

# Carbon Pricing in the Yukon – Potential Impact Analysis

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*This document provides data on potential estimated impacts of carbon pricing in the Yukon. 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

The modeling for this analysis was undertaken by Environment and Climate Change Canada and Finance Canada, in collaboration with the Government of Yukon.

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.”<sup>1</sup>

### **The 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 CO<sub>2</sub>e on a global basis in 2016 by ECCC<sup>2</sup>. 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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<sup>1</sup> 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>

<sup>2</sup> 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>

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- 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<sup>3</sup> 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 Yukon 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 the Yukon.<sup>4</sup>

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<sup>3</sup> Data were chosen to maximize the quality of the estimates while minimizing the likelihood of underestimating the impacts on households.

<sup>4</sup> 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. As noted above, 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.

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<sup>5</sup> 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.<sup>6</sup>

According to Census 2016, there were 15,215 private households in the Yukon in 2016, with an average household size of 2.3 people. Estimated median total household income among these households was \$84,521.<sup>7</sup>

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<sup>5</sup> Environment and Climate Change Canada: Canada's 2016 Greenhouse Gas Emissions Reference Case, 2017. For more information, see: <https://www.canada.ca/en/environment-climate-change/services/climate-change/publications/2016-greenhouse-gas-emissions-case.html>

<sup>6</sup> 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 50<sup>th</sup> percentile of the income distribution.

<sup>7</sup> Statistics Canada, Census Profile, Census 2016, Yukon. Median total household income across Canada was \$70,336 in 2015, with an average household size of 2.4 people.

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.<sup>8</sup>

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 the Yukon 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.<sup>9</sup> 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 the Yukon

#### **Projected Impact on GHG Emissions**

As shown in Figure 1, a carbon levy will generate estimated emissions reductions of approximately 6.8 kilotonnes (Kt) in 2018 or about 1% below the projected business-as-usual baseline, increasing to about 20Kt (3.4%) in 2020 and 32Kt (5.4%) in 2022.

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<sup>8</sup> 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.

<sup>9</sup> While the estimates of total impacts on households in the Yukon 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 the Yukon 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 the Yukon (Carbon Levy)**

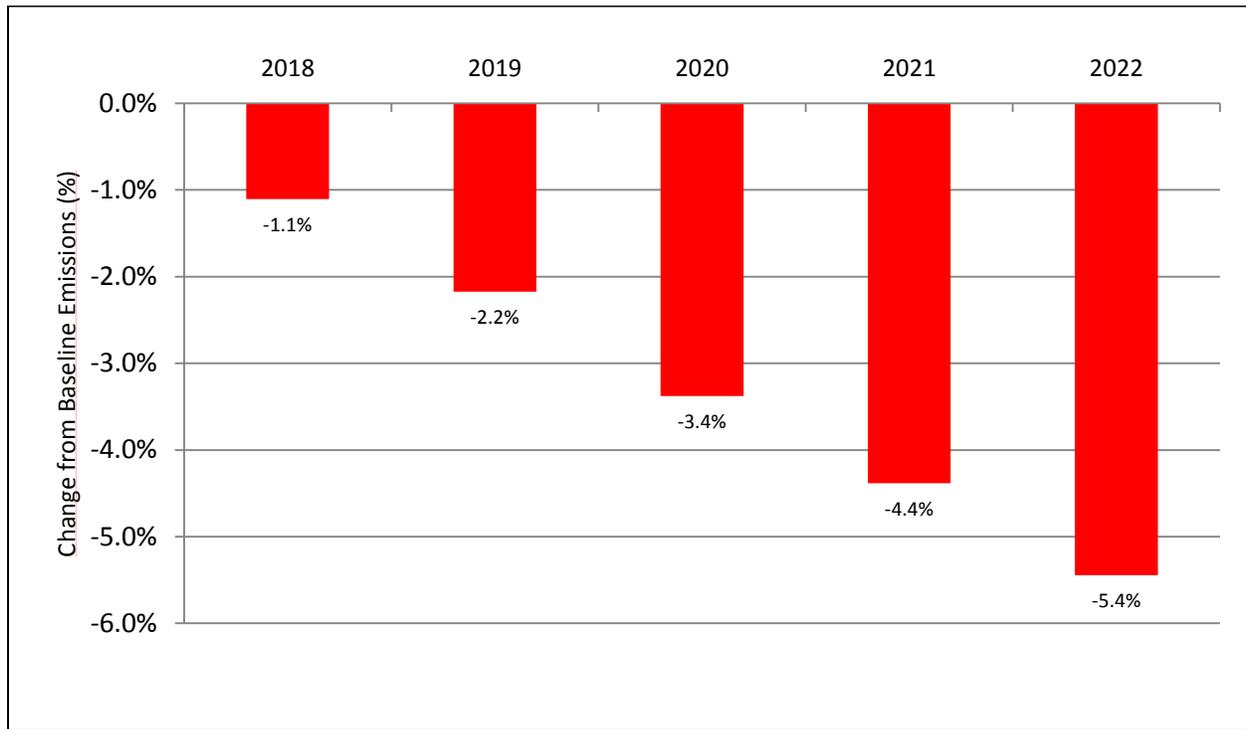
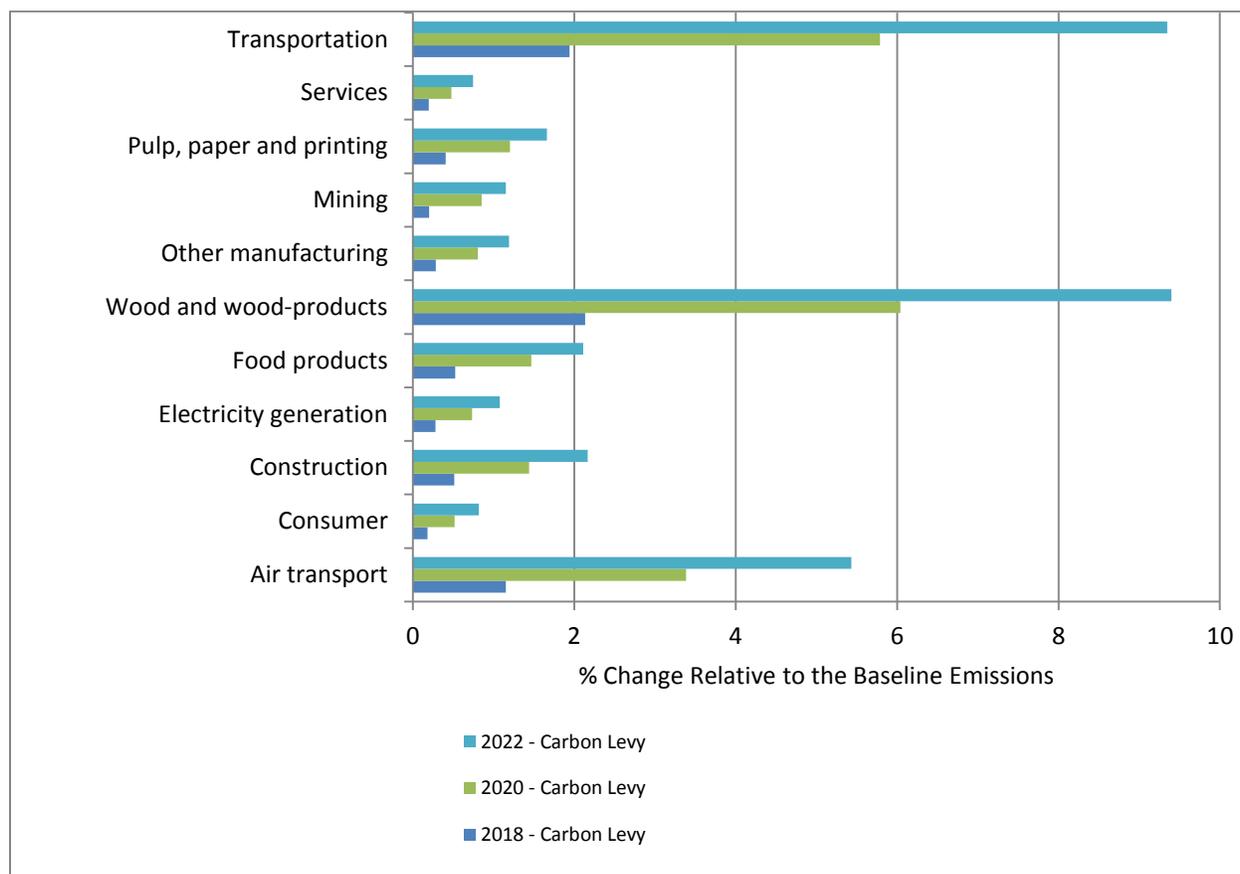


Figure 2 shows the estimated impacts of the carbon levy on GHG emissions by sector. In 2022, the largest reductions are in the transportation sector (freight, railways, pipelines, etc.) – about 9.4% or 22.7Kt below projected business-as-usual levels. The next largest impacts are expected in the air transport sector (5.4% or 5.6Kt) and then in the wood and wood-products sector (a 9.4% or 1.9Kt).

**Figure 2: Estimated Emission Reductions by Sector in the Yukon\***



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

**Estimated Economic Impacts of Carbon Pricing**

As indicated in Figure 3, the carbon levy is estimated to reduce GDP by about 0.03% (\$1.12 million in \$2011) in 2018, increasing to about 0.11% (\$4.11 million) in 2020 and about 0.19% (\$7.10 million) in 2022.

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 CO<sub>2</sub>e in 2016 by ECCC.

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

Figure 3: Estimated Economic Impacts in Yukon of a Carbon Levy (Real GDP)

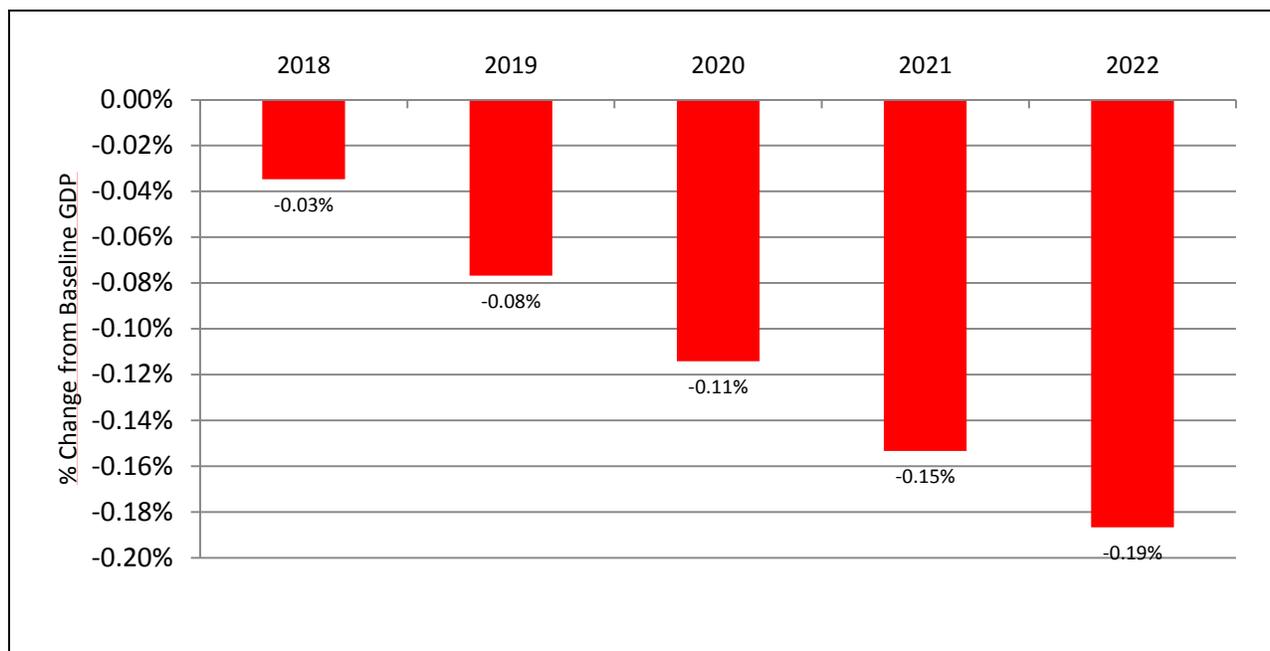
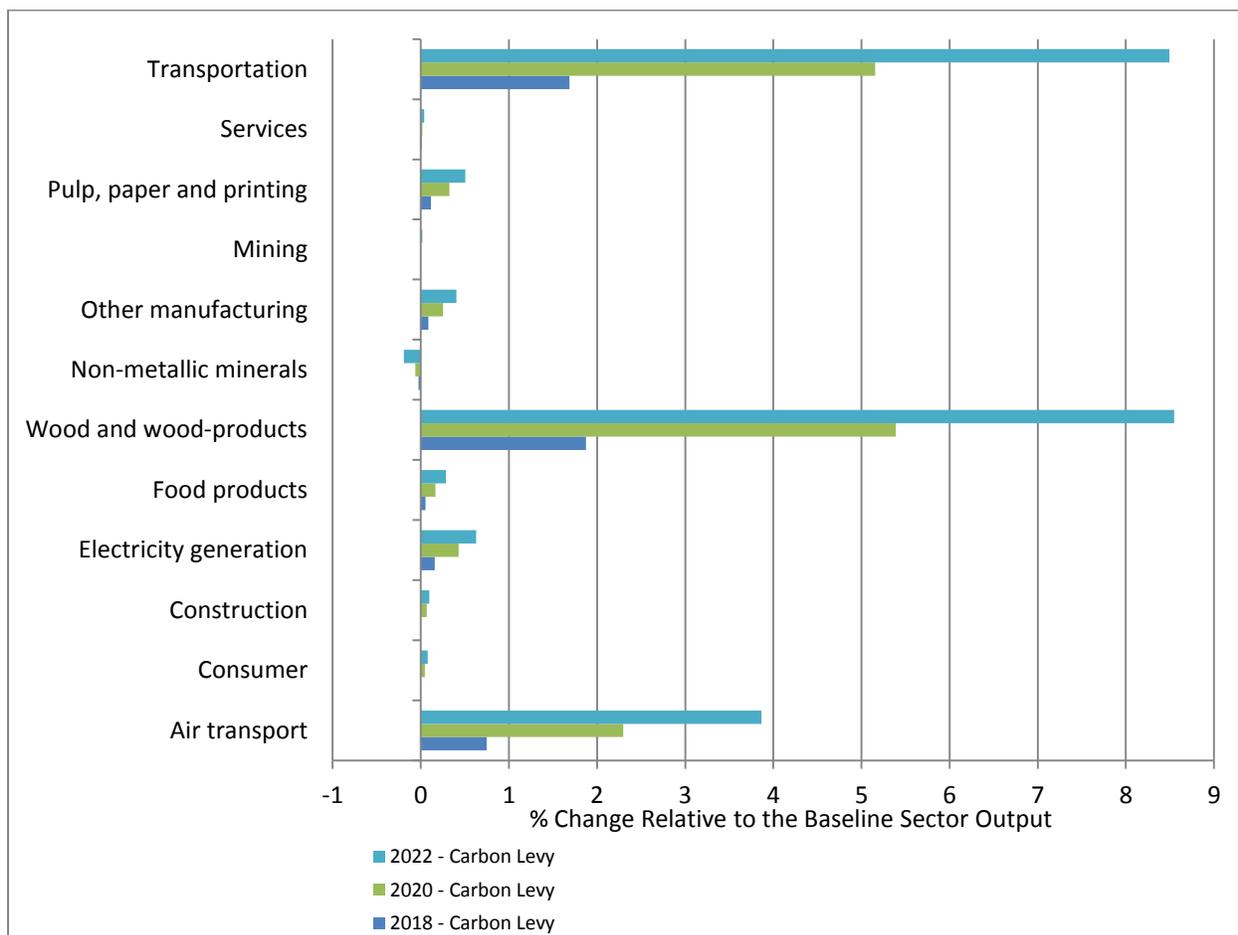


Figure 4 illustrates estimated sector-specific impacts associated with implementation of a carbon levy. The highest relative economic impact compared to business-as-usual projections is in the transportation sector (freight, railways, etc.), with an estimated impact of 1.7% (\$2.3 million) in 2018, increasing to 8.5% in 2022 (\$12.3 million). The next highest impacts are to the air transport sector, which is estimated to have an impact of 0.8% (\$1.0 million) in 2018 rising to 3.9% (\$4.9 million) in 2022. The next most affected sector is the service sector, but the impacts are slight – only fractions of a percent from the baseline. The wood and wood-products sector sees estimated impacts of 1.9% (\$0.2 million) in 2018, rising to 8.5% (\$1.2 million) in 2022.

All other sectors – including light manufacturing, food products, pulp, paper and printing, mining and electricity generation – are estimated to see minimal impacts (fractions of a percent) from the baseline.

The model output indicates a minor economic benefit to the non-metallic minerals sectors; this appears to be a result of the sector’s emissions being too small for EC-PRO to model accurately.

**Figure 4: Estimated Economic Impacts by Economic Sector in the Yukon\***



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

**Estimated Revenues Generated by Carbon Pricing**

Figure 5 shows that the estimated revenue generated from a carbon levy is approximately \$5.6 million in 2018, rising to an estimated \$15.9 million in 2020 and \$26.0 million in 2022 (at \$50/tonne). These estimates assume that carbon pricing is in place for the full year of 2018.

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

	2018	2019	2020	2021	2022
Carbon Levy	5.6	10.9	15.9	20.9	26.0

## **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 in jurisdictions with regimes in place. The cost of embedded carbon pricing (indirect cost) accounts for nearly three-quarters of the estimated cost to households. This is in part attributable to the relatively important role of imports in the Yukon.

*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.*

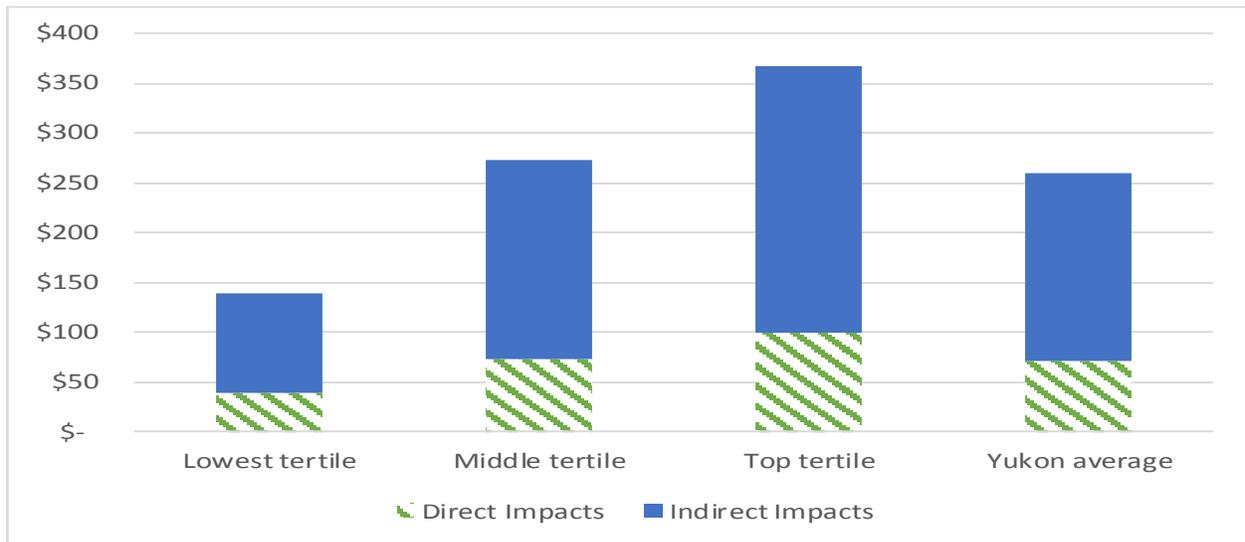
Annual impacts range from an average of \$140 per household for those in the lowest third of the household income distribution, to about \$275 in the middle third of the household income distribution, to a high of about \$370 in the top third of the household income distribution, with a territorial average across all households of about \$260 per household.<sup>10</sup> Higher average impacts on higher-income households 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 Yukon households for 2022 are estimated to be about three times the estimated impacts for 2018. This result is explained further in the discussion of Figure 9.

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<sup>10</sup> The territorial average impact per household of \$260 was derived by dividing total estimated impacts on Yukon households of about \$4.0 million in 2018 by the Census 2016 estimate of 15,215 households in the Yukon.

## Carbon Pricing in the Yukon

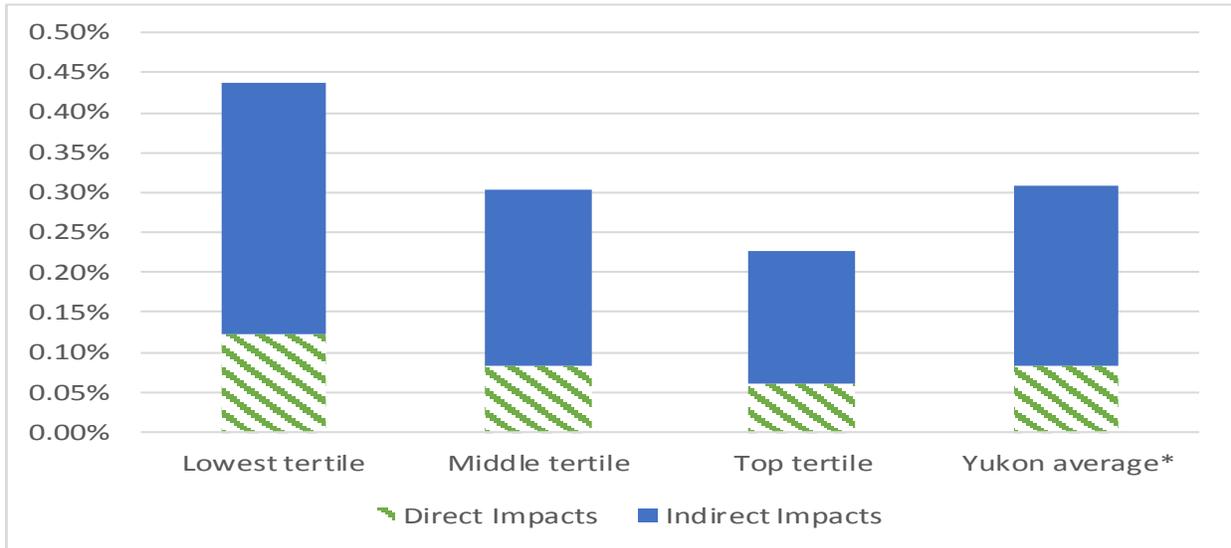
**Figure 6: Average per Household Impacts in 2018, by Tertile of Yukon Household Income Distribution (\$)\***



\* Estimates reflect the impact on all consumption by households in the Yukon 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 fuel that release GHGs in 2018 and outputs of ESTIOM.

Conversely, when expressed as a share of income, Figure 7 shows that estimated average impacts are strongest at the bottom of the income distribution and fall with income. These impacts were calculated by expressing the figures in Chart 6 as a share of estimated average household income in each of the three income groups separately. The territorial average annual household impact of \$260 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 Yukon 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 Yukon 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 of household income in 2018 for those in the lowest tertile, about one third of one percent for those in the middle tertile, and less than one quarter of one percent for those in the highest tertile income group. The territorial average household impact of \$260 as a share of median total household income in the Yukon in 2015 (\$84,521), as reported in Census 2016, is about 0.3% of income.

About 75% of the estimated carbon pricing impacts on households in the Yukon in 2018 are attributable to seven commodities (see Annex for a definition of commodity categories). The impacts of carbon pricing on households in the Yukon are estimated to be, on average:

- \$62 for gasoline and other fuels for vehicles and tools;
- \$33 for food purchased from stores;
- \$27 for “other” transportation ;
- \$25 for home heating fuel;
- \$18 for air transport;
- \$14 for electricity costs; and
- \$12 for recreation expenses.

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.

## Carbon Pricing in the Yukon

The impact of carbon pricing on households is expected to range somewhat across communities. As Figure 8 demonstrates, assuming territorial average spending for an illustrative household, carbon pricing is likely to have a larger impact in remote areas such as Old Crow than in Whitehorse, given higher transportation costs.<sup>11</sup> However, to the extent that average incomes may be lower in remote communities, household spending may also be lower. This means that the impacts shown in Figure 8 may overstate the impacts in remote communities and understate impacts in the capital. That said, given similar spending patterns by two households, adjusted for price differences, impacts are expected to be larger in remote regions. Moreover, a remote household may spend less in total but spend more heavily on carbon emissions-intensive commodities. On the other hand, households in remote regions may be less impacted by indirect impacts on some goods and services, given the limited availability for purchase in those communities.

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

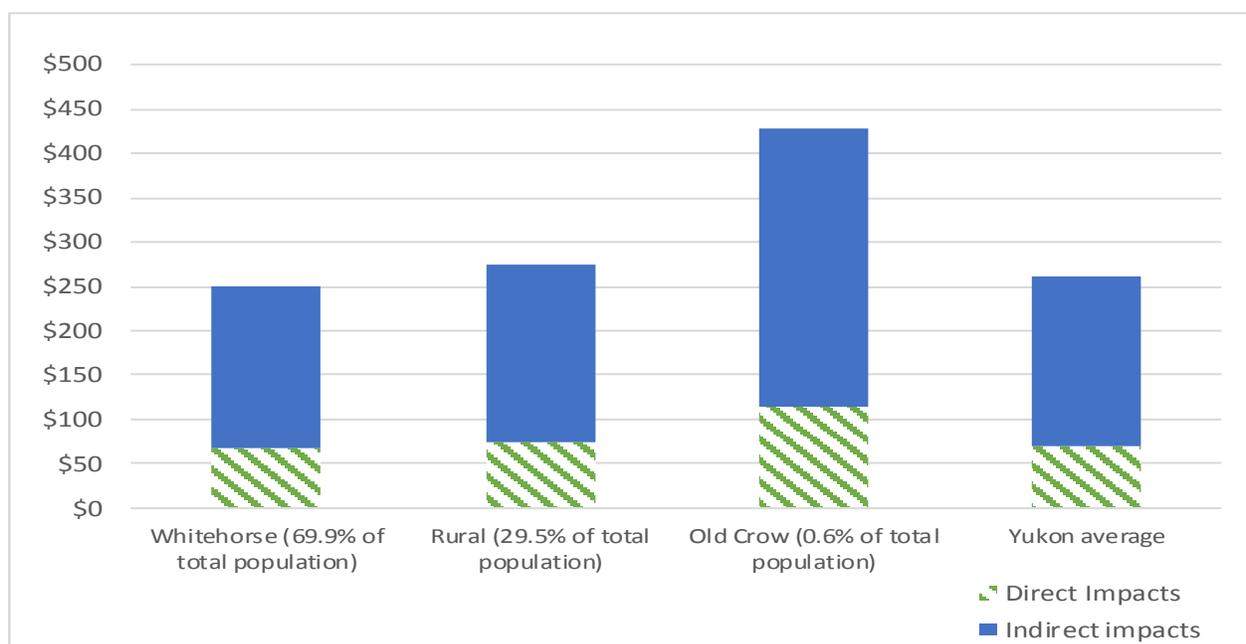
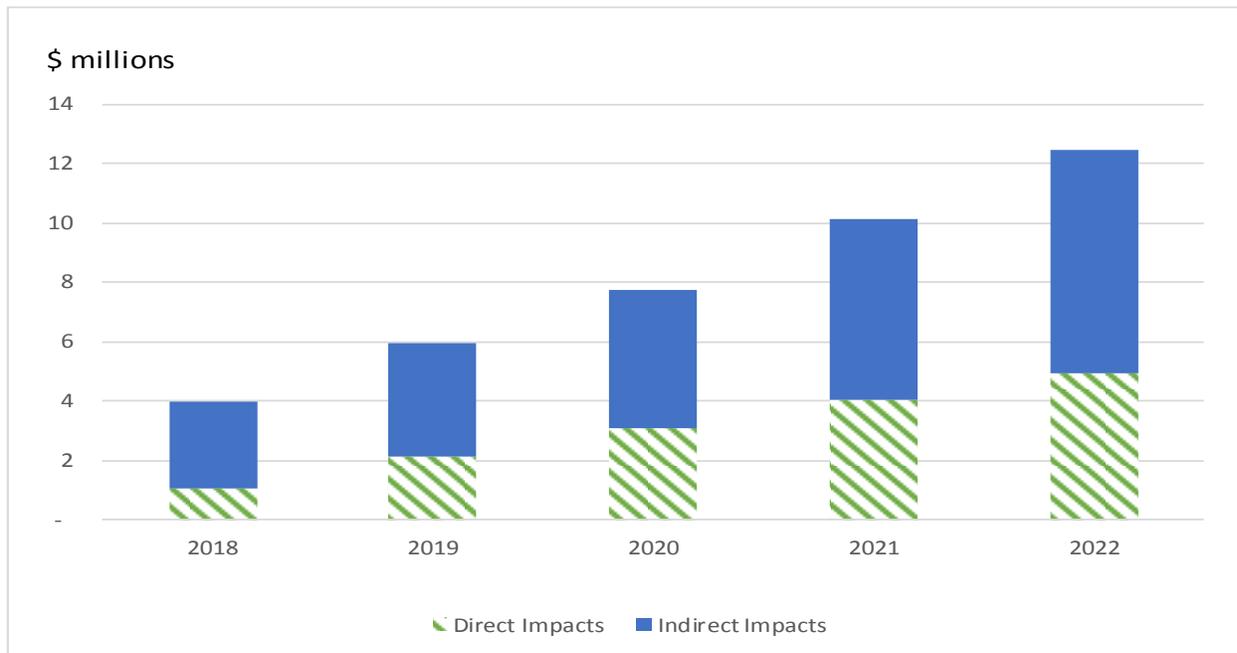


Figure 9 provides estimates of the total direct and indirect pricing impacts on households. These are expected to range from about \$4 million in 2018 to about \$12.5 million in 2022. The aggregate impacts on Yukon households are estimated to be slightly more than three times in 2022 what they are estimated to be for 2018, while indirect impacts are estimated to be about 2.6 times their 2018 levels in 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.

<sup>11</sup> To provide an illustration of how impacts may vary, differences in social assistance rate schedules across regions were used as proxies for potential differences in intra-territorial transportation costs and hence carbon-pricing costs among communities. Average impacts across all households in the territory were reweighted using these scaling factors and population data to provide this illustration. Notably, although differences in spending that reflect differences in incomes and in the composition of consumption in different communities are implicitly captured in the modeled impacts for the territory as a whole, the available data are not sufficient for a detailed accounting of these factors on a community by community basis.

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



## **ANNEX: Modelling Methodology**

### **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 – 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.

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The estimates provided are based on the 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.<sup>12</sup> 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).

The modelling 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<sup>st</sup>, 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.

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

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<sup>12</sup> 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.

**Baseline – Adjustment based on Yukon 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, 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-PRP 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 table below, provided by Yukon Department of Finance.

<b>Yukon GHG Emissions (Mt CO2e) – Source: Government of Yukon, 2017</b>			
<b>Sector</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>
Aviation Gas/Jet Fuel	0.039	0.043	0.049
Heating Diesel/Propane	0.126	0.124	0.104

## Carbon Pricing in the Yukon

LNG/Diesel for Electrical Generation	0.017	0.017	0.019
Off-road/exempt Diesel	0.111	0.095	0.062
Off-road/exempt Gasoline	0.001	0.001	0.001
On-road Diesel	0.148	0.148	0.156
On-road Gasoline	0.159	0.158	0.169
All Other	0.027	0.028	0.029
<b>Yukon Total</b>	<b>0.628</b>	<b>0.614</b>	<b>0.589</b>
<b>Canada</b>	<b>726.7</b>	<b>727.7</b>	<b>730</b>
<b>Yukon National Share</b>	<b>0.09%</b>	<b>0.08%</b>	<b>0.08%</b>

It is assumed that the difference between Yukon and NIR estimates is the result of diesel imported from Alaska which is not captured in either the emissions or fuel use data. As such, EC-PRO's total BaU emissions for Yukon from oil combustion are increased by the required factor to achieve the total targeted level. Beyond 2015, BaU emissions are increased by the factor required in 2015, and thus follow the same growth path as the BaU.

### 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 regional emission per dollar intensity of oil for each sector. The choice to use the regional intensity value was made under the assumption that missing emissions are associated with missing fuel purchases, and thus the intensity is reliable and preserves the regional price component of the per dollar figure. The margins are similarly increased to maintain the margin rate on intermediate demands.

Labor 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 imports. The additional output by each sector which remains in Yukon, 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 Yukon, Finance Canada, and ECCC.

**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.

<b>Category in the Survey of Household Spending</b>	<b>Subcategories (from the National Accounts)</b>
Food purchased from stores	<ul style="list-style-type: none"> <li>• Food</li> <li>• Non-alcoholic beverages</li> </ul>
Household operations	<ul style="list-style-type: none"> <li>• Materials for the maintenance and repair of the dwelling</li> <li>• Services for the maintenance and repair of the dwelling</li> <li>• Other services related to the dwelling and property</li> <li>• Telecommunication equipment</li> <li>• Telecommunication services</li> <li>• Information processing equipment</li> <li>• Property insurance</li> <li>• Child care services outside the home</li> <li>• Child care services in the home</li> <li>• Other social services</li> </ul>
Household furnishing and equipment	<ul style="list-style-type: none"> <li>• Furniture and furnishings</li> <li>• Carpets and other floor coverings</li> <li>• Household textiles</li> <li>• Major household appliances</li> <li>• Small electric household appliances</li> <li>• Major tools and equipment</li> <li>• Small tools and miscellaneous accessories</li> <li>• Other semi-durable household goods</li> <li>• Other non-durable household goods</li> <li>• Repair of personal and household goods except vehicles</li> <li>• Renting and leasing of personal and household goods except passenger vehicles</li> </ul>
Clothing and accessories	<ul style="list-style-type: none"> <li>• Garments</li> <li>• Cleaning of clothing</li> <li>• Clothing materials, other articles of clothing and clothing accessories</li> <li>• Footwear</li> <li>• Jewellery, clocks and watches</li> <li>• Other personal effects</li> </ul>
Automobile, purchase, rent, lease and parts	<ul style="list-style-type: none"> <li>• New passenger cars</li> <li>• New trucks, vans and sport utility vehicles</li> </ul>

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	<ul style="list-style-type: none"> <li>• Used motor vehicles</li> <li>• Other vehicles</li> <li>• Spare parts and accessories for vehicles</li> </ul>
Services related to automobile transportation	<ul style="list-style-type: none"> <li>• Maintenance and repair of vehicles</li> <li>• Parking</li> <li>• Passenger vehicle renting</li> <li>• Other services related to the operation of transport equipment</li> <li>• Insurance related to transport</li> </ul>
Other public transportation (referred to as “other” transportation in the text)	<ul style="list-style-type: none"> <li>• Railway transport</li> <li>• Urban transit</li> <li>• Interurban bus</li> <li>• Taxi and limousine</li> <li>• Water transport</li> <li>• Other transport services (includes moving and storage)</li> <li>• Postal services</li> </ul>
Health care	<ul style="list-style-type: none"> <li>• Therapeutic appliances and equipment</li> <li>• Pharmaceutical products and other medical products</li> <li>• Out-patient services</li> <li>• Hospital services</li> </ul>
Personal care	<ul style="list-style-type: none"> <li>• Personal grooming services</li> <li>• Electrical appliances for personal care</li> <li>• Other appliances, articles and products for personal care</li> </ul>
Recreation	<ul style="list-style-type: none"> <li>• Recording media</li> <li>• Audio-visual and photographic equipment</li> <li>• Major durables for outdoor recreation</li> <li>• Musical instruments and major durables for indoor recreation</li> <li>• Games, toys and hobbies</li> <li>• Equipment for sport, camping and open-air recreation</li> <li>• Garden products, plants and flowers</li> <li>• Veterinary and other services for pets</li> <li>• Pets and pet food</li> <li>• Recreational and sporting services</li> <li>• Cable, satellite and other program distribution services</li> <li>• Cinemas</li> <li>• Photographic services</li> <li>• Other cultural services</li> </ul>
Education	<ul style="list-style-type: none"> <li>• Books</li> <li>• Newspaper and periodicals</li> <li>• Miscellaneous printed matter and stationery and drawing materials</li> <li>• University education</li> <li>• Other education</li> </ul>
Tobacco products and alcoholic beverages	<ul style="list-style-type: none"> <li>• Alcoholic beverages</li> <li>• Tobacco</li> <li>• Alcoholic beverage services</li> </ul>

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Miscellaneous expenditures	<ul style="list-style-type: none"> <li>• Life insurance</li> <li>• Health insurance</li> <li>• Implicit loan charges</li> <li>• Implicit deposit charges</li> <li>• Stock and bond commissions</li> <li>• Other actual financial charges</li> <li>• Trusteed pension funds</li> <li>• Mutual funds</li> <li>• Undertaking and other funeral services</li> <li>• Legal and other services</li> </ul>
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### **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.

<b>EC-PRO Sector</b>	<b>NAICS Categories and Code Legend</b>
Crude oil	BS21100* - Oil and gas extraction
Coal mining	BS21210 – Coal Mining
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

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	<p>BS32530 - Pesticide, fertilizer and other agricultural chemical manufacturing</p> <p>BS32540 - Pharmaceutical and medicine manufacturing</p> <p>BS325C0 - Miscellaneous chemical product manufacturing</p> <p>BS32610 - Plastic product manufacturing</p> <p>BS32620 - Rubber product manufacturing</p>
Cement	<p>BS32731 - Cement manufacturing</p> <p>BS32732 - Ready-mix concrete manufacturing</p>
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)	<p>BS33610 - Motor vehicle manufacturing</p> <p>BS33620 - Motor vehicle body and trailer manufacturing</p> <p>BS33630 - Motor vehicle parts manufacturing</p> <p>BS33640 - Aerospace product and parts manufacturing</p> <p>BS33650 - Railroad rolling stock manufacturing</p> <p>BS33660 - Ship and boat building</p> <p>BS33690 - Other transportation equipment manufacturing</p>
Food products	<p>BS31110 - Animal food manufacturing</p> <p>BS31130 - Sugar and confectionery product manufacturing</p> <p>BS31140 - Fruit and vegetable preserving and specialty food manufacturing</p> <p>BS31150 - Dairy product manufacturing</p> <p>BS31160 - Meat product manufacturing</p> <p>BS31170 - Seafood product preparation and packaging</p> <p>BS311A0 - Miscellaneous food manufacturing</p> <p>BS31211 - Soft drink and ice manufacturing</p> <p>BS31212 - Breweries</p> <p>BS3121A - Wineries and distilleries</p> <p>BS31220 - Tobacco manufacturing</p>
Textiles-wearing apparel-leather	<p>BS31A00 - Textile and textile product mills</p> <p>BS31B00 - Clothing and leather and allied product manufacturing</p>
Other manufacturing	<p>BS33200 - Fabricated metal product manufacturing</p> <p>BS33300 - Machinery manufacturing</p> <p>BS33410- Computer and peripheral equipment manufacturing</p> <p>BS334B0 - Electronic product manufacturing</p> <p>BS335A0 - Electrical equipment and component manufacturing</p> <p>BS33520 - Household appliance manufacturing</p> <p>BS33700- Furniture and related product manufacturing</p> <p>BS33900 - Miscellaneous manufacturing</p> <p>BS32733 - Concrete pipe, brick and block manufacturing</p> <p>BS32739 - Other concrete product manufacturing</p>

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<p>Transportation and warehousing</p>	<p>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</p>
<p>Air transport</p>	<p>BS48100 - Air transportation</p>
<p>Services</p>	<p>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)</p>

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	<p>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</p>
<p>Consumer</p>	<p>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</p>

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	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

## Carbon Pricing in the Yukon

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