



CIRAIG^{MC}

Centre international de référence sur le
cycle de vie des produits, procédés et services



FINAL TECHNICAL REPORT

CARBON FOOTPRINT OF PURCHASES BY PUBLIC SERVICES AND PROCUREMENT CANADA - QUEBEC REGION

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**Public Services and Procurement Canada
Quebec Region**

To the attention of

Laure Gérard

Environmental Specialist, Real Property Branch

Annick Champoux

Chief, Contract Quality Management, Procurement Directorate



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CIRAIG

International Reference Center
for the Life Cycle of Products, Processes and Services
École Polytechnique de Montréal
Département de génie chimique
2900 Édouard-Montpetit
Montréal, Quebec, Canada
PO Box 6079, Downtown Station
H3C 3A7

www.ciraig.org

Report submitted by:
BUREAU DE LA RECHERCHE ET CENTRE DE
DÉVELOPPEMENT TECHNOLOGIQUE (BRCDT)
ÉCOLE POLYTECHNIQUE DE MONTRÉAL

Université de Montréal Campus
PO Box 6079, Downtown Station
Montréal, Quebec H3C 3A7

Working group

Conduct

Dominique Maxime, Ph.D.

Conduct of study

Constant Vallée-Schmitter, MSc.A.

Tracking tool development

Collaboration

Sophie Fallaha, M.Sc.A.

Director of Operations

Project coordination

Project management

Prof. Réjean Samson, eng., PhD

General Director, CIRAIG

Scientific project management

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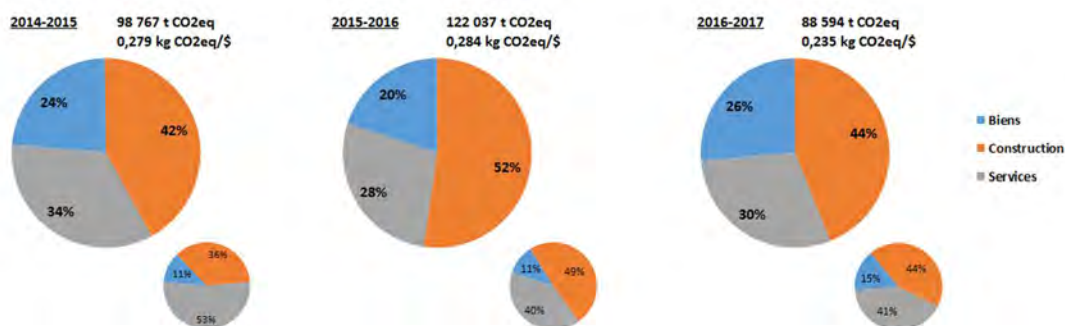
CA	Canada
CIRAIG	International Reference Centre for the Life Cycle of Products, Processes and Services
CO ₂	Carbon dioxide
CO ₂ eq	Carbon dioxide equivalent
ET	Excluding taxes
GHG	Greenhouse gases
GJ	Gigajoule
GSIN	Goods and Services Identification Number
GWP	Global warming potential
I/O	Input/output
I/O-E or IO-E	Environmental input/output
IOCC	Input Output Commodity Classification
IOIC	Input Output Industry Classification
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt-hour
LCA	Life cycle analysis
LCI	Life cycle inventory
LCIA	Life cycle impact assessment (called LCIA by ISO)
MJ	Megajoule
PSPC	Public Services and Procurement Canada
PSPC-QC	Public Services and Procurement Canada - Quebec Region
QC	Quebec
UNSPSC	<i>United Nations Standard Products and Services Code</i>

Résumé exécutif

Dans le cadre des engagements du gouvernement fédéral et de ses politiques pour la lutte contre les changements climatiques et la protection de l'environnement, Services publics et Approvisionnement Canada (SPAC) a le mandat de veiller aux caractères écologique et social des approvisionnements fédéraux et de chercher à réduire les émissions de gaz à effet de serre (GES) qui leurs sont associées. Cette étude pour SPAC-région de Québec (SPAC-QC) évalue les GES associés au cycle de vie (empreinte carbone) de l'ensemble des approvisionnements annuels dont il a le mandat, afin d'identifier parmi eux, ceux qui causent le plus d'impacts et sur lesquels il serait prioritaire d'agir (p.ex. via des critères ciblés dans ses appels d'offre).

L'étude a évalué les contrats d'approvisionnements annuels (bien et service) passés par SPAC-QC¹ pour chacune des trois dernières années fiscales (2014-2015 à 2016-2017) et, tout d'abord, en a dressé un portrait économique. Sont concernés, annuellement, de 2 000 à 3 000 contrats pour un montant total de 400 à 500 millions de dollars. L'empreinte carbone est calculée à l'aide de *openIO-Canada* un modèle d'analyse entrées-sorties environnementale, qui utilise des données financières et qui est adéquate pour évaluer des milliers de biens et services très différents entre eux, pour lesquels des informations précises et des données physiques ne sont pas disponibles. L'analyse se base sur une approche cycle de vie « du berceau à la porte » c'est-à-dire à l'usine de fabrication. Toutefois, pour les services, l'empreinte carbone inclut jusqu'à la livraison du service, c'est-à-dire sa réalisation².

L'empreinte carbone annuelle moyenne des approvisionnements de 2014 à 2017 est estimée à 103 133 tonnes CO₂eq, soit une intensité en GES moyenne de 0,266 kg CO₂eq par dollar hors taxes, avec une variabilité notable selon l'année et la nature des approvisionnements.



Empreinte carbone (tonnes CO₂eq), intensité carbone (kg CO₂eq/\$) et contributeurs à l'empreinte carbone selon les trois grandes catégories d'approvisionnements (en miniature : contribution par montant).

¹ Approvisionnements réalisés par la Direction des approvisionnements par une demande d'achat 9200.

² Par exemple, pour un service de construction, l'empreinte carbone inclut aussi les déplacements d'ouvriers, le transport de matériaux, l'utilisation de la machinerie nécessaire, la gestion des déchets générés sur le site. Le carburant consommé par la machinerie de l'entrepreneur et les GES de sa combustion sont inclus.

Les contributions aux émissions de GES des ministère-client sont très similaires aux contributions en valeur des achats totaux. L'importante contribution de SPAC à l'empreinte carbone des approvisionnements s'explique par la forte proportion de travaux construction et de services d'architecture et d'ingénierie civile. Les biens et services de ce type, et plus largement tous ceux associés à la construction, la maintenance et la réparation d'infrastructures (résidentielles ou non) et tous les travaux de génie civil, ont tous une forte intensité GES (0,47 kg CO₂eq/\$ et au-delà).

Principaux ministères-clients et catégories de biens et services contribuant à l'empreinte carbone des approvisionnements de SPAC-QC.

Client Bien ou service (NIBS)	2014 - 2017	
	% empreinte carbone totale	% empreinte carbone client
Travaux publics et Services gouvernementaux Canada	47%	
Construction d'autres édifices		39%
Autoroutes, rues, routes, voies ferrées, pistes d'aéroport		12%
Services de construction, non énumérés ailleurs		4%
Ouvrages de maçonnerie, ouvrages de pierre		3%
Ministère de la défense nationale	18%	
Domaine militaire (R&D)		13%
Services de traiteur		8%
Nettoyage et entretien, conciergerie		8%
Composants divers de véhicules - réparation		6%
Pêches et Océans Canada	12%	
Navires et bateaux de grandes dimensions - réparation, radoub et transformation		18%
Travaux généraux de construction maritime		12%
Voies de navigation, ports, barrages et autres adductions d'eau		11%
Bois de construction, traité, construction marine		10%
Service correctionnel du Canada	7%	
Provisions, divers		23%
Papier et carbonnage		10%
Provisions, divers (remplacé par nibs N8920ZC)		7%
Viande, volaille et poisson		7%
Agence spatiale canadienne	6%	
Astronautique (R&D)		45%
Mise au point d'instruments pour engin spatial (R&D)		18%
Services d'exploitation et d'entretien d'installations techniques et scientifiques		9%
Traitement de données du satellite et services connexes		5%
Conseil national de recherches du Canada	2%	
Équipement et approvisionnements de laboratoire		95%
Bioxyde de carbone, technique, glace sèche		2%
Dispositifs pour laboratoire, automation et robotique		1%
Instruments d'optique, matériel d'essai, composants et accessoires		1%
Autres ministères-clients	7%	
Grand Total	100%	

Sur l'ensemble des trois années, ce sont 72 biens et services uniques (sur environ 400 chaque année) qui cumulent 80% de l'empreinte carbone des approvisionnements. Une vingtaine d'entre eux seulement contribuent individuellement à plus de 1%, et ensemble pour 60% de l'impact total. Les services de recherche et de développement, les services de réparation de véhicules et aussi de navires, les produits alimentaires et services traiteurs, les services de nettoyage et d'entretien et enfin l'équipement et les approvisionnements de laboratoire sont

les autres approvisionnements sources des principales émissions de GES. Certains sont communs à beaucoup de ministères.

Des recommandations sont élaborées par rapport à ces approvisionnements clés et sur la manière dont SPAC-QC peut utiliser la présente analyse pour suivre ses progrès et améliorer ses pratiques pour l'écologisation de ses achats. L'analyse de contribution permet de révéler où les fournisseurs de SPAC pourraient réduire leurs émissions de GES dans leurs propres activités ou leur chaîne d'approvisionnement (par exemple, la production des matériaux de construction, l'efficacité énergétique lors des travaux de construction). Elle peut guider pour prioriser là où des exigences pourraient être requises des fournisseurs. Si les données comptables sources sont décrites avec suffisamment de détail (selon les détails de la classification NIBS, et à l'avenir UNSPSC), l'évaluation de l'empreinte carbone et l'analyse ultérieure peuvent aussi gagner en précision et permettre d'affiner des recommandations (par exemple sur des catégories d'aliments).

La présente étude ainsi que l'outil de suivi qui est fourni offrent une perspective macroscopique qui permet à SPAC-QC de rapporter annuellement sur l'empreinte carbone de l'ensemble des approvisionnements dont il a le mandat, de révéler l'émergence avec le temps de catégories de produits contributrices (et possiblement de forte intensité carbone), ou encore de suivre et de conseiller individuellement ses ministère-clients.

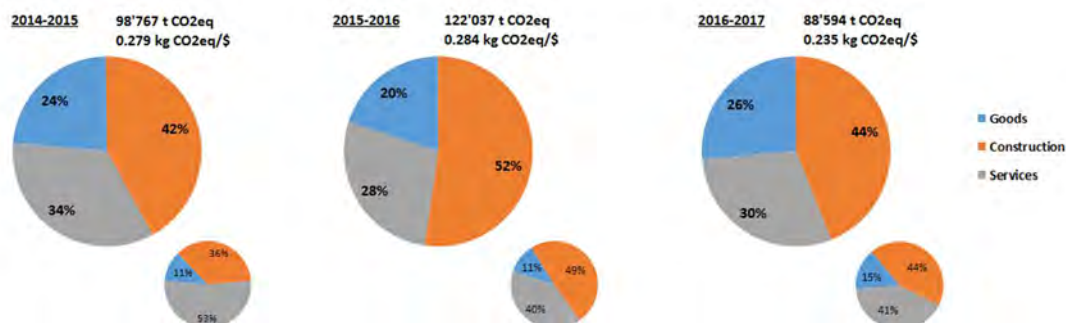
Enfin, il convient de garder à l'esprit que l'empreinte carbone calculée dans cette étude n'inclut pas les étapes d'utilisation et de fin de vie des biens achetés. Le portrait environnemental des approvisionnements est donc partiel, en particulier pour les biens durables consommateurs d'énergie durant leur vie utile. Une suite de l'étude pourrait aborder cet aspect.

Executive Summary

In line with the federal government's commitments to climate change and environmental protection, Public Services and Procurement Canada (PSPC) has to address the ecological and social aspects of federal procurement and seek to reduce their associated greenhouse gases emissions (GHG). This study evaluates the life cycle GHG (the carbon footprint) associated with the procurements under the authority of PSPC-Quebec Region (PSPC-QC), in order to identify those that have the largest impact and on which it would be a priority to act (e.g. via targeted criteria in its calls for tender).

Procurement contracts for goods and services awarded by PSPC-QC have been evaluated for each of the last three fiscal years (2014-2015 to 2016-2017).³ First of all, an economic overview is provided. About 2,000 to 3,000 contracts are covered annually for a total amount of \$400-500 million. Then, the carbon footprint is calculated using openIO-Canada, a model for environmentally extended input-output analysis (EEIO), which is based on financial data and is an appropriate method to evaluate thousands of goods and services that are very different from each other, and for which accurate information and physical data is not available. The analysis is based on a cradle-to-gate life cycle approach (gate of the manufacturing plant, for goods). However, for services, the carbon footprint is extended up to the delivery of the service.⁴

Averaged over 2014 to 2017, the yearly carbon footprint of procurements is estimated to 103,133 tonnes CO₂eq, equivalent to a GHG intensity of 0.266 kg CO₂eq per dollar (excluding taxes). It shows a rather significant variability along the years according to the type of procurements.



Carbon footprint (tonnes CO₂eq), GHG intensity (kg CO₂eq/\$) and contribution of goods, services and construction-related procurements to the annual carbon footprint (small pie charts: contribution in value to procurement amount).

Contributions to GHG emissions from procurements by departments are very similar to contributions in value of total purchases. PSPC's significant contribution to the carbon footprint

³ Procurement contracts awarded by the Procurement Directorate through a #9200 purchase order.

⁴ For instance, for a construction service, the carbon footprint also includes the transport of materials and workers up to the construction site, the use of the machinery needed, and the management of construction waste generated on site. The fuel consumed by the contractor's machinery and GHG from its combustion are included.

is due to the high proportion of construction works and architectural and civil engineering services. Goods and services of this type, and more broadly all those associated with the construction, maintenance and repair of buildings (residential or non-residential) and all civil engineering work, all have a high GHG intensity (0.47 kg CO₂eq/\$ and beyond).

Main contributors to the carbon footprint: the four most-contributing categories of procurements per department.

Department Good or Service (GSIN)	2014 - 2017	
	% overall carbon footprint	% department's carbon footprint
Public Works and Government Services Canada	47%	
Construction of Other Buildings		39%
Highways, Roads, Railways, Airfield Runways		12%
Construction Services, Not Elsewhere Specified		4%
Masonry, Stonework		3%
Department of National Defence	18%	
Military (R&D)		13%
Food Catering Services		8%
Cleaning and Maintenance, Janitorial		8%
Vehicular Components, Miscellaneous - Repair		6%
Fisheries and Oceans Canada	12%	
Ships and Vessels (large) - Repair, Refits and Conversions		18%
General Marine Construction Work		12%
Waterways, Harbours, Dams and Other Water Works		11%
Lumber, Treated, Marine Construction		10%
Correctional Service of Canada	7%	
Groceries, Miscellaneous		23%
Paper and Paperboard		10%
Groceries, Miscellaneous (replaced by gsin N8920ZC)		7%
Meat, Poultry and Fish		7%
Canadian Space Agency	6%	
Astronautics (R&D)		45%
Spacecraft Instrumentation Development (R&D)		18%
Operation and Maintenance Services of a Technical/Scientific Facility		9%
Satellite Data Processing and Related Services		5%
National Research Council Canada	2%	
Laboratory Equipment and Supplies		95%
Carbon Dioxide, Technical (Dry Ice)		2%
Laboratory, Automation And Robotics Devices		1%
Optical Instruments, Test Equipment, Components and Accessories		1%
Other Departments	7%	
Grand Total	100%	

Over the three years, 72 unique goods and services (out of about 400 each year) account for 80% of the carbon footprint of procurements. Only 20 of them contribute for more than 1% individually and together for 60% of the total impact. Research and development services, vehicle and ship repair services, food and catering products, cleaning and maintenance services, and laboratory equipment and supplies are the other major sources of GHG. Some are common to many departments.

Recommendations are being developed for these key procurement items and how SPAC-QC can use this analysis to track its progress towards greener procurement. Contribution analysis reveals where PSPC suppliers could reduce GHG emissions in their own operations or from their supply chain (for example, during the manufacturing and the transportation of building materials, through energy efficiency during construction operations). It can give guidance to prioritize the instances where requirements may be required from suppliers. If source data is described with sufficient detail (according to the details of the G SIN classification, and especially of the UNSPSC classification to be used in the short term), the carbon footprint assessment and subsequent analysis can also gain precision and allow for finer recommendations (e.g., for food categories).

This study, as well as the monitoring tool that is provided to SPAC-QC as an additional deliverable, provides a macroscopic perspective that allows SPAC-QC to report annually on the carbon footprint of procurements contracted, to spot the emergence with time of contributing categories (and possibly carbon-intensive ones), or to monitor and advise the client-departments.

Finally, it should be kept in mind that the carbon footprint calculated in this study does not include the use phase and the end of life of the goods purchased. The environmental picture of procurement is therefore partial, especially for durable goods that consume energy during their lifetime. A follow-up to the study could address this aspect.

1 Background

As part of the federal government's commitments and policies regarding climate change and environmental protection, Public Services and Procurement Canada (PSPC) has a mandate to monitor the ecological and social aspects of federal procurement and to reduce their associated greenhouse gas (GHG) emissions. As a result, PSPC-Quebec Region (PSPC-QC) first wants to assess the GHGs associated with the life cycle (carbon footprint) of all annual procurement for which it has a mandate in order to identify those that have the largest impact and for which it would be a priority to act (e.g., via targeted criteria in calls for tender). PSPC-QC also wants to develop an assessment tool that will enable it to estimate the carbon footprint of its procurement in future years and thus track its progress in procurement that has a low impact on climate change.

2 Objectives and Scope of Study

2.1 Objectives

More specifically, the objectives of the study are to:

- I. Provide an economic portrait of the annual procurement contracts awarded by PSPC-QC for the last three fiscal years (2014/2015, 2015/2016 and 2016/2017) with a detailed analysis:
 - i. By year;
 - ii. By procurement category (i.e., similar product groupings);
 - iii. By PSPC-QC client department.
- II. Assess the GHGs associated with the life cycle of producing these procurement items:
 - i. Identify the procurement categories that contribute most to the overall procurement carbon footprint;
 - ii. Analyze the results;
 - iii. Present recommendations.
- III. Develop a bilingual MS-Excel tool, with a user guide, that allows a PSPC-QC user to:
 - i. Repeat the annual procurement GHG overview in future years;
 - ii. Compare it with those of past years.

2.2 Scope of study

The purpose of this section is to clarify what the assessed carbon footprint will be, particularly with respect to the various stages of a procurement life cycle (good or service) and with respect to all the purchases that PSPC-QC may make.

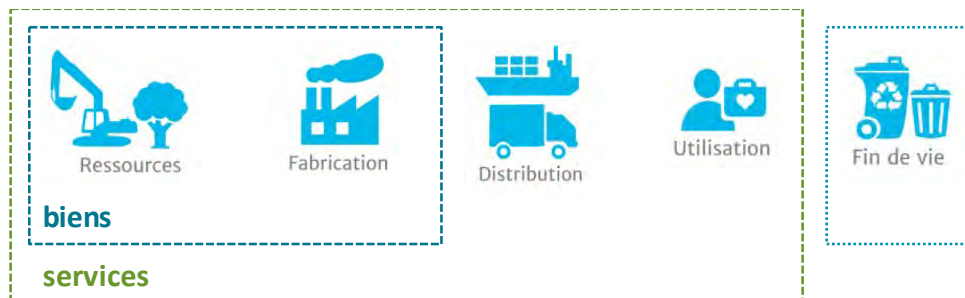
2.2.1 Description of the system studied and its boundaries

The study focuses on the goods and services that PSPC-QC procures on its own behalf and for its client departments through various purchasing tools. Three fiscal years, from April 1, 2014, to March 31, 2015, and then 2015/2016 and 2016/2017, were successively studied. It must be noted that the following were not considered here:

- Procurement that was not carried out by the Supply Branch (through a 9200 purchase order);
- Purchases made by PSPC employees or client departments on an individual basis regarding activities such as commuting from home to the workplace and their meals.

The total annual amounts of supplies considered varies from year to year, between \$400 million and \$500 million (taxes included) for 2,000 to 3,000 transactions. More details on procurement are provided in paragraph **Error! Reference source not found.** and in the economic analysis of the results in chapter **Error! Reference source not found.**.

The life cycle stages of procurement (goods and services) considered in the environmental assessment are shown in Figure 2-1.



Note:

*Au travers de certains services, la fin de vie de biens acquis dans l'année **mais aussi** dans le **passé** peut se trouver considérée pour partie.*

Figure 2-1: Boundaries of the system being studied

For a **good**, the impact is calculated “from cradle to gate,” that is, at the factory where it is manufactured. The stage of its distribution to the client department is not included for a variety of reasons:

- i. The information on the origin of the good and its specific destination is not necessarily known;
- ii. The environmental analysis model used below does not have this information for goods, even though it would be generic. This is one of the limitations of the model and, by extension, of the study.

The use stage of the good (for example, the electricity consumed by a computer, gasoline consumed by a vehicle) is not included because:

- i. PSPC procurement data do not contain sufficient descriptive detail about the good to model its use (for example, the specific electricity consumption of a device or the fuel consumed by a generator);
- ii. The thousands of contracts assessed cannot be stripped down to try to model a use step that is representative of each, even if it were generic; conversely, supplies are modelled by grouping according to the GSIN;⁵
- iii. The environmental analysis model used does not have this information for all products, even though it would be generic (it only has it for energy products, but for the sake of consistency, the use stage of these products has also been excluded from the scope of the study).

For a **service**, the environmental analysis model used includes the distribution and delivery stages of the service, that is, its completion (Figure 2-1). For example, an infrastructure repair service includes worker travel, material transportation, the use of necessary machinery, and the management of waste created at the site. Direct GHG emissions from the service provider are included. For example, for a construction service, the fuel consumed by the contractor's machinery is included and the GHG of its combustion are accounted for.

⁵ The federal government uses Goods and Services Identification Number (GSIN) codes to identify generic product descriptions as part of its procurement activities.

Generally, the **end of life for goods** is not considered. However, through some services, the end of life for goods acquired in the studied year, but also in the past, may be considered in part. The lack of detail and information on these services makes it difficult to link them to specific goods and to a specific procurement year. They may include services such as:

- Waste management services;
- Various repair and maintenance services (such as buildings, civil engineering infrastructure for transportation, energy, and telecommunications) that can generate waste (most typically building material waste) and that include the end-of-life management of the waste generated as a service.

3 Methodology

This chapter presents the methodology developed for the completion of the project. The method and environmental analysis model are first explained and then the provided procurement data are explained.

3.1 Analysis method

The methodology proposed for the study relies on the **Input-Output environmental analysis (IO-E)** derived from the Input-Output economic analysis. The IO-E analysis is commonly used to conduct environmental analyses in situations where the traditional life cycle analysis (LCA) is less appropriate. This is particularly the case when the system being studied involves a large number of goods and services and conducting an LCA for each of them to model the system is ultimately not possible (individual data not available or difficult to access, workload too high). With this methodology, the environmental impacts are assessed using the **amounts** of goods and services purchased and classified according to their type. More details on the principles of the IO-E analysis are provided in Appendix A.1.

3.1.1 Tool and model

The analysis tool used is an adaptation of openIO-Canada. Open IO-Canada is a Canadian IO-E model developed by CIRAIG in 2014.⁶ It is a multi-criteria analysis tool⁷ used as part of this study for GHG assessment. Its geographic scope is Canada, that is, it represents Canada's domestic economic activities and does not consider interactions with foreign countries. In other words, any goods or services that would be imported are modelled with the tool as if they were produced in Canada. The adaptation of openIO-Canada to the public version involves:

- The inclusion of **electricity production in Quebec**, in addition to average Canadian electricity, so that a choice can be made between a good or a service produced in Quebec and Canada. It must be noted that this **contextualization** i) does not make it an interprovincial model because the economies of the provinces and their trade are not distinguished, and ii) is only partial, since only the energy mix of electricity consumed is changed (i.e., all economic activities in Quebec other than the electricity generation industry are identical to the average Canadian counterparts for their direct GHG emissions);
- The calculation of emissions linked to the use stage of major petroleum energy products (functionality not relevant to this study as mentioned above).

The openIO-Canada economic model distinguishes more than 420 different types of goods and services (over 840 when Canada and the Quebec Region are separated) that cover all of Canada's economic activities and for each of which the environmental impacts can be calculated. It must be noted that these goods and services are identified according to

⁶ www.ciraig.org/en/open_io_canada/

⁷ The environmental data it integrates include GHG emissions and water use (direct environmental sampling and acquisition of procurement utilities) based on Statistics Canada's Environment Accounts and toxic air, water, and soil pollutant emissions based on Environment Canada's National Pollutant Release Inventory (NPRI).

Statistics Canada's Input-Output Commodity Classification (IOCC), which differs from the GSIN classification used by the federal government for its procurement.

The methodology and the openIO-Canada tool used are described in greater detail in Appendix A.1, the IOCC classification is presented in Appendix A.2, and the limits of the analysis model are listed in Appendix A.3.

3.1.2 *Impact indicator: carbon footprint*

The assessment of GHG emissions, represented by the ***Climate Change*** or ***Carbon Footprint*** indicator, was carried out using the IPCC 2007 method, considering the cumulative radiative forcing over a 100-year timespan. This method is based on the global warming potentials (GWPs) published by the Intergovernmental Panel on Climate Change (IPCC) in 2007 for each GHG. The GHGs considered by the openIO-Canada are those provided by Statistics Canada's Environment Accounts, which are CO₂, CH₄, and N₂O. The potential of each GHG is calculated in kilograms of carbon dioxide equivalent (kg CO₂eq), which is the reference unit of the Climate Change indicator. The GWPs used are consistent with those currently used for GHG inventory reports from the governments of Quebec and Canada.

It is important to keep in mind that the results of the *Climate Change* indicator represent potential and not real environmental impacts. These are relative expressions that do not allow for the prediction of the final impacts or risk to the receiving environments or the exceedance of safety margins or standards.

3.2 Procurement data

3.2.1 *PSPC-QC source data*

PSPC-QC provided the procurement data for the Quebec Region for the last three fiscal years as a spreadsheet that compiles the purchase contracts for goods and services. These may be either initial contracts, amendments to these contracts or amendments to earlier contracts. Other relevant information from the source data includes, for each contract: the amount (in Canadian dollars, taxes included), the client department (including PSPC itself), the GSIN code for the good or service, the description of the purchase, the supplier's region (Canadian province, state of the United States or, otherwise, a unique code for any other foreign country).

Table 3-1 summarizes these data. They are analyzed in greater detail in chapter **Error! Reference source not found.** in the economic analysis of the results.

Table 3-1: Procurement data analyzed

		2014-2015	2015-2016	2016-2017
Amount (\$ taxes included)		\$405,927,006	\$493,870,024	\$429,462,992
Number of contracts		2,585	2,330	2,238
Initial contracts	Number	1,015	959	889
	Amount (in %)	82%	86%	77%
Amendments to initial contracts	Number	401	36	303
	Amount (in %)	3%	3%	3%
Amendments to past years' contracts	Number	1,169	1,010	1,046
	Amount (in %)	15%	12%	20%
Supplier source (% of amount)	Canada	96.9%	98.4%	93.9%
	United States	1.8%	1.4%	2.2%
	Other	1.2%	0.2%	4.0%

3.2.2 Processing procurement data

To allow for further analysis, several data processing steps had to be carried out. They are described below. It must be remembered that the openIO-Canada environmental analysis model is based on Statistics Canada's IOCC goods and services classification and that it uses tax-free amounts. Since PSPC procurements are classified with GSIN codes, there is also an issue of correspondence between classifications. Matches between the classifications had to be made and are also described below.

3.2.2.1 Exclusion of certain contracts

Some undefined procurements are coded with **GSIN N9999** ("Miscellaneous items") and cannot be matched in another classification. However, they represent only one or two contracts each year and count for only 0.02% to 0.05% depending on the year. It was decided with the agreement of PSPC-QC to exclude their GHGs from the analysis. However, a sensitivity analysis was carried out by assigning to these contracts an IOCC commodity with a high GHG intensity (in this case, dairy products, the intensity of which is four times higher than the average procurement). The carbon footprint is only affected by 0.13% in this case, which strengthens the case for excluding these procurements.

3.2.2.2 Multi-year contracts

Some contracts related to procurements that will span several years. Although the source data have delivery start and end dates, there is no information to indicate what proportion of the amount must be allocated to each year of the period. Even if this were possible, allocating an amount of year n over several years would imply that any future analysis for years $n+1$, $n+2$ etc. would be capable of accounting for the shares of amounts allocated in previous years. There is therefore an issue regarding continuity, and accounting traceability should be implemented to ensure that these amounts are actually counted in full so as not to underestimate the carbon footprint of each year. For this study, it was decided with PSPC-QC's agreement to allocate **100% of the amount of multi-year contracts to the year of their signing.**

3.2.2.3 Amendments

As mentioned in paragraph **Error! Reference source not found.**, a significant number of contracts are amendments and they represent a significant share of the total amount (from 15% to 23% depending on the year, see Table 3-1). The vast majority of these amendments (80% to 87%) refer to initial contracts signed in a previous year. Of these amendments, many (from 36% to 41%) have no value—that is, their amount is worth \$0—and probably relate to non-financial terms of the original contract. A small portion of amendments (4%) is in a negative amount. The majority (55% to 61%, depending on the year) are positive. In agreement with PSPC-QC, it was decided **not to exclude any amendment** from the analysis, regardless of its value or year of initial contract, assuming that an amendment of a positive amount (respectively negative) corresponds to the delivery of an additional quantity (respectively reduced) of a good or service and to allocate it entirely to the year of the amendment.

3.2.2.4 Exclusion of tax

Because the environmental analysis tool required tax-free amounts, taxes had to be removed from the tax-inclusive amounts in the source data. The following rules were provided by PSPC-QC with rates that are valid for the three years being studied:

- Products (GSIN beginning with the letter N)
 - a. Canadian supplier: the tax application rule is that the tax charged is that of the delivery address. Considering that everything was delivered to Quebec, taxes of 14.975% are to be removed from the contract amount.
 - b. Foreign supplier: For suppliers from outside Canada, no tax was added and the contract amount is therefore tax free.
- Services
 - a. Canadian supplier: the tax application rule is that the tax charged is that of the purchaser's address. Therefore, since all purchasers are in the Quebec Region, taxes of 14.975% are to be removed from the contract amount.
 - b. Foreign supplier: For suppliers from outside Canada, no tax was added and the contract amount is therefore tax free.
- Construction (GSIN starting with 51)
 - a. Canadian supplier: the tax application rule is that the tax charged is that of the purchaser's address. Therefore, since all purchasers are in the Quebec Region, taxes of 14.975% are to be removed from the contract amount.
 - b. Foreign supplier: There should not be a foreign supplier for construction contracts.

3.2.2.5 Matching between GSIN-UNSPSC and UNSPSC-IOCC classifications

As mentioned above, the federal government uses the Goods and Services Identification Number (GSIN) codes to identify generic product descriptions as part of its procurement activities. PSPC-QC source data contain a GSIN code for each contract. The federal government is looking at replacing GSINs in the near future with the UNSPSC classification,⁸ which is an international classification that is used by many other countries, institutions, and governments, such as the government of Quebec. In June 2016, the federal government published a partial matching (or mapping) table for matching GSIN codes with a unique UNSPSC code. It contains

⁸ *United Nations Standard Products and Services Code* (www.unspsc.org).

matches for 4,835 G SIN codes, but around 500 are not matched.⁹ After the analysis of PSPC-QC procurement, **82 GSINs do not have matches in the table developed by the government. As a result, they had to be matched manually** and then validated by PSPC-QC (Appendix B).

On another note, the openIO-Canada environmental analysis model is based on Statistics Canada's IOCC classification. In its version that was updated by CIRAIG in 2017, a partial matching table was developed to match more than 1,200 UNSPSC codes with a single IOCC code. It is therefore logical to use the UNSPSC classification as the intermediary between the GSIN and IOCC classifications.¹⁰ After the analysis of PSPC-QC's procurement is converted to UNSPSC, it appears that nearly **252 relevant UNSPSC codes do not have IOCC matches in the available table. These matches were made as a result** (Appendix C). The procedure was to find out whether the immediate parent UNSPSC code had an IOCC match in the existing table. Otherwise, we looked for the grandparent and so on. In fact, the UNSPSC classification is hierarchical¹¹ and such research can therefore be automated for hundreds of codes. Completed matches were verified retrospectively for all commodities that contributed more than 1.5% of the annual carbon footprint calculated once and corrected if necessary. The carbon footprint is then recalculated using an iterative process. During this validation process, more than 120 new UNSPSC-IOCC matches were made. The table now contains 1,325 matches.

3.2.2.6 Procurement source and environmental modelling

With OpenIO-Canada being contextualized for Quebec, it gives the option for each good and service in the model to be produced either in Canada or in Quebec. The rules set out in Table 3-2 were used to model procurement based on the origin of the supplier indicated in the source data from PSPC-QC.

It should be noted that products from a Quebec supplier are not necessarily manufactured in Quebec, particularly when the corresponding industry does not exist in Quebec or is not well developed there, in which case there is a strong likelihood that the product is manufactured elsewhere in Canada or abroad and imported into the province by the supplier.

Depending on their nature, the services of a non-Quebec supplier may be carried out in the supplier's area (typically, if this is office work, such as a design office, a translation service, a computer service, etc. or even laboratory work) or be carried out in Quebec following the relocation of a service provider (for example, the supplier may send a team for field analyses, send scientists to do lab work in Quebec, etc.) Since it is not possible to distinguish between these possibilities due to a lack of information, we considered that all services from a non-Quebec supplier were performed outside Quebec and therefore modelled as a Canadian service. This choice is conservative (that is, it does not underestimate the carbon footprint) because more-carbon-intensive electricity is considered in the life cycle of the service.

⁹<https://buyandsell.gc.ca/procurement-data/unspsc/download-unspsc>.

¹⁰ It must be noted that there is no GSIN-IOCC mapping table that may have been developed by PSPC or Statistics Canada.

¹¹ A UNSPSC code always has 8 digits. In groups of two, the first digits in turn define the segment (e.g., 72000000: Building and construction and maintenance services), the family (e.g., 72190000: Infrastructure maintenance and repair services), the class (e.g., 72191500: Road maintenance) and lastly, the commodity (e.g., 72191501: Snow removal). Therefore, there is a parent/child relationship between these 4 levels.

Table 3-2: OpenIO-Canada model region chosen based on procurement source

Source	OpenIO-Canada model region
Foreign procurement (excluding United States)	CA
United States procurement	CA
Procurement from Canada (outside Quebec)	CA
Procurement from Quebec	
Services	QC
Building materials (GSIN starting with 51)	QC
Forestry and food products	QC
Other goods	CA

4 Results and Discussion

The first section of this chapter begins with an overview of PSPC-QC's procurement for the three years of the economic study. Afterwards, estimates of GHGs associated with procurement life cycle are presented and discussed.

4.1 Economic analysis of PSPC-QC procurement

The assessed contracts represent a total net amount, excluding taxes, of \$354.5 million in 2014/2015, \$430.5 million in 2015/2016 and \$376.6 million in 2016/2017, with an average of \$387.1 million per year over the three years.

Table 4-1 presents PSPC-QC's client departments. PSPC (here, *Public Works and Government Services Canada*) is the main buyer, accounting for about half the value of procurement. Along with the Department of National Defence, the Canadian Space Agency, and Fisheries and Oceans Canada, these four departments cover 80% (in 2014/2015) to 90% (the other years) of PSPC-QC's total procurement.

It was also noted that procurement was significantly higher for:

- Fisheries and Oceans Canada and the National Research Council of Canada in 2016/2017, compared with previous years; and
- Canada Border Services Agency and the Office of Infrastructure of Canada in 2014/2015 compared with the following years.

For the Jacques Cartier and Champlain Bridges Incorporated, the negative net amounts in 2015/2016 and 2016/2017 reflect, for those years, amendments for reimbursement that were greater than purchases (see paragraph **Error! Reference source not found.**).

As indicated in Table 3-1, by year, from 94% to 98% of procurement, in value, are contracts signed with Canadian suppliers. More specifically, from 10% to 17% are suppliers from Ontario and 74% to 85% are suppliers from Quebec. Some contracts were signed with foreign suppliers other than the United States: 20 contracts accounting for 1.2% of expenses in 2014/2015, 16 contracts for 0.2% in 2015/2016, and 28 contracts for 4% in 2016/2017.

Figure 4-1 to Figure 4-3 present the products (goods or services) by GISC categories, which account for 80% of total procurement for the three years.¹² In general, some forty product categories accounted for 80% of procurement. The main sectors concerned are:

- Very remotely, the construction sector (buildings, transportation infrastructure) and associated architecture and engineering services, including structural maintenance and repair;
- Research and development (R&D) contracts in the military and aerospace sectors;
- Maintenance and management of buildings (cleaning, caretaking, security services, etc.);
- Purchase and maintenance of movable property (vehicles, trucks, ships, and boats, etc.);
- Environmental services (audit, analyses, etc.);
- Food and catering services.

¹² The complete data are available in MS Excel format in Appendix D.

The 2015/2016 fiscal year appears to be different, with significant amounts for contracts classified in the “Construction of other buildings” category. These are contracts signed by PSPC that explain the department’s large contribution to procurement for that year (Table 4-1). Large amounts in 2016/2017 for the construction and maintenance of seaways and marine infrastructure and for vessels and parts explain the high contribution of Fisheries and Oceans Canada as a client department this year compared with previous years.

Table 4-2 and Table 4-3 detail the information in the previous figures, specifying the contributions of the client departments for each of the main products.

Table 4-1: Net amount, taxes excluded, of PSPC-QC procurement by client department (departments are ranked in descending order of 2015/2016 amounts)

Client	2014-2015			2015-2016			2016-2017		
	Montant net HT	% montant total	Nbr contrats	Montant net HT	% montant total	Nbr contrats	Montant net HT	% montant total	Nbr contrats
Travaux publics et Services gouvernementaux Canada	151 780 445 \$	43%	1 023	231 684 172 \$	54%	986	165 519 343 \$	44%	1 223
Ministère de la défense nationale	66 223 834 \$	19%	604	78 561 011 \$	18%	506	64 447 327 \$	17%	367
Agence spatiale canadienne	45 501 800 \$	13%	316	42 269 433 \$	10%	209	46 803 375 \$	12%	242
Pêches et Océans Canada	20 585 650 \$	6%	111	33 708 557 \$	8%	142	63 380 200 \$	17%	146
Service correctionnel du Canada	15 732 744 \$	4%	265	22 836 498 \$	5%	260	6 164 898 \$	2%	84
Environnement Canada	2 034 503 \$	1%	8	4 874 765 \$	1%	16	1 284 576 \$	0,3%	8
Conseil national de recherches du Canada	1 800 687 \$	1%	26	3 525 117 \$	0,8%	36	16 458 276 \$	4%	46
Agence des services frontaliers du Canada	21 519 296 \$	6%	11	3 326 411 \$	0,8%	13	1 422 027 \$	0,4%	6
Transports Canada	4 514 474 \$	1%	58	2 459 227 \$	0,6%	31	2 736 454 \$	1%	18
Anciens Combattants Canada	3 896 089 \$	1%	101	2 271 617 \$	0,5%	65	58 175 \$	0,0%	2
Bureau de l'infrastructure du Canada	17 146 300 \$	5%	1	1 883 750 \$	0,4%	5	- \$	0,0%	4
Ressources naturelles Canada	730 480 \$	0,2%	13	1 452 782 \$	0,3%	19	364 186 \$	0,1%	19
Santé Canada	- \$	0,0%	1	809 099 \$	0,2%	5	2 534 170 \$	1%	14
Parcs Canada	388 052 \$	0,1%	4	586 601 \$	0,1%	8	864 558 \$	0,2%	15
Agence de dévpt écon. du Canada pour les régions du QC	550 607 \$	0,2%	13	266 032 \$	0,1%	6	359 391 \$	0,1%	2
Agence canadienne d'inspection des aliments	132 205 \$	0,0%	3	257 403 \$	0,1%	7	642 138 \$	0,2%	9
Affaires autochtones et du Nord Canada	161 855 \$	0,0%	2	205 001 \$	0,0%	5	494 209 \$	0,1%	5
Ministère de la Justice Canada	89 339 \$	0,0%	2	145 880 \$	0,0%	2	290 411 \$	0,1%	2
Agriculture et Agroalimentaire Canada	546 338 \$	0,2%	11	145 094 \$	0,0%	3	2 888 698 \$	1%	18
Emploi et Développement social Canada	60 935 \$	0,0%	1	60 935 \$	0,0%	2	313 381 \$	0,1%	2
Industrie Canada	331 497 \$	0,1%	1		0,0%			0,0%	
Office national du film	196 804 \$	0,1%	3		0,0%		104 110 \$	0,0%	1
Les Ponts Jacques Cartier et Champlain Incorporée	553 326 \$	0,2%	7	-879 274 \$	-0,2%	4	-600 582 \$	-0,2%	5
Grand Total	354 477 258 \$	100%	2 585	430 450 112 \$	100%	2 330	376 529 320 \$	100%	2 238



Figure 4-1: Main goods and services purchased in 2014/2015 accounting for 80% of procurement



Figure 4-2: Main goods and services purchased in 2015/2016 accounting for 80% of procurement



Figure 4-3: Main goods and services purchased in 2016/2017 accounting for 80% of procurement

Table 4-2: Main products and client departments accounting for up to 67% of the total 2015/2016 procurement amount
(net amount, excluding taxes; product contribution in % of the total amount for the year; client contribution in % of the amount for the product; ranking for 2015/2016)

Produit	Code NIBS	2014-2015			2015-2016			2016-2017		
		Client	Montant net HT	% du montant total (gras): % du montant du produit	Nbr contrats	Client	Montant net HT	% du montant total (gras): % du montant du produit	Nbr contrats	Client
Construction d'autres édifices	5129B		19 799 006 \$	6%	81		117 831 840 \$	27%	87	
Travaux publics et Services gouvernementaux Canada			19 799 006 \$	100%	81		115 918 922 \$	98%	85	
Agence spatiale canadienne				0%			1 912 918 \$	2%	2	
Astronautique (R&D)	AR910400		17 203 898 \$	5%	126		28 940 070 \$	7%	119	
Agence spatiale canadienne			17 203 898 \$	100%	126		28 940 070 \$	100%	119	
Composants divers de véhicules - réparation	JX2590			0%			13 973 072 \$	3%	7	
Ministère de la défense nationale							13 973 072 \$	100%	7	
Domaine militaire (R&D)	AD917700		18 673 064 \$	5%	62		13 733 234 \$	3%	58	
Ministère de la défense nationale			18 673 064 \$	100%	62		13 733 234 \$	100%	58	
Ouvrages de maçonnerie, ouvrages de pierre	5156A		2 128 224 \$	1%	7		12 831 426 \$	3%	11	
Travaux publics et Services gouvernementaux Canada			2 128 224 \$	100%	7		12 831 426 \$	100%	11	
Services de traiteur	K102B		6 529 220 \$	2%	10		12 423 670 \$	3%	7	
Ministère de la défense nationale			3 639 295 \$	56%	9		9 223 670 \$	74%	6	
Agence des services frontaliers du Canada			2 889 925 \$	44%	1		3 200 000 \$	26%	1	
Voies de navigation, ports, barrages et autres adductions	5133C		12 425 432 \$	4%	5		12 047 083 \$	3%	11	
Pêches et Océans Canada				0%			10 829 880 \$	90%	6	
Travaux publics et Services gouvernementaux Canada			12 425 432 \$	100%	5		1 217 203 \$	10%	5	
Construction des édifices à logements multiples	5122A			0%			10 719 962 \$	2%	3	
Travaux publics et Services gouvernementaux Canada							10 719 962 \$	100%	3	
Nettoyage et entretien, conciergerie	K100A		14 089 323 \$	4%	77		8 874 165 \$	2%	38	
Ministère de la défense nationale			10 963 123 \$	78%	57		7 514 180 \$	85%	22	
Travaux publics et Services gouvernementaux Canada			1 573 592 \$	11%	12		1 146 287 \$	13%	9	
Transports Canada			213 369 \$	2%	3		128 331 \$	1%	3	
Agriculture et Agroalimentaire Canada			51 275 \$	0%	2		40 290 \$	0%	1	
Agence canadienne d'inspection des aliments			57 565 \$	0%	1		37 135 \$	0%	2	
Agence des services frontaliers du Canada			1 230 400 \$	9%	1		7 943 \$	0%	1	
Conseil national de recherches du Canada			- \$	0%	1		0 \$	0%		
Autoroutes, rues, routes, voies ferrées, pistes d'aéroport	5131C		27 451 022 \$	8%	34		8 540 257 \$	2%	27	
Travaux publics et Services gouvernementaux Canada			27 451 022 \$	100%	34		8 540 257 \$	100%	27	
Services professionnels / Analyse financière	R019R		99 324 \$	0%	4		7 770 001 \$	2%	4	
Travaux publics et Services gouvernementaux Canada			58 410 \$	59%	2		7 770 001 \$	100%	4	
Transports Canada			40 914 \$	41%	2		0 \$	0%		
Services de construction, non énumérés ailleurs	5139A		7 202 644 \$	2%	26		7 535 066 \$	2%	51	
Travaux publics et Services gouvernementaux Canada			7 127 682 \$	99%	20		7 533 805 \$	100%	50	
Ministère de la défense nationale			74 962 \$	1%	6		1 261 \$	0%	1	
Services d'entrepreneurs généraux, non énumérés ailleurs	5179FB		2 471 480 \$	1%	6		7 460 712 \$	2%	14	
Travaux publics et Services gouvernementaux Canada			1 742 480 \$	71%	5		7 262 207 \$	97%	11	
Service correctionnel du Canada			729 000 \$	29%	1		198 506 \$	3%	3	
Aide générale de bureau	R201A		40 000 \$	0%	2		7 112 932 \$	2%	2	
Ministère de la défense nationale				0%			7 112 932 \$	100%	2	
Agence des services frontaliers du Canada			40 000 \$	100%	2		0 \$	0%		
Navires et bateaux de grandes dimensions - réparation, r	JX1990A		6 754 654 \$	2%	20		6 306 448 \$	1%	15	
Pêches et Océans Canada			6 754 654 \$	100%	20		6 306 448 \$	100%	15	
Travaux généraux de construction maritime	5139D		11 671 981 \$	3%	22		6 176 567 \$	1%	14	
Travaux publics et Services gouvernementaux Canada			5 309 338 \$	45%	18		4 019 801 \$	65%	10	
Pêches et Océans Canada			6 362 643 \$	55%	4		2 156 766 \$	35%	4	
Services d'architectes et d'ingénieurs - bâtiments d'admi	C111A		3 951 600 \$	1%	97		5 489 459 \$	1%	90	
Travaux publics et Services gouvernementaux Canada			3 083 166 \$	78%	88		5 302 434 \$	97%	85	
Agence spatiale canadienne			860 416 \$	22%	7		138 425 \$	3%	4	
Service correctionnel du Canada			8 018 \$	0%	2		48 600 \$	1%	1	

Table 4-3 (Table 4-2 continued): Main products and client departments contributing 68% to 80% of the total 2015/2016 procurement amount

(net amount, excluding taxes; product contribution in % of the total amount for the year; client contribution in % of the amount for the product; ranking for 2015/2016)

Produit	Code NIBS	2014-2015			2015-2016			2016-2017		
		Montant net HT	% du montant total (gras): % du montant du produit	Nbr contrats	Montant net HT	% du montant total (gras): % du montant du produit	Nbr contrats	Montant net HT	% du montant total (gras): % du montant du produit	Nbr contrats
Équipement et approvisionnements de laboratoire	N6640	1 848 901 \$	1%	18	4 897 276 \$	1%	47	20 458 376 \$	5%	71
Conseil national de recherches du Canada		1 168 530 \$	63%	14	3 241 852 \$	66%	32	16 191 392 \$	79%	42
Santé Canada			0%		809 099 \$	17%	4	1 363 478 \$	7%	10
Ministère de la défense nationale		70 527 \$	4%	1	481 534 \$	10%	3	1 313 736 \$	6%	2
Environnement Canada		69 480 \$	4%	1	199 894 \$	4%	4	49 842 \$	0%	1
Agriculture et Agroalimentaire Canada			0%		104 803 \$	2%	2	1 217 293 \$	6%	10
Agence canadienne d'inspection des aliments			0%		60 095 \$	1%	2	223 209 \$	1%	4
Ressources naturelles Canada		391 381 \$	21%	1		0%		99 425 \$	0%	2
Agence spatiale canadienne		148 983 \$	8%	1		0%			0%	
Services d'architecture et d'ingénierie - Structures autre	C129A	2 708 981 \$	1%	21	4 475 908 \$	1%	16	5 105 346 \$	1%	42
Travaux publics et Services gouvernementaux Canada		2 708 981 \$	100%	21	4 414 748 \$	99%	15	4 078 301 \$	80%	38
Service correctionnel du Canada			0%		61 160 \$	1%	1	19 340 \$	0%	1
Pêches et Océans Canada			0%			0%		1 007 705 \$	20%	3
Provisions, divers	N8920ZC	4 279 843 \$	1%	43	4 239 950 \$	1%	40	6 771 515 \$	0%	10
Service correctionnel du Canada		3 229 155 \$	75%	32	2 775 174 \$	65%	23	108 901 \$	16%	6
Ministère de la défense nationale		746 274 \$	17%	7	1 181 788 \$	28%	12	568 614 \$	84%	2
Anciens Combattants Canada		304 414 \$	7%	4	282 988 \$	7%	5		0%	
Travaux publics et Services gouvernementaux Canada			0%			0%		- \$	0%	2
Services d'exploitation et d'entretien d'installations tech	M181A	681 868 \$	0%	7	4 053 055 \$	1%	6	634 279 \$	0%	4
Agence spatiale canadienne		681 868 \$	100%	7	4 053 055 \$	100%	6	634 279 \$	100%	4
Services de santé mentale	G103D		0%		4 018 947 \$	1%	9	-46 932 \$	0%	3
Service correctionnel du Canada					4 018 947 \$	100%	9	-46 932 \$	100%	3
Autres études environnementales	B109A	2 704 725 \$	1%	18	3 435 695 \$	1%	8	1 110 703 \$	0%	12
Travaux publics et Services gouvernementaux Canada		2 704 725 \$	100%	18	3 435 695 \$	100%	8	1 110 703 \$	100%	12
Navires et bateaux - réparation, radoub et transformat	JX1990C	1 207 173 \$	0%	15	3 368 988 \$	1%	21	3 188 456 \$	1%	26
Pêches et Océans Canada		1 207 173 \$	100%	15	3 368 988 \$	100%	21	3 188 456 \$	100%	26
Mise au point d'instruments pour engin spatial (R&D)	AR210480	13 074 131 \$	4%	38	3 323 917 \$	1%	20	10 786 957 \$	3%	20
Agence spatiale canadienne		13 074 131 \$	100%	38	3 323 917 \$	100%	20	10 786 957 \$	100%	20
Services d'architecture - bâtiments	C119A	2 825 004 \$	1%	25	3 127 645 \$	1%	24	3 387 433 \$	1%	41
Travaux publics et Services gouvernementaux Canada		2 825 004 \$	100%	25	3 127 645 \$	100%	24	3 258 072 \$	96%	37
Ressources naturelles Canada			0%			0%		129 361 \$	4%	4
Organes de propulsion pour bateaux et navires	N2010	141 544 \$	0%	1	3 072 864 \$	1%	2	4 981 362 \$	1%	1
Pêches et Océans Canada		141 544 \$	100%	1	3 072 864 \$	100%	2	4 981 362 \$	100%	1
Services d'architecture et d'ingénierie - Autoroutes, rout	C122A	19 026 760 \$	5%	45	3 016 792 \$	1%	42	6 442 674 \$	2%	54
Travaux publics et Services gouvernementaux Canada		1 581 519 \$	8%	34	3 016 792 \$	100%	38	6 442 674 \$	100%	53
Transports Canada		298 942 \$	2%	10		0%		- \$	0%	1
Bureau de l'infrastructure du Canada		17 146 300 \$	90%	1	- \$	0%	4		0%	
Traduction et interprétation	R109A		0%		2 925 000 \$	1%	1		0%	
Service correctionnel du Canada					2 925 000 \$	100%	1			
Services d'architectes et d'ingénieurs - Bâtiments	C211D	613 920 \$	0%	11	2 714 429 \$	1%	17	1 177 989 \$	0%	14
Travaux publics et Services gouvernementaux Canada		613 920 \$	100%	11	1 514 429 \$	56%	12	577 989 \$	49%	12
Agence spatiale canadienne			0%		1 200 000 \$	44%	5	600 000 \$	51%	2
Services pédagogiques, N.E.A.	U099C		0%		2 041 191 \$	0%	3	1 896 542 \$	1%	5
Ministère de la défense nationale					2 041 191 \$	100%	3	1 896 542 \$	100%	5
Instruments de traces, de levés de plans et de cartograp	N6675		0%		1 993 037 \$	0%	3	-53 264 \$	0%	3
Environnement Canada					1 993 037 \$	100%	3	-94 226 \$	177%	2
Agriculture et Agroalimentaire Canada						0%		40 962 \$	-77%	1
Fruits et légumes	N8915Z	1 062 685 \$	0%	138	1 976 731 \$	0%	123	132 433 \$	0%	12
Ministère de la défense nationale		201 367 \$	19%	35	937 628 \$	47%	52	27 410 \$	21%	4
Service correctionnel du Canada		761 010 \$	72%	76	934 189 \$	47%	58	105 023 \$	79%	8
Anciens Combattants Canada		100 308 \$	9%	27	104 913 \$	5%	13		0%	
Travaux d'excavation	5151A	347 908 \$	0%	8	1 969 589 \$	0%	12	10 725 901 \$	3%	16
Travaux publics et Services gouvernementaux Canada		347 908 \$	100%	8	1 969 589 \$	100%	12	10 725 901 \$	100%	16
Ponts, autoroutes surélevées, tunnels, viaducs et voies fr	5132A	1 036 527 \$	0%	4	1 900 070 \$	0%	5	128 135 \$	0%	9
Travaux publics et Services gouvernementaux Canada		249 843 \$	24%	3	1 900 070 \$	100%	5	434 477 \$	339%	8
Les Ponts Jacques Cartier et Champlain Incorporée		786 684 \$	76%	1		0%		-306 342 \$	-239%	1
Services environnementaux	E199D	14 286 935 \$	4%	89	1 861 385 \$	0%	31	646 757 \$	0%	22
Travaux publics et Services gouvernementaux Canada		14 086 935 \$	99%	87	1 711 384 \$	92%	30	646 757 \$	100%	21
Pêches et Océans Canada		200 000 \$	1%	2	150 000 \$	8%	1	- \$	0%	1

4.2 Carbon footprint of PSPC-QC procurement

The annual GHG emissions associated with the assessed procurement are:

- **98,767 tonnes CO₂eq for 2014/2015**, which is 0.279 kg CO₂eq/\$ excluding acquisition tax (emission intensity);
- **122,037 tonnes CO₂eq for 2015/2016** (0.284 kg CO₂eq/\$); and
- **88,594 tonnes CO₂eq for 2016/2017** (0.235 kg CO₂eq/\$).

For perspective, the emissions in 2015/2016 (122,037 t CO₂eq) are equivalent to travelling about 685,000 km by car. To offset these emissions, for example, 38,000 cars¹³ would have to be taken off the road or 872,000 trees be planted.¹⁴

4.2.1 Carbon footprint per client department

GHG emissions by client department are presented in Table 4-4. PSPC has been found to be the largest net contributor to total GHGs, at 43% to 53%, depending on the year (these rates are very similar to the value contributions of total purchases in Table 4-1. Then came the Department of National Defence, with a contribution already 2-3 times smaller than that of PSPC, then Fisheries and Oceans Canada, Correctional Service Canada, and the Canadian Space Agency.

PSPC's significant contribution to the carbon footprint of procurement is due to the high proportion of construction work and architecture and civil engineering services. Goods and services of this type, and more generally all those associated with the construction, maintenance and repair of infrastructure (residential or non-residential) and all civil engineering work, all have a high GHG intensity (0.47 kg CO₂eq/\$ and beyond).

The case of Fisheries and Oceans Canada in 2016/2017 (second-highest contributor that year) shows higher GHG emissions than the two previous years (in relation to procurement, of which the amount doubled, then tripled with time), while even the Department of National Defence reduced its emissions that same year, mainly due to less carbon-intensive procurement.

Parks Canada's GHG intensity was also very high each year, particularly in 2015/2016 (1.4 kg CO₂eq/\$). This is caused by the high volume of ferry services contracted this year in particular, which are associated with the consumption of fuel and the GHGs from its combustion.

Table 4-5 details the top four goods or services that contribute to the emissions of the six departments that emit the most through their procurement (over all three years to avoid bias; the annual details are available in Appendix D). These goods and services are associated with the construction of buildings and infrastructure for the first four PSPC procurements and also for one part of those for Fisheries and Oceans Canada. For the Department of National Defence and the Canadian Space Agency, these are largely research and development (R&D) and scientific services. This type of service is relatively low in carbon, hence the low GHG intensity observed in Table 4-4 (0.1 to 0.3). The carbon footprint of the Department of National Defence also includes a significant share of office cleaning services and vehicle repair services. Ship repair and

¹³ 0.178 kg CO₂eq/km; 18,000km/year driven by the vehicle, without considering the rebound experienced from the removal of vehicles.

¹⁴ Carbone boréal, 2018.

maintenance is the main contributor for Fisheries and Oceans Canada. Food products are a significant procurement item for Correctional Service Canada and more marginally for the Department of National Defence. Food and catering services typically have a high GHG intensity (largely associated with the agricultural production stage), which explains the high intensity observed for Correctional Service Canada in Table 4-4. For the National Research Council of Canada, the main contributors are scientific instruments, and laboratory equipment and consumables.

Through the annual variation in GHG emission intensity of client departments, it is possible to see that marked variability in procurement, in proportion and/or in kind, for certain departments (Figure 4-4). The average for the three years of the study is 0.266 kg CO₂eq/\$ excluding tax.

Table 4-4: GHGs and GHG emission intensity (tonnes CO₂eq/\$ excluding taxes) of PSPC-QC procurement, by client department
(departments are ranked in descending order of GHGs for 2015/2016)

Client	2014-2015			2015-2016			2016-2017		
	GES (t CO ₂ eq)	%	kg CO ₂ eq/\$	GES (t CO ₂ eq)	%	kg CO ₂ eq/\$	GES (t CO ₂ eq)	%	kg CO ₂ eq/\$
Travaux publics et Services gouvernementaux Canada	43 303	44%	0,285	64 299	53%	0,278	37 921	43%	0,229
Ministère de la défense nationale	18 689	19%	0,282	22 475	18%	0,286	14 248	16%	0,221
Pêches et Océans Canada	8 192	8%	0,398	12 376	10%	0,367	17 555	20%	0,277
Service correctionnel du Canada	9 672	10%	0,615	9 787	8%	0,429	3 655	4%	0,593
Agence spatiale canadienne	6 174	6%	0,136	6 459	5%	0,153	6 195	7%	0,132
Conseil national de recherches du Canada	632	1%	0,351	1 100	1%	0,312	5 093	6%	0,309
Anciens Combattants Canada	1 466	1%	0,376	1 045	1%	0,460	4	0%	0,072
Environnement Canada	588	1%	0,289	994	1%	0,204	309	0%	0,241
Agence des services frontaliers du Canada	5 055	5%	0,235	992	1%	0,298	259	0%	0,182
Parcs Canada	339	0%	0,872	818	1%	1,394	634	1%	0,733
Transports Canada	1 307	1%	0,290	715	1%	0,291	899	1%	0,328
Ressources naturelles Canada	320	0%	0,438	353	0%	0,243	73	0%	0,199
Bureau de l'infrastructure du Canada	2 294	2%	0,134	288	0%	0,153			
Santé Canada				256	0%	0,317	622	1%	0,245
Affaires autochtones et du Nord Canada	37	0%	0,229	70	0%	0,340	172	0%	0,349
Agence canadienne d'inspection des aliments	24	0%	0,181	50	0%	0,194	182	0%	0,284
Agriculture et Agroalimentaire Canada	144	0%	0,264	40	0%	0,279	716	1%	0,248
Agence de dévpt écon. du Canada pour les régions du QC	80	0%	0,145	38	0%	0,143	46	0%	0,127
Ministère de la Justice Canada	6	0%	0,072	11	0%	0,072	63	0%	0,216
Emploi et Développement social Canada	6	0%	0,106	6	0%	0,104	108	0%	0,346
Office national du film	40	0%	0,203				20	0%	0,188
Industrie Canada	60	0%	0,180						
Les Ponts Jacques Cartier et Champlain Incorporée	337	0%	0,609	-134	0%	0,153	-180	0%	0,299
Grand Total	98 767	100%	0,279	122 037	100%	0,284	88 594	100%	0,235

Table 4-5: The top four GHG-producing procurement items (according to GSIN description) for each of the six client departments of PSPC-QC that contributed the most to the total carbon footprint over the three years

Client	2014-2017	
	GES (t CO ₂ eq)	% du total GES (gras): % des GES du client
Produit NIBS		
Travaux publics et Services gouvernementaux Canada	145 523	47%
Construction d'autres édifices	56 464	39%
Autoroutes, rues, routes, voies ferrées, pistes d'aéroport	17 396	12%
Services de construction, non énumérés ailleurs	5 624	4%
Ouvrages de maçonnerie, ouvrages de pierre	4 658	3%
<i>Autres produits</i>	<i>61 380</i>	<i>42%</i>
Ministère de la défense nationale	55 412	18%
Domaine militaire (R&D)	7 033	13%
Services de traiteur	4 702	8%
Nettoyage et entretien, conciergerie	4 461	8%
Composants divers de véhicules - réparation	3 537	6%
<i>Autres produits</i>	<i>35 678</i>	<i>64%</i>
Pêches et Océans Canada	38 124	12%
Navires et bateaux de grandes dimensions -réparation, radoub et transformation (mise en cale sèche comprise)	6 752	18%
Travaux généraux de construction maritime	4 574	12%
Voies de navigation, ports, barrages et autres adductions d'eau	4 068	11%
Bois de construction, traité, construction marine	3 700	10%
<i>Autres produits</i>	<i>19 030</i>	<i>50%</i>
Service correctionnel du Canada	23 114	7%
Provisions , divers	5 207	23%
Papier et carbonnage	2 361	10%
Provisions, divers (remplacé par nibs N8920ZC)	1 575	7%
Viande, volaille et poisson	1 558	7%
<i>Autres produits</i>	<i>12 413</i>	<i>54%</i>
Agence spatiale canadienne	18 828	6%
Astronautique (R&D)	8 491	45%
Mise au point d'instruments pour engin spatial (R&D)	3 313	18%
Services d'exploitation et d'entretien d'installations techniques et scientifiques	1 631	9%
Traitement de données du satellite et services connexes	962	5%
<i>Autres produits</i>	<i>4 431</i>	<i>24%</i>
Conseil national de recherches du Canada	6 826	2%
Équipement et approvisionnements de laboratoire	6 464	95%
Bioxyde de carbone, technique, glace sèche	115	2%
Dispositifs pour laboratoire, automation et robotique	46	1%
Instruments d'optique, matériel d'essai, composants et accessoires	38	1%
<i>Autres produits</i>	<i>163</i>	<i>2%</i>
Autres ministères-clients	21 572	7%
Grand Total	309 398	100%

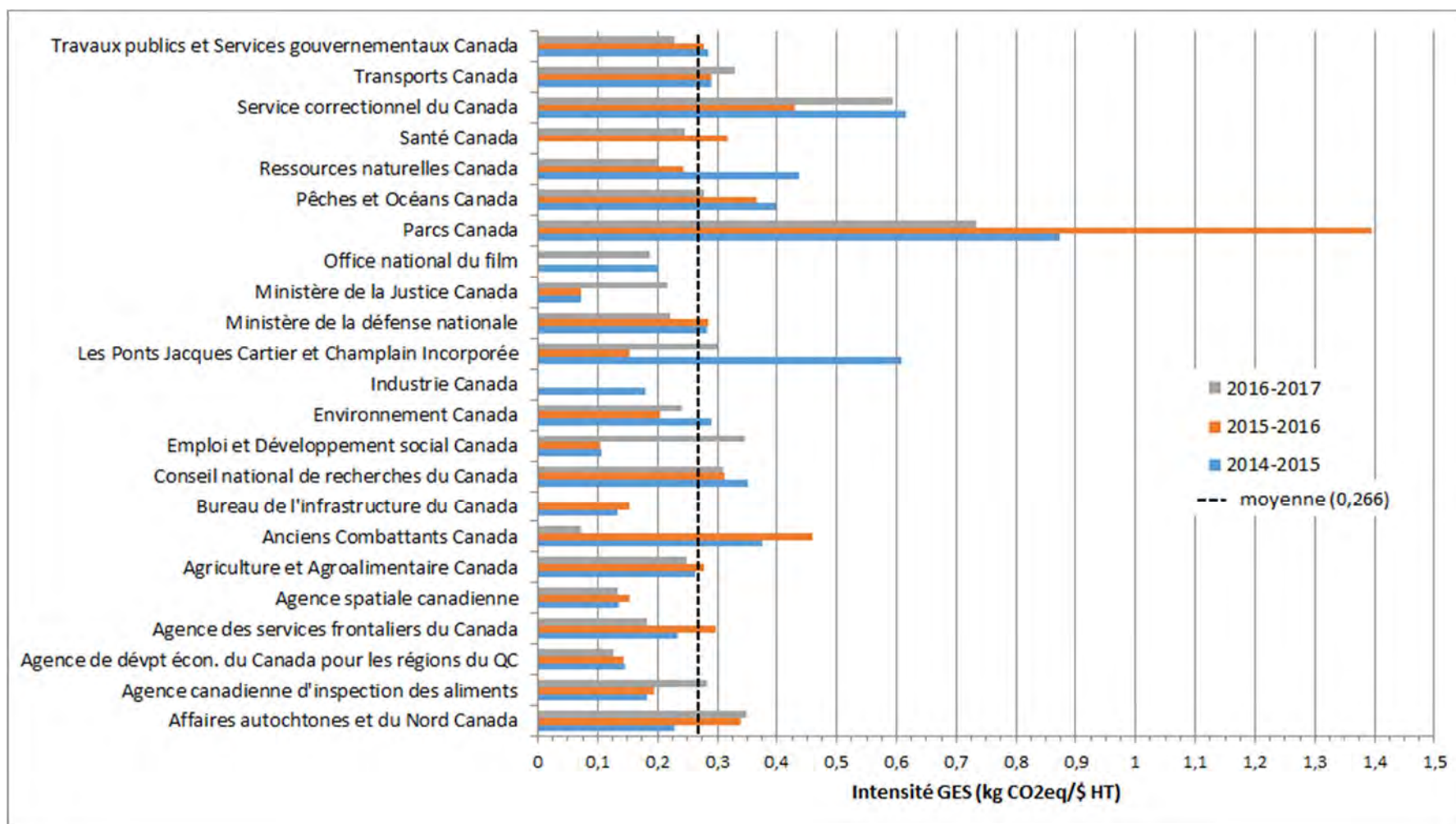


Figure 4-4: Annual variation in GHG emission intensity of client departments and average, 2014 to 2017 (tonnes CO₂EQ/\$ excluding taxes).

4.2.2 Carbon footprint by category of goods and services

4.2.2.1 Carbon footprint by G SIN description of goods and services

Construction-related procurement items (GSIN codes starting with 51) contributed 42% to 52% of the annual carbon footprint (Figure 4-5). The rest are slightly more associated with services (around 30%) than with other types of goods (around 25%).

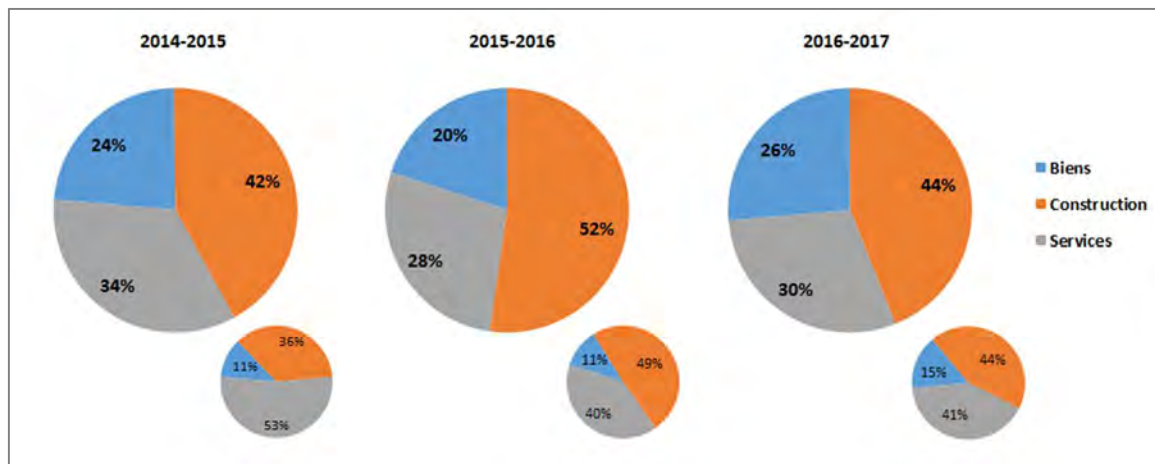


Figure 4-5: Carbon footprint contributors according to the three main procurement categories (miniature: contribution by amount)

Depending on the year, 36 to 45 goods and services (out of about 400 each year) account for 80% of the carbon footprint of procurement. Their list is available in Appendix D. Over all three years, 72 unique goods and services contributed to the bulk of the carbon footprint. Only about 20 of them contribute individually to more than 1% and together for 60% of the total impact (Table 4-6). The same table with the details of the client departments is available in Appendix D. It notes that laboratory equipment and supplies, cleaning and maintenance services, and lastly, food products and catering services are common procurement items for many departments. As previously mentioned, this is also the case for construction and the related trade services.

Table 4-6: Goods and services (based on G SIN description) each of which make up more than 1% of the total carbon footprint of procurement over the three years of the study

Produits NIBS	2014 à 2017	
	GES (t CO ₂ eq)	% du total GES
Construction d'autres édifices	57 310	18,5%
Autoroutes, rues, routes, voies ferrées, pistes d'aéroport	17 396	5,6%
Voies de navigation, ports, barrages et autres adductions d'eau	8 636	2,8%
Équipement et approvisionnements de laboratoire	8 542	2,8%
Astronautique (R&D)	8 491	2,7%
Provisions, divers	7 797	2,5%
Travaux généraux de construction maritime	7 322	2,4%
Domaine militaire (R&D)	7 033	2,3%
Navires et bateaux de grandes dimensions -réparation, radoub et transformation (mise en cale sèche comprise)	6 752	2,2%
Services de traiteur	6 597	2,1%
Nettoyage et entretien, conciergerie	5 952	1,9%
Services de construction, non énumérés ailleurs	5 648	1,8%
Ouvrages de maçonnerie, ouvrages de pierre	4 658	1,5%
Bois de construction, traité, construction marine	4 401	1,4%
Construction des édifices à logements multiples	4 180	1,4%
Viande, volaille et poisson	3 943	1,3%
Services d'architecture et d'ingénierie - Autoroutes, routes, ponts, voies ferrées, et barrages	3 773	1,2%
Composants divers de véhicules - réparation	3 537	1,1%
Organes de propulsion pour bateaux et navires	3 527	1,1%
Navires et bateaux - réparation, radoub et transformation, mise en cale sèche non comprise	3 446	1,1%
Travaux de construction d'autres corps de métiers	3 409	1,1%
Mise au point d'instruments pour engin spatial (R&D)	3 313	1,1%

4.2.2.2 Carbon footprint by UNSPSC description of goods and services

Aside from the fact that PSPC should in the short term move from the G SIN description system to the UNSPSC classification, the UNSPSC system also has the advantage of being explicitly hierarchical, thus facilitating groupings at different levels of aggregation. The carbon footprint per UNSPSC segment (highest level of UNSPSC classification, with two significant digits – see note at the bottom of page 11) shows that building construction and maintenance work ultimately accounts for more than one-third of the footprint (Figure 4 of Appendix D). However, it was noted that the segment level is probably too aggregated and does not provide as much information as the G SIN description on the nature of the goods and services.

The family level (lower level in the UNSPSC classification, with four significant digits) gives a bit more information (Figure 4-6): about 20 families account for more than 83% of the carbon footprint. It is still very granular and sometimes not very descriptive of its denomination if an accurate identification of procurement is desired. However, this level could be used for annual monitoring.

Whether with the G SIN or UNSPSC classification, at both the segment and family levels, it must be kept in mind that these classifications always require a cut-off threshold to be determined in order to allow a decent number of categories to be represented in tables or monitoring charts. For example, in Table 4-6 with the G SINS, a 1% contribution threshold is used; in Figure 4-6, with UNSPSC families, a 1% threshold shows 20 families out of the 165 affected by procurement from

2014 to 2017 (but out of a total of 465 families available in the entire classification and potentially affected in the future).

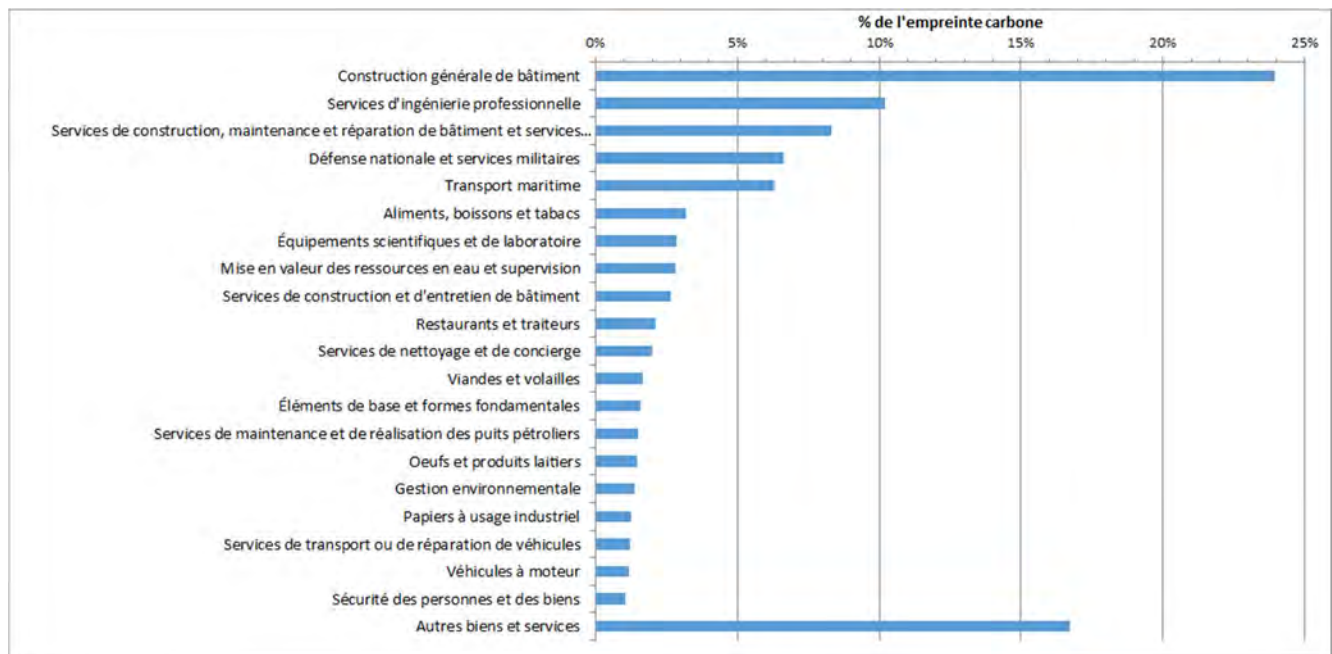


Figure 4-6: Goods and services (according to UNSPSC families) that each contributed more than 1% to the carbon footprint of PSPC-QC procurement from 2014 to 2017.¹⁵

145 families of less than 1% are grouped into "Other goods and services"

4.2.3 Suppliers' main contributors

The results presented so far show which purchased products the carbon footprint of PSPC-QC procurement is "channelled" through. The IO-E approach also lets us analyse a level below, upstream in the supply chain, and identify which products purchased by suppliers of PSPC-QC goods and services affect the GHGs of PSPC-QC's carbon footprint.

The following figures present sheets for eight procurement categories that contribute the most to PSPC-QC's carbon footprint. Each one lets us visualize the goods and services that contribute the most to the supplier's procurement. These major contributors are those to which PSPC-QC should ask its suppliers to pay special attention. The sheets involve:

- non-residential construction
- repair construction services
- cement and concrete materials

¹⁵ The "Well Drilling and Construction Services" family refers to GSIN 5138 A, B, and C of dredging services; the "National Defence and Military Services" family refers to the GSIN for R&D in the military, astronautics and radar technology domain; the "Marine Transport" family comes from the UNSPSC segment "Commercial and Military and Private Vehicles and their Accessories and Components" and mainly concerns ship repair services, ships, and ferry services.

- research and development services
- laboratory and scientific equipment
- vehicle repair and servicing
- building cleaning services
- food products

The cement and concrete data sheet was proposed because, although this material was not identified as a major direct procurement item for PSPC-QC, it is the highest impact item for suppliers of construction services and construction-related repair services. In other words, this sheet also lets us visualize an additional level upstream from PSPC-QC procurement.

Direct emissions represent the GHGs emitted directly by the product manufacturer or service provider. For example, direct emissions from “repair construction services” are GHGs emitted mainly from fuel combustion in the machinery used. Direct emissions in the “cement and concrete materials” document are GHGs emitted by cement plants.

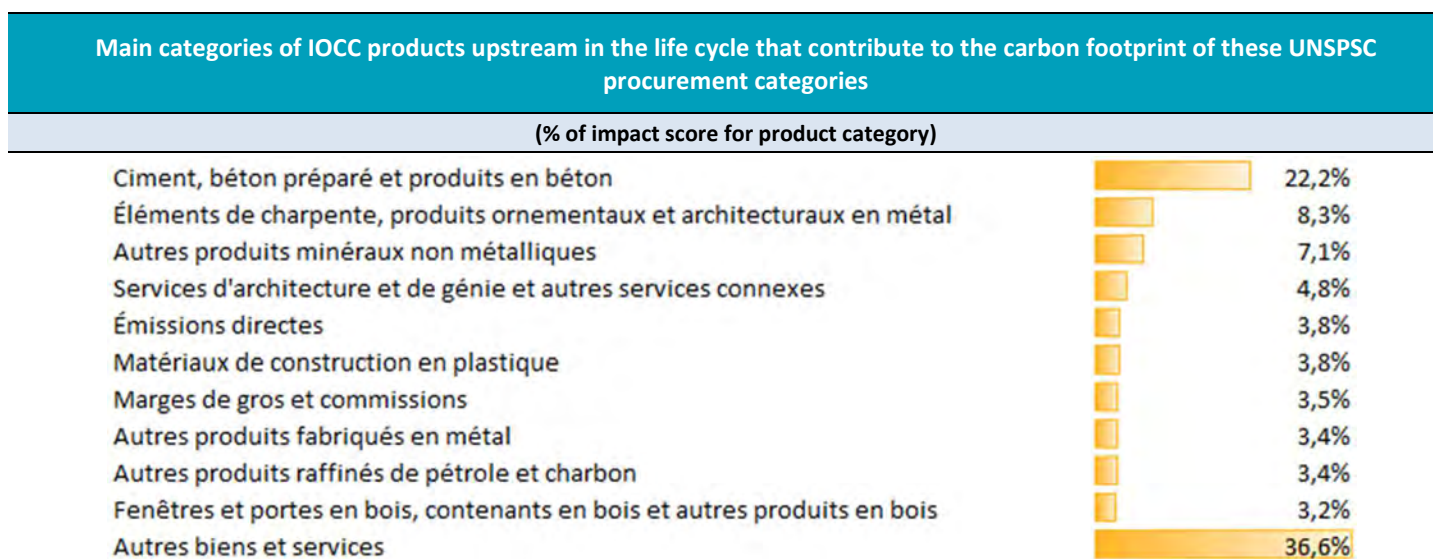
Data sheet of the main procurement categories that contribute to the carbon footprint: non-residential construction

UNSPSC procurement category	% of total procurement amount 2014 to 2017	Carbon footprint contribution
		(% of total GHGs 2014 to 2017)
72130000 – General building construction	18.0%	20.3%
72131600 – Commercial or industrial construction	1.8%	2.0%
72102500 – Masonry and stonework and tile setting	1.3%	1.5%
72101601 – Roofing installation or repair	0.7%	0.8%
30222201 – Radar station	0.5%	0.5%
72101600 – Roofing and siding and sheet metal work	0.1%	0.1%

Note: these UNSPSC categories are modelled by the same IOCC product category.

Matching IOCC product category (region of origin):

Non-residential building construction (QC)



Note: only the top 10 contributors are displayed, the rest are grouped in "Other goods and services".












Data sheet of the main procurement categories that contribute to the carbon footprint: repair construction services

UNSPSC procurement category (top 5 of 19)	% of total procurement amount 2014 to 2017	Carbon footprint contribution
		(% of total GHGs 2014 to 2017)
72100000 – Building construction and support and maintenance and repair services	2.4%	2.5%
72102300 – Plumbing and heating and air conditioning	0.7%	0.7%
72102305 – Air conditioning installation or maintenance or repair services	0.3%	0.3%
72102800 – Refurbishing services	0.3%	0.3%
72103000 – Site preparation services	0.2%	0.2%

Note: these UNSPSC categories are modelled by the same IOCC product category.

Matching IOCC product category (region of origin):

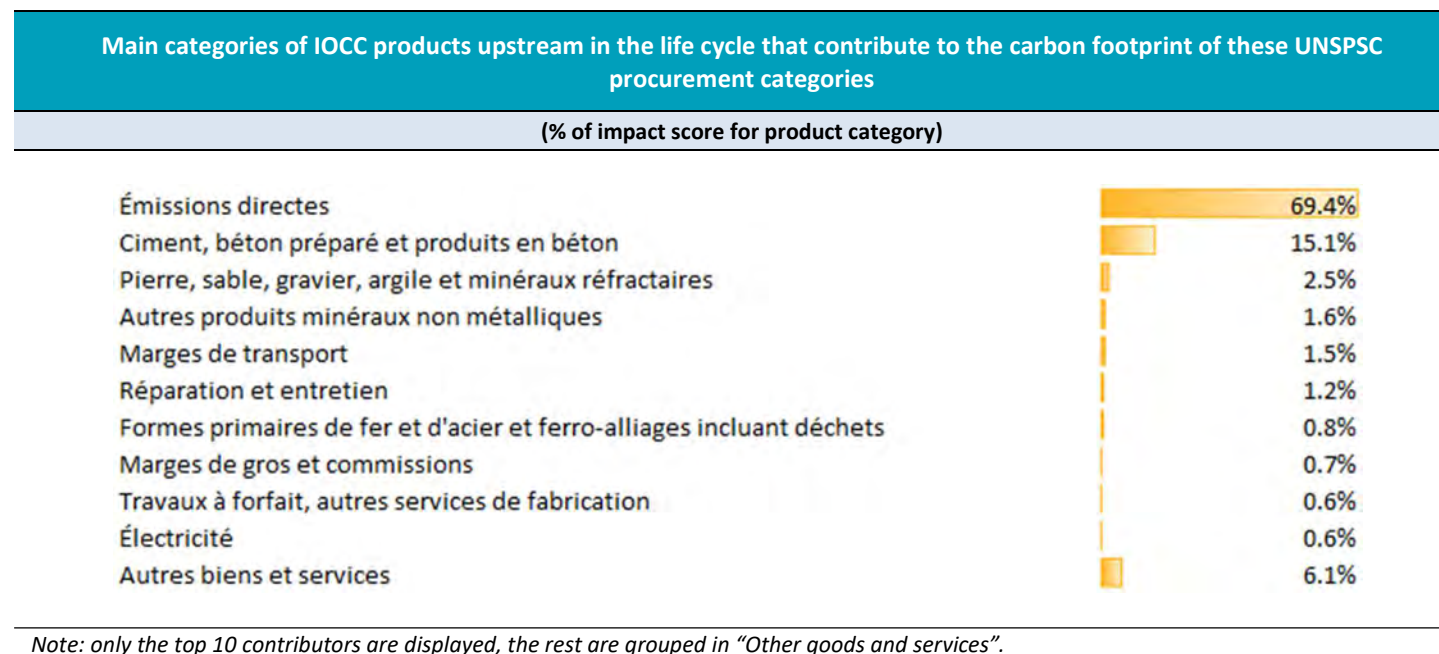
Repair construction services (QC)

Main categories of IOCC products upstream in the life cycle that contribute to the carbon footprint of these UNSPSC procurement categories		
(% of impact score for product category)		
Ciment, béton préparé et produits en béton		12,9%
Autres produits raffinés de pétrole et charbon		11,5%
Émissions directes		7,3%
Peintures, revêtements et produits adhésifs		7,0%
Éléments de charpente, produits ornementaux et architecturaux en métal		5,2%
Matériaux de construction en plastique		3,9%
Autres produits fabriqués en métal		3,6%
Fenêtres et portes en bois, contenants en bois et autres produits en bois		3,6%
Autres produits minéraux non métalliques		3,4%
Marges de transport		3,4%
Autres biens et services		38,2%

Note: only the top 10 contributors are displayed, the rest are grouped in "Other goods and services".

Data sheet of the main procurement categories that contribute to the carbon footprint: cement and concrete materials

UNSPSC procurement category	% of total procurement amount 2014 to 2017	Carbon footprint contribution
		(% of total GHGs 2014 to 2017)
30130000 – Structural building products	0.02%	0.1%
<i>Note: cement/concrete is a major input for construction and repair services</i>		
<i>Note: these UNSPSC categories are modelled by the same IOCC product category.</i>		
Matching IOCC product category (region of origin):	Cement, prepared concrete and concrete products (QC)	

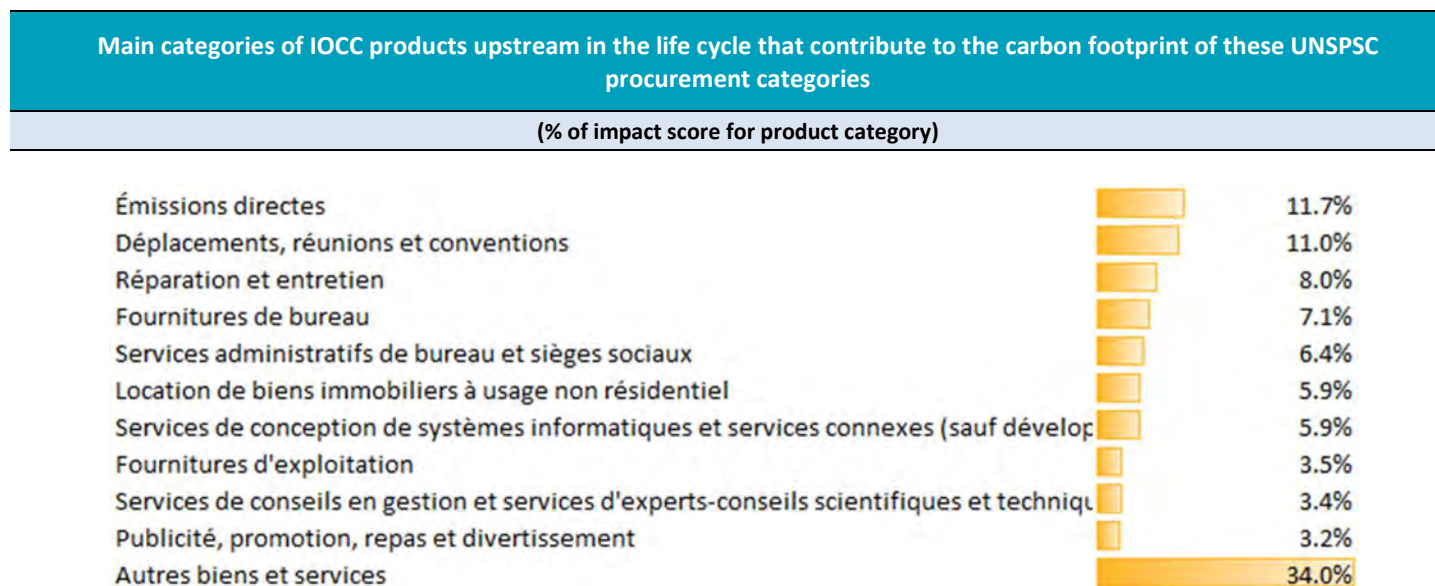


Data sheet of the main procurement categories that contribute to the carbon footprint: research and development

UNSPSC procurement category	% of total procurement amount 2014 to 2017	Carbon footprint contribution
		(% of total GHGs 2014 to 2017)
92111700 – Military science and research	14.7%	6.6%

Note: these UNSPSC categories are modelled by the same IOCC product category.

Matching IOCC product category (region of origin):	Research and development services (QC)
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Note: only the top 10 contributors are displayed, the rest are grouped in "Other goods and services".

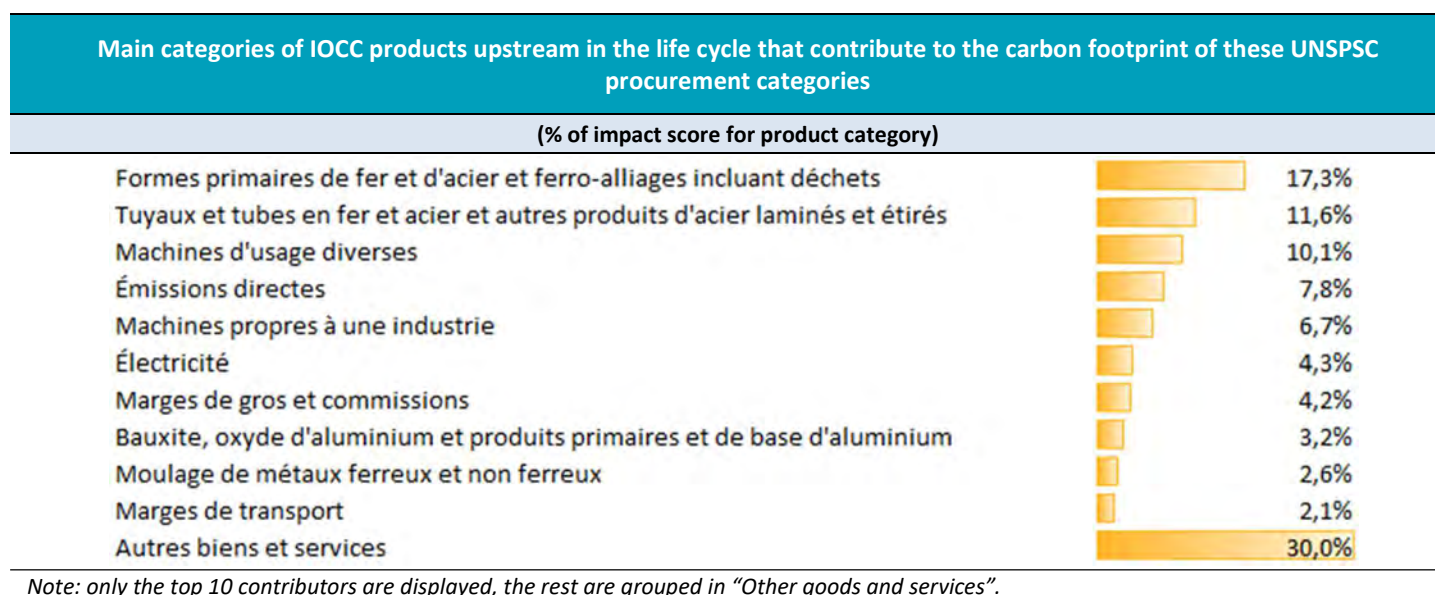
Data sheet of the main procurement categories contributing to the carbon footprint: Laboratory equipment

UNSPSC procurement category	% of total procurement amount 2014 to 2017	Carbon footprint contribution
		(% of total GHGs 2014 to 2017)
41100000 – Laboratory and scientific equipment	2.3%	2.8%

Note: these UNSPSC categories are modelled by the same IOCC product category.

Matching IOCC product category (region of origin):

General purpose machinery (CA)



Note: only the top 10 contributors are displayed, the rest are grouped in "Other goods and services".

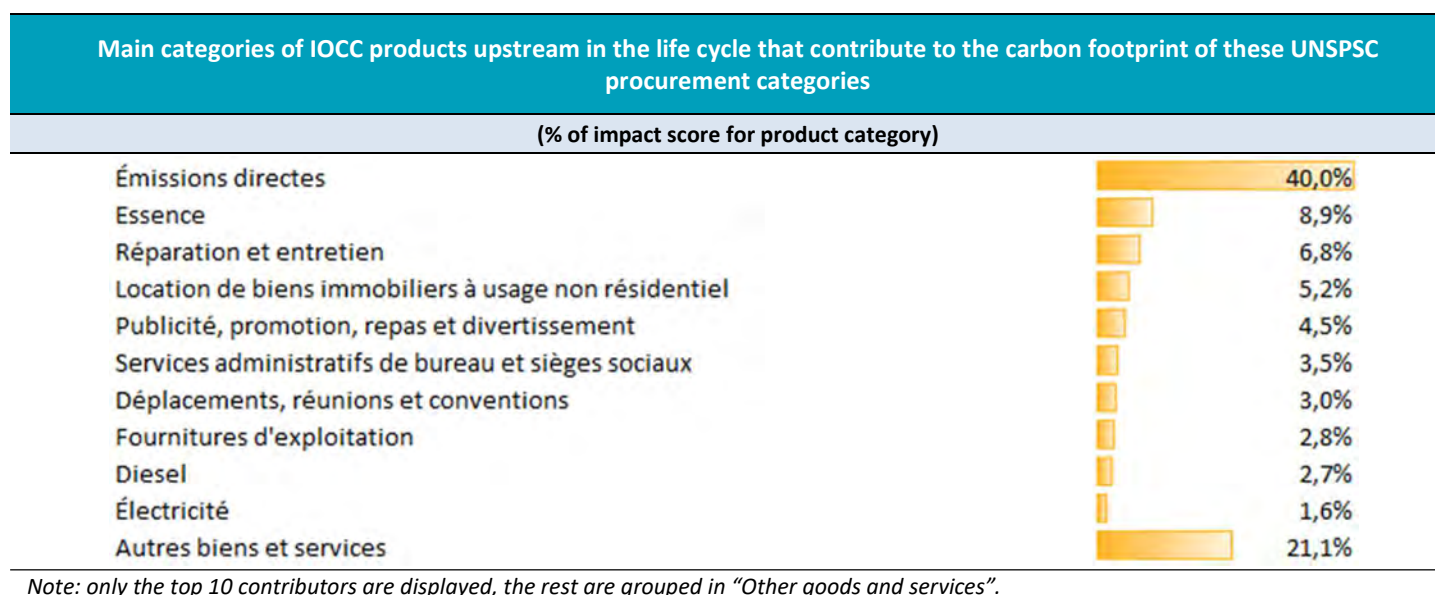
Data sheet of the main procurement categories contributing to the carbon footprint: Vehicle repair and servicing

UNSPSC procurement category	% of total procurement amount 2014 to 2017	Carbon footprint contribution
		(% of total GHGs 2014 to 2017)
78180100 – Vehicle maintenance and repair services	1.3%	1.2%
78180102 – Transmission repair	0.01%	0.0%

Note: these UNSPSC categories are modelled by the same IOCC product category.

Matching IOCC product category (region of origin):

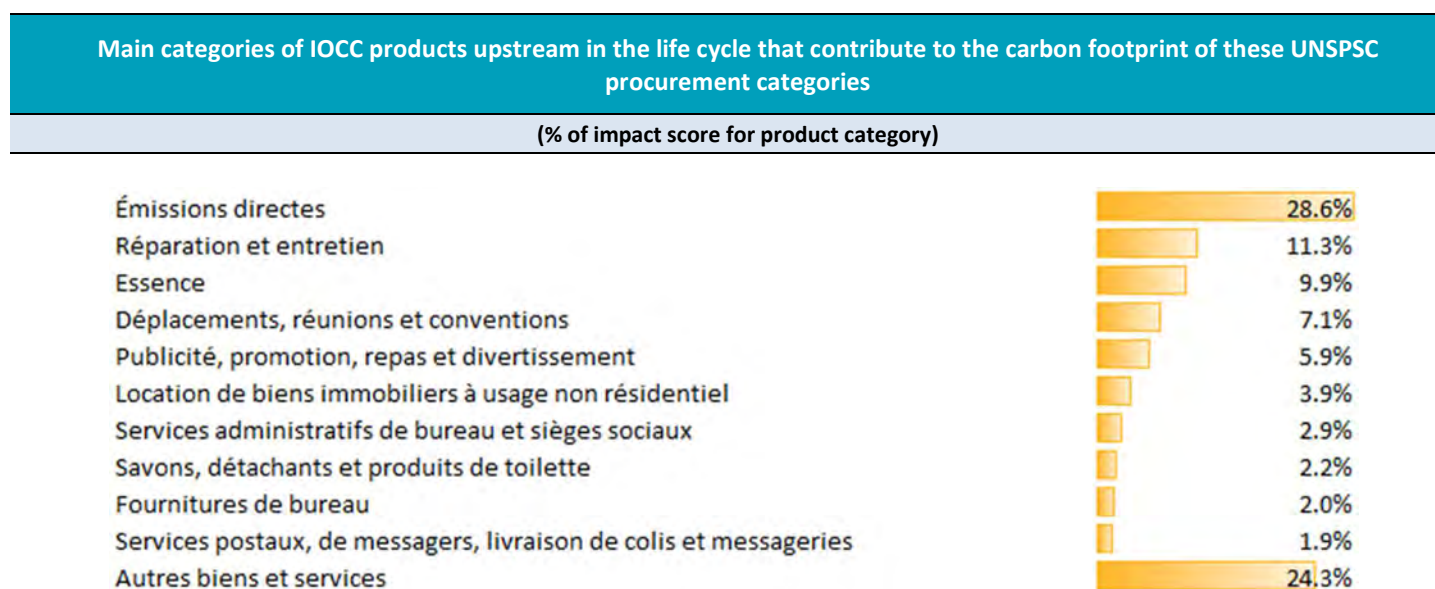
Motor vehicle repair and maintenance services (QC)



Note: only the top 10 contributors are displayed, the rest are grouped in "Other goods and services".

Data sheet of the main procurement categories that contribute to the carbon footprint: building cleaning

UNSPSC procurement category	% of total procurement amount 2014 to 2017	Carbon footprint contribution
		(% of total GHGs 2014 to 2017)
76111501- Building cleaning services (and other more marginal services)	2.8%	1.9%
<i>Note: these UNSPSC categories are modelled by the same IOCC product category.</i>		
Matching IOCC product category (region of origin):	Services to buildings and dwellings (QC)	



Note: only the top 10 contributors are displayed, the rest are grouped in "Other goods and services".

Data sheet of the main procurement categories that contribute to the carbon footprint: food products

UNSPSC procurement category	% of total procurement amount 2014 to 2017	Carbon footprint contribution
		(% of total GHGs 2014 to 2017)
50000000 - Food, beverage and tobacco products	1.0%	3.2%
50110000 – Meat and poultry products	0.5%	1.7%

Note: these UNSPSC categories are modelled by the same IOCC product category.

Matching IOCC product category (region of origin):

Meat products (QC)

Main categories of IOCC products upstream in the life cycle that contribute to the carbon footprint of these UNSPSC procurement categories

(% of impact score for product category)

Animaux vivants	68,2%
Produits de viande	19,8%
Émissions directes	3,5%
Produits en papier transformés	1,4%
Marges de transport	0,8%
Marges de gros et commissions	0,6%
Autres produits alimentaires divers	0,6%
Produits en plastique	0,6%
Réparation et entretien	0,5%
Gaz naturel	0,4%
Autres biens et services	3,6%

Note: only the top 10 contributors are displayed, the rest are grouped in "Other goods and services".

4.3 Procurement recommendations and its monitoring by PSPC

4.3.1 Construction work and associated services

A major share of purchases and estimated impact are from performing construction and repair work on buildings and transportation infrastructure, and from professional architecture and engineering services. It is seldom possible to reduce or rationalize the volume of these procurement items, especially if large construction/repair sites need to be built (for example, PSPC-QC in 2015/2016).

As indicated in the previous sheets, these services cause direct GHG emissions at the work site (and/or for the transportation of heavy materials) through the consumption of fuel purchased by the service provider. In this context, PSPC can influence its purchases and have bidding companies compete to offer their services based on additional criteria for consumption, control of emissions from vehicles and machine tools, etc.

→ *Guides and recommendations exist on energy efficiency, fuel-efficient use of vehicles and machinery (Natural Resources Canada/Office of Energy Efficiency, ECPAR, etc.)*

The performance of work involves the production of materials that are the purchase's main contributors. These are cement and concrete, metal materials, paints, and adhesives purchased by the contractor to provide the service (see "repair construction services" data sheet). Environmental gains can be achieved by requiring the service provider to focus on these procurement items (for example, it can optimally reduce its use of cement and concrete by adding cement aggregates) and PSPC can also play a role in its contractual requirements. A building construction contract may require the bidder to show that its cement and concrete supplier uses production technology that reduces emissions or has completed an environmental product declaration.

4.3.2 Food products

Two findings of the study showed that food product procurement is a relatively significant contributor to the carbon footprint and that they are often too crudely described in the data compiled by PSPC. These procurement items should be listed, if possible, according to GSIN or UNSPSC codes that are more detailed than "Food and beverages" or "Provision" to distinguish the categories of food products available in the openIO-Canada environmental analysis model (cf. Appendix A.2), such as meat products, dairy products, fruits and vegetables, beverages, bakery products, etc. These food categories have significantly different GHG intensities and the analysis would become more accurate as a result. In addition, PSPC-QC could i) implement more accurate annual monitoring; ii) develop recommendations or incentives for its client departments that would seek to replace high-carbon foods, such as meat and dairy products, with lower-carbon foods, promote vegetarian menus, etc.

4.3.3 Posterior analysis of procurement contracts

Using cross-sectional analysis by goods and services and by client department, PSPC-QC can identify similar procurement item types that are repeatedly required by various departments. For the ones that were identified above as the greatest contributors to the carbon footprint, PSPC-QC could implement a posterior analysis protocol for contracts and/or offers of service in order to identify suppliers that would have to demonstrate that they are proactively reducing

their GHGs or have even carried out an environmental assessment of their activity or product. In such cases, not only could these suppliers be identified as “champions,” but above all, they themselves define the criteria that may be requested as mandatory for all suppliers in the goods or services category.

4.3.4 Time monitoring by PSPC-QC

Repeating the analysis over several years, using the monitoring tool, may over time reveal a larger number of products that are major contributors (and possibly very carbon intensive) to which closer attention will need to be paid. Similarly, individual monitoring by client department is possible, at least for the ones with a high volume and wide range of procurement items. PSPC can then engage in more focused and personalized discussions with its clients.

4.4 Choosing a reference year

Table 4-7 presents the arithmetic means for each department over the three-year period of the study, GHG emissions of procurement, and GHG intensity. The average GHG intensity is calculated as the average of the annual intensities, rather than dividing the total over the three years of emissions by that of the purchases, since this approach is strongly biased if negative amount amendments are significant (this was the case for Jacques Cartier and Champlain Bridges Incorporate, for which the intensity would be negative).

The calculation of means over the three years eludes the issue of choosing only one year from the three of the study as a reference year. Several peculiarities were identified above based on the years. For example, in 2015/2016, the volume of purchases by PSPC was significantly higher than for the previous year and the following year, and accounted for the purchases of all PSPC-QC clients up to the grand total. The year 2015/2016 was also a special year for Parks Canada and Correctional Service Canada, while 2014/2015 was a special one for the Canada Border Services Agency. In short, choosing a year would be like setting an unrepresentative reference point, which is not recommended. The means approach smooths out both changes in the procurement volumes and profiles of each department over time and the variations between departments.

The means for the three years of the study therefore provide an acceptable reference point for starting the annual monitoring exercise that PSPC wants to carry out. Over time, the main objective will be to see that the GHG intensity of procurement is decreasing with each year. In the event that procurement items of a very different nature become frequently required as compared to the previous year (such as ferry services for Fisheries and Oceans Canada in 2016/2017), the intensity can change significantly, but neither the approach nor efforts at greening procurement should be called into question. In this case, using a moving average (rolling, over the last three or four years) in the future may be more suitable for following trends and progress. If progress tends to be steady over time, a weighted moving average that would give more weight to the most recent years would be more appropriate to define a more ambitious reference point each year.

Table 4-7: GHGs and GHG emission intensity (CO₂eq/\$ excluding taxes) average of PSPC-QC procurement over the three years of the study, by client department

Client	Moyenne 2014 à 2017		
	GES (t CO ₂ eq)	%	kg CO ₂ eq/\$
Travaux publics et Services gouvernementaux Canada	48 508	46,8%	0,264
Ministère de la défense nationale	18 471	17,8%	0,263
Pêches et Océans Canada	12 708	12,2%	0,347
Service correctionnel du Canada	7 705	7,4%	0,545
Agence spatiale canadienne	6 276	6,0%	0,140
Conseil national de recherches du Canada	2 275	2,2%	0,324
Agence des services frontaliers du Canada	2 102	2,0%	0,238
Bureau de l'infrastructure du Canada	1 291	1,2%	0,143
Transports Canada	974	0,9%	0,303
Anciens Combattants Canada	838	0,8%	0,303
Environnement Canada	630	0,6%	0,245
Parcs Canada	597	0,6%	1,000
Santé Canada	439	0,4%	0,281
Agriculture et Agroalimentaire Canada	300	0,3%	0,264
Ressources naturelles Canada	248	0,2%	0,293
Affaires autochtones et du Nord Canada	93	0,1%	0,306
Agence canadienne d'inspection des aliments	85	0,1%	0,220
Industrie Canada	60	0,1%	0,180
Agence de dévpt écon. du Canada pour les régions du QC	55	0,1%	0,138
Emploi et Développement social Canada	40	0,04%	0,185
Office national du film	30	0,03%	0,196
Ministère de la Justice Canada	27	0,03%	0,120
Les Ponts Jacques Cartier et Champlain Incorporée	8	0,01%	0,353
Grand Total Moyen	103 133		0,266

4.5 Other recommendations

Several other recommendations can be made in relation to the procurement data compiled by PSPC-QC and that feed into the environmental analysis and ways to improve the openIO-Canada model for more relevant and more representative environmental analyses in the future.

4.5.1 Entry of procurement data by PSPC

In order to facilitate and refine environmental analysis, it is recommended that PSPC-QC:

- Enter contract amounts in their sales tax-excluded value.
- Do not describe contracts with a code that is too vague. For example, avoid the following GSINs that are difficult, if not impossible, to match with a UNSPSC code or an IOCC code in the analysis model:

- N9999 – Miscellaneous items

The recommendation also applies to the future entry of UNSPSC codes where aggregated Segment or even Family levels should be avoided.

4.5.2 Prospects for improving the tool and assessing the carbon footprint

4.5.2.1 Update of the openIO-Canada model

The results of this study are based on the data from the openIO-Canada model. The MS Excel tracking tool was also developed around the same model. The model can be improved in several ways to increase the representativeness and robustness of the results obtained for the carbon footprint.

Economic model

The underlying Input-Output economic model applies to 2009. More up-to-date tables (2015) exist and were published by Statistics Canada. This would increase the representativeness over time of cross-sectoral economic exchanges in the Canadian economy.

Environmental extensions

The Environment Accounts Division of Statistics Canada now publishes GHG emissions tables that are synchronized with the latest economic data (2015). Such an update would improve the technological representativeness of the openIO-Canada model and would reflect the progress of Canadian industries in reducing GHG emissions.

Contextualization and regionalization

Like the model's contextualization to simulate a Quebec economy through a Canadian economy powered by electricity from Quebec's energy mix, a **similar contextualization** could be done for each of the other provinces of Canada by considering their own energy mix. This partial regionalization is a simplified way to improve the geographical representativeness of the analysis. As a priority, a contextualization for Ontario could be added, since it is the second province of origin for PSPC-QC's Canadian procurement.

True Canadian regionalization would consist of a **multiprovincial** model, including both the economic production model for each province and the interprovincial economic exchanges (Statistics Canada's interprovincial Input-Output tables), as well as the environmental data for the industries in each province. Developing such a model is a major R&D effort; it also faces the challenge of the increased aggregation of data made public by Statistics Canada for these tables and, therefore, greater granularity of the resulting analysis model (on the order of about a hundred goods and services instead of 240).

Another perspective of regionalization is a **multiregional global** model, where each country is a region. Such Input-Output models for environmental analysis exist, such as Exiobase and Eora, which detail over a hundred countries. They allow for exchanges between countries to be considered and therefore take into account, for example, that electronic and computer products purchased in Canada are manufactured in Asian countries. On the other hand, they have drawbacks, such as the granularity of goods and services (typically about a hundred) and the inability, without a significant R&D effort, to distinguish the regions within a country, such as the Canadian provinces.

5 Tracking Tool

An MS Excel tracking tool was developed during the project at the same time as this study. The tool is bilingual French/English.

- It contains the procurement data for 2014 to 2017, which were evaluated here, together with the results of their carbon footprint (also available in an Excel attachment to this report).
- It allows a PSPC-QC user to replicate the annual carbon footprint of procurement exercise for subsequent years and to study the contributions by client department and by procurement categories.
- It compares the carbon footprint for several years.

6 Conclusion

Every year, PSPC-QC signs 2,000 to 3,000 procurement contracts worth \$400 million to \$500 million. The carbon footprint of all procurement items—from the cradle to the gate of the manufacturing plant of the good or at the point of delivery of the service—was assessed for the three fiscal years (2014 to 2017). On an annual average, it totalled 103,133 tonnes CO₂eq or an intensity of 0.266 kg CO₂eq/\$ excluding taxes. The three major client department contributors to the footprint are:

- PSPC itself, for 47% (0.264 kg CO₂eq/\$), mainly for construction of buildings and transportation infrastructure;
- the Department of National Defence, for 18% (0.263 kg CO₂eq/\$), mainly for research and development services, but also for food services and for office cleaning services; and
- Fisheries and Oceans Canada, for 12% (0.347 kg CO₂eq/\$), for ship repair and marine construction work.

In order to green its procurement, PSPC-QC should prioritize these procurement categories to reduce their carbon footprint. Where possible, efforts should first be made to reduce or streamline the volumes of these procurement items. The study showed that this is not always possible, especially if large construction/repair sites need to be created (this was the case for PSPC-QC in 2015/2016, for example). This is probably easier for procurement items that are more regular and stable over time, such as research and development services, food services, cleaning services, and vehicle repair services. Efforts in these areas should reduce spending and the total annual carbon footprint. The tracking tool will allow PSPC-QC to monitor such a trend.

Another direction for effort is to develop specific requirements for the procurement items in these categories in PSPC-QC calls for tenders that suppliers should follow or at least show that they are making efforts to meet them. The contribution sheets developed for a series of eight procurement categories can offer guidance on the issues that these requirements should address. The tracking tool developed for PSPC-QC does not quantify the reduction in the carbon footprint that can be achieved as a result of such improvements by suppliers, as it remains too granular in its analysis. However, it allows contribution analyses to be conducted for other procurement categories.

Instead, the tracking tool provides a more macroscopic perspective that also allows PSPC-QC to report annually on the carbon footprint of all procurement for which it has a mandate, to reveal the emergence over time of categories of contributor products (which may have high carbon intensity) or even to track and advise its client departments individually.

This study adapted a “hotspot analysis” style of environmental analysis to the context of PSPC-QC procurement classified according to the GSIN description. In particular, it will have made it possible to find matches with the UNSPSC classification for 82 missing GSIN codes in the mapping table published by PSPC. These codes accounted for 15% to 20% of the value of PSPC-QC’s annual procurement.

Lastly, it must be kept in mind that the carbon footprint calculated in this study represents potential GHG emissions and not real impacts, and does not include the use and end-of-life stages of the purchased goods. The environmental portrait of procurement is therefore partial,

especially for energy-consuming durable goods during their useful lives. A follow-up to the study may address this aspect.

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Appendix A.1

Input-Output (IO-E) environmental analysis method

The proposed methodology for the study is based on the **Input-Output environmental (IO-E) analysis**, which is derived from the Input-Output (IO) economic analysis. The IO-E analysis is commonly used to conduct environmental analyses in situations where the traditional LCA¹⁶ is poorly or less well adapted. This is particularly the case when the system being studied involved a large number of products and services, and carrying out an LCA for each of them to model the system is ultimately not possible (individual data not available or difficult to access, workload too high). Typically, IO-E analyses are used to assess the impacts of an entire nation (Hertwich & Peters 2009; Huppes et al. 2006), a region (Erickson et al. 2010; Larsen & Hertwich 2011) or a city (Larsen & Hertwich 2010; Wiedmann et al. 2015), including trade between these economies (Norman et al. 2007; Hertwich & Peters 2009; Wiedmann et al. 2015; Kanemoto et al. 2016). It is also suitable for assessing the multiple activities and procurement items of organizations such as corporations (e.g., Huang et al. 2009), universities (Baboulet & Lenzen 2010; Thurston & Eckelman 2011; Larsen et al. 2013; Townsend & Barrett 2015; Gómez et al. 2016) or public services and governments (Minx et al. 2009; Wiedmann & Barrett 2011; Larsen & Hertwich 2011; Alvarez & Rubio 2015; Kjaer et al. 2015). The IO-E analysis is also used in conjunction with the traditional LCA in the preliminary phases of the analysis, since like the traditional LCA, it identifies the sources of impact along supply chains and also identifies the responsibilities between suppliers and consumers. Furthermore, the size of the systems that it can analyze makes the method suitable for supporting public policies related to consumption, such as when it comes to identifying action priorities by categories of products and services (see Minx et al. 2009; Tukker 2006; Huppes et al. 2006).

The following paragraphs briefly introduce the general principles of the IO analysis and its extension to the IO-E environmental analysis. Then, the analysis model developed for the study is presented.

The Input/Output economic analysis

IO analyses consider the entire economy as a set of players grouped into industries (or sectors) that buy and sell goods and services (“products”). Monetary IO tables are constructed using data from national statistics agencies. These IO tables are national accounting inventories and refer to one year. The “final” consumption of products by households and governments, as well as imports and exports are represented in separate tables. Any other flows that cannot be considered a product exchange are represented in extensions; for an economic analysis, this typically boils down to value added, namely pay for salaries and profits.

IO tables are generally constructed symmetrically in order to describe which products are used in the production of which products (**Z**, see Figure 7-1). In other words, we eliminate industries from the representation of the economy and we focus on the interdependence between different products.

An IO table is then standardized in relation to the total production of each product. Each column is a kind of “cooking recipe” to produce \$1 of a product (Leontief, 1970). The **Z** flow matrix then becomes the matrix of technical coefficients (**A**). The latter is then used in IO analysis models

¹⁶ Later, “LCA” is understood to be the traditional life cycle analysis method using unit processes that are exclusively in physical data. The inventory is usually truncated by using a cut-off threshold (e.g., inputs representing less than 1% by mass of total process inputs are excluded from the inventory based on the principle that their contribution will not be significant to the impact) or by excluding certain activities, such as the transportation of employees to their workplace. *Ecoinvent* is a recognized example of an “LCA”-type database.

using the Leontief matrix ($L=(I-A)^{-1}$), which introduces the **life cycle** approach. By multiplying a vector for final product demand (e.g., household demand) by L , we then calculate the total “**cradle to consumer**” production required for each product to meet demand. This so-called “quantity” model is central to any IO analysis and also the traditional LCA. The IO analysis and the LCA therefore share the mathematical foundations and many assumptions.

[€]		Produits manufacturés	Électricité	Services	Ménages	total
Prod. manufacturés	Z :	0	20	45	35	100
Électricité		30	0	30	140	200
Services		0	80	0	70	150
Valeur ajoutée	va :	70	100	75		
total	x' :	100	200	150		

Figure 7-1: Non-standardized Input-Output tables (simplified fictional example of 3 products)

The “Electricity” column compiles the flows of various products (Z) and the value added (va) dedicated to the production of electricity in the economy; the “Electricity” row counts the consumption of electricity in the production of various commodities (Z) and by the final consumers (h). The sums of the rows and columns must be equal ($x=x'$).

Multiregional IO analysis: By combining the tables of all available countries and by reconciling their reported imports and exports, we can develop an overall portrait of the entire world in which each country is explicitly represented and each industry uses domestic and imported inputs. The compilation of multiregional IO tables is a fairly difficult task, carried out by experts from the academic world, but their use is no more complicated than that of a national IO table. Such tables open the way to analyses in which the origin of products can be considered.

IO tables are typically published every 5 years by national statistics agencies and with a delay of a few years. Analysts must therefore manage this temporality aspect using price indices to correct for inflation or deflation as needed (see Appendix A.4).

The Input-Output environmental analysis (IO-E)

The IO analysis calculates (in \$) the total production from “cradle to consumer” required for a given final consumption. One of the main uses of the IO-E analysis is instead to calculate **the total emissions for a given consumption**. This is done by adding environmental extensions to the economy inventory data. Mathematically, environmental extensions are compiled and processed in the same way as the value added presented above in Figure 7-1. The IO-E tables are therefore IO tables enhanced by a matrix of environmental flows expressed in physical units, such as air emissions in kg CO₂ or kg SO₂, water samples in m³, kg of crude oil, etc. Each column, that is, each production process and service activity (cf. Figure 7-1), therefore has an inventory of its environmental inputs (natural resources taken) and its direct emissions into the environment (air, water or soil pollutants). Some IO-E tables also provide emissions from the product use phase in the form of direct household emissions per \$ of purchase of each product (e.g., CO₂ emitted per \$ of purchase of automobile gasoline).

The environmental extensions can be added to economic tables by the statistical agencies themselves, but they are often limited to GHGs and a few resources. The most complete models are instead developed by the academic world. The resources involved are very important, both for collecting available data and for the work of estimating missing data, scaling up, and quality control (bias identification, consistency of totals, etc.) This explains the overall reduced availability of databases for IO-E analysis (i.e., IO-E tables), both national and multiregional. It is very important to note that, although an IO-E analysis ensures that the economic activities involved are comprehensively considered, the environmental issues are only partially covered if the inventory in the tables is incomplete. An IO-E analysis model, if considered sufficiently detailed and complete, can be used in conjunction with an LCA to guide data collection and modelling in an exploratory phase prior to the traditional LCA (Bretz & Frankhauser 1996; Huang et al. 2009).

The openIO-Canada model (adapted)

OpenIO-Canada is a Canadian IO-E model developed by CIRAIG¹⁷ in 2014. Its main features are (Lesage, 2014):

- Coverage and reference year: Canada, 2009
- “L61” economic tables for disaggregation published by Statistics Canada: 112 industries and 246 commodities (goods and services) (see Appendix A.2)
- Environmental data: **GHG emissions** and **water use** (direct environmental sampling and acquisition of procurement utilities) according to Statistics Canada’s Environment Accounts and **emission of toxic air, water and soil pollutants** according to Environment Canada’s National Pollutant Release Inventory (NPRI). In version 1.0, it does not include land use or fossil and mineral resource extraction. It lists 238 different substances that are exchanged with the environment.
- Type of model developed (v. 1.0): Standardized 112-dimension matrix based on an “*Industry-Industry*” approach, with coproduct allocation based on the assumption that a given industry produces all its coproducts in the same way (the “*Industry-Technology*” hypothesis).

¹⁷ http://www.ciraig.org/en/open_io_canada/

OpenIO-Canada is an “open source” model and an online tool was created using the model. It has limitations that are directly linked to the completeness, transparency, and quality of the primary data on which it is based. The main limitations are listed in Appendix A.3.

OpenIO-Canada is a model that represents Canada’s economy as a whole, without providing details at the provincial level. In addition, it considers Canada as an economy that is isolated from the rest of the world, as imports/exports are not included. These two limitations reduce the model’s value in assessing products purchased and used in Quebec when we know that many of them can be manufactured and imported from abroad or manufactured and used locally in Quebec by taking advantage of hydroelectricity, which has a significantly different environmental profile from the “average” Canadian electricity. In addition, version 1.0 of openIO-Canada does not include emissions from the product use stage (e.g., the CO₂ emitted when combusting natural gas that is purchased for heating) or their end of life. For this review, the model used is an adaptation that affects the following aspects:

- a) Changing the model to include electricity generation in Quebec
- b) Calculations of emissions related to the use of purchased energy products

a) Modifying the openIO-Canada model

First, in order to improve the model’s performance and to facilitate its ongoing development, openIO-Canada is integrated into a Python programming environment. The model is then modified as follows:

- The initial tables are redefined with the addition of the geographic dimension (in this case, CA for Canada) so that industries and products specific to the geography of Quebec (QC) can be added at a later date.
- Products expressed in physical units are added to the tables, including electricity production in Quebec (expressed in kWh); the combustion of gasoline, diesel, marine fuel, and aviation fuel in vehicle fleets (both light and heavy), machinery, buses, trains, boats, and aircraft (expressed in litres); and the combustion of natural gas, heating oil, and propane (expressed in MJ). The calculation of combustion emissions is explained in the following section.
- For electricity generation, emissions into the environment at “life cycle” emissions that take into account, for example, the construction of hydroelectric dams, transportation and distribution, and electricity imports. The emissions are based on a study conducted by CIRAIG for Hydro-Québec and are extracted from theecoinvent life cycle inventory database v. 3.2 (2016).
- Subsequently, Canadian goods and services from the initial tables can be duplicated in the expanded IO-E tables and virtually “delocalized” to Quebec (i.e., powered by Quebec electricity) if it is found that such goods or services produced in Quebec are in fact purchased by the government and should be modelled as such. This recontextualization is carried out for all 246 goods and services in the IO-E tables so that the analysis model contains two versions, one Canadian and one for Quebec, for each of the goods and services. The analysis will then determine which version is used for each acquisition category.
- For this recontextualization, it was necessary to convert the amount of electricity purchased for each product on the IO-E tables into a physical quantity (kWh) of electricity. Two electricity prices were considered to account for “large consumers,” who

receive a lower **industrial rate** (\$0.0479/kWh) than small consumers, who receive Hydro-Québec's **residential rate** (\$0.0678/kWh). With the purchase of electricity per unit of equal product, the lower the assumed price, the greater the emissions associated with electricity generation per unit of product.

b) Emissions related to the product use stage

Direct emissions from the use stage are added to the model for petroleum products and purchased fuels. These emissions are extracted from theecoinvent life cycle inventory database v. 3.2 (2016) based on the details presented elsewhere.

Limitations of the analysis model

- The openIO-Canada model considers the structure of the Canadian economy and the emissions into the environment of each of its sectors as in 2009, while we are seeking to assess the potential impact for the years 2014 to 2017. Any structural changes in the economy, and technological advances that allowed for reductions in environmental emissions, but also any deterioration in environmental performance of industrial activities that may have occurred since 2009 are not taken into account. However, in our experience, a 5–8-year timeframe is very acceptable as part of an exploratory analysis that aims to identify the main contributors to impacts.
- The model's adaptation to a Quebec context is only partial, since it concerns only the production of electricity.
- Intrinsically, the IO-E analysis is granular because of the limited number of product and service categories considered by the model. The level of aggregation reduces the possibility of distinguishing relatively similar acquisitions, such as those grouped in the computers and peripheral devices category.
- The environmental extensions for openIO-Canada are not comprehensive and do not allow for certain impacts to be characterized, such as the depletion of fossil and mineral primary resources and damage to biodiversity (through land use).
- Environmental extensions are not perfectly aligned with the available life cycle impact assessment methods. For example, metal and metalloid emissions are often expressed in the National Pollutant Release Inventory (NPRI; the main source of pollutant emissions for the openIO model) as "metallic compounds" or simply "metal," while the characterization factors for metals in the Impact 2002+ method are given for metals in ion form, which overestimates the ecotoxic impact and, consequently, the damage score for Ecosystem Quality.
- Lastly, the NPRI only provides emissions for site that are larger than a threshold, which omits some small sources of emissions.

All limitations associated with the openIO model are described in Appendix A.3.

Appendix A.2: Input-Output Commodity Codes (IOCC), 2009, link 1961 level, used in openIO-Canada

Source: Statistics Canada

The last column presents the chosen rate for electricity consumed to produce products or services (CIRAIG).

The appendix is included in the file “**CIRAIG_SPAC-QC_Empreinte C_Annexes.xlsx**”, which has been provided with the final report (“Support mapping” tab, and “IOCC_noms” and “IOCC_region” tables).

Appendix A.3:

Limitations of openIO-Canada (v. 1.0)

See also: http://www.ciraig.org/en/open_io_canada/known_limitation.html

Note: As described below, the 2009 environmental data for GHG emissions and water use were updated in 2017 by Statistics Canada.

A) ECONOMIC DATA

Missing elements in the original Input and Output tables

For confidentiality reasons, Statistics Canada wilfully excluded some elements from the Supply and Use tables. Some of these elements were estimated by CIRAIG in version 1.0 of OpenIO-Canada. Missing elements ultimately lead to an underestimation of impacts and potential errors in contribution analyses.

Imports, exports, investments, etc.

Imports, exports and any other issue not directly covered in the Supply and Use table were ignored in the model.

B) ENVIRONMENTAL DATA

Greenhouse gases coverage (2017 update of 2009 data)

The data from Statistics Canada on GHG emissions used in this model only covers three gases: CO₂, CH₄ and N₂O. What is more, the emissions data is only made available as an aggregate Carbon dioxide equivalent (CO₂e) and use global warming potentials (GWP) of 25 and 298 for CH₄ and N₂O, respectively (IPCC 2007, 100-year time horizon). The 2017 update of 2009 emission data covers the following sources: “combustion of fossil fuels and biomass; non-combustion uses of fossil fuels; industrial processes; agricultural soils; livestock manure and enteric fermentation.”

Incomplete data on emissions due to excluded facilities in NPRI

Emission data for non-GHG substances comes from the NPRI, a pollutant release inventory managed by Environment Canada. It collects data from Canadian industries on their emissions of over 300 substances or grouped substances. However, not all facilities are required to report to the NPRI. For example, facilities where less than 20,000 employee-hours are worked in a given year are not, under certain conditions, required to report. See <https://www.ec.gc.ca/inrp-npri/> for all requirements. This necessarily leads to an underestimation of emissions.

VOC emissions

VOC emission data comes from the NPRI. The sum of speciated VOC emissions was subtracted from total VOC emissions to avoid double counting. This resulted in negative emissions for 4 industries (GS91300-Other municipal government services, BS541D0-Computer systems design and other professional, scientific and technical services, BS31B00-Clothing and leather and allied product manufacturing and BS31110-Animal food manufacturing). The cause for these negative values is unknown. The sum of unspciated VOC emissions from these sectors was set to 0.

Total reduced sulphur

Total reduced sulphur emission data comes from the NPRI. As explained on their website, emissions of Total Reduced Sulphur (TRS) are actually the sum of six emissions, three of which

(hydrogen sulphide [H₂S], carbon disulphide [CS₂] and carbonyl sulfide [COS]) are also reported separately. In order to avoid double counting, the sum emission of these three substances, expressed in H₂S equivalents, was removed from the reported Total reduced sulphur emission. This was done separately for air, water and soil emissions. This resulted in negative TRS emissions for some industries. The cause for these negative values is unknown. The TRS values for these industries was set to 0. This happened in the following cases:

- Air: BS21220, BS21300, BS22110, BS327A0, BS33100 and BS56200.
- Water: BS221A0
- Soil: BS21100, BS221A0

Particulate matter emissions

Particulate matter emission data comes from the NPRI. The particulate matter emissions, reported as Total PM, PM₁₀ and PM_{2.5}, are converted to the elementary flow names (and corresponding values) used in ecoinvent and most LCIA methods, i.e., "Particulates, > 10 µm" (PM-PM₁₀), "Particulates, > 2.5 µm, and < 10µm" (PM₁₀-PM_{2.5}) and Particulates, < 2.5 µm (PM_{2.5}). This resulted in negative emissions of "Particulates, > 10 µm" in 31 cases and negative emissions of "Particulates, > 2.5 µm, and < 10µm" in one case: these were set to 0. Contrary to TRS and VOC emissions, the cause of these negative calculated emissions is known and is unavoidable with the current data.

Compounds reported as elements

In the NPRI, some substances are reported as elements and their compounds/salts. This necessarily overestimates the weight of the actual elements, and hence leads to an overestimation of their impacts once characterized. The substances are: Acrylic acid (and its salts); Aniline (and its salts); Antimony (and its compounds); Arsenic (and its compounds); Cadmium (and its compounds); Chromium (and its compounds); Cobalt (and its compounds); Copper (and its compounds); Hexavalent chromium (and its compounds); Lead (and its compounds); Manganese (and its compounds); Mercury (and its compounds); Nickel (and its compounds); Nonylphenol and its ethoxylates; Selenium (and its compounds); Silver (and its compounds); Zinc (and its compounds).

Grouped emissions: isomers

In the NPRI, some substances are reported as "molecules and their isomers". Isomers will likely not have the same characterization factors, and hence this leads to a misrepresentation of impacts (uncertainty). The molecules are "HCFC-123 and all isomers" and "Xylene (all isomers)."

Water use (2017 update of 2009 data)

Physical flows of water use from Statistics Canada' environmental accounts are used in this model. The original dataset is modified to match the IOIC L-61 classification since it is provided with some more aggregated sectors, particularly for the manufacturing sectors. The account provides water use volume for every IOIC sector of the economy which is the sum of water withdrawn directly from the environment by the sector plus the tap water intake supplied to it by public/municipal systems.

Appendix A.4:

Table of inflation rates by category used with IOCC goods and services in openIO-Canada

Source: Statistics Canada

Price indices

- IPPI: Industrial Product Price Index
- CPI: Consumer Price Index
- WPI: Wholesale Price Index
- RPI: Retail Price Index

This appendix is included in the tracking tool that will be provided.

Appendix B: GSIN–UNSPSC–IOCC matches

Tables of matches between IOCC and UNSPSC codes for the 82 GSINs that are not covered in the mapping table provided by PSPC (June 22, 2016 version published by Open Data Canada).

This table is available in the Excel file “**CIRAIG_SPAC-QC_Empreinte C_Annexes.xlsx**” that is provided with the final report (“nibs-gsin_unspsc” tab).

Appendix C: UNSPSC–IOCC matches

Table of matches between IOCC codes in the openIO-Canada environmental analysis model and UNSPSC codes not covered in CIRAIG’s existing mapping table (April 2017 version).

This table is available in the Excel file “**CIRAIG_SPAC-QC_Empreinte C_Annexes.xlsx**” that is provided with the final report (“UNSPSC-IOCC-10_03_2018” tab).

Appendix D:

Other PSPC-QC procurement impact results

- 1- The top four GHG-producing procurement goods and services (based on GSIN description) for each of PSPC-QC's six client departments that contribute the most to the annual carbon footprint
- 2- Major goods and services, based on GSIN description, that contribute 80% of the annual carbon footprint of PSPC-QC procurement, in descending order of contribution (per year)
- 3- 22 goods and services (based on GSIN description), each of which make up more than 1% of the total carbon footprint of procurement over the three years of the study (in descending order of contribution and by recipient client department)
- 4- Goods and services (according to UNSPSC segments) that each contributed more than 1% to the carbon footprint of PSPC-QC procurement from 2014 to 2017

Other more complete tables are available in the Excel file "**CIRAIG_SPAC-QC_Print C_Appendices.xlsx**" that is provided with the final report ("Table empreinte" tab and "Table eco" tab).

The "Pivot Compilation" pivot table can be used to perform additional analyses and overviews.

Figure 1: The top four GHG-producing procurement goods and services (based on G SIN description) for each of PSPC-QC's six client departments that contribute the most to the annual carbon footprint (ranking for 2015/2016)

Client	2014-2015		2015-2016		2016-2017	
	GES (t CO ₂ eq)	% du total GES (gras); % des GES du client	GES (t CO ₂ eq)	% du total GES (gras); % des GES du client	GES (t CO ₂ eq)	% du total GES (gras); % des GES du client
Travaux publics et Services gouvernementaux Canada	43 303	44%	64 299	53%	37 921	43%
Construction d'autres édifices	6 220	14%	35 042	54%	15 202	40%
Ouvrages de maçonnerie, ouvrages de pierre	669	2%	3 879	6%	111	0,3%
Autoroutes, rues, routes, voies ferrées, pistes d'aéroport	12 917	30%	3 867	6%	612	2%
Construction des édifices à logements multiples			3 834	6%	345	0,9%
<i>Autres produits</i>	23 498	54%	17 677	27%	21 650	57%
Ministère de la défense nationale	18 689	19%	22 475	18%	14 248	16%
Composants divers de véhicules - réparation			3 518	16%	19	0,1%
Services de traiteur	1 114	6%	2 879	13%	709	5%
Domaine militaire (R&D)	2 246	12%	1 624	7%	3 163	22%
Nettoyage et entretien, conciergerie	2 010	11%	1 351	6%	1 100	8%
<i>Autres produits</i>	13 319	71%	13 102	58%	9 257	65%
Pêches et Océans Canada	8 192	8%	12 376	10%	17 555	20%
Navires et bateaux de grandes dimensions -réparation, radoub et transformation (mise en cale sèche comprise)	3 380	41%	2 793	23%	579	3%
Voies de navigation, ports, barrages et autres adductions d'eau			2 389	19%	1 679	10%
Navires et bateaux - réparation, radoub et transformation, mise en cale sèche non comprise	591	7%	1 489	12%	1 366	8%
Organes de propulsion pour bateaux et navires	71	1%	1 338	11%	2 119	12%
<i>Autres produits</i>	4 150	51%	4 368	35%	11 813	67%
Service correctionnel du Canada	9 672	10%	9 787	8%	3 655	4%
Provisions , divers	2 844	29%	2 274	23%	89	2%
Viande, volaille et poisson (remplacé par nibs N8905Z)			1 167	12%	14	0,4%
Provisions, divers (remplacé par nibs N8920ZC)	776	8%	799	8%		
Traduction et interprétation			742	8%		
<i>Autres produits</i>	6 051	63%	4 805	49%	3 552	97%
Agence spatiale canadienne	6 174	6%	6 459	5%	6 195	7%
Astronautique (R&D)	2 132	35%	3 473	54%	2 887	47%
Services d'exploitation et d'entretien d'installations techniques et scientifiques	215	3%	1 229	19%	188	3%
Construction d'autres édifices			578	9%	267	4%
Mise au point d'instruments pour engin spatial (R&D)	1 622	26%	403	6%	1 288	21%
<i>Autres produits</i>	2 205	36%	776	12%	1 566	25%
Conseil national de recherches du Canada	632	0,6%	1 100	0,9%	5 093	6%
Équipement et approvisionnements de laboratoire	382	60%	1 027	93%	5 055	99%
Dispositifs pour laboratoire, automation et robotique			46	4%		
Équipement de climatisation			12	1%		
Combinaisons et instruments divers			10	1%		
<i>Autres produits</i>	250	40%	6	0,5%	38	1%
Autres ministères-clients	12 105	12%	5 541	5%	3 927	4%
Grand Total	98 767	100%	122 037	100%	88 594	100%

Figure 2a: Major goods and services that contribute 80% of the annual carbon footprint of PSPC-QC procurement in 2014/2015, in descending order of contribution (GSIN description)

Produits NIBS	2014-2015	
	GES (t CO2eq)	% cumulé du total GES
Autoroutes, rues, routes, voies ferrées, pistes d'aéroport	12 917	13%
Construction d'autres édifices	6 220	19%
Provisions, divers	3 770	23%
Navires et bateaux de grandes dimensions - réparation, radoub et transformation (mise en cale sèche comprise)	3 380	27%
Services de sécurité commerciaux et services connexes	3 030	30%
Voies de navigation, ports, barrages et autres adductions d'eau	2 848	33%
Nettoyage et entretien, conciergerie	2 588	35%
Services d'architecture et d'ingénierie - Autoroutes, routes, ponts, voies ferrées, et barrages	2 547	38%
Viande, volaille et poisson	2 325	40%
Services de construction, non énumérés ailleurs	2 263	42%
Domaine militaire (R&D)	2 246	45%
Services environnementaux	2 226	47%
Astronautique (R&D)	2 132	49%
Construction d'édifices commerciaux	2 099	51%
Services de traiteur	2 056	53%
Services de dragage - installation flottante	1 844	55%
Construction d'entrepôts et de bâtiments industriels	1 809	57%
Mise au point d'instruments pour engin spatial (R&D)	1 622	59%
Travaux généraux de construction maritime	1 562	60%
Carton compact, embouti	1 469	62%
Dragage	1 371	63%
Instruments d'optique, matériel d'essai, composants et accessoires	1 157	64%
Laitiers	984	65%
Provisions, divers (remplacé par nibs N8920ZC)	946	66%
Fromage	867	67%
Véhicules à moteur de tourisme - réparation et révision - General Motors	855	68%
Traitement de données du satellite et services connexes	844	69%
Travaux de couverture et d'imperméabilisation	802	70%
Produits de boulangerie	799	70%
Animaux vivants, non élevés pour la consommation	743	71%
Services d'entrepreneurs généraux, non énumérés ailleurs	721	72%
Ouvrages de maçonnerie, ouvrages de pierre	669	73%
Travaux de construction d'autres corps de métiers	612	73%
Équipement et approvisionnements de laboratoire	604	74%
Navires et bateaux - réparation, radoub et transformation, mise en cale sèche non comprise	591	74%
Produits chimiques	564	75%
Fruits et légumes	544	76%
Poisson, sauf diététique (remplacé par nibs N8905ZA)	540	76%
Services d'architectes et d'ingénieurs - bâtiments d'administration et de service	530	77%
Construction d'un et deux édifices à logements	510	77%
Presses à moteur, mécaniques	501	78%
Ponts, autoroutes surélevées, tunnels, viaducs et voies ferrées	488	78%
Camions, équipement pour déblayage de la neige	486	79%
Aménagement intérieur/rénovations	478	79%
Huile pour moteur diesel, marine, conditions rigoureuses	432	80%
<i>Autres produits</i>	20 176	20%
Grand Total	98 767	100%

Figure 2b: Major goods and services that contribute 80% of the annual carbon footprint of PSPC-QC procurement in 2015/2016, in descending order of contribution (GSIN description)

Produits NIBS	2015-2016	
	GES (t CO ₂ eq)	% cumulé du total GES
Construction d'autres édifices	35 620	29%
Ouvrages de maçonnerie, ouvrages de pierre	3 879	32%
Autoroutes, rues, routes, voies ferrées, pistes d'aéroport	3 867	36%
Construction des édifices à logements multiples	3 834	39%
Services de traiteur	3 832	42%
Composants divers de véhicules - réparation	3 518	45%
Provisions, divers	3 474	48%
Astronautique (R&D)	3 473	50%
Navires et bateaux de grandes dimensions -réparation, radoub et transformation (mise en cale sèche comprise)	2 793	53%
Voies de navigation, ports, barrages et autres adductions d'eau	2 657	55%
Services de construction, non énumérés ailleurs	2 278	57%
Services d'entrepreneurs généraux, non énumérés ailleurs	2 093	58%
Domaine militaire (R&D)	1 624	60%
Nettoyage et entretien, conciergerie	1 596	61%
Équipement et approvisionnements de laboratoire	1 551	62%
Navires et bateaux - réparation, radoub et transformation, mise en cale sèche non comprise	1 489	64%
Organes de propulsion pour bateaux et navires	1 338	65%
Aide générale de bureau	1 271	66%
Instruments d'optique, matériel d'essai, composants et accessoires	1 230	67%
Services d'exploitation et d'entretien d'installations techniques et scientifiques	1 229	68%
Distribution et transmission de l'électricité	1 195	69%
Viande, volaille et poisson (remplacé par nibs N8905Z)	1 167	70%
Laitiers	1 116	71%
Bois de construction, traité, construction marine	1 098	71%
Viande, volaille et poisson	1 048	72%
Provisions, divers (remplacé par nibs N8920ZC)	975	73%
Fruits et légumes	974	74%
Services professionnels / Analyse financière	936	75%
Ponts, autoroutes surélevées, tunnels, viaducs et voies ferrées	860	75%
Travaux généraux de construction maritime	811	76%
Traduction et interprétation	742	77%
Fromage	728	77%
Papier et carbonnage	726	78%
Services d'architectes et d'ingénieurs - bâtiments d'administration et de service	721	78%
Traversiers	704	79%
Huile pour moteur diesel, marine, conditions rigoureuses	605	80%
<i>Autres produits</i>	24 984	20%
Grand Total	122 037	100%

Figure 2c: Major goods and services that contribute 80% of the annual carbon footprint of PSPC-QC procurement in 2016/2017, in descending order of contribution (GSIN description)

Produits NIBS	2016-2017	
	GES (t CO ₂ eq)	% cumulé du total GES
Construction d'autres édifices	15 470	17%
Équipement et approvisionnements de laboratoire	6 387	25%
Travaux généraux de construction maritime	4 949	30%
Bois de construction, traité, construction marine	3 302	34%
Domaine militaire (R&D)	3 163	38%
Voies de navigation, ports, barrages et autres adductions d'eau	3 131	41%
Astronautique (R&D)	2 887	44%
Travaux de construction d'autres corps de métiers	2 414	47%
Organes de propulsion pour bateaux et navires	2 119	49%
Nettoyage et entretien, conciergerie	1 768	51%
Papier et carbonnage	1 635	53%
Travaux d'excavation	1 433	55%
Navires et bateaux - réparation, radoub et transformation, mise en cale sèche non comprise	1 366	56%
Mise au point d'instruments pour engin spatial (R&D)	1 288	58%
Véhicules à moteur de tourisme - réparation et révision - General Motors	1 266	59%
Travaux de couverture et d'imperméabilisation	1 221	61%
Construction de bâtiments scolaires	1 192	62%
Services de construction, non énumérés ailleurs	1 107	63%
Services d'architectes et d'ingénieurs - bâtiments d'administration et de service	961	64%
Dragage	959	65%
Services d'architecture et d'ingénierie - Autoroutes, routes, ponts, voies ferrées, et barrages	830	66%
Services de traiteur	709	67%
Navires et bateaux, de petites dimensions - réparation, radoub et transformation, (mise en cale sèche comprise)	708	68%
Entrepreneurs en services de ventilation	687	69%
Services d'architecture et d'ingénierie - Structures autres que celles du bâtiment	658	70%
Huile pour moteur diesel, marine, conditions rigoureuses	639	70%
Bateaux divers - réparation	638	71%
Services d'inspection et d'entretien des unités de chauffage, ventilation et de climatisation	624	72%
Produits en papier pour la toilette	622	72%
Autoroutes, rues, routes, voies ferrées, pistes d'aéroport	612	73%
Autres travaux d'installation	602	74%
Instruments d'optique, matériel d'essai, composants et accessoires	593	74%
Navires et bateaux de grandes dimensions - réparation, radoub et transformation (mise en cale sèche comprise)	579	75%
Viande, volaille et poisson	570	76%
Installations électriques et réparations majeures	559	76%
Provisions, divers	553	77%
Excavation et terrassement	517	78%
Technologie du radar (R&D)	437	78%
Services d'architecture - bâtiments	436	79%
Enlèvement et élimination de substances dangereuses - Secteur construction	390	79%
Mononeige, pièces de rechange	389	79%
Construction d'édifices commerciaux	380	80%
Autres produits	17 845	20%
Grand Total	88 594	100%

Figure 3: 22 goods and services (based on G SIN description and recipient client department), each of which make up more than 1% of the total carbon footprint of procurement over the three years of the study (in descending order)

Produit NIBS Client	2014 à 2017	
	GES (t CO ₂ eq)	% du total GES (gras): % des GES du produit
Construction d'autres édifices	57 310	18,5%
Travaux publics et Services gouvernementaux Canada	56 464	98,5%
Agence spatiale canadienne	846	1,5%
Autoroutes, rues, routes, voies ferrées, pistes d'aéroport	17 396	5,6%
Travaux publics et Services gouvernementaux Canada	17 396	100,0%
Voies de navigation, ports, barrages et autres adductions d'eau	8 636	2,8%
Travaux publics et Services gouvernementaux Canada	4 569	52,9%
Pêches et Océans Canada	4 068	47,1%
Équipement et approvisionnements de laboratoire	8 542	2,8%
Conseil national de recherches du Canada	6 464	75,7%
Santé Canada	682	8,0%
Ministère de la défense nationale	586	6,9%
Agriculture et Agroalimentaire Canada	413	4,8%
Ressources naturelles Canada	159	1,9%
Environnement Canada	102	1,2%
Agence canadienne d'inspection des aliments	89	1,0%
Agence spatiale canadienne	49	0,6%
Astronautique (R&D)	8 491	2,7%
Agence spatiale canadienne	8 491	100,0%
Provisions , divers	7 797	2,5%
Service correctionnel du Canada	5 207	66,8%
Ministère de la défense nationale	2 089	26,8%
Anciens Combattants Canada	500	6,4%
Travaux généraux de construction maritime	7 322	2,4%
Pêches et Océans Canada	4 574	62,5%
Travaux publics et Services gouvernementaux Canada	2 747	37,5%
Domaine militaire (R&D)	7 033	2,3%
Ministère de la défense nationale	7 033	100,0%
Navires et bateaux de grandes dimensions -réparation, radoub et transformation (mise en cale sèche compr	6 752	2,2%
Pêches et Océans Canada	6 752	100,0%
Services de traiteur	6 597	2,1%
Ministère de la défense nationale	4 702	71,3%
Agence des services frontaliers du Canada	1 895	28,7%
Nettoyage et entretien, conciergerie	5 952	1,9%
Ministère de la défense nationale	4 461	75,0%
Travaux publics et Services gouvernementaux Canada	743	12,5%
Agence des services frontaliers du Canada	334	5,6%
Agriculture et Agroalimentaire Canada	238	4,0%
Transports Canada	155	2,6%
Agence canadienne d'inspection des aliments	21	0,4%

Figure 3 (cont'd): 22 goods and services (based on GSIN description and recipient client department), each of which make up more than 1% of the total carbon footprint of procurement over the three years of the study (in descending order)

Produit NIBS Client	2014 à 2017	
	GES (t CO2eq)	% du total GES (gras): % des GES du produit
Services de construction, non énumérés ailleurs	5 648	1,8%
Travaux publics et Services gouvernementaux Canada	5 624	99,6%
Ministère de la défense nationale	24	0,4%
Ouvrages de maçonnerie, ouvrages de pierre	4 658	1,5%
Travaux publics et Services gouvernementaux Canada	4 658	100,0%
Bois de construction, traité, construction marine	4 401	1,4%
Pêches et Océans Canada	3 700	84,1%
Travaux publics et Services gouvernementaux Canada	700	15,9%
Construction des édifices à logements multiples	4 180	1,4%
Travaux publics et Services gouvernementaux Canada	4 180	100,0%
Viande, volaille et poisson	3 943	1,3%
Ministère de la défense nationale	1 880	47,7%
Service correctionnel du Canada	1 558	39,5%
Anciens Combattants Canada	282	7,2%
Pêches et Océans Canada	223	5,7%
Services d'architecture et d'ingénierie - Autoroutes, routes, ponts, voies ferrées, et barrages	3 773	1,2%
Bureau de l'infrastructure du Canada	2 294	60,8%
Travaux publics et Services gouvernementaux Canada	1 438	38,1%
Transports Canada	41	1,1%
Composants divers de véhicules - réparation	3 537	1,1%
Ministère de la défense nationale	3 537	100,0%
Organes de propulsion pour bateaux et navires	3 527	1,1%
Pêches et Océans Canada	3 527	100,0%
Navires et bateaux - réparation, radoub et transformation, mise en cale sèche non comprise	3 446	1,1%
Pêches et Océans Canada	3 446	100,0%
Travaux de construction d'autres corps de métiers	3 409	1,1%
Travaux publics et Services gouvernementaux Canada	2 069	60,7%
Environnement Canada	782	23,0%
Transports Canada	343	10,1%
Agence canadienne d'inspection des aliments	109	3,2%
Agence spatiale canadienne	97	2,8%
Ministère de la défense nationale	10	0,3%
Mise au point d'instruments pour engin spatial (R&D)	3 313	1,1%
Agence spatiale canadienne	3 313	100,0%
Autres produits	123 735	40%
Total	309 398	100%

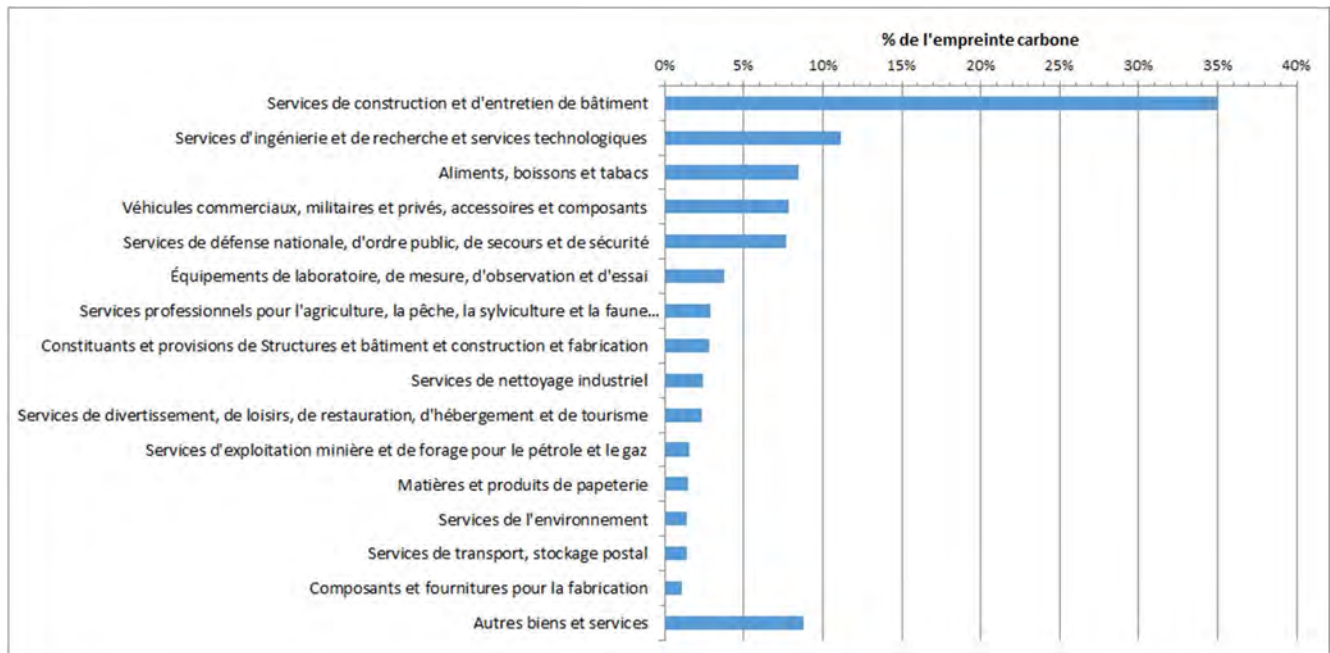


Figure 4: Goods and services (according to UNSPSC segments) that each contributed more than 1% to the carbon footprint of PSPC-QC procurement from 2014 to 2017. ¹⁸
 (37 segments of less than 1% are grouped into “Other goods and services”)

¹⁸ The “Mining and Oil and Gas Services” segment refers to GSIN 5138 A, B, and C of dredging services; the “National Defence and Public Order and Security and Safety Services” segment refers to the GSIN for R&D in the military, astronautics and radar technology domain.