dwelling PEC04510 - Electricity PEC04520 - Gas PEC045A0 - Other fuels PEC04A00 - Water supply and sanitation services PEC05110 - Furniture and furnishings PEC05120 - Carpets and other floor coverings PEC05200 - Household textiles PEC05310 - Major household appliances PEC05320 - Small electric household appliances PEC05510 - Major tools and equipment PEC05520 - Small tools and miscellaneous accessories PEC05A10 - Other semi-durable household goods PEC05A20 - Other non-durable household goods PEC05A31 - Repair of personal and household goods except vehicles PEC05A32 - Renting and leasing of personal and household goods except passenger vehicles PEC05A39 - Other services related to the dwelling and property PEC06130 - Therapeutic appliances and equipment PEC061A0 - Pharmaceutical products and other medical products PEC06200 - Out-patient services PEC06300 - Hospital services PEC07111 - New passenger cars PEC07112 - New trucks, vans and sport utility vehicles PEC07113 - Used motor vehicles PEC071A0 - Other vehicles PEC07210 - Spare parts and accessories for vehicles PEC07220 - Fuels and lubricants PEC07230 - Maintenance and repair of vehicles PEC07241 - Parking PEC07242 - Passenger vehicle renting PEC07249 - Other services related to the operation of transport equipment PEC07310 - Railway transport PEC07321 - Urban transit PEC07322 - Interurban bus PEC07323 - Taxi and limousine PEC07330 - Air transport PEC07340 - Water transport PEC07360 - Other transport services PEC08110 - Postal services PEC08120 - Telecommunication equipment

	PEC08130 - Telecommunication services PEC09130 - Information processing equipment PEC09140 - Recording media PEC091A0 - Audio-visual and photographic equipment PEC09210 - Major durables for outdoor recreation PEC09220 - Musical instruments and major durables for indoor recreation PEC09310 - Games, toys and hobbies PEC09320 - Equipment for sport, camping and open-air recreation PEC09330 - Garden products, plants and flowers PEC09350 - Veterinary and other services for pets PEC093A0 - Pets and pet food PEC09410 - Recreational and sporting services PEC09421 - Cable, satellite and other program distribution services PEC09422 - Cinemas PEC09423 - Photographic services PEC09424 - Other cultural services PEC09430 - Games of chance PEC09510 - Books PEC09520 - Newspapers and periodicals PEC095A0 - Miscellaneous printed matter and stationery and drawing materials PEC101A1 - University education PEC101A9 - Other education PEC111A1 - Food and non-alcoholic beverage services PEC111A2 - Alcoholic beverage services PEC11200 - Accommodation services PEC15110 - Expenditure by Canadians abroad PEC15120 - Expenditure by Canadians in other provinces or territories PEC15210 - Expenditure by non-residents in Canada PEC15220 - Expenditure by Canadians residing in other provinces or territories

* BS21100 disaggregated based on ECCC's Environment model, E3MC.