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BIG AND LITTLE FEET PROVINCIAL PROFILES: QUEBEC[†]

Sarah Dobson and G. Kent Fellows

This communiqué provides a summary of the production- and consumption-based greenhouse gas emissions accounts for Quebec, as well as their associated trade flows. It is part of a series of communiqués profiling the Canadian provinces and territories.¹

In simplest terms, a production-based emissions account measures the quantity of greenhouse gas emissions produced in Quebec. In contrast, a consumption-based emissions account measures the quantity of greenhouse gas emissions generated during the production process for final goods and services that are consumed in Quebec through household purchases, investment by firms and government spending. Trade flows refer to the movement of emissions that are produced in Quebec but which support consumption in a different province, territory or country (and vice versa). For example, emissions associated with the production of a Quebec manufactured good that is exported to Ontario for sale are recorded as a trade flow from Quebec to Ontario. Moving in the opposite direction, emissions associated with the production of motor gasoline in New Brunswick that is exported to Quebec for sale are recorded as a trade flow from New Brunswick to Quebec.

For further details on these results in a national context, the methodology for generating them and their policy implications, please see the companion papers to this communiqué series: (1) Fellows and Dobson (2017); and (2) Dobson and Fellows (2017). Additionally, the consumption emissions and trade flow data for each of the provinces and territories are available at: <http://www.policyschool.ca/embodied-emissions-inputs-outputs-data-tables-2004-2011/>.

Unless otherwise noted, all emissions data referenced in this communiqué are for 2011.

[†] This communiqué benefited from financial support provided by Alberta Innovates and by donors through The School of Public Policy's Energy for Life program.

¹ Nunavut, the Northwest Territories and the Yukon Territory are grouped into a single profile both for convenience and due to the underlying structure of available data.

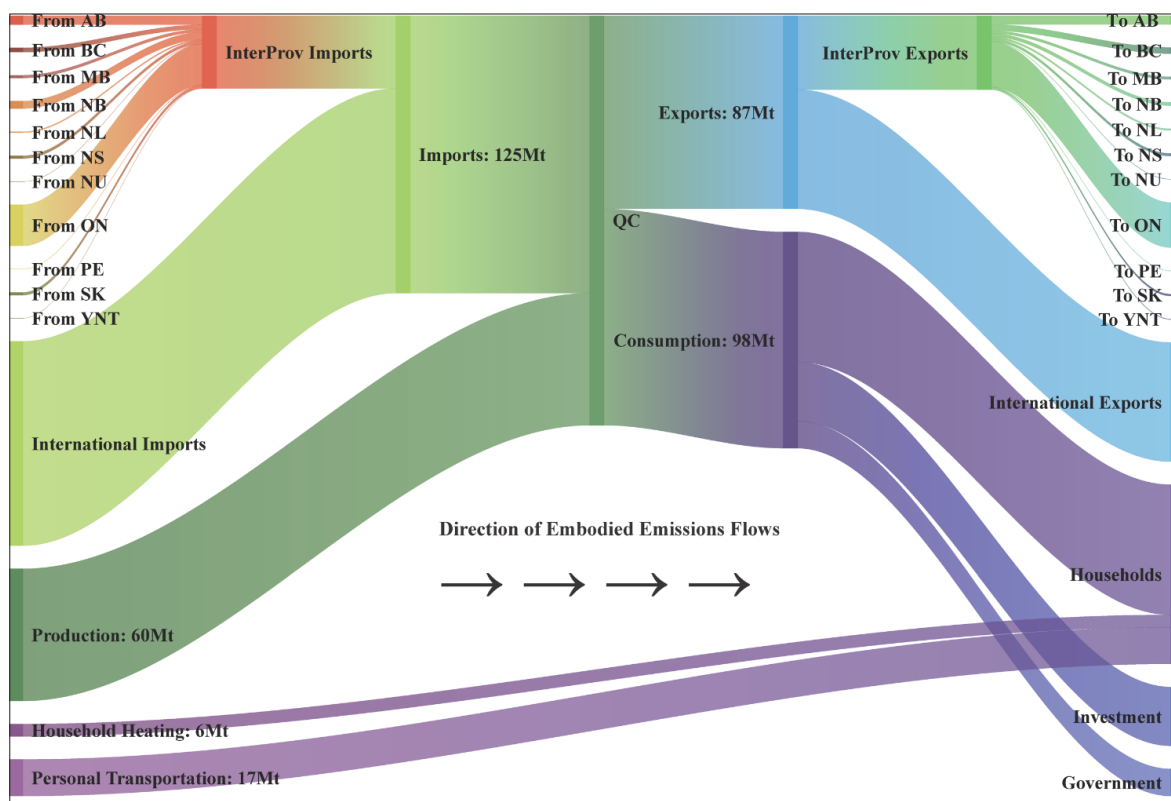
PRODUCTION- AND CONSUMPTION-BASED EMISSIONS ACCOUNTS

The relationship between production- and consumption-based greenhouse gas emissions is given by the following equation:

$$\text{Consumption Emissions} = \text{Production Emissions} + \text{Interprovincial Imports} + \text{International Imports} - \text{Interprovincial Exports} - \text{International Exports}$$

Quebec's total production emissions in 2011 were 82.0 megatonnes (Mt) of CO₂e (Figure 1), corresponding to per capita emissions of 10.2 t. The province is a net importer of greenhouse gas emissions from international sources (+38.6 Mt) and a net exporter of greenhouse gas emissions to the other provinces (-0.5 Mt). As Quebec's international net imports exceed its interprovincial net exports, total emissions increase when moving to a consumption-based accounting approach, rising to 120.0 Mt total CO₂e emissions or 15.0 t of CO₂e per capita.²

FIGURE 1 EMISSIONS FLOWS THROUGH THE QUEBEC ECONOMY



Net exporter of emissions to:	British Columbia, Ontario, Prince Edward Island, Newfoundland and Labrador, Territories
Net importer of emissions from:	International, Alberta, Saskatchewan, Manitoba, New Brunswick, Nova Scotia

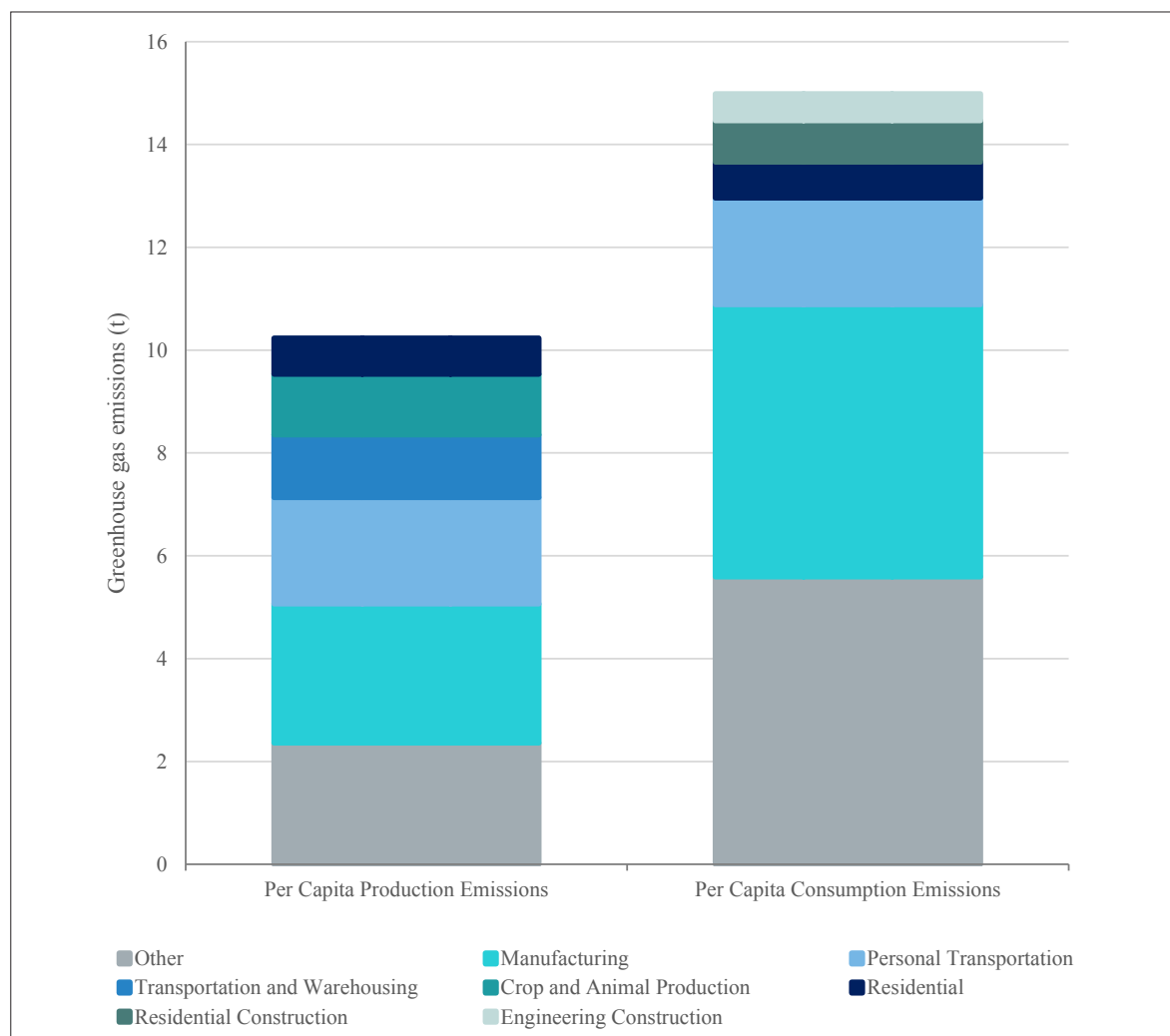
Data Source: Fellows, G. Kent and Sarah Dobson. 2017. "Embodied Emissions in Inputs and Outputs: A Value-Added Approach to National Emissions Accounting." *Canadian Public Policy*, 43(2): 140-164. <https://doi.org/10.3138/cpp.2016-040>.

Data tables are available at: <http://www.policyschool.ca/embodied-emissions-inputs-outputs-data-tables-2004-2011/>.

² Production and consumption totals indicated here include residential and personal transportation emissions. However, these emissions are not "embodied" in any traded good within the provincial economies, since they are produced during the act of final consumption by households. As such, these emissions are recorded as separate parallel flows in Figure 1.

The largest sectors responsible for per capita production emissions in Quebec are manufacturing (2.7 t), personal transportation (2.1 t), transportation and warehousing (1.2 t), crop and animal production (1.2 t) and residential (0.7 t). In comparison, the largest sectors responsible for per capita consumption emissions are manufacturing (5.3 t), personal transportation (2.1 t), residential construction (0.8 t), residential (0.7 t) and engineering construction (0.5 t) (Figure 2).

FIGURE 2 BREAKDOWN BY SECTOR OF QUEBEC PER CAPITA PRODUCTION AND CONSUMPTION EMISSIONS



Note: See the appendix of Dobson and Fellows (2017) for a full listing of the sectors included in the “Other” category. Note also that the figure displays individually only the top five sectors contributing to per capita production emissions and the top five sectors contributing to per capita consumption emissions. As a result, a sector that is a primary source of production emissions but not consumption emissions will be included in the “Other” category for consumption emissions (and vice versa).

Three sectors – manufacturing, personal transportation and residential – overlap as main sources of both production and consumption emissions in Quebec. Emissions in the manufacturing sector increase by 96 per cent (+2.6 t) when moving from a production- to a consumption-based accounting approach while emissions from the personal transportation and residential sectors remain unchanged. The increase in manufacturing sector emissions is attributable to three factors. First, the sector uses substantial intermediate inputs with associated emissions produced by upstream suppliers. Second, the sector is a key supplier of final consumption goods for households and firm investment. Third, the sector engages in significant trade with a large share of intermediate inputs and final consumption goods being produced by suppliers in other provinces

and internationally. Combined, these factors result in a large number of production emissions from Quebec, elsewhere in Canada and internationally being reallocated to Quebec's manufacturing sector – and specifically household consumption and firm investment – under a consumption-based accounting approach. It is interesting to note, however, that although the increase in Quebec manufacturing sector emissions is significant, the province's large domestic manufacturing sector means that it is on the lower end relative to many of the other provinces. Provinces with smaller manufacturing sectors, which in turn must import a greater share of their intermediate and final goods, see much larger emissions increases, often in excess of 200 per cent. In comparison, emissions from the personal transportation and residential sectors are unchanged when moving from a production- to a consumption-based accounting approach as all of the production emissions in these sectors are generated by household consumption of fossil fuels in personal vehicles and in homes. Production and consumption emissions are therefore the same.

The crop and animal production and transportation and warehousing sectors are primary sources of production emissions in Quebec but not consumption emissions. Emissions from both sectors fall by approximately 60 per cent (-0.7 t) when moving from a production- to a consumption-based accounting approach. In the crop and animal production sector this is the result of a large share of output from the sector being sold to intermediate suppliers – food manufacturers, distributors, restaurants and grocery stores – in Quebec, elsewhere in Canada and internationally. Production emissions associated with this output are subsequently reallocated to the sector and region that supply the final consumption good for which Quebec's farm output is an input. Similarly, in the transportation and warehousing sector the storage and transportation of goods are generally intermediate steps in bringing a final good to market. Accordingly, production emissions associated with these steps are reallocated in a consumption-based approach to the sector and region where final consumption of the good occurs.

Last, the residential and engineering construction sectors are the only sectors that are a primary source of consumption emissions in Quebec but not production emissions. Per capita emissions in the residential construction sector increase from virtually zero under a production-based accounting approach to 0.7 t under a consumption-based accounting approach while emissions in the engineering construction sector increase from 0.1 t to 0.5 t. The increases are a result of both sectors absorbing all of the emissions associated with production of their inputs. For example, when a builder purchases timber for framing a home, emissions associated with production of the timber are reallocated from the forestry and manufacturing sectors to the residential construction sector. Notably, output from the construction sectors reflects only expenditure by firms and all of the consumption emissions are therefore allocated to firm investment.

As shown on the right-hand side of Figure 1, Quebec's consumption emissions can additionally be broken down by household, firm investment and government spending. Per capita consumption emissions for each of these groups, as well as the breakdown of emissions in each of these groups by sector, are summarized in Table 1.

TABLE 1 QUEBEC PER CAPITA CONSUMPTION EMISSIONS BY CONSUMPTION GROUP AND SECTOR

Household Consumption Emissions		Firm Investment Consumption Emissions		Government Consumption Emissions	
Per Capita Consumption Emissions <i>(Share of Total Per Capita Consumption Emissions)</i>					
10.1 t (68%)		3.3 t (22%)		1.5 t (10%)	
Top Sectors Contributing to Consumption Emissions					
Manufacturing:	3.9 t	Manufacturing:	1.4 t	Other provincial government services:	0.5 t
Personal transportation:	2.1 t	Residential construction:	0.8 t	Other municipal government services:	0.3 t
Residential:	0.7 t	Engineering construction:	0.5 t	Other federal government services:	0.3 t
Accommodation and food services:	0.5 t	Non-residential building construction:	0.3 t	Government education services:	0.3 t
Transportation and warehousing:	0.5 t	Natural gas extraction:	0.1 t	Government health services:	0.2 t
Other:	2.4 t	Other:	0.3 t	Other Aboriginal government services:	0.02 t

Note: See the appendix of Dobson and Fellows (2017) for a full listing of the sectors included in the “Other” category for household and firm investment emissions. The appendix additionally lists household and firm investment consumption emissions for each of these sectors. Government consumption emissions by sector are fully accounted for as they are limited to the six government-specific sectors listed in the table.

INTERPROVINCIAL TRADE FLOWS

Quebec’s only significant source of net interprovincial exports of emissions is from the manufacturing sector. With the exception of New Brunswick, the province is a net exporter of manufacturing sector emissions to all of the remaining provinces and territories, with the largest flows going to Ontario, British Columbia and Alberta. The manufacturing sector in New Brunswick is Quebec’s largest source of interprovincial net imports of emissions. These net imports most likely correspond to the embedded emissions in refined petroleum products that are produced at the Irving Oil Refinery in Saint John, New Brunswick and sold in Quebec.

Quebec additionally has small net interprovincial imports of greenhouse gas emissions from the crop and animal production sectors in Saskatchewan and Alberta, from the natural gas extraction sectors in Alberta and Ontario, and from the utilities and finance, insurance, real estate and rental and leasing sectors in Ontario.³ Emissions associated with natural gas imports into Quebec are lower than those in other provinces without significant domestic natural gas production as Quebec’s electricity grid is primarily driven by hydro power. Electricity is additionally its main source of household heating (Statistics Canada, 2011). Accordingly, natural gas accounted for only 12 per cent of Quebec’s energy demand in 2011 (National Energy Board, 2016). In comparison, in Ontario in 2011 natural gas accounted for 27 per cent of energy demand.

INTERNATIONAL TRADE FLOWS

Internationally, Quebec has large net imports of emissions from the manufacturing, crude oil extraction, other (non-energy) mining, crop and animal production, and accommodation and food services sectors. International imports of crude oil extraction emissions are higher than domestic, consistent with Quebec refineries previously receiving the majority of their crude oil feedstock

³ As natural gas production in Ontario is limited, emissions from Ontario are mostly likely associated with re-exports of natural gas imported into Ontario.

from international sources.⁴ The only sectors in Quebec with large net exports of emissions internationally are wholesale trade and transportation and warehousing.

TIME TREND OF PER CAPITA PRODUCTION AND CONSUMPTION EMISSIONS

Total production emissions in Quebec declined over the period of 2004 to 2011 (-9 per cent) (Figure 3). Quebec's population grew over this period (+6 per cent), leading to an even larger percentage drop in the province's per capita production emissions (-15 per cent) (Figure 4). The decrease in total emissions is largely a result of steadily declining emissions in the province's manufacturing sector over the entire period of 2004 to 2011, as well as a significant drop in emissions in the transportation and warehousing sector from 2010 to 2011. The decline in emissions from the manufacturing sector is consistent with declining output from a number of the province's manufacturing subsectors over this same period (Statistics Canada, 2017).

The decline in Quebec's production emissions over the period of 2004 to 2011 did not translate into a decline in consumption emissions. Rather, total consumption emissions in the province increased by 12 per cent from 2004 to 2011. When combined with a growing population, however, the net increase in per capita consumption emissions falls to five per cent. Quebec was a net importer of greenhouse gas emissions in 2004 and with consumption emissions increasing and production emissions decreasing, its per capita net imports increased from 2.2 t in 2004 to 4.8 t in 2011.

Consumption emissions related to firm investment saw the largest percentage growth from 2004 to 2011. Specifically, total firm investment consumption emissions increased by 23 per cent while per capita emissions increased by 16 per cent. Total and per capita emissions were generally consistently growing over the period, with only a small decline in 2006 and a more notable decline in 2009. The increase in emissions was driven primarily by the aggregate construction sector, with residential construction accounting for the majority of the growth in construction sector emissions since 2009.⁵

Total and per capita government consumption emissions increased by 12 and six per cent respectively from 2004 to 2011. Emissions were relatively constant from 2004 to 2009 and then sharply increased in 2010. The increase was driven primarily by an uptick in emissions from the other (non-health care and education) provincial government services sector.⁶ There was additionally a small increase in emissions from the other municipal government services sector. Emissions in the remaining government subsectors were largely unchanged.

Total and per capita household consumption emissions had the lowest rates of growth from 2004 to 2011, rising by only nine and two per cent respectively. Absolute growth in total emissions, however, was the highest among the three consumption groups. Per capita emissions remained relatively constant over the entire period, varying between 9.7 t (2008 low) and 10.1 t (2011 high), while total emissions displayed limited variation from 2004 to 2009, followed by a more pronounced increase in both 2010 and 2011. The manufacturing and accommodation and food services sectors saw the largest increases in household consumption emissions, with most of the growth coming over the period of 2009 to 2011. There was also significant growth in emissions from the transportation and warehousing sector from 2004 to 2010. In contrast, household consumption emissions were declining in the finance, insurance, real estate and rental and leasing, utilities and retail trade sectors.

⁴ With the rise of crude oil travelling by rail post-2011, and the reversal of the Line 9 pipeline in December 2015 (which allows western-produced Canadian crude oil to reach Montreal), Quebec has significantly improved access to domestic sources of crude oil for its refinery feedstock. A similar analysis with current data would therefore likely show Quebec as having significant net imports of emissions from the crude oil extraction sectors in Alberta and Saskatchewan.

⁵ Prior to 2009 emissions data are only available for the aggregate construction sector.

⁶ Prior to 2009 emissions data are only available for the aggregate government services sector.

FIGURE 3 TOTAL PRODUCTION AND CONSUMPTION EMISSIONS, QUEBEC: 2004 TO 2011

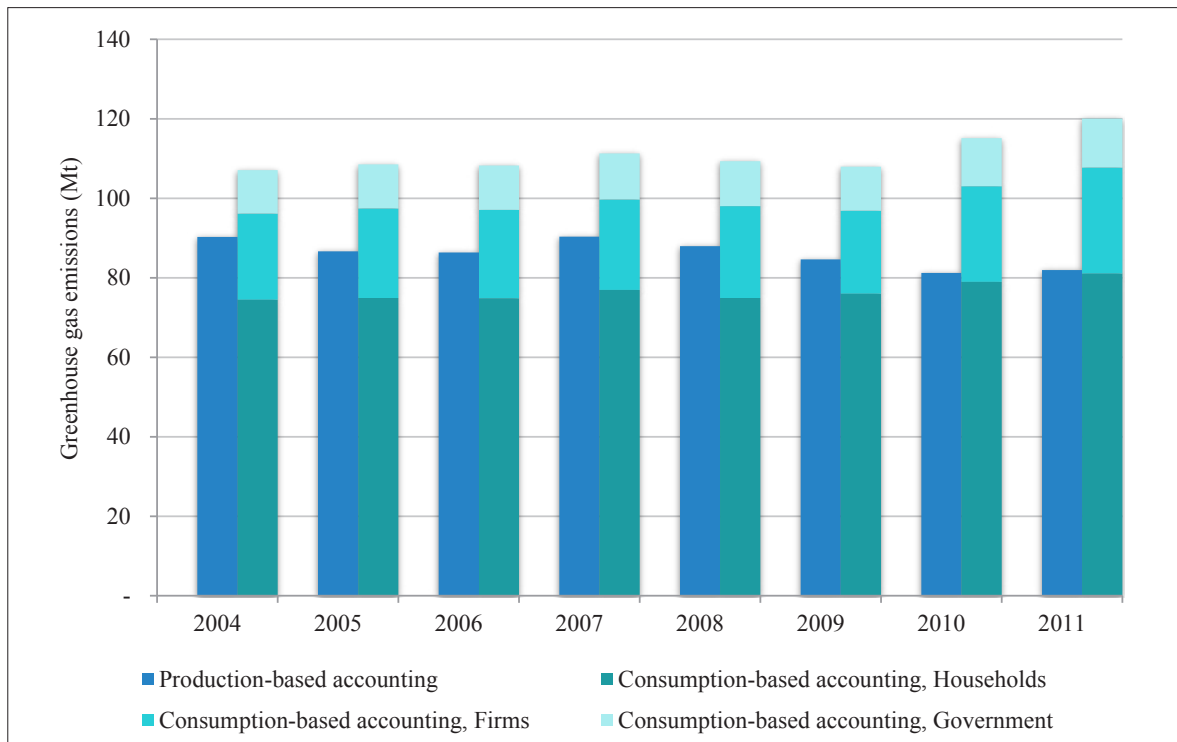
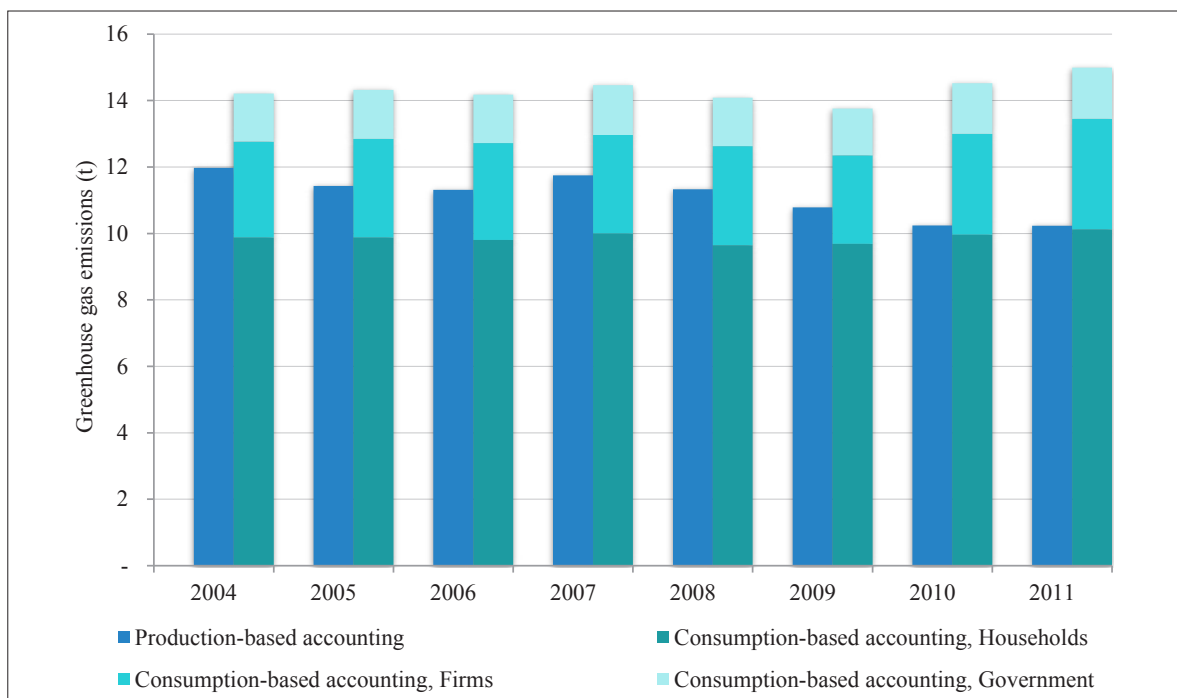


FIGURE 4 PER CAPITA PRODUCTION AND CONSUMPTION EMISSIONS, QUEBEC: 2004 TO 2011



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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.

G. Kent Fellows (PhD, Calgary) is a research associate at The School of Public Policy, University of Calgary. Kent has previously worked as a researcher for the University of Alberta's School of Public Health and as an intern at the National Energy Board. He has published articles on the effects of price regulation and bargaining power on the Canadian pipeline and pharmaceutical industries as well as the integration of renewable generation capacity in the Alberta electricity market. His current research agenda focuses on the area of computational economics as applied to the construction and use of large-scale quantitative models of inter-sector and interprovincial trade within Canada. Kent is also involved in forwarding The School of Public Policy's Canadian Northern Corridor research program, which is aimed at studying the concept of a multi-modal linear infrastructure right of way through Canada's North and near North.

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The School of Public Policy

University of Calgary, Downtown Campus
906 8th Avenue S.W., 5th Floor
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