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SPP Communiqués are brief articles that deal with a singular public policy issue and are intended to provide the reader with a focused, concise critical analysis of a specific policy issue.

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BIG AND LITTLE FEET PROVINCIAL PROFILES: ALBERTA*†

Sarah Dobson and G. Kent Fellows

This communiqué provides a summary of the production- and consumption-based greenhouse gas emissions accounts for Alberta, 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 Alberta. 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 Alberta through household purchases, investment by firms and government spending. Trade flows refer to the movement of emissions that are produced in Alberta but which support consumption in a different province, territory or country (and vice versa). For example, emissions associated with the production of Alberta crude oil that is exported to British Columbia for refining and sale as motor gasoline are recorded as a trade flow from Alberta to British Columbia. Moving in the opposite direction, emissions associated with the production of Saskatchewan crops that are exported to Alberta for processing and sale in Alberta grocery stores are recorded as a trade flow from Saskatchewan to Alberta.

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 research was financially supported by the Government of Canada via a partnership with Western Economic Diversification.

† 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.

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GRANDS ET PETITS PAS DES PROVINCES : L'ALBERTA*†

Sarah Dobson et G. Kent Fellows

Ce communiqué donne un aperçu de la comptabilisation des émissions de gaz à effet de serre liées à la production et à la consommation en Alberta, de même que des flux commerciaux qui y sont associés. Il fait partie d'une série de communiqués établissant le profil des provinces et territoires canadiens¹.

En termes simples, la comptabilisation des émissions de production mesure la quantité d'émissions de gaz à effet de serre produite en Alberta. En revanche, la comptabilisation des émissions de consommation mesure la quantité d'émissions de gaz à effet de serre générée pendant la production des biens et services finaux consommés en Alberta dans le cadre d'achats ménagers, d'investissements d'entreprises ou de dépenses gouvernementales. Les flux commerciaux font référence à la circulation des émissions produites en Alberta mais qui répondent à des besoins de consommation dans d'autres provinces, territoires ou pays (et vice-versa). Par exemple, les émissions associées à la production de pétrole brut albertain exporté en Colombie-Britannique pour y être raffiné et vendu sous forme d'essence à moteur aux consommateurs britanno-colombiens seront comptabilisées comme un flux commercial de l'Alberta vers la Colombie-Britannique. À l'inverse, les émissions associées à la production de récoltes en Saskatchewan qui sont exportées en Alberta pour la transformation et la vente dans les épiceries albertaines seront comptabilisées comme un flux commercial de la Saskatchewan vers l'Alberta.

Pour plus de détails sur ces résultats dans leur contexte national, sur la méthodologie utilisée pour les établir et sur leurs répercussions pour les politiques, veuillez consulter les articles accompagnant cette série de communiqués : (1) Fellows et Dobson (2017); et (2) Dobson et Fellows (2017). Par ailleurs, les données sur les émissions liées à la consommation et aux flux commerciaux pour chacune des provinces et territoires sont disponibles à : <http://www.policyschool.ca/embodyed-emissions-inputs-outputs-data-tables-2004-2011/>.

Sauf indication contraire, toutes les données d'émissions citées dans ce communiqué valent pour 2011.

* Cette recherche a été soutenue financièrement en partie par le gouvernement du Canada via Diversification de l'économie de l'Ouest Canada.

† Cet article a bénéficié d'un soutien financier du réseau *Alberta Innovates* et des donateurs du programme *Energy for life* de l'École de politiques publiques.

¹ Le Nunavut, les Territoires du Nord-Ouest et le Yukon sont regroupés en un seul profil tant par commodité qu'en raison de la structure sous-jacente des données disponibles.

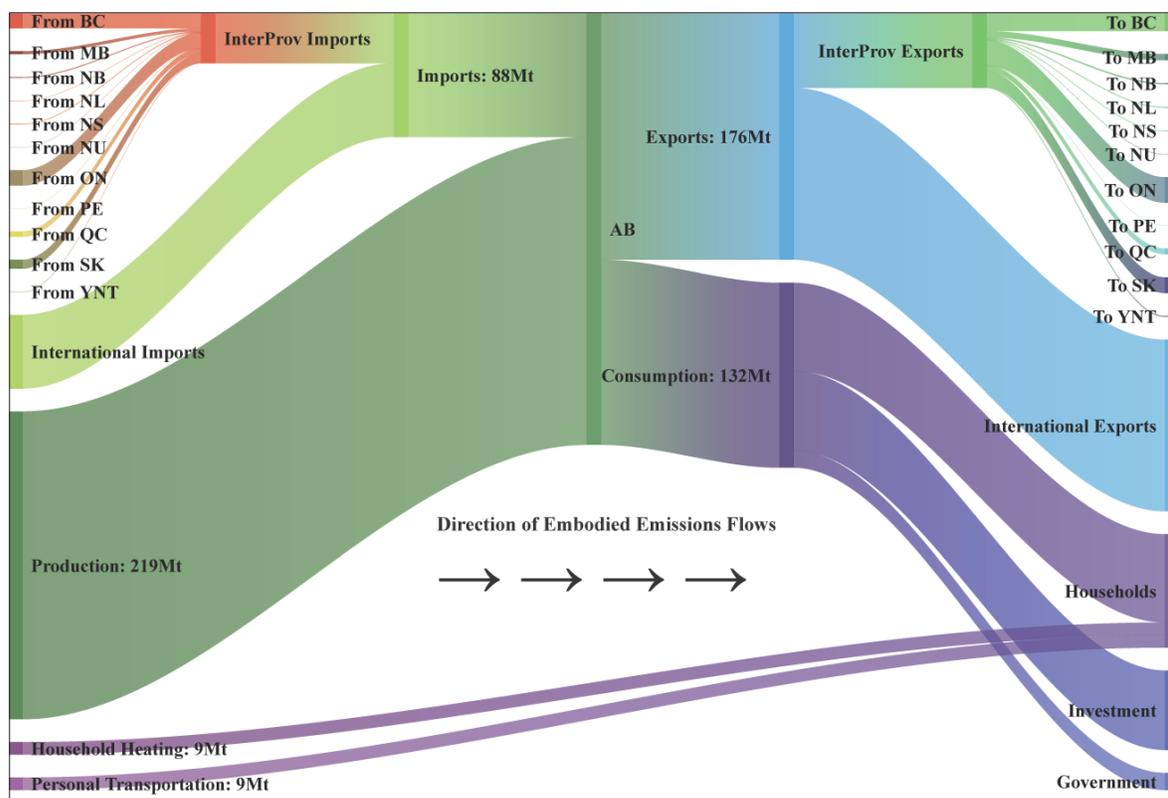
PRODUCTION- AND CONSUMPTION-BASED EMISSIONS ACCOUNTS

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

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

Alberta's total production emissions in 2011 were 237.1 megatonnes (Mt) of CO₂e (Figure 1), corresponding to per capita production emissions of 62.5 t. The province is a net exporter of greenhouse gas emissions internationally (-69.8 Mt) and to all of the other provinces (-17.7 Mt). Alberta's emissions therefore decrease when moving to a consumption-based accounting approach, falling to 149.6 Mt total CO₂e emissions or 39.5 t of CO₂e per capita.²

FIGURE 1 EMISSIONS FLOWS THROUGH THE ALBERTA ECONOMY



Net exporter of emissions to:	International, British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland & Labrador, Territories
Net importer of emissions from:	N/A

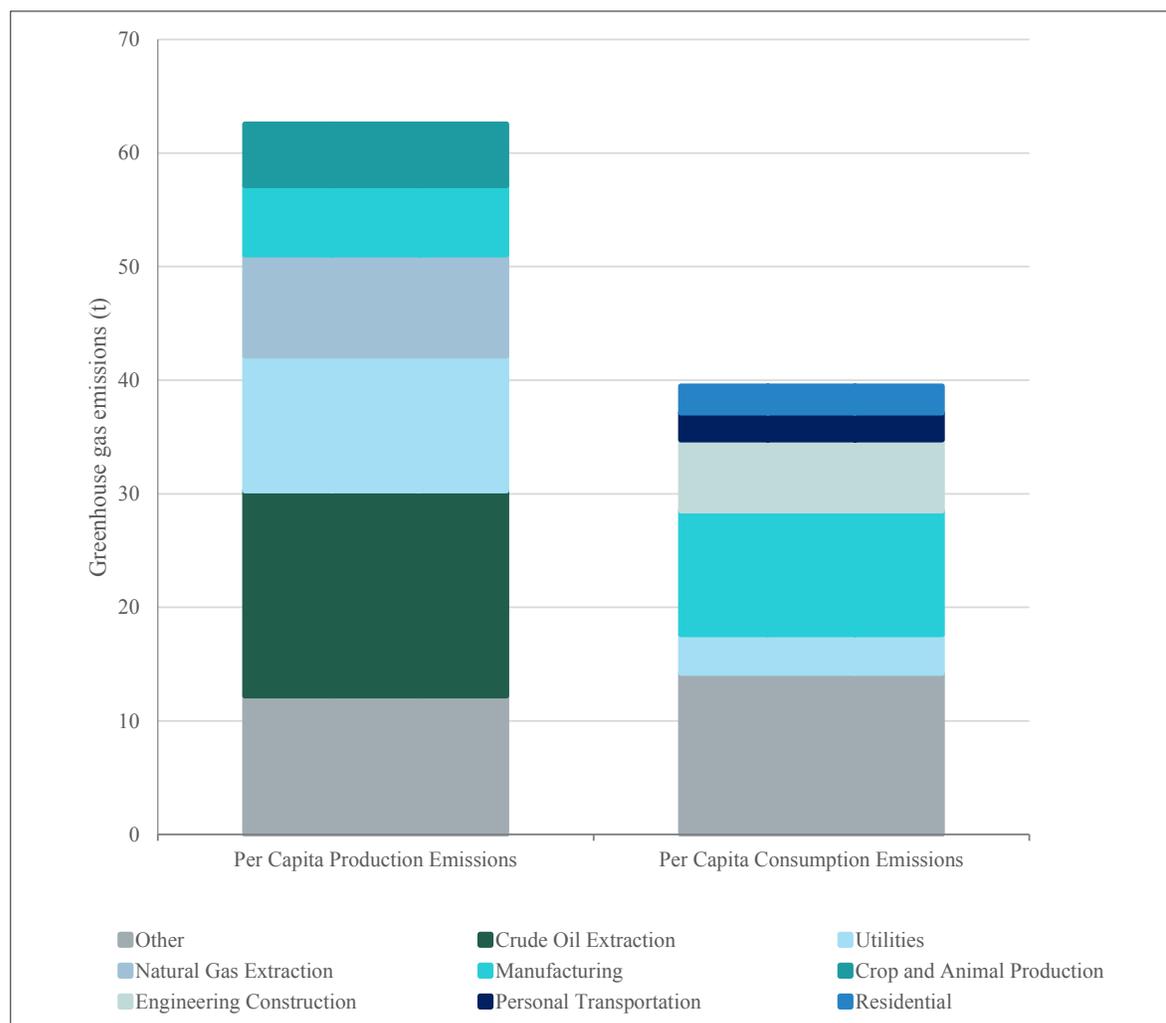
Data Source: Fellows, G. Kent and Sarah Dobson. 2017. "Embodied Emissions in Inputs and Outputs: A Value-Added Approach to National Emissions Accounting." *Canadian Public Policy*, 43(2): 140-164. <https://doi.org/10.3138/cpp.2016-040>.

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 Alberta are crude oil extraction (18.1 t), utilities (11.9 t), natural gas extraction (8.9 t), manufacturing (6.1 t), and crop and animal production (5.4 t). In comparison, the largest sectors responsible for per capita consumption emissions are manufacturing (10.9 t), engineering construction (6.3 t), utilities (3.4 t), personal transportation (2.4 t) and residential (2.4 t) (Figure 2).

FIGURE 2 BREAKDOWN BY SECTOR OF ALBERTA 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).

Only two sectors – utilities and manufacturing – overlap as a primary source of both production and consumption emissions in Alberta. Emissions in the utilities sector decrease by 71 per cent (-8.5 t) when moving from a production- to a consumption-based accounting approach while emissions in the manufacturing sector increase by 79 per cent (+4.8 t). The decrease in emissions in the utilities sector is due to the fact that electricity purchased by firms and government accounts for a large share of output from the sector. This electricity – and its associated emissions – then becomes an intermediate input into the production of goods or provision of services that are sold to final consumers in Alberta, other provinces or internationally. Accordingly, under a consumption-based accounting approach these emissions are reallocated to the sector and region in which final

consumption of these goods and services occurs. Emissions that remain in the utilities sector under both a production- and a consumption-based accounting approach are primarily those associated with the generation of electricity for household use, which is a final consumption good. In contrast, the increase in emissions in the manufacturing sector is a result of three related 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 Alberta, elsewhere in Canada and internationally being reallocated to Alberta's manufacturing sector – and specifically household consumption and firm investment – under a consumption-based accounting approach.

Emissions from the crude oil extraction, natural gas extraction, and crop and animal production sectors are primary sources of production emissions in Alberta but not consumption emissions. The change in emissions when moving from a production- to a consumption-based accounting approach is most drastic in the crude oil extraction sector, with emissions falling to zero (-18.1 t). This is because crude oil is not consumed in its raw form, but is rather an input into the production of refined petroleum products. Production emissions from the sector are subsequently reallocated to the sector and region – most often interprovincial or international – in which consumption of the refined petroleum product occurs. Emissions from the natural gas extraction sector and from the crop and animal production sector similarly fall by 84 per cent (-7.4 t) and 81 per cent (-4.4 t) respectively. This is again the result of a large share of output from both sectors being sold to intermediate suppliers – food manufacturers, restaurants, food distributors and grocery stores in the crop and animal production sector, and oil and gas companies, utilities and manufacturers in the natural gas extraction sector. Production emissions are then reallocated to the sector and region that supply the final consumption good or service for which Alberta's farm output or natural gas is an input.

Last, the engineering construction, personal transportation and residential sectors are primary sources of consumption emissions in Alberta but not production emissions. Emissions in the engineering construction sector increase from only 0.2 t under a production-based accounting approach to 6.0 t under a consumption-based accounting approach. The increase in engineering construction emissions is driven by the sector absorbing all of the emissions associated with production of its inputs. For example, when an oil and gas services firm purchases cement to secure a well casing, emissions associated with the production of the cement are reallocated from the other (non-energy) mining and manufacturing sectors to the engineering construction sector. Notably, output from the engineering construction sector reflects only expenditure by firms, and all of the consumption emissions are therefore allocated to firm investment. In contrast, emissions in the personal transportation and residential sectors do not change 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.

As shown on the right-hand side of Figure 1, Alberta'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 ALBERTA 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>					
21.3 t (54%)		15.0 t (38%)		3.2 t (8%)	
Top Sectors Contributing to Consumption Emissions					
Manufacturing:	6.7 t	Engineering construction:	6.3 t	Other provincial government services:	1.1 t
Utilities:	3.3 t	Manufacturing:	4.2 t	Other municipal government services:	0.8 t
Personal transportation:	2.4 t	Residential construction:	1.4 t	Government education services:	0.5 t
Residential:	2.4 t	Natural gas extraction:	1.2 t	Government health services:	0.4 t
Transportation and warehousing:	1.1 t	Non-residential building construction:	0.9 t	Other federal government services:	0.3 t
Other:	5.5 t	Other:	1.0 t	Other Aboriginal government services:	0.2 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

The majority of Alberta’s interprovincial net exports of emissions are associated with crude oil and natural gas extraction. Alberta is a net exporter of crude oil extraction emissions to British Columbia, Saskatchewan and Ontario; all three provinces with refineries that process Alberta oil. Net exports of natural gas extraction emissions are sent to Saskatchewan, Manitoba, Ontario and Quebec. These are the four provinces on TransCanada’s mainline, the main pipeline for moving natural gas from Alberta to demand centres east of the province. In addition to its resource extraction emissions, Alberta is also a large net exporter of manufacturing emissions to British Columbia, Manitoba, Saskatchewan and the Territories. These emissions are likely driven in large part by the export of refined petroleum products from Alberta’s refineries.

Due to the dominance of its resource extraction emissions, Alberta is the only province that is a net exporter of emissions to all other provinces. However, looking at individual sectors, Alberta’s largest net imports of greenhouse gas emissions are from the manufacturing sectors in Ontario and Quebec, and from the natural gas extraction sector in British Columbia. This latter source is consistent with the import of natural gas from British Columbia to meet Alberta industrial demand, most notably in the oil sands. Alberta additionally has large net imports of emissions from the crop and animal production sector in Saskatchewan and from the finance, insurance, real estate, and rental and leasing sector in Ontario.

INTERNATIONAL TRADE FLOWS

Internationally, emissions from the crude oil extraction and natural gas sectors drive Alberta’s net exports of emissions. The majority of these emissions are going to the United States, which received 99 per cent of the value of Alberta’s crude oil and natural gas exports in 2011 (Industry Canada, 2017). Alberta is also a large net exporter of emissions from the crop and animal production, transportation and warehousing, wholesale trade and coal mining sectors, and is a significant net importer of emissions in the manufacturing and accommodation and food services sectors.

TIME TREND OF PER CAPITA PRODUCTION AND CONSUMPTION EMISSIONS

Total production emissions in Alberta increased over the period of 2004 to 2011 (+5 per cent) (Figure 3). Growth in the province's population (+17 per cent), however, outpaced the growth in emissions. As a result, on net, per capita production emissions in the province declined by 10 per cent (Figure 4). The growth in emissions was driven largely by increased activity in the oil sands and rising emissions in the crude oil extraction sector. Starting in 2007, however, the growth in oil sands emissions was countered by declining production – and emissions – from Alberta's natural gas production sector (National Energy Board, 2016). As a result, Alberta's peak production emissions were reached in 2007.

Total consumption emissions in Alberta similarly grew over the period of 2004 to 2011 and outpaced the growth in production emissions. Specifically, total consumption emissions in the province increased by 12 per cent while the increase in per capita consumption emissions was eight per cent. Alberta was a net exporter of greenhouse gas emissions in 2004. As the growth in consumption emissions outpaced the growth in production emissions, the gap between them narrowed over the period of 2004 to 2011, with per capita net exports falling from 33.1 t in 2004 to 23.1 t in 2011.

The impact of the 2008/2009 global recession is evident in the pattern for both household and firm investment consumption emissions. Specifically, after growing from 2004 to 2007, total and per capita emissions for both groups declined in 2008 and 2009 and then recovered in 2010 and 2011. On net from 2004 to 2011, total household consumption emissions increased (+16 per cent) while per capita emissions remained relatively unchanged (-1.0 per cent). Notably, however, there were large differences in trends within the consumption subsectors. Specifically, the transportation and warehousing, manufacturing and wholesale trade sectors saw moderate increases in household consumption emissions while the finance, insurance, real estate, rental and leasing sector, and the retail trade sector saw large decreases.

In contrast to household consumption emissions, both total and per capita firm investment consumption emissions increased substantially – by +45 and +23 per cent respectively – from 2004 to 2011. The aggregate construction sector saw the largest increase in firm investment emissions, with the engineering construction sector driving most of the growth since 2009.³ This again points toward increased activity in the province's oil sands as a primary driver of rising emissions.

Total and per capita government consumption emissions increased by 33 and 13 per cent respectively from 2004 to 2011. They were generally steadier than household and firm investment emissions, with only one notable increase – stemming from increased emissions in the “other” (non-health care and education) municipal, provincial and Aboriginal government services sectors – from 2009 to 2010.⁴

³ Prior to 2009 emissions data are only available for the aggregate construction sector.

⁴ Prior to 2009 emissions data are only available for the aggregate government services sector.

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

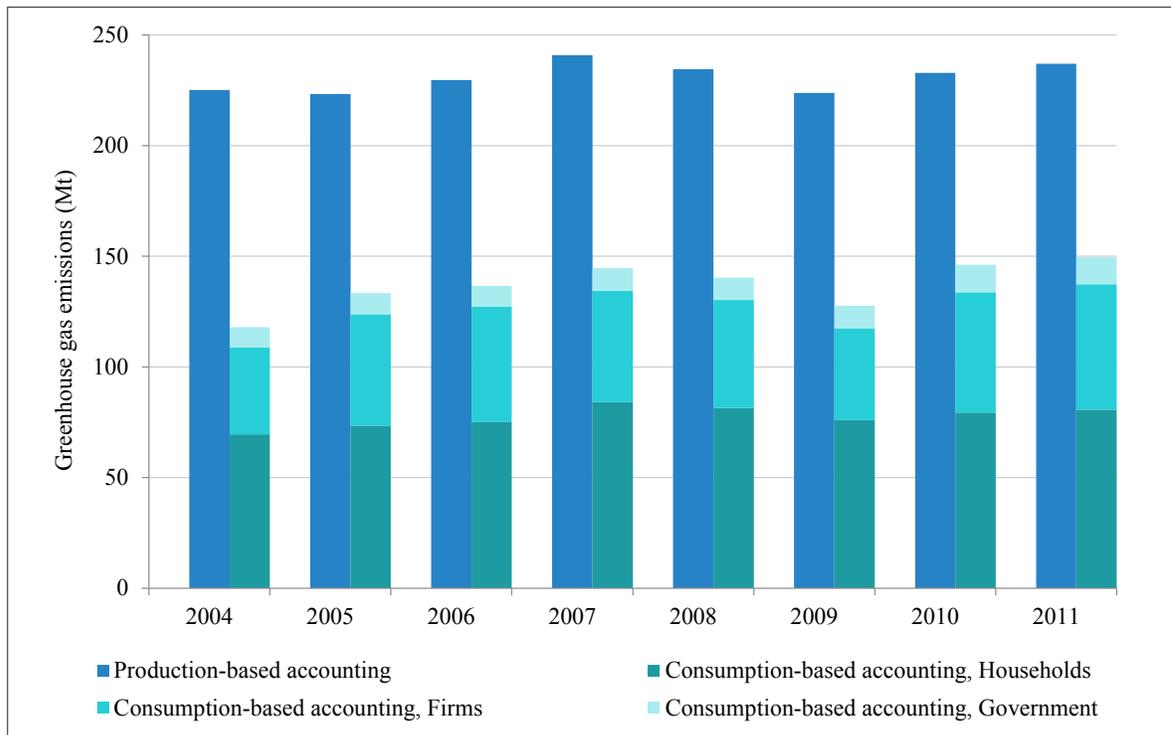
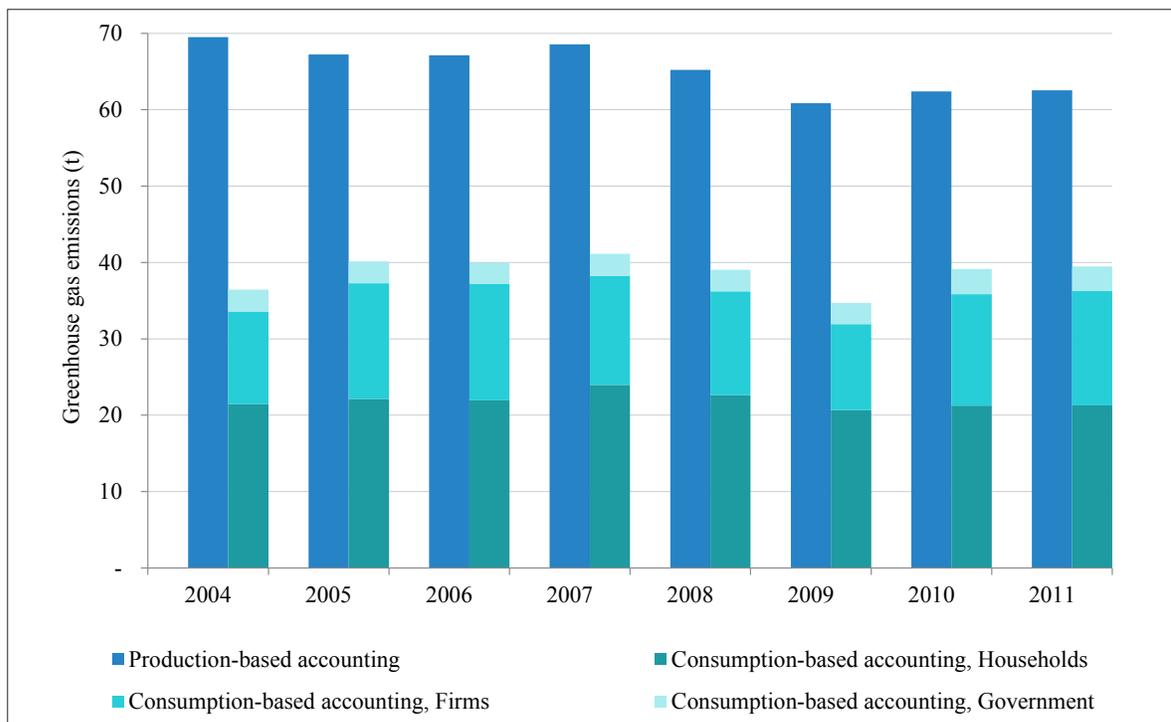


FIGURE 4 PER CAPITA PRODUCTION AND CONSUMPTION EMISSIONS, ALBERTA: 2004 TO 2011



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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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