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BIG AND LITTLE FEET: A COMPARISON OF PROVINCIAL LEVEL CONSUMPTION- AND PRODUCTION-BASED EMISSIONS FOOTPRINTS*†

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SUMMARY

A comprehensive national climate policy needs to provide both producers and consumers with incentives for reducing greenhouse gas emissions. Too often, policy discussions focus on emissions reduction among producers. This limited perspective fails to take into account the complex relationship between emissions production in one region and consumption demands in another.

All economic production requires both a producer and a consumer. If no consumer for a good or service exists, then that good or service will not be produced. We understand the producer's role in generating Canada's greenhouse gas emissions, but often forget the consumer's role. In this paper, we explore both the conventional production-based emissions accounting as well as consumption-based accounting, wherein all of the emissions generated in order to produce a final consumption good are allocated to consumers of those goods.

Production and consumption are not a simple case of cause and effect. Rather, production emissions diverge strongly across Canadian provinces while consumption emissions tend to be similar. Significant interprovincial and international trade flows in emissions enable this pattern. Recognition of these trade flows provides important insights for the development of Canada's national climate change strategy.

Interprovincial trade flows provide a strong argument in support of Canada's forthcoming national carbon price. By ensuring the large majority of emissions in Canada are similarly priced – regardless of where they are produced – it minimizes the risk of interprovincial carbon leakage (where companies avoid the carbon price by relocating to a jurisdiction with weaker climate measures) and increases the likelihood that Canadian consumers will face an incentive to adjust their demand of domestically produced carbon intensive goods.

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Implementation of a national carbon price must make allowances for production sectors with significant international trade flows in emissions, or risk damaging that trade. Higher costs for Canadian producers can have a detrimental effect on competition in these sectors, resulting in less demand for Canadian products domestically and internationally. It can also lead to international carbon leakage. The resultant increase in global greenhouse gas emissions defeats the purpose of enacting stringent regulations in Canada. Striking a balance requires that the federal government create complementary policies that reduce the burden of a national carbon price on trade-exposed Canadian producers while still providing incentives for them to invest in reducing their emissions.

In Canadian sectors with minimal trade exposure – i.e., those with emissions that are largely produced and consumed within Canada – it is best to focus complementary policies to a national carbon price on achieving additional emissions reductions. The utilities, personal transportation and residential sectors are all good targets for these types of complementary policies.

Another important policy question is how to equitably divide the burden of meeting Canada's national emissions reduction target across the provinces. This does not lend itself to simple solutions. Some provinces have significant hydroelectric resources, providing them with a non-fossil fuel electricity source that leads to lower emissions. An approach that mandates similar emissions intensities per capita across Canada will be to those provinces' advantage. However, there is also a historical approach to burden sharing that puts the provinces with lower emissions at a disadvantage. This allows a province like Alberta to have higher emissions levels because it has always had them.

The best model for distributing Canada's emissions reduction target is a hybrid one that all provinces can support without any of them feeling they are at a disadvantage. There is a strong case for granting all provinces an equal right to consumption emissions as a starting point. However, a final emissions allocation must come with the recognition that a province's consumption is often supported by production emissions outside of that province.

Drafting climate policy can be fraught with consequences that come from focusing on one side only of the production/consumption equation. Where consumption drives emissions is as important as where they are produced. A balanced policy that reflects the implications of domestic and international emissions trade flows is the best and fairest way for Canada to contribute to reducing the world's greenhouse gas emissions.

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GRANDS ET PETITS PAS : COMPARAISON ENTRE PROVINCES DE L'EMPREINTE CARBONIQUE DUE À LA PRODUCTION ET À LA CONSOMMATION*†

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RÉSUMÉ

Une politique climatique nationale doit offrir, tant aux producteurs qu'aux consommateurs, des incitatifs pour la réduction des émissions de gaz à effet de serre. Les discussions sur ces politiques sont trop souvent centrées sur des mesures de réduction d'émissions du côté des producteurs. Cette optique limitée ne tient pas compte des relations complexes entre les émissions de production dans une région, et la demande de consommation dans une autre région.

Toute production économique implique à la fois un producteur et un consommateur. S'il n'y a pas de consommateurs pour un bien ou un service, tel bien ou service ne sera tout simplement pas produit. Nous comprenons tous que les producteurs ont un rôle à jouer dans la génération de gaz à effet de serre au Canada, mais nous oublions trop souvent que les consommateurs ont également un rôle à assumer. Dans cet article, nous nous penchons sur la comptabilisation habituelle des émissions liées à la production, mais aussi sur la comptabilisation liée à la consommation, où toutes les émissions générées pendant la production de biens de consommation finaux sont attribuées aux consommateurs de ces biens.

La relation entre la production et la consommation ne s'explique pas par une simple relation de cause à effet. Les émissions de production varient grandement d'une province à l'autre au Canada, alors que les émissions de consommation tendent à être plus uniformes. D'importants flux commerciaux interprovinciaux et internationaux expliquent ce déséquilibre au niveau des émissions. La prise en compte des flux commerciaux apporte une meilleure perspective pour l'élaboration d'une stratégie nationale pour lutter contre le changement climatique au Canada.

Les flux commerciaux interprovinciaux constituent un bon argument en faveur d'un plan national de tarification du carbone, tel que prévu prochainement au Canada. En s'assurant que la grande majorité des émissions canadiennes soit tarifée de

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façon similaire – sans égards à leur lieu de production – on peut diminuer le risque d'exode interprovincial du carbone (c'est-à-dire quand des sociétés évitent la tarification du carbone en relocalisant leur production dans une juridiction qui comporte moins de mesures climatiques) tout en augmentant la probabilité d'inciter les consommateurs canadiens à ajuster leur demande de biens à forte empreinte carbonique produits localement.

L'établissement d'une tarification nationale uniforme du carbone doit pouvoir accommoder les secteurs de production comportant d'importants flux commerciaux internationaux en terme d'émissions, faute de quoi on risque de faire tort à ces secteurs commerciaux. Les coûts plus élevés auxquels font face les producteurs canadiens ont un effet délétère sur leur compétitivité dans ces secteurs, ce qui entraîne une baisse de la demande des produits canadiens, tant aux fronts domestique qu'international. Cela peut également mener à un exode international du carbone. L'augmentation des gaz à effet de serre qui pourrait en résulter met en échec l'objectif même de la mise sur pied d'une réglementation sévère au Canada. Trouver le bon équilibre demande que le gouvernement fédéral mette en place des politiques complémentaires qui réduisent le fardeau d'une tarification nationale du carbone pour les producteurs canadiens exposés au commerce, tout en leur offrant des incitatifs à l'investissement pour réduire leurs émissions.

Dans les secteurs canadiens qui ne sont que minimalement exposés au commerce – c'est-à-dire les industries dont les émissions sont le fruit d'une production et d'une consommation internes – il est souhaitable de s'en tenir à des politiques complémentaires quant à la tarification du carbone pour atteindre une réduction des émissions. Les secteurs des services publics, du transport et résidentiels sont de bonnes cibles pour ce type de politiques complémentaires.

Une autre question importante au sujet des politiques à suivre serait de déterminer comment répartir de façon équitable les objectifs de réduction d'émissions entre les provinces. Il n'existe pas de solution simple. Certaines provinces ont des ressources hydroélectriques considérables qui leur offre un potentiel électrique qui n'est pas issu des énergies fossiles, ce qui entraîne moins d'émissions. Une approche requérant des émissions par habitant similaires pour l'ensemble du territoire canadien serait à l'avantage de ces provinces. Par contre, la répartition du fardeau pourrait également être approchée dans une perspective historique, ce qui désavantagerait alors les provinces engendrant moins d'émissions. Puisqu'elle en a toujours produit autant, une province comme l'Alberta se verrait octroyer un taux d'émissions plus élevé.

Le meilleur modèle pour répartir les objectifs de réduction des émissions du Canada serait une approche hybride endossée par toutes les provinces, sans qu'aucune ne se sente lésée. Comme prémisse de départ, il y a beaucoup d'arguments en faveur de l'octroi à toutes les provinces d'un droit égal quant à l'empreinte carbonique lié à la consommation. Cependant, une allocation tenant compte de la finalité des émissions découle de la reconnaissance du fait que la consommation dans une province donnée est souvent assurée par la production d'émissions à l'extérieur de cette province.

Le fait de s'attarder à un seul côté de l'équation production-consommation dans l'élaboration de politiques en matière de changement climatique peut être lourd de conséquences. Là où la pression de la consommation sur les émissions s'effectue est aussi important que l'endroit où elles sont produites. Une politique équilibrée reflétant l'impact des flux commerciaux nationaux et internationaux sur les émissions est la façon la plus juste et équitable pour le Canada de contribuer à réduire les émissions de gaz à effet de serre dans le monde.

INTRODUCTION

Production-based accounting is the standard method of measuring greenhouse gas emissions, both in Canada and internationally. Under the production-based approach, greenhouse gas emissions are allocated to the province (or, in the international context, the country) in which they are produced. The United Nations Framework Convention on Climate Change (UNFCCC) adopted this approach in large part due to its relative simplicity compared with other approaches to emissions accounting (Ahmed and Wyckoff, 2003). Specifically, measuring greenhouse gas emissions at their point of production is the most straightforward approach. It ignores, however, that there is extensive trade between regions, and that the production of greenhouse gas emissions in one region is often driven by the demand for final consumption goods and services in another region.

An alternative accounting method for greenhouse gas emissions is to use a consumption-based approach. The UNFCCC has considered such an approach as a potentially more equitable mechanism to assign responsibility for emissions and the associated mitigation efforts required to address them. It has received less formal attention, however, due to the methodological difficulty in calculating consumption-based emissions (Ahmed and Wyckoff, 2003).

Under a consumption-based approach to emissions accounting, greenhouse gas emissions associated with the production of an intermediate input are allocated to the province (or other geographical region) in which the consumption of the final good or service occurs.[1] For example, under a consumption-based approach, all of the greenhouse gas emissions associated with producing a litre of gasoline that is purchased and consumed by an Ontario motorist are assigned to Ontario. This accounts for the fact that Ontario demand for gasoline is driving the production of greenhouse gas emissions from crude oil extraction and refining – as well as the emissions in industries supporting crude oil extraction and refining – in the regions where these activities occur.

In this paper we compare Canada's provincial emissions profiles under a production- and consumption-based accounting approach, and discuss the implications for Canada's climate change strategy. The data we present are available at: https://www.policyschool.ca/publication-category/research-data/ and are constructed from the model presented in Fellows and Dobson (2017).

It is important to acknowledge two points from the outset. First, the emissions profiles we present are derived from data on annual financial flows in the Canadian economy. They are first and foremost the result of an accounting exercise and although they are useful for informing climate policy, they do not offer any insights on behavioural responses to policy implementation. While we offer some speculative commentary based on other research, we are generally not in a position to discuss how consumption patterns or emissions profiles will change as a result of introducing any new climate policies.

Second, many of Canada's production-based emissions are inputs to final consumption goods that are consumed outside of Canada. Similarly, many of Canada's final consumption goods embody greenhouse gas emissions from intermediate inputs produced abroad. From a global climate policy perspective, the impact of emissions transfers via international trade is important, particularly as developed countries import large quantities of manufactured goods from developing countries. As a result, many developed countries have positive net imports of consumption-based greenhouse gas emissions (Davis and Caldeira, 2010), which in turn fuels ethical questions around how the global burden of emissions reductions should be shared. Although an important question, considering the implications of international trade in emissions on Canada's climate policy is beyond the primary scope of our work and we offer only limited commentary in this area.

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[1] Intermediate inputs are semi-finished goods and services that become inputs into final goods and services that are sold to households, firms or government. It is worth noting that a single good may be sold either as an intermediate input or as a final good. For example, electricity sold directly to consumers for household use is a final good while electricity sold to the manufacturing sector for the production of other output goods is an intermediate input.

The remainder of the paper proceeds as follows. We start by providing a comparison between production- and consumption-based emissions and then move on to a brief description of the methodology for generating the data. Next, we present an overview of the production- and consumption-based emissions accounts for each of the provinces, and look at the main sources of emissions under both accounts. We then discuss how looking at the distribution of Canadian greenhouse gas emissions according to a consumption-based approach can inform Canada's national climate change strategy. In this section we identify both broad policies that can be used across the country and economic sectors, as well as specific emissions sources that stand out for targeting by unilateral action. Last, we consider the implications of consumption-based emissions on the discussions around burden sharing among the provinces to meet Canada's national reduction target.

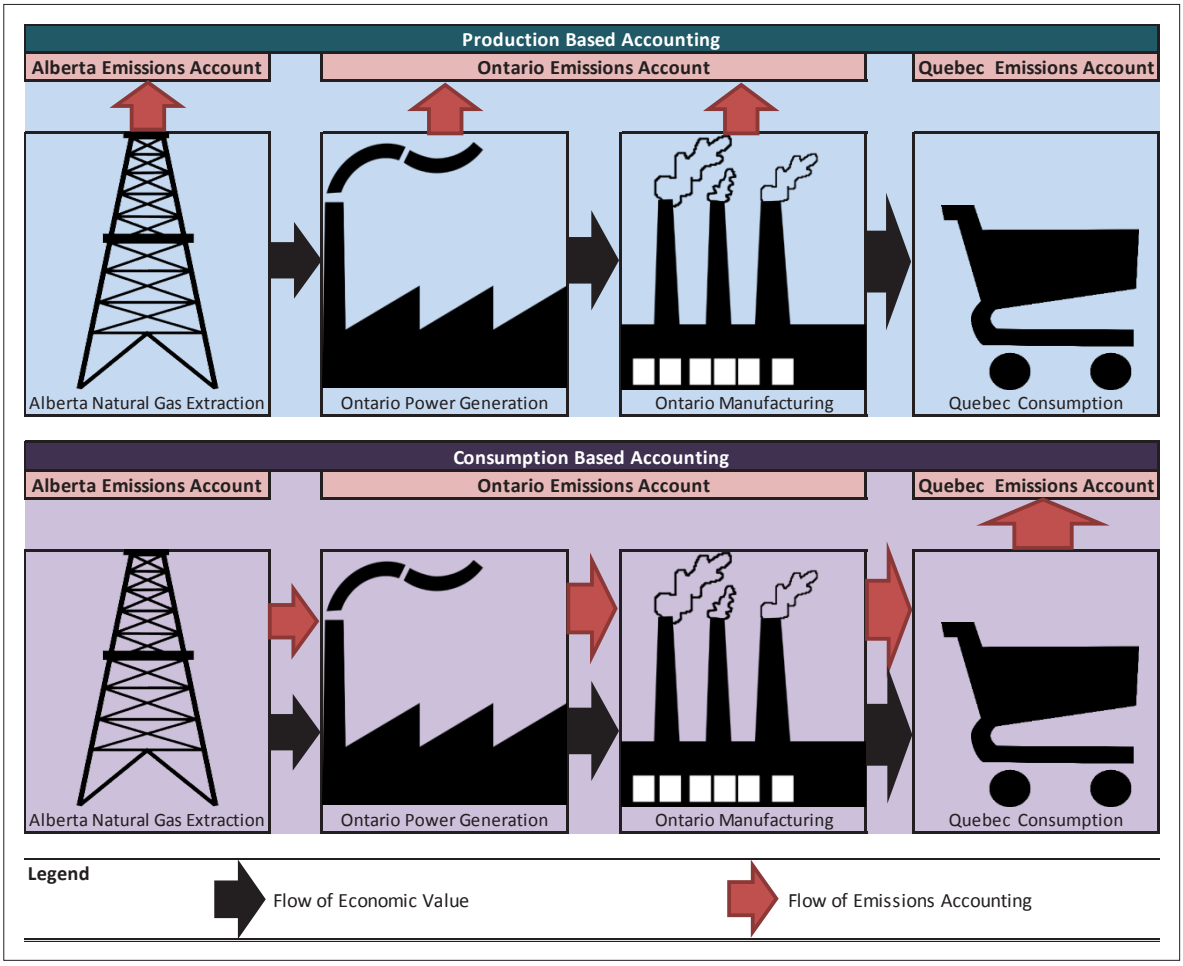
A COMPARISON OF PRODUCTION- AND CONSUMPTION-BASED EMISSIONS

Figure 1 provides a pictorial explanation of the difference between production- and consumption-based emissions accounting for a simplified production chain describing a hypothetical manufactured good consumed in Quebec. In this stylized example natural gas produced in Alberta is used to fire a natural gas electrical generation facility in Ontario, which in turn provides electricity to a manufacturing plant (also in Ontario). The final manufactured good is then shipped to Quebec where it is purchased by an end consumer. Under the conventional production-based accounting approach (top panel of Figure 1), the emissions from each stage of the value chain are allocated to the emissions account of the province in which they are produced. That is, the emissions from natural gas extraction in Alberta are allocated to Alberta, and the emissions from electricity generation and manufacturing in Ontario are allocated to Ontario. Conversely, under the consumption-based accounting approach (bottom panel of Figure 1) all of the emissions from the entire value chain are allocated to Quebec, as that is the region in which consumption of the final product occurs. In effect, the embodied emissions flow follows the same course as the value chain flow.

It should be stressed that Figure 1 illustrates an overly simplified value chain. Actual value chains within the Canadian economy are considerably more complex as any manufactured goods produced in Ontario would require more than just electricity as an input. If the good being considered were a dairy product, for example, it would require milk from the agricultural sector (either in Ontario or elsewhere) as an input. Plastic or some other packaging would also be required, as well as transportation services (to move the milk to the manufacturing facility and to move the packaged milk to market), and a host of others. By extension, each of those additional inputs would themselves have inputs which would require additional inputs in turn and so on up the production chain.

Rather than try to sort out this type of complex life-cycle assessment (where we individually examine the production chain of every final good the Canadian economy produces and try to identify the associated emissions) we instead model inter-sector and inter-regional Canadian trade as a single system. An overview of this approach is provided in the next section.

FIGURE 1 PRODUCTION- VS CONSUMPTION-BASED EMISSIONS ACCOUNTS (SIMPLIFIED)



It is worth noting that when moving to a consumption-based approach, not only are emissions reallocated to the region in which final consumption occurs, they are also reallocated to the sector that supplies the good to a final consumption sink. In Figure 1 above, for example, under a production-based accounting approach emissions are allocated to the natural gas extraction sector in Alberta, to the utilities sector in Ontario, and to the manufacturing sector in Ontario. Under a consumption-based approach all of these emissions are instead allocated to the manufacturing sector in Quebec, as this is the sector that sells the final good to a consumer.

The change in emissions at the sector level when moving from a production- to a consumption-based approach will generally depend on three key factors, with the most important being the destination of each sector's output – whether it is to be consumed domestically (within the province) as a final product, used domestically as an intermediate input, or exported to another province or internationally. The two other contributing factors are the emissions intensity of the sector itself, as well as the emissions intensity of intermediate inputs that the sector uses.

If only a small share of a sector's output is sold domestically for final consumption, then regardless of the emissions intensity of its own output or of its intermediate inputs, the sector will not have significant consumption-based emissions. Rather, the majority of emissions associated with the production of the sector's output, or the production of intermediate inputs used by the sector, will be passed on to other sectors and regions until they reach a final consumption sink. In this scenario emissions associated with a sector will decrease when moving from a production- to a consumption-based accounting approach. For example, provincial emissions associated with fossil

fuel extraction (oil, natural gas and coal) fall to near zero when moving from a production- to a consumption-based accounting approach as fossil fuels are generally not consumed in their raw form as final goods.

Alternatively, if a large share of a sector's output is sold domestically for final consumption, then the sector's consumption-based emissions will depend on the emissions intensity of its own production, as well as the emissions intensity of its intermediate inputs. Notably, this means that if a sector has a low direct emissions intensity but uses high emissions intensity inputs, then it can have low production-based emissions and high consumption-based emissions. For example, provincial emissions associated with the accommodation and food services sector increase by an average of over 10 times when moving from a production- to a consumption-based accounting approach, as the sector absorbs all of the emissions associated with the production and transportation of the food that restaurants purchase, prepare and serve to customers.

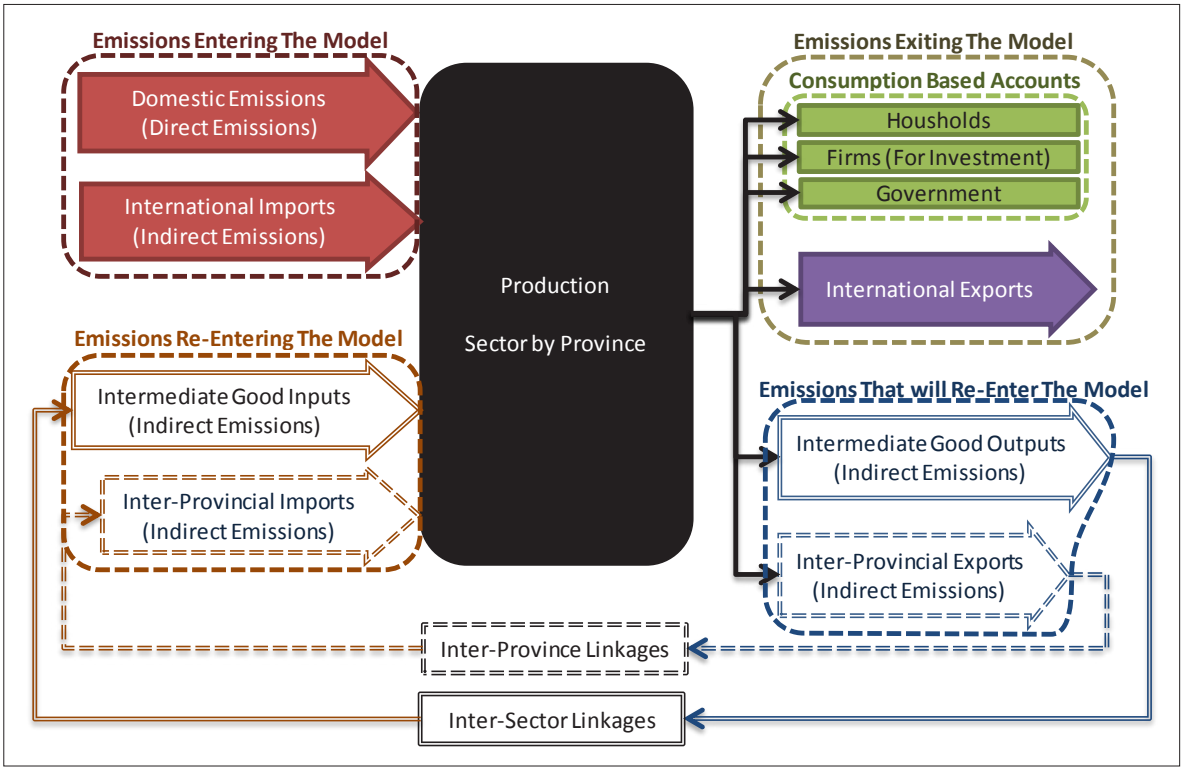
The movement of emissions between sectors makes trade patterns and sources of production emissions by sector a key determinant in how a province's emissions profile will change when moving from a production- to a consumption-based accounting approach. Most notably, if a province has significant production emissions from sectors that do not sell final consumption products, and which export a large share of their output, then the province's consumption-based emissions will be lower than their production-based emissions. Alternatively, if a province's economy is characterized by sectors that tend to import a significant share of emissions-intensive inputs or final consumer goods, then the province's consumption-based emissions will be higher than their production emissions.

METHODOLOGY

This section provides a very brief overview of the analytical work underpinning the calculations behind the emissions data and figures presented below. As a general description, we use a mathematical model of the Canadian economy to calculate measures of the emissions embodied in final goods and services. A comprehensive description of the model developed and used for this analysis, including detailed descriptions of the underlying data sources and the exact mathematical construction, is presented in a companion paper: *Embodied Emissions in Inputs and Outputs: A 'Value Added' Approach to National Emissions Accounting* (Fellows and Dobson, 2017). This section serves as a rough description of the model's intuition and is intended only to provide context for the results presented below.

Figure 2 gives a basic representation of modelled economy-wide linkages that account for the flow of embodied emissions from initial production to final consumption for a single province and sector.

FIGURE 2 MODELLED EMISSIONS FLOWS



On the left side of the flow chart, emissions enter the model either as domestic production (the conventional production-based accounts of Canadian emissions) or as emissions embodied in international imports. Emissions resulting directly from production are called direct emissions while the embodied emissions in international imports are one of three sources of indirect emissions for each province and sector. The other two sources of indirect emissions are the emissions embodied in intermediate inputs which come from other sectors in the same province and those which come from other provinces.[2] All direct and indirect emissions for each sector are allocated to the appropriate province and sector that uses those inputs. Summing all these direct and indirect emissions for a sector gives the total emissions generated to produce that sector's resulting output.

Moving to the right of the figure, the total embodied emissions for each sector and province can take one of two paths.

The first path is that a share of embodied emissions will exit the model associated with the use of an output good for final use or international export. Final use can take one of three forms: household consumption (Households), firm investment purposes (Firms) or government spending (Government). In the households category are all goods that individuals or households purchase for personal consumption (effectively, consumer goods). In the firms category are all goods purchased by firms for the purposes of building future production capacity; an example here would be steel purchased for use in an office building or factory construction. In the government category are all goods purchased by municipal, provincial or federal governments through spending on public services; an example here would be the public health-care services government pays for. International exports are any good that is sold to an intermediate or end user outside of Canada.

[2] In the example in Figure 1 Ontario power generation is an intermediate input into Ontario manufacturing, while Alberta natural gas extraction is in turn an intermediate input into Ontario power generation.

The second path the embodied emissions can take is to re-enter the model in another province or another sector. Such re-entry occurs whenever a good is used inside Canada as an intermediate input.

Regardless of the complex volume of inter-regional and inter-sectoral trade within the Canadian economy, all production value eventually flows to one of four consumption sinks in each of the provinces: household consumption, firms, government spending and exports. As a result, through this process all emissions that enter the system are eventually allocated by province to a consumption-based account or are exported.

The full constructed model calculates the indicated direct and indirect emissions flows and consumption-based accounts simultaneously for 36 sectors in 13 regions (468 sector-by-region pairs in total). The regions considered are the 10 Canadian provinces, Nunavut, a region combining the Yukon and Northwest Territories and a region representing Canadian territorial enclaves abroad.[3]

While the underlying mathematical model is relatively complex, the conceptual understanding need not be. In simplest terms, our model tracks the flow of embodied emissions through the Canadian value chain, starting with the known production emissions in each sector and region and calculating the previously unknown emissions embodied in final consumption. It does this using available data on the production of emissions by sector and on the economic value of goods traded between sectors and regions. Specifically, we calculate production-based emissions data using two sources: Statistics Canada's economic and environmental accounts (CANSIM tables 153-0034 and 153-0114) and Environment and Climate Change Canada's greenhouse gas emissions data (specifically, the data tables accompanying the 2016 National Inventory Report) (Environment and Climate Change Canada, 2016; Statistics Canada, 2012; and Statistics Canada, 2016b). Statistics Canada's national and provincial symmetric input-output tables indicate the value of goods traded between sectors and regions (Statistics Canada, 2015a; Statistics Canada, 2015b). For each individual sector we use these data sets to calculate embodied emissions consisting of the direct emissions produced within that sector and the indirect emissions embodied in intermediate inputs used by that sector. Those embodied emissions are themselves allocated either to final consumption accounts or as indirect-embodied emissions in further downstream production.

The result is a comprehensive data set indicating the role that end demand plays in motivating emissions production. As noted in the introduction, this data set is available at: https://www.policyschool.ca/publication-category/research-data/.

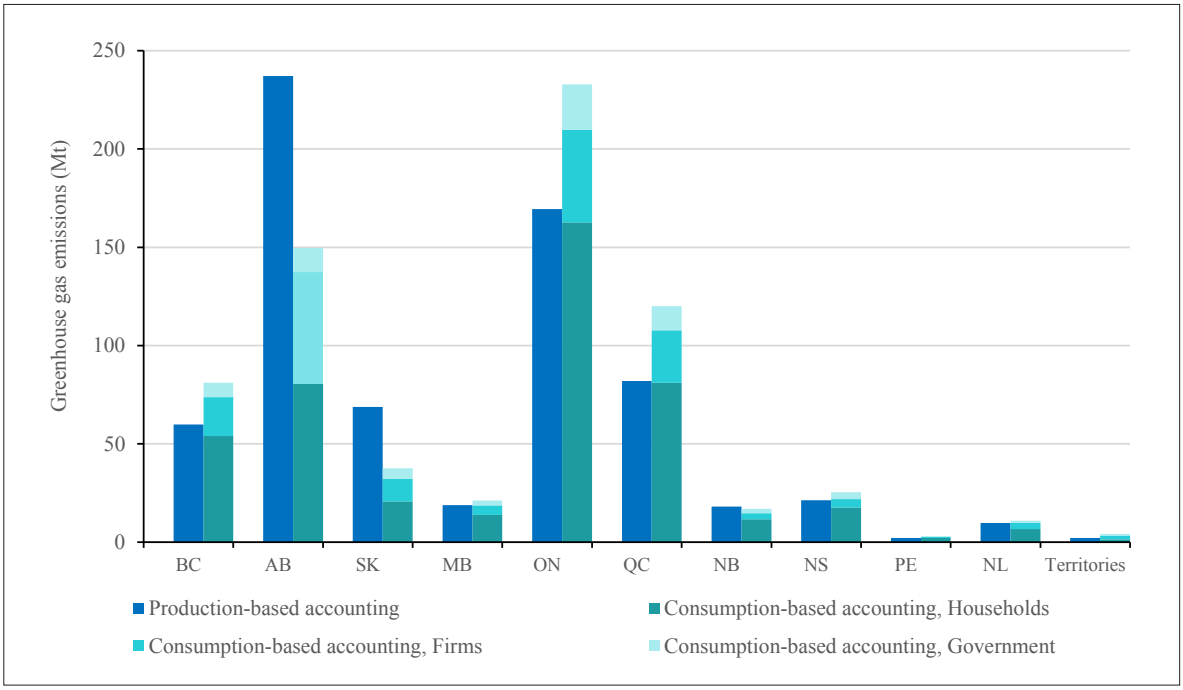
RESULTS

Provincial Overview

Figure 3 provides a comparison by province of Canada's production- and consumption-based emissions in 2011. It is immediately apparent that emissions from Alberta and Saskatchewan decrease significantly when moving from a production- to a consumption-based accounting approach. This is reflective of both provinces generating a significant amount of production emissions from oil and gas operations, and the majority of extracted oil and gas being exported outside of the province for refining and final consumption elsewhere. In Ontario, Quebec and British Columbia the opposite pattern is observed, with greenhouse gas emissions increasing significantly when changing to a consumption-based accounting approach. This pattern is consistent with these provinces having lower greenhouse gas emissions from primary industries and large populations that consume final goods where at least a portion of the production process takes place outside of the province.

[3] See Appendix for a complete list of production- and consumption-based emissions accounts by sector in each region.

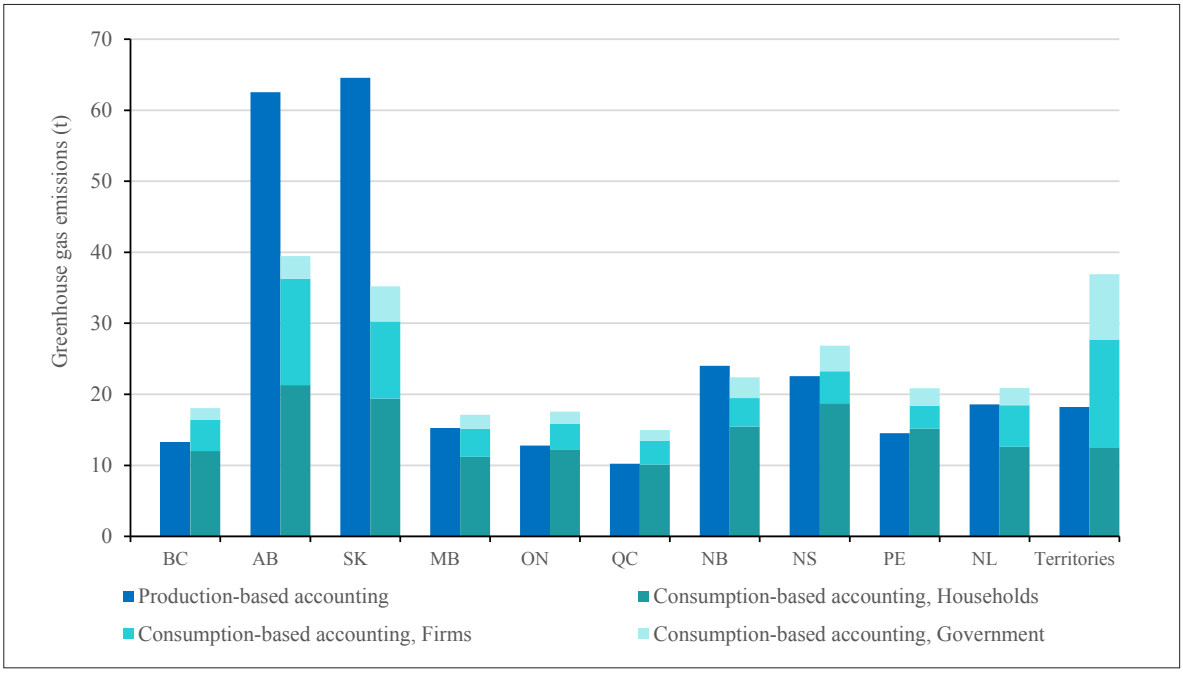
FIGURE 3 PROVINCIAL EMISSIONS BY PRODUCTION- AND CONSUMPTION-BASED ACCOUNTING (2011)



In British Columbia, Ontario and Quebec, the greenhouse gas emissions embedded in household consumption are very close to production emissions. Additionally, household consumption is responsible for approximately two-thirds of total consumption emissions in each of these provinces. In contrast, in Alberta and Saskatchewan, the value of household consumption emissions is only a third of the value of production emissions and households are responsible for just over half of consumption emissions. This difference is driven by the fact that both Alberta and Saskatchewan have higher levels of investment expenditure by firms and the investment tends to be more carbon intensive. Specifically, investment expenditure as a share of GDP in Alberta and Saskatchewan is approximately 25 to 30 per cent, and is dominated by industry spending on construction and on machinery and equipment. In the remaining provinces investment expenditure accounts for less than 21 per cent of GDP and the largest source of investment spending is typically residential construction (Statistics Canada, 2016d).

As shown in Figure 4, the same patterns are observed when comparing per capita production- and consumption-based emissions. Per capita emissions in Alberta and Saskatchewan in 2011 drop by approximately 40 per cent when moving from a production- to consumption-based accounting approach, while per capita emissions in Ontario, Quebec and British Columbia increase by over 30 per cent. Consequently, the resulting range in per capita emissions across the provinces narrows significantly. Specifically, under a production-based accounting approach the range of provincial per capita emissions is between 10.2 and 64.5 tonnes of CO_2e. Under a consumption-based accounting approach the range falls to between 15.0 and 39.5 tonnes of CO_2e. When looking only at the per capita consumption emissions of households the range narrows even further to between 10.1 and 21.3 tonnes of CO_2e. This is consistent with provinces and territories differing more substantially in their industry makeup than in their household consumption patterns.

FIGURE 4 PER CAPITA PROVINCIAL EMISSIONS BY PRODUCTION- AND CONSUMPTION-BASED ACCOUNTING (2011)



Emissions Flows by Interprovincial and International Trade

The relationship between production and consumption emissions in each province is given by the following equation:

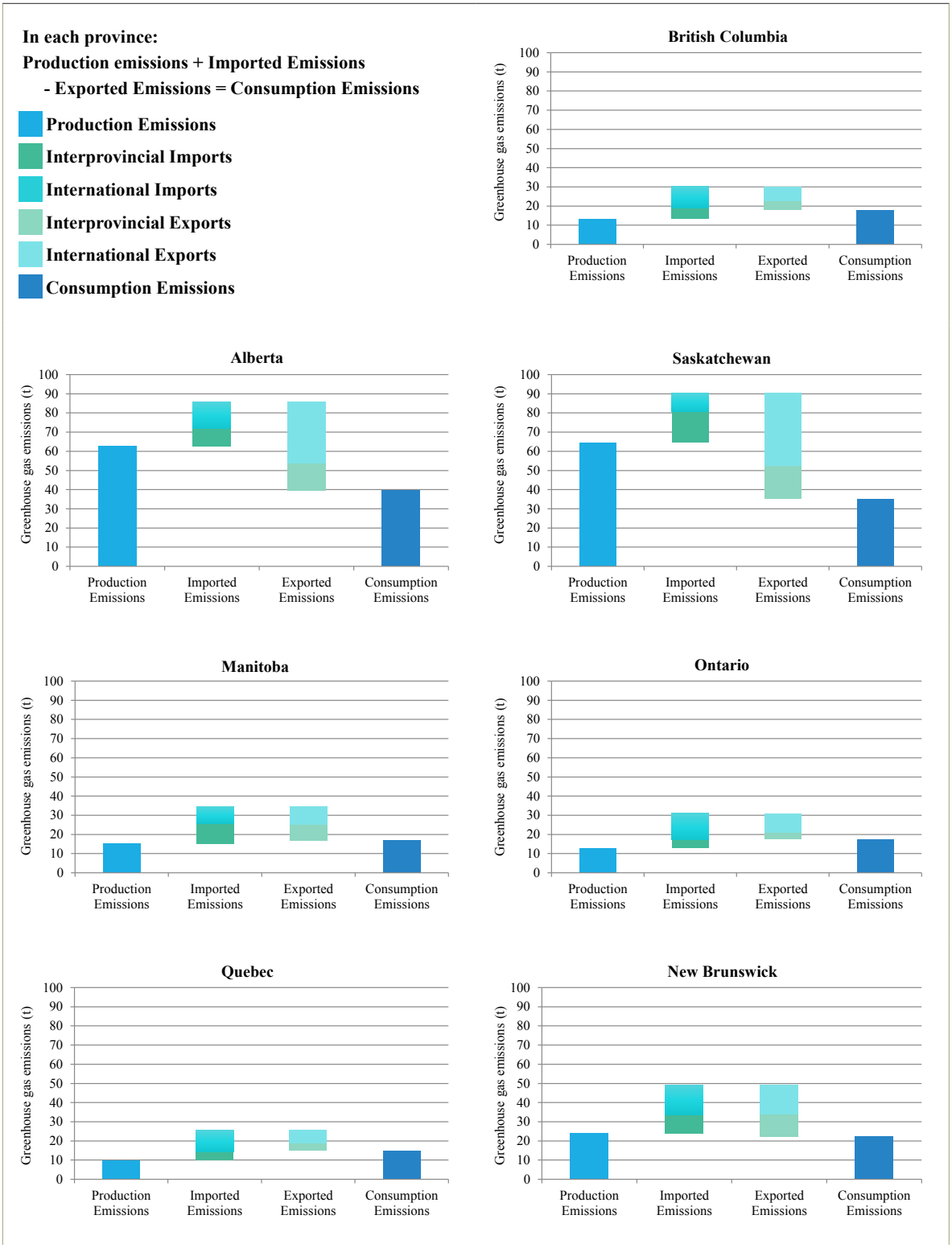
Consumption Emissions = Production Emissions + Interprovincial Imports + International Imports – Interprovincial Exports – International Exports;

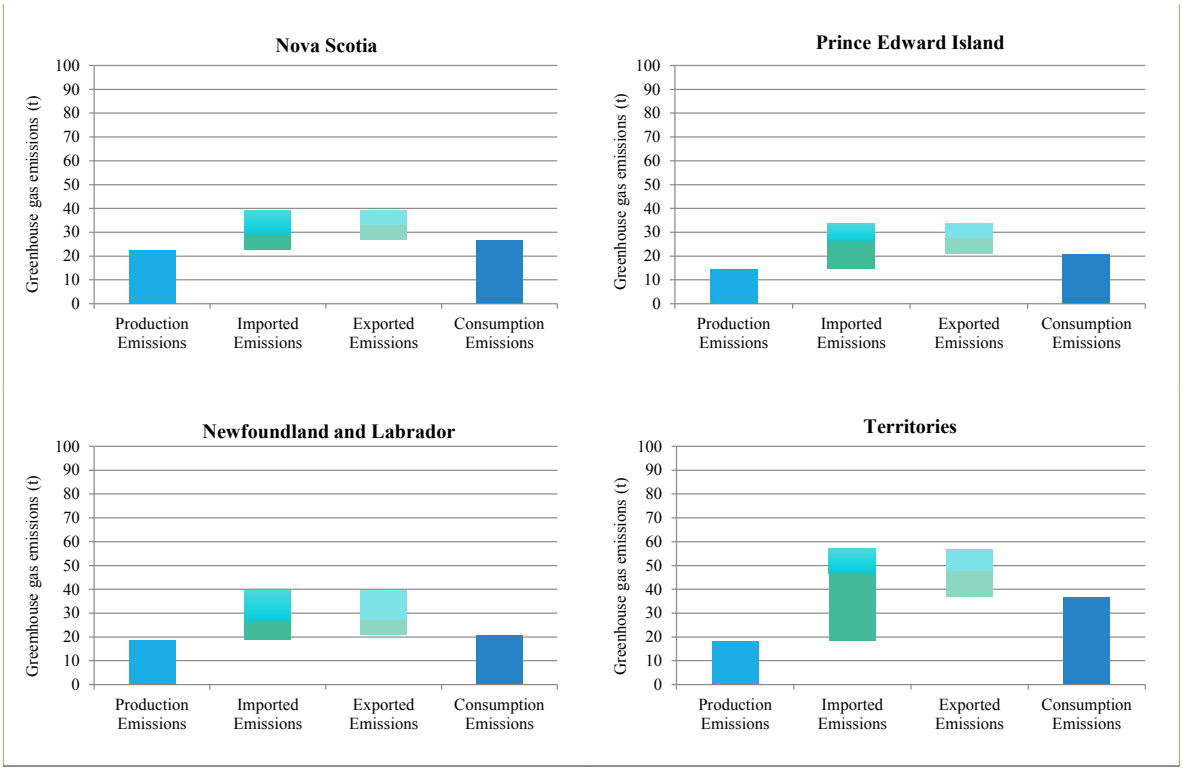
where interprovincial imports, international imports, interprovincial exports and international exports refer to the emissions embodied in goods and services that are traded between jurisdictions. If the sum of emissions embedded in imports to a province is greater than the sum of emissions embedded in exports, then the province's emissions will increase when moving from a production- to a consumption-based accounting approach. Alternatively, a province's emissions will decrease when moving between the two approaches if the sum of emissions embedded in exports is greater than the sum of emissions embedded in imports.

Figure 5 provides a summary of per capita production, imported, exported and consumption emissions by province. A number of patterns are evident. First, trade in emissions is significant. Particularly notable is that in seven out of 10 provinces, as well as in the territories, emissions embedded in imports to the province are greater than the province's production emissions.

Second, international trade tends to be the larger source of embedded emissions in both imports and exports. In Canada as a whole, a total of approximately 205.5 Mt of emissions were embedded in goods and services traded among provinces in 2011. In comparison, there were approximately 429.5 Mt of emissions embedded in international imports while 415.8 Mt of emissions were embedded in international exports. The exceptions to this are the territories, Prince Edward Island and imported emissions to Manitoba and Saskatchewan. The higher shares of emissions from interprovincial trade in these jurisdictions are consistent with none of them having a major international port.

FIGURE 5 PER CAPITA PRODUCTION, IMPORTED, EXPORTED AND CONSUMPTION EMISSIONS BY PROVINCE (2011)





Third, with the exception of the territories, the variation in per capita imported emissions to a province is significantly less than the variation in per capita exported emissions. Specifically, per capita imported emissions in the provinces range from a low of 15.7 tonnes in Quebec to a high of 25.8 tonnes in Saskatchewan. In contrast, per capita exported emissions in the provinces range from 10.9 tonnes in Quebec to 55.1 tonnes in Saskatchewan. This is again reflective of provinces differing more in their industry makeup (which primarily drives exported emissions) as opposed to household consumption (which primarily drives imported emissions). It is additionally worthwhile to note, however, that certain industries – particularly those that are capital intensive – will tend to import equipment and other inputs with significant embedded emissions, leading to higher levels of firm (investment) consumption emissions. As a result, industry makeup also plays a role in driving up imported emissions. Correspondingly, provinces with higher levels of exported emissions also tend to have higher levels of imported emissions.

As a more tangible example, we note that the provinces with the highest levels of per capita imported and exported emissions are those with the largest shares of their economies driven by oil and gas production or oil refining.[4] Alberta, Saskatchewan, Newfoundland and Labrador and New Brunswick are the only four provinces with per capita imported emissions in excess of 20.0 tonnes per capita and exported emissions in excess of 18.0 tonnes per capita. In New Brunswick, imported emissions are driven up by the demand for crude oil processed at the Irving Oil refinery. Irving Oil is Canada's largest refinery with a refined petroleum product capacity of 300,000 barrels per day. As New Brunswick has only limited crude oil production, the majority of its feedstock is imported from international sources, leading to high levels of embedded emissions in international imports. Exported emissions are in turn driven up by sale of the refinery's output to other eastern provinces, as well as the northeastern U.S. Alberta, Saskatchewan and Newfoundland and Labrador are the

[4] Specifically, petroleum refining accounted for 3.1 per cent of New Brunswick's GDP and 1.0 per cent of Newfoundland and Labrador's GDP in 2011. In no other province or territory did its contribution exceed 0.7 per cent. Contributions of oil and gas extraction to the GDPs of Alberta, Saskatchewan and Newfoundland and Labrador in 2011 were 24.3 per cent, 15.0 per cent and 27.0 per cent respectively. Contributions of the sector to the other provinces and territories were 9.5 per cent in the Northwest Territories, 3.9 per cent in British Columbia and below 3.0 per cent in the remaining provinces and territories. Source: Statistics Canada (2017)

main oil and gas-producing provinces in the country. As a relatively capital-intensive industry, these provinces also have the highest level of per capita consumption emissions attributable to firm investment. Accordingly, all three provinces have a relatively higher level of emissions embedded in imports to the manufacturing sector while exported emissions are increased by the export of crude oil (all three provinces), natural gas production (Alberta and Saskatchewan) and refined petroleum products (Alberta and Saskatchewan).

Although it is clear that trade in emissions is significant, the exact share of production emissions that are exported from a province is more difficult to pinpoint. This is because the available data do not allow us to distinguish between the export of produced emissions and the re-export of emissions that pass through a province. The import of crude oil and export of gasoline by the Irving Oil refinery in New Brunswick provides a useful example of emissions pass-through. When Irving Oil purchases crude oil from international suppliers, the emissions associated with the production of this crude oil are recorded as imported emissions to New Brunswick. Now let's suppose this crude oil is used to produce gasoline that is subsequently sold at an Irving gas station in Nova Scotia. With the export of the New Brunswick-produced gasoline to Nova Scotia, the emissions associated with the international crude oil production are recorded again as a trade flow; this time as an export from New Brunswick and as an import to Nova Scotia. Note that there is no limit to the number of times that emissions can be passed between jurisdictions and they may also pass in and out of the same jurisdiction more than once. For example, if the Nova Scotia gasoline is purchased by a farmer whose output is sold in New Brunswick, then the emissions associated with the international crude oil extraction would move again from Nova Scotia to New Brunswick.

While the current version of our emissions accounting model does not calculate the share of domestically produced emissions that a province exports, it is possible to modify the model to provide this number. Specifically, the model's current version is unable to distinguish between domestically produced emissions and imported emissions once they enter a value chain together (that is, once they are traded between sectors within the economy of a single region). However, the model can be modified to calculate the quantity of domestically produced emissions that are exported separately from the quantity of embodied emissions that are effectively re-exported (regardless of the movement between sectors within an economy). We intend to undertake this modification in future research. The ability to distinguish between emissions produced within a region and then embodied in exports from those that enter a region and then are exported will significantly aid in our understanding of the potential for carbon leakage (discussed further in the policy implications section below).

Household Consumption Emissions by Sector

From this point forward we focus primarily on household consumption-based emissions. We choose this focus for three reasons. First, with the exception of the territories, households are the largest contributors to consumption-based emissions. Nationally in 2011, for example, households accounted for nearly two-thirds of consumption-based emissions. Second, households are arguably the largest driver of consumption emissions associated with government spending and firm investment. For example, government spending is primarily associated with government services, such as health care and education, which are mainly consumed by households. The data used in our model do not track this value chain, however, as government services are typically provided to households either free of charge or at highly subsidized rates. Similarly, long-term capital investments by firms are typically intended to support the long-term production of primary resources, intermediate inputs or final goods that will be consumed by households. Our model, however, relies on data that represent annual value chains. As a result, capital expenditures are represented as firm investments, and their value is not tracked to household consumption. Last, there is limited overlap between sources of final consumption emissions for households, firms and

government.[5] As a result, a meaningful analysis requires a separate discussion of the emissions for each group. For the reasons just presented, we opt to focus on households in this paper.

We now turn to a discussion of production- and consumption-based household emissions by sector. The largest contributors to production-based emissions in the provinces are generally the following sectors: crude oil extraction, natural gas extraction, other (non-energy) mining, utilities, transportation and warehousing, manufacturing, crop and animal production, personal transportation and residential.[6]

In the extractive resource sectors – crude oil extraction, natural gas extraction and other (non-energy) mining – only a negligible amount of output, if any, is sold to households for final consumption. As a result, household consumption emissions in each of these sectors are generally either zero, or very close to zero. It is important to note, however, that these emissions still show up indirectly in the consumption-based accounts. Specifically, they become a component of the embodied emissions in final production goods for which extractive resources enter into the value chain at some point. For example, in provinces with natural gas power plants, household consumption-based emissions in the utilities sector (from which households purchase electricity) will include the production-based emissions associated with the natural gas that power plants consume.

The utilities, transportation and warehousing, and crop and animal production sectors provide a combination of intermediate inputs and final goods. The majority of output from each sector, however, generally enters the value chain of the economy at an intermediate point. As a result, a substantial proportion of the emissions produced by these sectors shows up indirectly (as emissions embodied in goods produced further down the value chain) rather than directly (as emissions embodied in final production goods produced by these sectors). Emissions in these sectors will therefore generally decline when moving from a production- to a consumption-based accounting approach.

In the utilities sector, for example, the majority of generated electricity is typically sold to commercial or industrial customers. The production emissions associated with this electricity are therefore reallocated to the sectors that purchase it. Household consumption emissions are limited to the production emissions associated with electricity that is sold to residential customers. In the transportation and warehousing sector, any emissions associated with the transport and storage of intermediate inputs or final goods are allocated to the sector (most often manufacturing) that sells the final goods to consumers. Final consumption emissions from the sector are those associated with public transport options including taxis, public transit, and travel by air, rail, ferry and bus. Last, in the crop and animal production sector, the majority of agricultural output is generally sold to the manufacturing sector for further processing and sale to consumers through grocery stores or restaurants. Emissions associated with this output therefore get reallocated to the manufacturing or accommodation and food services sector. The only production emissions from the crop and animal production sector that are counted as household consumption emissions are those associated with the output from smaller farms that sell directly to consumers.

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5 Government consumption emissions are limited to six government-specific sectors that account for all government spending (government education services, government health services, other federal government services, other provincial and territorial government services, other municipal government services and other Aboriginal government services). Firm consumption emissions are primarily associated with capital expenditures in the manufacturing sector (for machinery and equipment) and in the residential, engineering and non-residential building construction sectors. Households also have large consumption emissions associated with the manufacturing sector as many of the physical goods used by households are purchased from this sector. Our value chain data, however, do not show any direct household purchases from the various construction sectors. Household consumption emissions associated with these sectors are therefore zero. Rather, the larger sources of consumption emissions for households are associated with the emissions directly generated by household heating and personal transportation, as well as those coming from expenditures in the utilities, transportation and warehousing, and food and accommodation sectors.

6 Emissions in the residential sector are primarily a result of the combustion of fuels for household heating (most often natural gas or heating oil in a household furnace, boiler, heating stove or fireplace). When household heating is provided via electricity (e.g., electric baseboards) the emissions associated with this consumption are allocated to the utilities sector.

The manufacturing sector also provides a combination of intermediate inputs and final consumption goods. Emissions from this sector, however, almost always increase when moving from a production- to a consumption-based accounting approach. This is largely because the manufacturing sector provides the vast majority of final consumption goods that households purchase, including automobiles, refined petroleum products (motor gasoline and heating oil), clothing and jewelry, home furnishings and electronics, and processed food and beverages. In addition, the sector absorbs the upstream emissions associated with the production of all of the inputs to manufactured goods. Although the sector also produces a large share of intermediate inputs, these are very often inputs to other manufactured products that are final consumption goods. As a result, the emissions associated with this production remain allocated to the manufacturing sector under a consumption-based approach.

Although there is a significant difference in consumption- and production-based emissions for most sectors, there is also a large component of provincial and territorial emissions accounts that remain unchanged between the two approaches. Specifically, emissions produced in the personal transportation and residential sectors are all a direct result of household consumption within a region. That is, the emissions produced from burning a litre of gasoline in a personal vehicle are the result of a motorist purchasing a litre of gasoline and consuming it by driving his/her vehicle. Similarly, the emissions produced from burning natural gas in a home furnace or stove are the result of a household purchasing the natural gas and consuming it by heating their home or preparing a meal. Since the physical production, and the act of consumption which compels this production, occur by definition by the same individual (household) and within the same region, provincial and territorial production emissions are identical to provincial and territorial consumption emissions for these categories.[7]

The largest sectors contributing to household consumption-based emissions in the provinces and territories are manufacturing, personal transportation, residential, transportation and warehousing, accommodation and food services, and utilities (Figure 6). Unsurprisingly, these are all sectors that either directly produce greenhouse gas emissions through their supply of final consumption goods to consumers (residential, personal transportation, utilities), use inputs with significant production emissions that are allocated to the sector under a consumption-based approach (accommodation and food services), or have a combination of the two (manufacturing, transportation and warehousing).

The utilities sector has the largest variations in household consumption emissions across the provinces and territories, with annual per capita household emissions ranging from 0.1 tonnes (Quebec) to 4.4 tonnes (Nova Scotia). This is reflective of the diverse sources of electricity generation and demand across the provinces. In Quebec, less than 1 per cent of electricity generated within the province came from emitting sources (sources other than renewables and nuclear generation) in 2011.[8] In Nova Scotia, in contrast, the proportion of electricity generated within the province from fossil fuel sources was 84 per cent. The province with the highest share of fossil fuel electricity generation was Alberta at nearly 95 per cent. Alberta's per capita household emissions in the utilities sector are lower than Nova Scotia, however, as Nova Scotia has a higher per capita electricity demand. This is the result of Nova Scotia having a higher share of households that use electricity for household heating (Statistics Canada, 2011).

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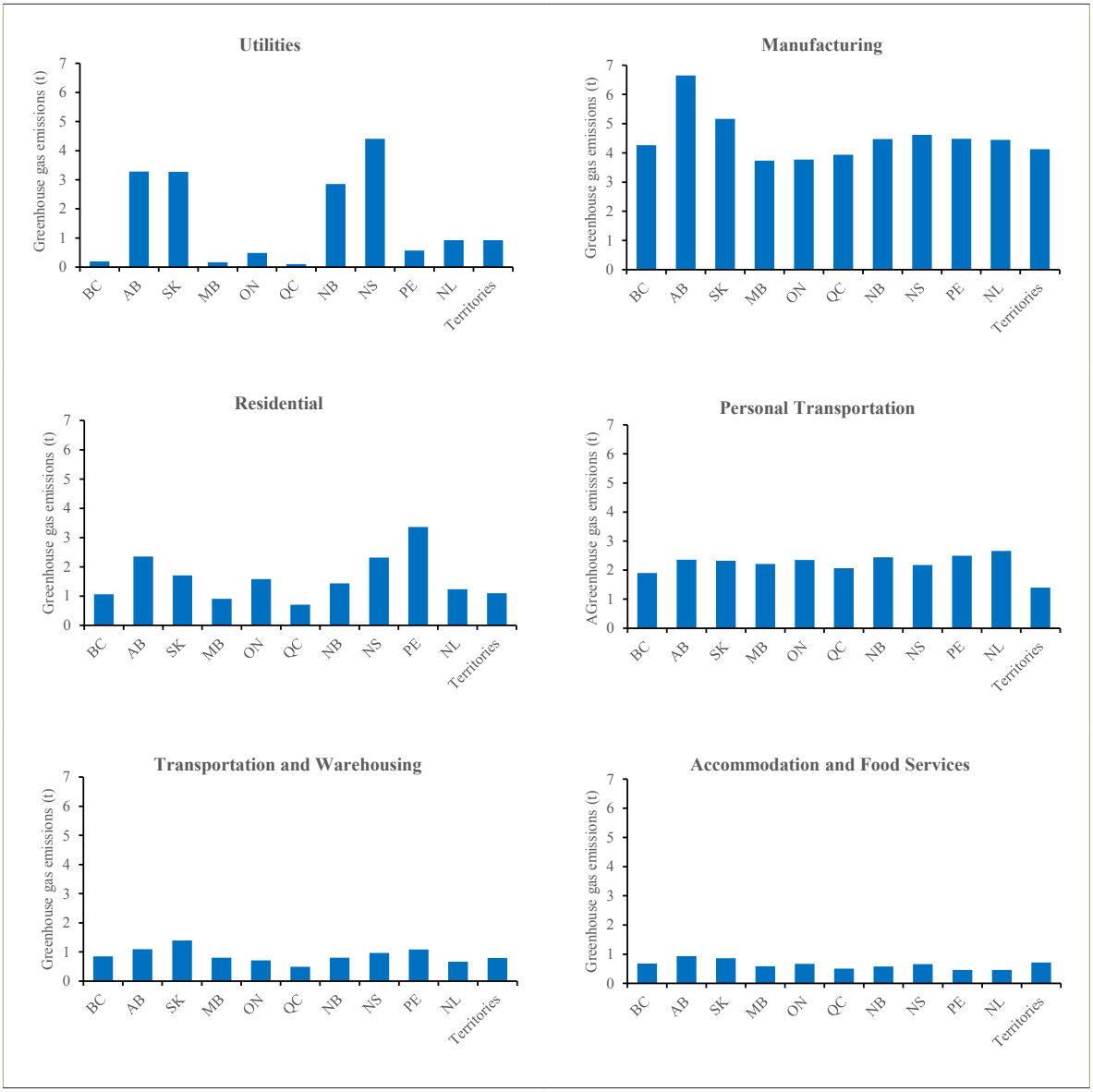
7 The production and consumption emissions in both the personal transportation and residential sectors are only those emissions associated with burning the fuel. Upstream emissions that are a result of the production process for bringing the fuel to market are allocated to the industry sector that sells the fuel to the household. For example, for a litre of gasoline, the emissions from crude oil extraction, pipeline transport of crude oil to a refinery, refining, and transport of motor gasoline to a retail outlet are allocated to the manufacturing sector, which sells the gasoline to the consumer.

8 Author calculations; Source: Statistics Canada (2016a).

FIGURE 6 PER CAPITA CONSUMPTION-BASED HOUSEHOLD EMISSIONS BY SECTOR AND PROVINCE (2011)



With the exception of Nova Scotia, the manufacturing sector is the largest contributor to household consumption emissions in all of the provinces and territories. Alberta has the highest level of per capita emissions, averaging 6.7 tonnes, while per capita emissions in the remaining provinces range from 3.7 tonnes (Manitoba) to 5.2 tonnes (Saskatchewan). Alberta's high level of manufacturing emissions is consistent with the province having a higher average income, and as a result, higher expenditures on consumption goods relative to the other provinces (Statistics Canada, 2016c). Variations in consumption emissions in the remaining provinces can likely be explained by smaller variations in income, as well as – once again – sources of electricity generation. Specifically, the provinces with higher shares of fossil fuel-generated electricity – a key input to manufactured goods – generally have higher consumption-based emissions in the manufacturing sector.

In the residential sector consumption-based emissions range from a low of 0.7 tonnes per capita in Quebec to a high of 3.4 tonnes per capita in Prince Edward Island. As was the case in the utilities sector, this range can be attributed primarily to sources of household heating, which is the main residential use of fossil fuels. In 2011, 85 per cent of households in Quebec used electricity as their primary heat source and an additional seven per cent used wood and wood pellets. The only household heating emissions reported for Quebec are therefore those related to the minority share

of households that use natural gas (three per cent) or oil (eight per cent). In contrast, 76 per cent of households in Prince Edward Island used heavy oil as their primary heating fuel in 2011. All of the emissions from burning the heavy oil are reported as household heating emissions, and the heavy oil is additionally more carbon intensive than natural gas, the primary heating fuel used in most of the remaining provinces.

In the personal transportation, transportation and warehousing, and accommodation and food services sectors, the range of household consumption-based emissions across the provinces and territories is much narrower. Specifically, in the personal transportation sector emissions range from 1.4 (Territories) to 2.7 (Newfoundland and Labrador) tonnes per capita, in the transportation and warehousing sector emissions range from 0.5 (Quebec) to 1.4 (Saskatchewan) tonnes per capita, and in the accommodation and food services sector emissions range from 0.5 (Newfoundland and Labrador) to 0.9 (Alberta) tonnes per capita. It is harder to pinpoint the sources of these differences but they appear to be largely attributable to provincial variations in income, the rural/urban population divide, and sources of electricity generation and heating.

With an understanding of what drives production- and consumption-based emissions, their differences and how consumption-based emissions vary across the provinces we next turn to a discussion of how these patterns can inform Canada's national climate change strategy.

POLICY IMPLICATIONS FOR CANADA'S CLIMATE CHANGE STRATEGY

Canada's current climate change target is benchmarked to the country's production emissions. Although a production-based target is standard for countries worldwide, it ignores the fact that the demand for final goods drives the production of greenhouse gas emissions. Further, this demand is often in a jurisdiction that is geographically distinct from where the greenhouse gas emissions embedded in intermediate inputs are produced. This has important implications for the effectiveness of provincial and national climate change policies that are aimed, respectively, at making a national and global contribution to greenhouse gas emissions reductions.

Using a consumption-based approach to measure Canada's greenhouse gas emissions identifies the emissions that tend to be produced and consumed in the same jurisdiction, and the emissions that tend to be traded both interprovincially and internationally. As a result, it offers a number of insights that can inform the development of Canada's national climate change strategy.

Interprovincial Emissions Trade: A National Carbon Price

The transition from a production- to a consumption-based accounting approach for greenhouse gas emissions highlights the large quantities of emissions that are embedded in traded goods. This points toward the possibility of carbon leakage resulting from unilateral implementation of climate policy.[9] Carbon leakage refers to a scenario in which production shifts from a jurisdiction that has unilaterally implemented a stringent climate policy to one in which there is a weaker policy or none at all. It is largely driven by competitiveness concerns and is a risk in any industry where the output is traded and climate policy increases the producer's cost of supply. In a competitive market it is unlikely the producer will be able to pass these additional costs on to its customer. As a result, the producer must generally face one of three outcomes: 1) lower profits leading to a lower rate of return on investment; 2) relocating its operations to a jurisdiction with weaker climate policy; or 3) shutting down.

[9] The issue of carbon leakage has been widely studied, with a large literature that looks to identify the degree of leakage under various conditions. Estimates vary widely and have been shown to depend on a number of factors including domestic policies to combat leakage and technology spillover effects. A small sampling of this literature includes: Felder and Rutherford (1993), Babiker (2005), Di Maria and van der Werf (2008), Elliot et al., (2010), and Fischer and Fox (2012).

In the event of carbon leakage, emissions reductions in the jurisdiction that implements a stringent climate policy are offset by an increase in emissions elsewhere. The net emissions impact of the climate policy on a national or global scale is therefore reduced. The simplest solution for carbon leakage is to implement a consistent climate policy across jurisdictions. This removes the incentive for firms to relocate, or for production to shift to suppliers in a jurisdiction with weaker climate policy, as the same policy applies regardless of location.

With the introduction of a national carbon price, the federal government has taken a significant step towards implementing a domestically consistent climate policy across Canada. Announced in October 2016, the national carbon price will start at $10 per tonne in 2018 and rise to $50 per tonne in 2022. A key component of the federal plan is giving provinces the flexibility to implement their own pricing systems. If a province opts not to implement a system – or if its system falls short of the minimum standards outlined by the federal government – then a federal backstop system will be implemented instead.

The tradeoff of providing provinces with the flexibility of implementing their own carbon price system is that there may continue to be small differences across provinces in the level of the price and in its coverage.[10] The federal government, however, has still taken a significant step toward ensuring that the large majority of emissions produced in Canada are priced, and is thereby minimizing the risks of interprovincial carbon leakage. Importantly, for emissions embedded in goods and services that are largely confined to the Canadian market (and not exposed to international trade) this increases the likelihood of Canadian consumers receiving a strong carbon price signal[11] and correspondingly adjusting their demand for carbon-intensive goods – regardless of where production or consumption occurs.

International Emissions Trade: Support for Trade-Exposed Producers

As noted in the introduction, a discussion of policies to address the international trade in emissions flows is beyond the scope of this work. Given the magnitude of these flows, however, it is important to recognize how they may impact Canadian industries, as well as Canada's efforts to make a global contribution to reduce greenhouse gas emissions. We therefore offer some brief qualitative comments on this topic.

The large quantities of emissions embedded in international trade indicate a potential for unilateral Canadian climate policy to negatively impact Canadian firms and to result in carbon leakage. These outcomes are most likely to occur when Canadian producers are unable to pass emissions pricing costs onto consumers in export markets. It is worth noting, however, that there are two potential situations in which an emissions pricing cost doesn't get passed through. Both will result in a negative impact on Canadian firms but only one will result in carbon leakage.

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[10] Specifically, the prevailing carbon price in each province will depend on the mechanism that is used to implement the price. For example, with a stand-alone carbon tax the price of emissions will be equal to the tax, which must be at least equal to the minimum federal floor price in each year. With a cap-and-trade program, however, the prevailing price will depend on the results of the auction for emissions permits. With multiple auctions per year, the price may also vary within any given year. There may also be small differences in coverage of the carbon price across the provinces due to different choices regarding exemptions. For example, both Alberta and British Columbia exempt marked fuels used in farming operations from their respective carbon taxes and the federal government has also indicated that its backstop system will provide some form of relief – either an exemption or rebate – to fuel used by registered farmers in certain farming activities (Government of British Columbia, 2017a; Alberta Government, 2017; Environment and Climate Change Canada, 2017). In contrast, Ontario's cap-and-trade program does not provide either an exemption to the fuel used by farmers or carbon credits of any kind (Lynch, 2017).

[11] The carbon price signal refers to the increase in the price of the good that is attributable to the carbon price. A national carbon price increases the likelihood of consumers facing higher prices for carbon-intensive goods as all domestic producers face higher input prices.

The first situation occurs if the export consumer has a very elastic demand for the Canadian product but there are no close substitutes for it. In this case, an increase in its price means that consumers in the export region don't want to buy as much of it anymore. Facing decreased market demand, Canadian producers will likely cut production of the good, causing the associated emissions to fall as well. While this represents a loss to Canadian producers (since production and, therefore, overall economic activity have fallen) it does not represent carbon leakage as international consumers have not substituted a good that is produced elsewhere. The overall global reduction in emissions is therefore of similar magnitude to the reduction in emissions in Canada.

The second situation occurs if the export consumer again has elastic demand for the Canadian product but additionally has access to similar products that are produced either in their own region (assuming they do not also price emissions) or from another region that doesn't price emissions. In this case, carbon pricing raises the cost of the Canadian product, but the export consumer simply switches to a variant produced without carbon pricing in some other region. This represents the same economic detriment to Canada as the first scenario (production and overall economic activity have fallen). Additionally, since the good is still being produced and consumed in other regions, there may be no overall global reduction in emissions. Production and emissions will simply relocate to jurisdictions where there is no carbon price.

The desire to maintain Canadian firms' competitiveness in the international market, as well as the potential for carbon leakage, provide an argument for introducing policies to decrease the burden of a national carbon price on Canada's trade-exposed industries. Although the exact details have not yet been announced, the federal government has indicated that its federal backstop will include an output-based pricing system for industrial facilities that will maintain the carbon price's incentive while minimizing competitiveness and carbon leakage risks (Environment and Climate Change Canada, 2017). Alberta is similarly planning to introduce output-based allocations to supplement its carbon tax while both Ontario and Quebec are providing a portion of permits in their cap-and-trade programs to market participants at zero cost (Alberta Government, 2017; Ontario Ministry of the Environment and Climate Change, 2017; Gouvernement du Québec, 2014). Credits against the carbon price are fewer in British Columbia, although commercial greenhouse growers are eligible to apply to receive up to an 80 per cent rebate on carbon taxes paid (Government of British Columbia, 2017b). Additionally, unlike the pricing systems in Alberta, Quebec and Ontario, British Columbia's carbon tax currently does not apply to non-combustion emissions from industrial facilities.

Last, it is also worth noting that international trade in emissions and carbon leakage has the potential to impact Canadian producers not only in the international market, but also domestically. Notably, this means that a decrease in Canada's production emissions may not translate into a decrease in consumption emissions. For example, suppose that a Canadian manufacturer raises the price of its output as a result of cost increases attributable to the carbon price. If an international competitor is able to supply a similar good at a lower price, then Canadian consumers are likely to substitute toward the international product. A decrease in demand for the Canadian manufacturer's output will likely lead to a contraction of its operations and a corresponding decline in its production emissions. This in turn will lead to a decline in Canada's total production emissions. The change in Canada's consumption emissions, however, will depend on the emissions intensity of Canadian production in comparison to its international competition. If the Canadian and international producer have the same emissions intensity, then consumption emissions are unlikely to change by a significant amount (as consumption has not substantially changed). Alternatively, if the international producer has a lower emissions intensity, then consumption emissions will decrease (but by a lower amount than the decrease in production emissions), while if the international producer has a higher emissions intensity, then consumption emissions will increase.

The potential for a national carbon price to result in substitution in the Canadian market from domestic to international suppliers provides a strong argument for monitoring the effectiveness of

Canada's climate policies through the measurement of both production and consumption emissions. If Canada's consumption emissions are holding steady while production emissions are declining, then it suggests further policies may be required to provide support to Canadian firms and to ensure that Canada is making a global contribution to emissions reductions.

Complementary Policies Targeting Domestic Emissions

As noted earlier, the national carbon price being introduced by the federal government is an important first step toward achieving a domestically consistent national climate policy. At its currently proposed minimum levels (starting at $10 per tonne in 2018 and rising to $50 per tonne in 2023), however, the price alone is unlikely to be sufficient for Canada to reach its national climate target (Sawyer and Bataille, 2016). As a result, both federal and provincial governments are introducing complementary policies that target reductions from specific emissions sources.

The potential for international carbon leakage in sectors with significant trade in emissions suggests that the largest reductions in global greenhouse gas emissions are likely to be achieved by focusing complementary climate policies on industries where the emissions are largely produced and embedded in goods that are consumed in Canada.[12] Of the high production emission sectors in Canada – crude oil extraction, natural gas extraction, manufacturing, transportation and warehousing, utilities, crop and animal production, and other (non-energy) mining – the utilities sector has the largest differential between total embodied emissions (direct and upstream), and exports of emissions. Specifically, in Canada in 2011, our model estimates the utilities sector had total embodied (direct and upstream) emissions of 95.7 Mt. International exports from the sector totalled only 1.8 Mt in 2011, accounting for less than two per cent of total embodied emissions. In stark contrast, the estimate for embodied emissions in the crude oil extraction sector is 107.0 Mt in 2011, with international exports in the same year totalling 81.3 Mt. This corresponds to an export share of 76 per cent of embodied emissions.

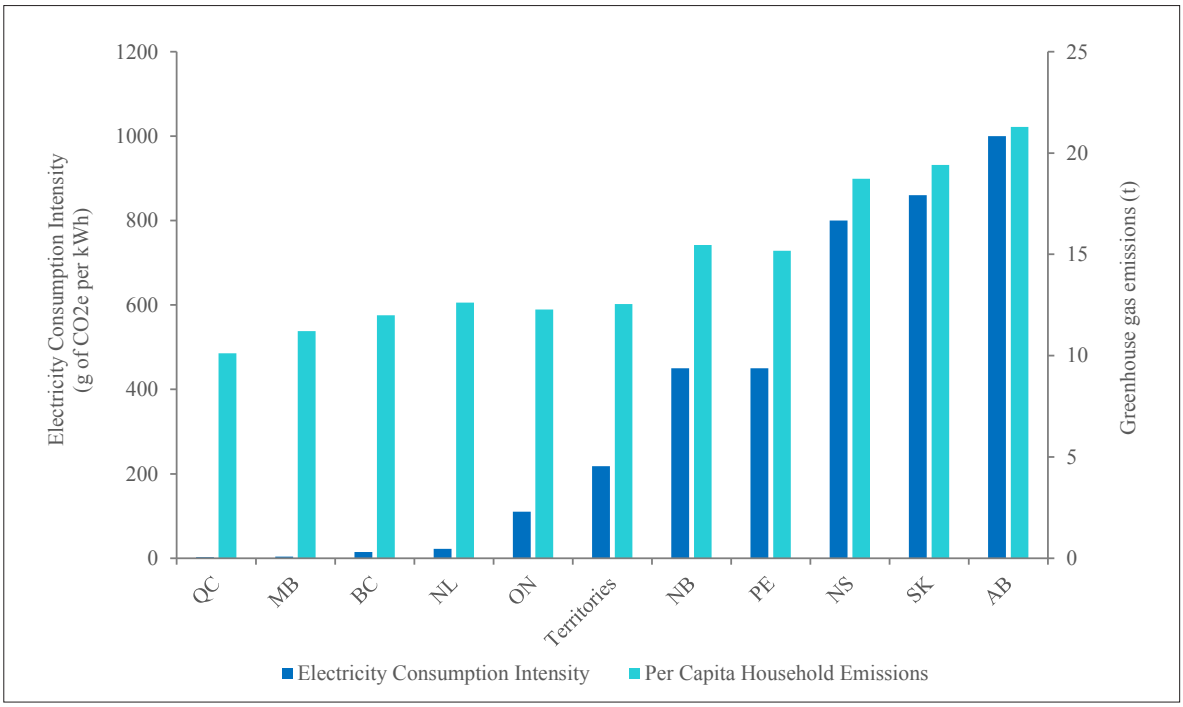
It is worth noting that a portion of the remaining production emissions in both sectors will also be exported via other goods. For example, any manufactured goods produced in Alberta and exported to the United States will contain embodied emissions from Alberta's utilities sector. In considering the remaining sectors in Canada with high production emissions, however, every other sector directly exported at least 30 per cent of its embodied emissions in 2011. This suggests that the utilities sector is likely to have the greatest share of its production emissions either directly consumed in Canada, or embedded in goods and services that are consumed in Canada.

The federal government took a large step towards achieving emissions reductions in the utilities sector through the announcement of its goal to virtually eliminate coal from Canada's electricity mix by 2030. Looking at the profile of provincial consumption emissions provides further support for the development of a national climate change strategy that supports the provinces in achieving emissions reductions in the utilities sector. First, as noted earlier, emissions attributable to the utilities sector are the largest single source of variation in per capita household consumption emissions across the provinces. The impact of the utilities sector on each province's emissions profile, however, extends beyond this single measure. Specifically, electricity is an essential input to every sector that supplies goods or services to households. A sector operating in a province with a higher carbon intensity of electricity generation will therefore have higher embedded carbon emissions in all of the goods and services it sells to consumers. As a result, provinces with cleaner electricity grids tend to have consistently lower levels of per capita emissions across virtually all sectors, and thereby lower levels of household consumption emissions overall (Figure 7).

[12] Our objective in this section is primarily to identify the sectors that are best targeted by complementary policies and to provide examples of policies that could be introduced. For a more in-depth discussion on how to evaluate and define specific policies that best complement a national carbon price, see Ecofiscal Commission (2017).

Other supplementary measures that can be implemented to achieve emissions reductions in the utilities sector include a regulated improvement in the emissions intensity of fossil fuel-generation plants, greenhouse gas emissions caps for the electricity industry, implementing carbon capture-and-storage projects, introducing more zero emissions intensity generation technology which could include both renewable energy options as well as nuclear power, and providing incentives for residential, commercial and industrial adoption of energy efficiency technologies. Examples of all of these measures exist in current provincial and federal climate change policies. A national climate change strategy that provides support for further pursuit of these measures is likely to have a large impact on reducing Canada's global greenhouse gas footprint.[13]

FIGURE 7 ELECTRICITY CONSUMPTION INTENSITY AND PER CAPITA HOUSEHOLD CONSUMPTION EMISSIONS BY PROVINCE (2011)



Source: Environment and Climate Change Canada (2016) and author results.

Note: The above graph shows the carbon intensity of electricity consumption in each province. This value is less than 10 grams of CO_2e per kWh in Quebec and Manitoba and therefore appears on the graph as effectively zero. The provinces have been ordered on the figure from lowest to highest carbon intensity of electricity consumption in order to highlight the general trend of household consumption emissions increasing with the carbon intensity of electricity generation in a province. Data on the carbon intensity of electricity consumption are taken from Part 3 of Canada's 2016 National Inventory Report (NIR) (Environment and Climate Change Canada, 2016). The intensity number we use for Prince Edward Island is the same as the number for New Brunswick, as per the NIR noting this number is more appropriate due to Prince Edward Island's high level of electricity imports from New Brunswick.

[13] As with any sector, there are limitations to the emissions reductions that can be achieved in the utilities sector. Most notably, with the exception of Ontario that has significant nuclear power, provinces with the lowest carbon intensity of electricity generation typically derive the majority of their power from hydro resources. In contrast, the provinces that are most reliant on fossil fuel generation do not have the resources for significant hydroelectric power. As a result, although it is reasonable to expect these provinces can increase the share of renewable electricity in their grids, fossil fuel generation will still be required for baseload power. These provinces will therefore be unable to reach similarly low levels of electricity generation emissions intensity unless technologies such as carbon capture and storage are also introduced. Nuclear power is also an option for zero emissions intensity baseload power. The refurbishment of existing nuclear power in Ontario, for example, helped the province complete its transition off of coal-fired electricity in 2014. However, there appears to be very limited interest in the development of new nuclear power in any of the remaining provinces that are looking to transition off of, or reduce their emissions from coal.

The remaining sectors with significant contributions to production and household consumption emissions across all of the provinces are manufacturing, household heating and personal transportation. The manufacturing sector is the largest source of household consumption-based emissions in all of the provinces except Nova Scotia where it is the second largest source (falling just behind utilities). Emissions trade in the manufacturing sector, however, is immense. Our model estimates total embodied emissions in the manufacturing sector of 442.0 Mt in 2011. International imports into the sector are estimated at 323.3 Mt and international exports are estimated at 195.0 Mt. These numbers may include both re-export and re-import of emissions, making it difficult to pinpoint the exact quantity of domestic manufacturing emissions that are exported or international manufacturing emissions that are imported. However, even without knowing the exact amount of repeat trade, the emissions flows are substantial enough to suggest that the embedded emissions in a large share of household consumption goods are likely a combination of domestic and international emissions (with the exact proportions varying depending on the good).

As was the case with the carbon price, complementary climate policies applied to Canadian manufacturers may have a negative competitiveness impact and create the conditions for carbon leakage. As a result, rather than having complementary policies that target additional emissions reductions, this creates an incentive for the use of mechanisms such as the earlier noted output-based allocations and free carbon permits. These mechanisms maintain the emissions reduction incentive of the carbon price while also reducing its burden on trade-exposed industries. A second option is to introduce complementary policies that target international emissions. These are difficult to implement, however, as they require controversial mechanisms such as a border tax adjustment, the legality of which is disputed under World Trade Organization (WTO) law.[14]

In contrast, household consumption emissions in the residential and personal transportation sectors measure the emissions that are produced when fuel – typically natural gas, heating oil, diesel or gasoline – is combusted for household or transportation purposes. As noted earlier, production emissions are therefore the same as consumption emissions. Additionally, as the emissions are the result of end-use consumption, there is no trade. Both sectors are therefore a good target for emissions reductions. In the short to medium term, residential emissions can be reduced through energy efficiency measures and green building standards, while personal transportation emissions can be reduced though investment in public transit, road congestion reduction measures, fuel efficiency standards, and city and neighbourhood planning that supports low or zero emission modes of transport. In the longer term, recent research on decarbonization in Canada through to 2030 and beyond has shown the greatest opportunity for emissions reductions in both sectors is through a decarbonized electricity grid, and policies that support electrification of household heating requirements (space and water) and personal vehicles.[15] This provides further support for including in Canada's national climate change strategy supplemental policies that prioritize achieving emissions reductions in the near term in the utilities sector.

BURDEN SHARING

Canada's current climate change target is a reduction in emissions of 17 per cent below 2005 levels by 2020 and 30 per cent below 2005 levels by 2030. A key policy question that has received increasing interest in recent years is how the burden of meeting Canada's national target should be divided among the provinces. This question is most commonly looked at from the perspective of how much each of the provinces and territories should be allowed to emit in the years for which Canada has an explicit target.

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[14] For more information on border tax adjustments and WTO law, see Trachtman (2016), Weber (2015) and Pauwelyn (2012).

[15] See for example: 1) Trottier Energy Futures Project (2016), and 2) Bataille et al., (2015).

Two mechanisms commonly discussed for burden sharing are the egalitarian approach and the historical production approach.[16] Under the egalitarian approach each province is allocated a share of national emissions in the target year that is equivalent to its share of the national population. Under the historical production approach each province is allocated a share of national emissions in the target year that is based on its share of national production emissions in an earlier year.

Previous work on burden sharing (Böhringer et al., 2015; Boothe and Boudreault, 2016) has highlighted that emissions allocations according to the egalitarian and historical approaches each favour a different group of provinces. This is largely because of the wide spread in production emissions across the provinces (as highlighted above), which in turn is largely a result of Canada's diverse allocation of natural resources. Provinces with significant hydroelectric resources, for example, are predisposed to having lower emissions. As a result, they will be relatively more advantaged by the egalitarian approach, in which emissions are assigned independently of historical production (that is, they do not receive a lower allocation on account of having lower historical emissions). Provinces with significant oil and gas resources will tend to be advantaged by the historical production approach, which provides these provinces with a higher allocation of emissions on account of their higher historical emissions. These observations motivate a key conclusion from previous work – that a hybrid approach to burden sharing will likely be required in order to gain the support of all of the provinces.

Looking at provincial emissions from a consumption-based perspective highlights some of the downsides of using either the egalitarian or historical emissions approach in isolation and can also provide guidance in developing a hybrid approach. An emissions allocation that is assigned based only on population shares ignores trade in emissions, and the fact that production emissions in one region of the country will often support consumption in another region. We can again turn to the oil and gas-producing provinces as an example here. Given that a share of production from these provinces is exported to other provinces for consumption, there is a strong argument for providing them with additional emissions allocations above and beyond what they would receive under an egalitarian approach to burden sharing.

Alternatively, an emissions allocation that is assigned based only on historical emissions shares ignores the fact that – for emissions that are largely not traded – high production emissions in a province will translate into high consumption emissions. This in turn implies greater opportunities for emissions reductions in these provinces. Here we can again turn to electricity as an example. It is unreasonable to expect that a province with a relatively clean electricity grid will be able to achieve the same emissions reductions as a province with an electricity grid that relies primarily on fossil fuel generation. In this case there is a strong argument for providing a relatively equal allocation in emissions permits across provinces, which results in provinces with high-emitting electricity sources receiving fewer emissions allocations than they would receive under an historical emissions approach to burden sharing.

Viewing burden sharing through the lens of consumption-based emissions effectively advocates for an approach that provides provinces with an equal right to consumption emissions but which accounts for the location of production emissions when allocating emissions permits. This can be

[16] Both of these approaches are discussed in recent papers on burden sharing by Böhringer et al., (2015) and by Boothe and Boudreault (2016). The Böhringer et al. paper additionally considers an ability-to-pay approach that allocates emissions in reverse proportion to per capita income (that is, a higher per capita income implies a province receives fewer emissions permits), as well as three approaches that require a computational model that allocates emissions permits based on ex-post criteria (equal welfare losses across the provinces, minimizing costs, and minimizing costs to the poorest regions). The Boothe and Boudreault paper additionally considers an efficiency approach which is again an ex-post criterion that is the allocation resulting from a common carbon price coupled with interprovincial permit transfers. We opt to discuss only the egalitarian and historical production approaches as these are the two approaches that overlap between both papers. Additionally, the ability-to-pay approach is very similar to the historical production approach (so does not offer additional insight) while meaningful discussion of any of the ex-post allocations would require further computation that is outside the scope of this paper.

implemented through a number of different approaches. One option is to start with an egalitarian allocation and then redistribute permits based on trade patterns. A second, and likely more straightforward option, is to allocate emissions based on the egalitarian approach in sectors for which there is limited trade (most notably utilities, personal transportation and household heating) and then to use the historical production approach to allocate emissions in sectors that have greater trade exposure. This option is consistent with our discussion in the preceding policy implications section, as an egalitarian approach to emissions allocations in sectors with limited trade will likely result in these sectors being targeted for the largest emissions reductions.

CONCLUSIONS

The production of greenhouse gas emissions is ultimately driven by the demand for the final goods and services that embody these emissions. Looking at Canada's emissions profile using a consumption-based accounting approach therefore provides important insights that can inform the development of Canada's national climate change policy. Notably, the consumption-based approach reveals that the differences in greenhouse gas emissions profiles across provinces are much less stark than the standard production-based approach suggests. Alberta and Saskatchewan still have the highest level of per capita emissions, but the gap to the remaining provinces narrows significantly. This reflects the fact that Canadian households – regardless of where they are located – tend to have similar consumption patterns.

The similarity of Canadian consumption patterns across the country is enabled by large amounts of interprovincial and international trade. This presents a significant challenge for climate change policy, however, as policy that is implemented in one jurisdiction and not another can result in carbon leakage and negative competitiveness impacts, while having limited effect on the final demand for carbon-intensive goods and services. Within Canada this challenge is best addressed by a unified national climate policy. This provides a strong argument in favour of the national carbon price announced by the federal government in fall 2016.

The sectors that are the largest contributors to household consumption-based emissions in Canada are manufacturing, personal transportation, residential, and – in the subset of provinces that rely primarily on fossil fuel-generated electricity – utilities. Correspondingly, differences in per capita consumption-based emissions across the provinces can largely be explained by the emissions intensity of each province's utilities sector. As trade in the utilities sector is limited, a significant share of production emissions support local (within province) consumption of final goods and services. As a result, a reduction in production emissions from the utilities sector will drive a direct reduction in provincial consumption emissions. This suggests that federal regulation and incentives that drive provinces to transition towards cleaner sources of electricity generation should be a key focus for national climate change policy. A similar opportunity exists for emissions reductions in the personal transportation and residential sectors for which, by definition, there is no trade. In contrast, the manufacturing sector has the largest amounts of emissions embedded in international trade flows. As a result, complementary policies in this sector are best focused on minimizing the negative competitive impacts of a carbon price while also maintaining the incentive for Canadian firms to invest in emissions reductions.

A consumption-based approach also provides insights on burden sharing to meet Canada's national emissions reduction target. It suggests the highest burden should fall on those provinces and sectors where the greatest emissions reductions can be achieved. That is, provinces with high per capita consumption emissions in sectors – most notably utilities – for which there is limited trade. In contrast, provinces with high per capita production emissions in sectors with significant trade flows should not be unduly penalized with a reduction target that fails to reflect that a large share of emissions produced in the province are in support of consumption outside of the province.

Looking at emissions from a consumption-based approach is a reminder to policy-makers that where greenhouse gas emissions are effectively demanded is just as important as where the greenhouse gas emissions are produced. In turn, focusing on achieving emissions reductions in sectors where the greenhouse gas emissions are produced and consumed in Canada provides the greatest opportunity for the country to take unilateral action that makes a global contribution to addressing climate change.

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APPENDIX

The tables in the appendix give a more detailed breakdown of Canada's national and provincial consumption- and production-based emissions by sector. In the following tables the consumption-based total is calculated as the aggregate value of emissions embodied in household consumption, government spending and firm investment. Net international exports are calculated as international exports less international imports. Net interprovincial exports are similarly calculated as interprovincial exports less interprovincial imports.

The production-based totals indicated here, and used throughout the paper, are the sum of emissions produced by sector as indicated by: 1) Statistics Canada (2016b), CANSIM Table 153-0114, "Physical flow account for greenhouse gas emissions" and 2) Environment and Climate Change Canada (2016), "National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada: The Canadian Government's Submission to the UN Framework Convention on Climate Change." Minister of the Environment, Government of Canada, Ottawa, ON. The full methodology used in calculating these totals is described in: Fellows, G. Kent and Sarah Dobson. 2017. "Embodied Emissions in Inputs and Outputs, A 'Value Added' Approach to National Emissions Accounting," *Canadian Public Policy*, 43(2): 140-164.

CONSUMPTION AND PRODUCTION ACCOUNTS BY SECTOR (KILOTONNES OF CO_2E): CANADA

Sector	Household Consumption	Government Spending	Firms (for Investment)	Consumption-Based Total	Net International Exports	Production-Based Total
Crop and Animal Production	17,393	-	1,276	18,669	11,960	68,720
Forestry and Logging	477	-	69	547	-554	1,452
Fishing, Hunting and Trapping	352	-	55	406	-328	712
Support Activities for Agriculture and Forestry	9	-	12	21	30	881
Coal Mining	0	-	89	89	2,615	2,429
Crude Oil Extraction	-	-	3	3	67,235	85,486
Natural Gas Extraction	3,824	-	10,114	13,938	14,835	49,884
Other (non-energy) Mining	45	-	777	821	-6,325	6,356
Support activities for oil and gas extraction and mining	8	-	1,723	1,731	-347	6,391
Utilities	31,282	-	742	32,023	-1,600	87,947
Residential Construction	-	-	29,624	29,624	-	1,289
Non-Residential Building Construction	-	-	13,734	13,734	-	470
Engineering Construction	-	-	46,726	46,726	-	4,381
Repair Construction	82	-	-	82	-	670
Other activities of the construction industry	112	-	113	225	-78	1,021
Manufacturing	147,220	-	64,909	212,128	-128,328	105,796
Wholesale Trade	6,173	-	-	6,173	16,216	11,965
Retail Trade	7,549	-	593	8,142	316	7,175
Transportation and Warehousing	25,978	-	377	26,354	16,236	67,175
Information and Cultural Industries	5,190	-	780	5,971	1,080	1,400
Finance, Insurance, Real Estate and Associated	18,761	-	2,575	21,336	-477	9,426
Owner-occupied Dwellings	9,740	-	0	9,740	-	6,282
Professional, Scientific and Technical Services	718	-	2,216	2,935	1,753	1,924
Administrative, Waste Management, Remediation Services	899	-	119	1,018	1,127	6,143
Educational Services	430	-	6	437	70	247
Health Care and Social Assistance	3,728	-	21	3,749	-20	2,025
Arts, Entertainment and Recreation	4,545	-	29	4,574	183	268
Accommodation and Food Services	22,653	-	15	22,668	-9,399	1,875
Other Services (Except Public Administration)	6,002	-	31	6,033	-132	3,226
Non-profit institutions serving households	9,969	-	33	10,002	36	3,370
Government education services	1,618	11,283	1,307	14,207	127	4,150
Government health services	831	10,379	44	11,255	42	1,181
Other federal government services	194	11,051	550	11,795	151	3,229
Other provincial and territorial government services	489	21,218	187	21,895	65	1,690
Other municipal government services	2,303	15,118	84	17,505	97	8,473
Other Aboriginal government services	27	2,147	1	2,175	-	257

* Totals exclude emissions caused at the point of consumption. (For example, emissions associated with the combustion of transportation fuel for personal use and home heating).

CONSUMPTION AND PRODUCTION ACCOUNTS BY SECTOR (KILOTONNES OF CO_2E): BRITISH COLUMBIA

Sector	Household Consumption	Government Spending	Firms (for Investment)	Consumption-Based Total	Net Interprovincial Exports	Net International Exports	Production-Based Total
Crop and Animal Production	2,218	-	66	2,284	211	-1,674	2,859
Forestry and Logging	25	-	2	26	65	-63	286
Fishing, Hunting and Trapping	34	-	3	38	24	-24	97
Support Activities for Agriculture and Forestry	1	-	1	2	78	14	251
Coal Mining	0	-	12	12	-42	2,844	1,998
Crude Oil Extraction	-	-	-	-	-225	272	570
Natural Gas Extraction	635	-	1,915	2,550	1,857	2,573	11,292
Other (non-energy) Mining	9	-	255	263	0	37	-
Support activities for oil and gas extraction and mining	1	-	227	228	-132	-45	281
Utilities	864	-	16	880	-205	-946	401
Residential Construction	-	-	4,073	4,073	-	-	204
Non-Residential Building Construction	-	-	1,455	1,455	-	-	52
Engineering Construction	-	-	4,820	4,820	-	-	29
Repair Construction	13	-	-	13	-	-	84
Other activities of the construction industry	13	-	8	21	-10	-13	117
Manufacturing	19,193	-	5,814	25,007	-6,826	-24,891	7,334
Wholesale Trade	669	-	-	669	-52	903	1,034
Retail Trade	827	-	74	902	76	68	999
Transportation and Warehousing	3,800	-	42	3,842	1,611	4,106	11,313
Information and Cultural Industries	674	-	92	766	-86	170	193
Finance, Insurance, Real Estate and Associated	2,716	-	425	3,141	-507	-81	1,293
Owner-occupied Dwellings	1,707	-	-	1707	-	-	1,237
Professional, Scientific and Technical Services	111	-	277	388	-30	276	232
Administrative, Waste Management, Remediation Services	119	-	12	131	-134	126	661
Educational Services	92	-	1	93	2	21	48
Health Care and Social Assistance	502	-	3	505	-22	-3	267
Arts, Entertainment and Recreation	680	-	5	684	86	44	43
Accommodation and Food Services	3,069	-	2	3071	386	-1,243	309
Other Services (Except Public Administration)	785	-	3	788	85	-7	449
Non-profit institutions serving households	1,250	-	4	1,254	2	7	445
Government education services	196	1,036	123	1,354	-20	21	492
Government health services	95	1,051	1	1,147	14	6	123
Other federal government services	37	935	20	991	-10	11	304
Other provincial and territorial government services	75	2,968	18	3,061	5	12	235
Other municipal government services	257	1,243	7	1,507	-4	11	1,005
Other Aboriginal government services	0	174	0	174	-0	-	39

* Totals exclude emissions caused at the point of consumption. (For example, emissions associated with the combustion of transportation fuel for personal use and home heating).

CONSUMPTION AND PRODUCTION ACCOUNTS BY SECTOR (KILOTONNES OF CO_2E): ALBERTA

Sector	Household Consumption	Government Spending	Firms (for Investment)	Consumption-Based Total	Net Interprovincial Exports	Net International Exports	Production-Based Total
Crop and Animal Production	3,093	-	796	3,889	-471	8,095	20,479
Forestry and Logging	36	-	27	63	-144	-84	139
Fishing, Hunting and Trapping	22	-	0	22	-25	-18	1
Support Activities for Agriculture and Forestry	2	-	2	3	-43	23	103
Coal Mining	0	-	41	41	47	564	-
Crude Oil Extraction	-	-	-	-	8,192	62,769	68,473
Natural Gas Extraction	999	-	4,556	5,555	5,237	14.709	33,754
Other (non-energy) Mining	2	-	106	108	294	-206	-
Support activities for oil and gas extraction and mining	2	-	818	821	1,083	0	4,352
Utilities	12,445	-	450	12,895	374	-56	44,999
Residential Construction	-	-	5,374	5,374	-	-	170
Non-Residential Building Construction	-	-	3,245	3,245	-	-	69
Engineering Construction	-	-	23,736	23,736	-	-	820
Repair Construction	19	-	-	19	-	-	78
Other activities of the construction industry	49	-	39	89	6	-1	255
Manufacturing	25,219	-	16,060	41,280	3,057	-22,988	23,100
Wholesale Trade	1,242	-	-	1,242	226	1,907	1,848
Retail Trade	1,241	-	48	1,289	273	76	1,043
Transportation and Warehousing	4,142	-	98	4,240	-256	5,591	12,200
Information and Cultural Industries	702	-	136	838	-140	53	184
Finance, Insurance, Real Estate and Associated	3,463	-	433	3,897	-585	-113	1,173
Owner-occupied Dwellings	1,608	-	-	1,608	-	-	913
Professional, Scientific and Technical Services	143	-	357	500	74	167	316
Administrative, Waste Management, Remediation Services	125	-	18	143	-191	9	898
Educational Services	88	-	1	90	-18	-1	29
Health Care and Social Assistance	543	-	2	545	-10	-3	260
Arts, Entertainment and Recreation	649	-	1	650	-45	23	28
Accommodation and Food Services	3,535	-	2	3,537	284	-758	310
Other Services (Except Public Administration)	893	-	6	898	410	-14	594
Non-profit institutions serving households	1,496	-	3	1,499	-2	4	338
Government education services	249	1,883	192	2,324	19	17	502
Government health services	143	1,640	27	1,810	-10	0	145
Other federal government services	36	1,166	30	1,232	-10	0	208
Other provincial and territorial government services	90	4,094	52	4,237	-13	3	210
Other municipal government services	525	2,864	27	3,415	58	10	1,184
Other Aboriginal government services	20	602	0	622	0	-	34

* Totals exclude emissions caused at the point of consumption. (For example, emissions associated with the combustion of transportation fuel for personal use and home heating).

CONSUMPTION AND PRODUCTION ACCOUNTS BY SECTOR (KILOTONNES OF CO_2E): SASKATCHEWAN

Sector	Household Consumption	Government Spending	Firms (for Investment)	Consumption-Based Total	Net Interprovincial Exports	Net International Exports	Production-Based Total
Crop and Animal Production	573	-	-	573	2,667	11,169	14,356
Forestry and Logging	4	-	1	4	57	2	16
Fishing, Hunting and Trapping	3	-	0	4	-4	1	2
Support Activities for Agriculture and Forestry	1	-	0	1	-7	3	41
Coal Mining	0	-	7	7	94	-0	431
Crude Oil Extraction	-	-	-	-	-282	14,887	14,428
Natural Gas Extraction	190	-	1,065	1,255	-1,214	-3	3,666
Other (non-energy) Mining	2	-	109	111	-2	3,827	1,312
Support activities for oil and gas extraction and mining	1	-	250	251	-94	-78	-
Utilities	3,486	-	18	3,504	362	-103	14,048
Residential Construction	-	-	1,242	1,242	-	-	39
Non-Residential Building Construction	-	-	677	677	-	-	18
Engineering Construction	-	-	4,755	4,755	-	-	487
Repair Construction	3	-	-	3	-	-	27
Other activities of the construction industry	2	-	2	4	-9	-4	17
Manufacturing	5,504	-	3,069	8,573	-141	-5,678	2,815
Wholesale Trade	269	-	-	269	-14	1,339	479
Retail Trade	517	-	-	517	47	10	243
Transportation and Warehousing	1,490	-	12	1,502	221	5,044	10,600
Information and Cultural Industries	226	-	24	250	-70	14	30
Finance, Insurance, Real Estate and Associated	969	-	140	1,109	-221	-16	217
Owner-occupied Dwellings	374	-	-	374	-	-	217
Professional, Scientific and Technical Services	26	-	68	95	-286	-12	35
Administrative, Waste Management, Remediation Services	26	-	2	28	-126	13	103
Educational Services	7	-	0	7	-11	-5	4
Health Care and Social Assistance	190	-	1	191	30	-0	45
Arts, Entertainment and Recreation	310	-	1	311	-9	10	8
Accommodation and Food Services	915	-	0	915	35	-202	59
Other Services (Except Public Administration)	306	-	1	307	19	-3	102
Non-profit institutions serving households	525	-	1	526	0	3	85
Government education services	130	1,267	95	1,491	4	6	142
Government health services	62	693	0	755	-8	0	53
Other federal government services	21	406	19	447	-1	1	70
Other provincial and territorial government services	56	1,245	9	1,311	4	3	74
Other municipal government services	207	1,232	7	1,446	0	5	231
Other Aboriginal government services	0	445	0	446	-0	-	29

* Totals exclude emissions caused at the point of consumption. (For example, emissions associated with the combustion of transportation fuel for personal use and home heating).

CONSUMPTION AND PRODUCTION ACCOUNTS BY SECTOR (KILOTONNES OF CO_2E): MANITOBA

Sector	Household Consumption	Government Spending	Firms (for Investment)	Consumption-Based Total	Net Interprovincial Exports	Net International Exports	Production-Based Total
Crop and Animal Production	597	-	-	597	910	2,670	6,199
Forestry and Logging	8	-	-	8	-18	-3	2
Fishing, Hunting and Trapping	4	-	-	4	-14	9	5
Support Activities for Agriculture and Forestry	1	-	0	1	2	31	25
Coal Mining	0	-	4	4	-69	-95	-
Crude Oil Extraction	-	-	-	-	198	157	274
Natural Gas Extraction	126	-	273	399	-757	-211	64
Other (non- energy) Mining	1	-	21	22	-2	1	346
Support activities for oil and gas extraction and mining	0	-	41	41	-16	-7	-
Utilities	200	-	5	205	-103	-51	151
Residential Construction	-	-	875	875	-	-	34
Non-Residential Building Construction	-	-	480	480	-	-	11
Engineering Construction	-	-	1,346	1,346	-	-	158
Repair Construction	2	-	-	2	-	-	25
Other activities of the construction industry	3	-	1	4	6	-2	33
Manufacturing	4,608	-	1,560	6,168	-3,007	-3,076	1,671
Wholesale Trade	194	-	-	194	-77	454	376
Retail Trade	324	-	18	342	-253	2	243
Transportation and Warehousing	993	-	7	1,000	685	1,126	3,672
Information and Cultural Industries	150	-	14	164	-29	14	43
Finance, Insurance, Real Estate and Associated	538	-	72	610	-124	-9	254
Owner-occupied Dwellings	334	-	-	334	-	-	239
Professional, Scientific and Technical Services	18	-	41	60	-129	5	32
Administrative, Waste Management, Remediation Services	26	-	2	28	-90	5	119
Educational Services	9	-	0	9	-	-1	4
Health Care and Social Assistance	148	-	1	148	-22	-0	57
Arts, Entertainment and Recreation	246	-	2	248	-12	9	8
Accommodation and Food Services	722	-	0	722	-12	-324	55
Other Services (Except Public Administration)	191	-	0	192	-18	-3	92
Non-profit institutions serving households	365	-	2	367	2	1	144
Government education services	43	351	34	428	-7	1	142
Government health services	24	337	0	361	-2	-0	54
Other federal government services	9	458	20	487	0	1	119
Other provincial and territorial government services	23	885	4	913	-5	1	82
Other municipal government services	62	335	2	400	-10	0	218
Other Aboriginal government services	6	127	0	133	0	-	42

* Totals exclude emissions caused at the point of consumption. (For example, emissions associated with the combustion of transportation fuel for personal use and home heating).

CONSUMPTION AND PRODUCTION ACCOUNTS BY SECTOR (KILOTONNES OF CO_2E): ONTARIO

Sector	Household Consumption	Government Spending	Firms (for Investment)	Consumption-Based Total	Net Interprovincial Exports	Net International Exports	Production-Based Total
Crop and Animal Production	6,377	-	337	6,714	-992	-6,352	13,287
Forestry and Logging	124	-	9	133	-48	-154	229
Fishing, Hunting and Trapping	193	-	3	196	-84	-204	15
Support Activities for Agriculture and Forestry	3	-	1	4	42	-7	181
Coal Mining	0	-	8	8	0	-435	-
Crude Oil Extraction	-	-	-	-	-8,223	-2,706	21
Natural Gas Extraction	1,684	-	517	2,200	-3,388	-1,690	322
Other (non-energy) Mining	28	-	85	114	-113	-6,612	1,107
Support activities for oil and gas extraction and mining	4	-	89	92	-310	-70	1,084
Utilities	6,489	-	175	6,664	169	-369	13,218
Residential Construction	-	-	9,687	9,687	-	-	478
Non-Residential Building Construction	-	-	4,406	4,406	21	-	200
Engineering Construction	-	-	5,571	5,571	-	-	1,406
Repair Construction	20	-	-	20	3	-	300
Other activities of the construction industry	28	-	46	74	26	-28	390
Manufacturing	49,963	-	22,305	72,269	2,160	-37,466	42,072
Wholesale Trade	2,119	-	-	2,119	256	8,100	5,411
Retail Trade	2,367	-	287	2,654	390	98	2,556
Transportation and Warehousing	9,464	-	111	9,575	-2,466	-3,057	11,886
Information and Cultural Industries	2,108	-	337	2,445	461	530	596
Finance, Insurance, Real Estate and Associated	6,228	-	993	7,221	1,905	-166	4,470
Owner-occupied Dwellings	3,229	-	-	3,229	-	-	2,261
Professional, Scientific and Technical Services	277	-	918	1,196	659	838	857
Administrative, Waste Management, Remediation Services	342	-	60	401	643	711	2,748
Educational Services	117	-	2	120	31	58	108
Health Care and Social Assistance	1,380	-	9	1,389	32	-8	838
Arts, Entertainment and Recreation	1,430	-	9	1,439	-141	34	110
Accommodation and Food Services	8,922	-	9	8,931	-492	-4,812	633
Other Services (Except Public Administration)	2,179	-	14	2,193	-328	-73	1,096
Non-profit institutions serving households	3,597	-	15	3,611	-17	11	1,393
Government education services	651	3,554	465	4,670	-3	48	1,689
Government health services	294	3,701	12	4,008	31	26	411
Other federal government services	51	4,186	344	4,580	16	115	1,517
Other provincial and territorial government services	93	5,863	37	5,993	-27	28	457
Other municipal government services	868	5,418	28	6,314	-38	47	3,891
Other Aboriginal government services	0	432	0	433	-0	-	49

* Totals exclude emissions caused at the point of consumption. (For example, emissions associated with the combustion of transportation fuel for personal use and home heating).

CONSUMPTION AND PRODUCTION ACCOUNTS BY SECTOR (KILOTONNES OF CO_2E): QUEBEC

Sector	Household Consumption	Government Spending	Firms (for Investment)	Consumption-Based Total	Net Interprovincial Exports	Net International Exports	Production-Based Total
Crop and Animal Production	3,595	-	58	3,653	-1,942	-2,106	9,435
Forestry and Logging	133	-	8	141	134	-212	413
Fishing, Hunting and Trapping	76	-	2	78	-40	-86	55
Support Activities for Agriculture and Forestry	1	-	7	8	-82	-6	220
Coal Mining	0	-	10	10	-0	-66	-
Crude Oil Extraction	-	-	-	-	-133	-4,799	-
Natural Gas Extraction	155	-	881	1,036	-1,036	-63	7
Other (non-energy) Mining	2	-	86	87	-398	-2,794	950
Support activities for oil and gas extraction and mining	0	-	119	119	-0	-38	543
Utilities	809	-	25	834	-622	-317	510
Residential Construction	-	-	6,424	6,424	-	-	277
Non-Residential Building Construction	-	-	2,288	2,288	-	-	89
Engineering Construction	-	-	4,186	4,186	-	-	976
Repair Construction	15	-	-	15	-	-	121
Other activities of the construction industry	13	-	15	28	-23	-31	161
Manufacturing	31,545	-	10,886	42,431	6,202	-31,333	21,643
Wholesale Trade	1,352	-	-	1,352	-125	2,922	2,374
Retail Trade	1,539	-	130	1,669	-376	47	1,566
Transportation and Warehousing	3,974	-	88	4,061	-316	1,134	9,753
Information and Cultural Industries	935	-	142	1,077	-14	240	276
Finance, Insurance, Real Estate and Associated	3,507	-	386	3,893	-221	-98	1,589
Owner-occupied Dwellings	1,634	-	-	1,634	-	-	940
Professional, Scientific and Technical Services	103	-	458	561	-67	455	385
Administrative, Waste Management, Remediation Services	203	-	23	226	-168	204	1,258
Educational Services	81	-	1	81	-0	-3	39
Health Care and Social Assistance	614	-	5	619	-7	-4	429
Arts, Entertainment and Recreation	836	-	9	845	122	51	63
Accommodation and Food Services	4,048	-	1	4,049	-283	-1,721	389
Other Services (Except Public Administration)	1,201	-	7	1,208	-61	-24	716
Non-profit institutions serving households	1,848	-	6	1,855	7	7	775
Government education services	182	2,021	270	2,473	-9	18	869
Government health services	127	1,696	2	1,825	-23	1	280
Other federal government services	13	2,027	80	2,121	1	14	609
Other provincial and territorial government services	84	3,611	58	3,753	32	14	418
Other municipal government services	215	2,771	12	2,998	-1	10	1,590
Other Aboriginal government services	0	168	0	168	-0	-	34

* Totals exclude emissions caused at the point of consumption. (For example, emissions associated with the combustion of transportation fuel for personal use and home heating).

CONSUMPTION AND PRODUCTION ACCOUNTS BY SECTOR (KILOTONNES OF CO_2E): NEW BRUNSWICK

Sector	Household Consumption	Government Spending	Firms (for Investment)	Consumption-Based Total	Net Interprovincial Exports	Net International Exports	Production-Based Total
Crop and Animal Production	280	-	-	280	24	-85	754
Forestry and Logging	31	-	21	51	-10	-33	153
Fishing, Hunting and Trapping	7	-	4	11	10	-234	66
Support Activities for Agriculture and Forestry	0	-	0	0	-7	2	22
Coal Mining	0	-	1	1	-8	-35	-
Crude Oil Extraction	-	-	-	-	-259	-3,529	0
Natural Gas Extraction	8	-	50	58	-1,055	-573	1
Other (non-energy) Mining	0	-	21	22	-2	-1,408	-
Support activities for oil and gas extraction and mining	0	-	16	16	-455	-101	0
Utilities	2,156	-	30	2,186	184	248	4,955
Residential Construction	-	-	468	468	-	-	26
Non-Residential Building Construction	-	-	243	243	-	-	9
Engineering Construction	-	-	696	696	-	-	211
Repair Construction	3	-	-	3	-	-	10
Other activities of the construction industry	1	-	0	1	-5	-4	6
Manufacturing	3,380	-	1,329	4,709	2,594	4,277	4,422
Wholesale Trade	94	-	-	94	-96	272	151
Retail Trade	212	-	11	223	-80	4	154
Transportation and Warehousing	604	-	11	615	453	1,274	3,249
Information and Cultural Industries	127	-	14	141	-41	9	23
Finance, Insurance, Real Estate and Associated	392	-	36	428	-77	-6	127
Owner-occupied Dwellings	249	-	-	249	-	-	127
Professional, Scientific and Technical Services	12	-	32	44	-71	12	20
Administrative, Waste Management, Remediation Services	18	-	1	19	189	17	163
Educational Services	11	-	0	11	-	1	5
Health Care and Social Assistance	133	-	0	133	0	-0	38
Arts, Entertainment and Recreation	118	-	1	119	-3	3	3
Accommodation and Food Services	434	-	0	434	39	-148	33
Other Services (Except Public Administration)	138	-	0	138	-53	-2	51
Non-profit institutions serving households	203	-	1	204	1	1	48
Government education services	33	245	20	299	-5	2	86
Government health services	30	365	0	395	-8	1	34
Other federal government services	7	432	9	448	6	1	106
Other provincial and territorial government services	18	765	2	785	-0	1	55
Other municipal government services	62	358	1	421	-3	7	112
Other Aboriginal government services	0	46	0	46	-0	-	6

* Totals exclude emissions caused at the point of consumption. (For example, emissions associated with the combustion of transportation fuel for personal use and home heating).

CONSUMPTION AND PRODUCTION ACCOUNTS BY SECTOR (KILOTONNES OF CO_2E): NOVA SCOTIA

Sector	Household Consumption	Government Spending	Firms (for Investment)	Consumption-Based Total	Net Interprovincial Exports	Net International Exports	Production-Based Total
Crop and Animal Production	382	-	-	382	-312	119	750
Forestry and Logging	64	-	-	64	-96	-3	115
Fishing, Hunting and Trapping	8	-	0	8	93	139	251
Support Activities for Agriculture and Forestry	0	-	0	0	14	0	18
Coal Mining	0	-	0	0	-13	-162	-
Crude Oil Extraction	-	-	-	-	-115	-936	-
Natural Gas Extraction	17	-	20	37	-24	341	659
Other (non-energy) Mining	0	-	3	4	-2	-844	64
Support activities for oil and gas extraction and mining	0	-	7	7	-4	-0	30
Utilities	4,161	-	18	4,179	-65	-7	8,559
Residential Construction	-	-	793	793	-	-	27
Non-Residential Building Construction	-	-	360	360	-	-	9
Engineering Construction	-	-	390	390	-	-	47
Repair Construction	4	-	-	4	-	-	14
Other activities of the construction industry	2	-	0	2	6	4	18
Manufacturing	4,364	-	2,400	6,763	-213	-3,541	1,612
Wholesale Trade	147	-	-	147	14	222	173
Retail Trade	333	-	25	358	55	5	191
Transportation and Warehousing	915	-	6	921	435	781	3,164
Information and Cultural Industries	171	-	15	186	-34	15	31
Finance, Insurance, Real Estate and Associated	606	-	61	667	-8	18	172
Owner-occupied Dwellings	361	-	-	361	-	-	200
Professional, Scientific and Technical Services	19	-	38	58	-14	15	27
Administrative, Waste Management, Remediation Services	28	-	1	29	-52	30	105
Educational Services	12	-	0	13	-2	-1	5
Health Care and Social Assistance	145	-	1	145	1	-1	53
Arts, Entertainment and Recreation	162	-	1	163	1	7	4
Accommodation and Food Services	620	-	0	620	81	-99	45
Other Services (Except Public Administration)	198	-	0	198	-11	-2	66
Non-profit institutions serving households	479	-	1	480	7	2	80
Government education services	108	615	84	807	30	10	113
Government health services	38	566	1	604	14	6	44
Other federal government services	12	1,015	16	1,043	0	6	191
Other provincial and territorial government services	20	530	2	552	4	3	66
Other municipal government services	72	638	1	711	4	5	134
Other Aboriginal government services	0	64	0	65	-0	-	9

* Totals exclude emissions caused at the point of consumption. (For example, emissions associated with the combustion of transportation fuel for personal use and home heating).

CONSUMPTION AND PRODUCTION ACCOUNTS BY SECTOR (KILOTONNES OF CO_2E): PRINCE EDWARD ISLAND

Sector	Household Consumption	Government Spending	Firms (for Investment)	Consumption-Based Total	Net Interprovincial Exports	Net International Exports	Production-Based Total
Crop and Animal Production	47	-	-	47	123	138	415
Forestry and Logging	5	-	0	5	2	-0	3
Fishing, Hunting and Trapping	1	-	2	3	-2	3	33
Support Activities for Agriculture and Forestry	0	-	0	0	-0	-0	5
Coal Mining	0	-	0	0	-0	-	-
Crude Oil Extraction	-	-	-	-	-	-	-
Natural Gas Extraction	3	-	0	3	-4	-	-
Other (non-energy) Mining	0	-	0	0	-1	0	-
Support activities for oil and gas extraction and mining	0	-	0	0	-6	0	1
Utilities	82	-	-	82	-233	0	1
Residential Construction	-	-	103	103	-	-	4
Non-Residential Building Construction	-	-	38	38	-	-	2
Engineering Construction	-	-	86	86	-	-	29
Repair Construction	0	-	-	0	-	-	2
Other activities of the construction industry	0	-	-	0	-3	-0	1
Manufacturing	645	-	206	851	-406	-475	153
Wholesale Trade	17	-	-	17	-18	14	13
Retail Trade	44	-	-	44	-16	1	30
Transportation and Warehousing	156	-	2	158	-104	97	363
Information and Cultural Industries	20	-	1	21	-10	1	4
Finance, Insurance, Real Estate and Associated	71	-	7	78	-14	2	23
Owner-occupied Dwellings	44	-	-	44	-	-	27
Professional, Scientific and Technical Services	2	-	4	6	-7	-0	3
Administrative, Waste Management, Remediation Services	3	-	0	3	14	5	21
Educational Services	2	-	0	2	-	4	1
Health Care and Social Assistance	22	-	0	22	-1	-0	6
Arts, Entertainment and Recreation	24	-	0	24	9	1	1
Accommodation and Food Services	66	-	-	66	7	-18	8
Other Services (Except Public Administration)	26	-	0	26	-5	-0	11
Non-profit institutions serving households	35	-	0	35	-1	0	10
Government education services	10	56	5	71	-2	1	18
Government health services	3	44	0	46	-4	0	6
Other federal government services	3	86	6	95	0	0	26
Other provincial and territorial government services	6	131	1	138	1	1	14
Other municipal government services	5	35	-	40	-3	0	14
Other Aboriginal government services	0	4	-	4	-0	-	1

* Totals exclude emissions caused at the point of consumption. (For example, emissions associated with the combustion of transportation fuel for personal use and home heating).

CONSUMPTION AND PRODUCTION ACCOUNTS BY SECTOR (KILOTONNES OF CO_2E): NEWFOUNDLAND AND LABRADOR

Sector	Household Consumption	Government Spending	Firms (for Investment)	Consumption-Based Total	Net Interprovincial Exports	Net International Exports	Production-Based Total
Crop and Animal Production	137	-	18	156	-147	-8	141
Forestry and Logging	47	-	2	49	60	-3	97
Fishing, Hunting and Trapping	3	-	40	43	42	84	187
Support Activities for Agriculture and Forestry	0	-	0	0	3	0	13
Coal Mining	0	-	3	3	-3	-	-
Crude Oil Extraction	-	-	-	-	506	1,119	1,496
Natural Gas Extraction	3	-	137	140	1,084	-249	1
Other (non-energy) Mining	0	-	26	26	165	962	2,182
Support activities for oil and gas extraction and mining	0	-	51	51	-66	-8	-
Utilities	485	-	5	490	155	0	866
Residential Construction	-	-	463	463	-	-	26
Non-Residential Building Construction	-	-	433	433	-	-	8
Engineering Construction	-	-	846	846	-	-	207
Repair Construction	2	-	-	2	-	-	7
Other activities of the construction industry	1	-	0	1	-3	-1	7
Manufacturing	2,332	-	982	3,313	-2,082	-2,294	958
Wholesale Trade	58	-	-	58	-61	70	84
Retail Trade	119	-	-	119	-81	3	121
Transportation and Warehousing	350	-	1	351	-269	134	669
Information and Cultural Industries	65	-	4	69	-27	32	16
Finance, Insurance, Real Estate and Associated	190	-	20	210	-119	-9	75
Owner-occupied Dwellings	169	-	-	169	-	0	97
Professional, Scientific and Technical Services	5	-	18	23	-55	-2	14
Administrative, Waste Management, Remediation Services	8	-	0	8	-45	2	47
Educational Services	11	-	0	11	-	-1	2
Health Care and Social Assistance	38	-	0	38	-1	-0	27
Arts, Entertainment and Recreation	85	-	0	86	-3	1	1
Accommodation and Food Services	241	-	0	241	-19	-59	25
Other Services (Except Public Administration)	73	-	0	73	-13	-1	42
Non-profit institutions serving households	102	-	0	102	0	0	33
Government education services	11	144	18	173	-2	1	73
Government health services	14	199	0	213	1	1	25
Other federal government services	5	225	4	234	-2	1	56
Other provincial and territorial government services	12	540	2	554	-0	0	48
Other municipal government services	21	144	0	166	-2	-0	66
Other Aboriginal government services	0	21	0	21	-0	-	6

* Totals exclude emissions caused at the point of consumption. (For example, emissions associated with the combustion of transportation fuel for personal use and home heating).

CONSUMPTION AND PRODUCTION ACCOUNTS BY SECTOR (KILOTONNES OF CO_2E): YUKON AND NORTHWEST TERRITORIES

Sector	Household Consumption	Government Spending	Firms (for Investment)	Consumption-Based Total	Net Interprovincial Exports	Net International Exports	Production-Based Total
Crop and Animal Production	80	-	0	80	-52	-4	46
Forestry and Logging	1	-	-	1	-2	-0	-
Fishing, Hunting and Trapping	0	-	0	1	-0	0	0
Support Activities for Agriculture and Forestry	0	-	-	0	2	0	2
Coal Mining	0	-	4	4	-4	-	-
Crude Oil Extraction	-	-	-	-	340	-	224
Natural Gas Extraction	4	-	359	363	-355	-	117
Other (non-energy) Mining	0	-	46	46	-0	712	396
Support activities for oil and gas extraction and mining	0	-	84	84	-0	-	99
Utilities	56	-	0	56	-16	0	94
Residential Construction	-	-	78	78	-	-	4
Non-Residential Building Construction	-	-	64	64	-	-	2
Engineering Construction	-	-	236	236	-	-	11
Repair Construction	0	-	-	0	-	-	3
Other activities of the construction industry	1	-	-	1	12	1	15
Manufacturing	363	-	241	604	-962	-654	16
Wholesale Trade	11	-	-	11	-38	13	19
Retail Trade	22	-	-	22	-26	0	23
Transportation and Warehousing	73	-	0	73	118	13	304
Information and Cultural Industries	10	-	1	11	-8	1	4
Finance, Insurance, Real Estate and Associated	62	-	3	65	-20	1	25
Owner-occupied Dwellings	25	-	-	25	-	-	21
Professional, Scientific and Technical Services	1	-	3	5	-52	-1	4
Administrative, Waste Management, Remediation Services	1	-	0	1	-29	3	14
Educational Services	0	-	0	0	-2	-2	0
Health Care and Social Assistance	11	-	0	11	2	-0	4
Arts, Entertainment and Recreation	5	-	0	5	-2	1	0
Accommodation and Food Services	70	-	-	70	-16	-12	9
Other Services (Except Public Administration)	10	-	0	10	-18	-1	6
Non-profit institutions serving households	41	-	0	41	-0	0	13
Government education services	5	83	0	88	-4	1	16
Government health services	1	47	0	48	-3	1	4
Other federal government services	1	84	1	86	-1	0	18
Other provincial and territorial government services	3	330	1	334	-1	1	31
Other municipal government services	5	51	0	56	-1	0	26
Other Aboriginal government services	0	64	0	64	-0	-	9

* Totals exclude emissions caused at the point of consumption. (For example, emissions associated with the combustion of transportation fuel for personal use and home heating).

CONSUMPTION AND PRODUCTION ACCOUNTS BY SECTOR (KILOTONNES OF CO_2E): NUNAVUT

Sector	Household Consumption	Government Spending	Firms (for Investment)	Consumption-Based Total	Net Interprovincial Exports	Net International Exports	Production-Based Total
Crop and Animal Production	15	-	-	15	-18	-2	-
Forestry and Logging	0	-	0	0	-1	-0	-
Fishing, Hunting and Trapping	0	-	0	0	0	1	-
Support Activities for Agriculture and Forestry	0	-	-	0	-1	-0	-
Coal Mining	-	-	-	-	-	-	-
Crude Oil Extraction	-	-	3	3	-3	-	-
Natural Gas Extraction	0	-	341	341	-345	-	-
Other (non-energy) Mining	0	-	19	19	60	-	-
Support activities for oil and gas extraction and mining	0	-	23	23	0	-	-
Utilities	49	-	0	49	0	1	144
Residential Construction	-	-	43	43	-	-	0
Non-Residential Building Construction	-	-	45	45	-	-	0
Engineering Construction	-	-	57	57	-	-	0
Repair Construction	0	-	-	0	-	-	0
Other activities of the construction industry	0	-	-	0	-3	-0	0
Manufacturing	103	-	56	159	-370	-209	0
Wholesale Trade	2	-	-	2	-14	-1	3
Retail Trade	5	-	-	5	-5	0	5
Transportation and Warehousing	17	-	0	17	-80	-8	-
Information and Cultural Industries	2	-	0	3	-3	0	1
Finance, Insurance, Real Estate and Associated	19	-	1	19	-8	-0	8
Owner-occupied Dwellings	5	-	-	5	-	-	4
Professional, Scientific and Technical Services	0	-	1	1	-15	-1	1
Administrative, Waste Management, Remediation Services	0	-	0	0	-7	-0	6
Educational Services	0	-	-	0	-	-0	-
Health Care and Social Assistance	2	-	-	2	-1	-0	1
Arts, Entertainment and Recreation	1	-	0	1	-1	0	0
Accommodation and Food Services	12	-	-	12	-8	-3	1
Other Services (Except Public Administration)	2	-	-	2	-5	-0	1
Non-profit institutions serving households	27	-	0	27	-0	0	7
Government education services	1	28	0	29	-1	-0	8
Government health services	0	41	0	42	-2	-0	1
Other federal government services	0	31	0	31	-0	0	6
Other provincial and territorial government services	8	255	1	264	-0	-0	-
Other municipal government services	3	29	0	32	1	0	-
Other Aboriginal government services	-	-	-	-	-	-	-

* Totals exclude emissions caused at the point of consumption. (For example, emissions associated with the combustion of transportation fuel for personal use and home heating).

About the Authors

Sarah Dobson (PhD, UC Berkeley) is a research associate at The School of Public Policy, University of Calgary. Her research interests are focused on studying the design, implementation and evaluation of energy and environmental regulatory policy. In prior work she has considered such issues as the welfare implication of climate change policy, and the optimal design of regulatory policy to take into account the trade-off between the economic benefits of resource development and the ecological consequences of management decisions. Sarah's work with The School of Public Policy covers a range of topics including carbon pricing, climate change policy design, political response to hydraulic fracturing, and markets for Canadian oil and LNG.

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