CIRAIG™

International Reference Centre for the
Life Cycle of Products, Processes and Services

FINAL REPORT

ENVIRONMENTAL FOOTPRINT OF PROCUREMENTS BY SHARED SERVICES CANADA

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Prepared for

Shared Services Canada

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POLYTECHNIQUE MONTRÉAL

TECHNOLOGICAL UNIVERSITY

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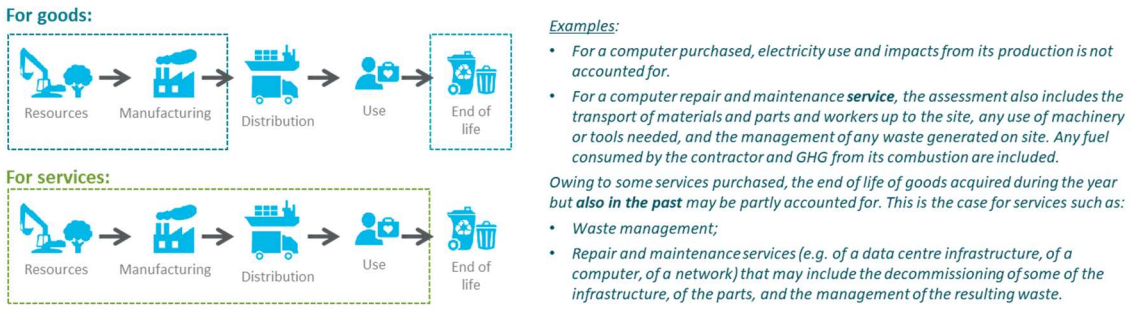
Abbreviations and acronyms

ADP	Automatic Data Processing
CA	Canada
CIRAIG	International Reference Centre for the Life Cycle of Products, Processes and Services
CO_2	Carbon Dioxide
CO_2eq	Carbon Dioxide equivalent
EEIO	Environmentally Extended Input-Output
EPD	Environmental Product Declaration
FY	Fiscal year
GHG	Greenhouse gases
GJ	Giga Joule (10^{+9} J)
GSIN	Goods and Services Identification Number
GWP	Global Warming Potential
IO	Input-Output
IOCC	Input Output Commodity Classification
IOIC	Input Output Industry Classification
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
IT	Information Technology
kWh	kiloWatt-hour
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
MJ	Mega Joule (10^{+6} J)
SSC	Shared Services Canada
TJ	Tera Joule (10^{+12} J)
UNSPSC	United Nations Standard Products and Services Code

Executive Summary

In line with the federal government's commitments to climate change and environmental protection, Shared Services Canada (SSC) has to address the ecological and social aspects of the federal procurement under its authority – mostly information technology products and services – and seek to reduce their associated impacts, including, but not limited to, greenhouse gases emissions (GHG), water use and energy use. This study evaluates the partial life cycle GHG (carbon footprint), cumulative water use and energy use associated with the procurement under the authority of SSC across Canada in order to identify those key procurement that cause the most impacts and on which it would be a priority to act (e.g. close monitoring of the procurement, adding targeted environmental criteria to calls for tender).

First, an update of the model used for the environmental assessment, namely *openIO-Canada,* is performed to make it representative of the Canadian industry as of 2016 (previous version was representative of 2009). *openIO-Canada* is a model for environmentally extended input-output analysis (EEIO), which is based on financial and environmental data and is an appropriate tool to evaluate thousands of goods and services that are very different from each other, and for which neither accurate description nor physical data is easily available. Contracts for goods and services awarded by SSC for the last three fiscal years (FY2017-2018 to FY2019-2020) have been evaluated. About 9 200 contracts are covered for a total amount of $ 5.9 billion. The three environmental indicators (GHG – or carbon footprint, water use, and energy use) are estimated using the updated The analysis is "cradle-to-gate" (gate of the manufacturing plant) for goods. Thus, the environmental assessment does not cover the whole life cycle of a good with respect to the GHG, water and energy use associated with its distribution, use during lifetime and end-of-life management. However, for services, the assessment includes the delivery/provision of the service to the user. The boundaries of the footprint assessment can be pictured as follow. Therefore, it is only a partial life cycle assessment.



Scope and boundaries of the life cycle assessment.

Over the three years, the environmental scores (GHG expressed as tonnes of CO_2-equivalent, m^3 of cumulative water use, and MJ of cumulative energy use) and the resulting average intensities (kg CO_2eq., litre water and MJ energy per dollar purchased, tax included) are as follows.

Total over FY17-18 to FY19-20	Environmental score and intensity per $ procurement		Equivalent to…
Carbon footprint	676,391	t CO2eq	driving 147,000 passenger vehicles in a year
Average GHG intensity	0.142	kg CO2eq/$	
Energy use	11,027	TJ	the energy of 1,808 thousands barrels of oil
Average Energy use intensity	2.32	MJ/$	
Water use	42,339	thousands m3	17,000 olympic swimming pool or the annual residential water use by 527,300 Canadians
Average Water use intensity	9.2	L/$	

The share of the environmental performance across the 11 main categories of procurement shows that IT Hardware procurement cause about 35% (GHG), 36% (energy use) and 41% (water use) of total impact, IT Professional Services 15% to 18%, Software & Maintenance 14% to 16% and Telecommunications and Voice Equipment 12% to 13%, depending the environmental indicator considered.

Contribution of the main categories of procurement to the environmental scores over the three years

Category of procurement	GHG (t CO2eq)	Energy use (GJ)	Water use (m3)	GHG intensity (kg CO2eq/$)	Energy use intensity (MJ/$)	Water use intensity (L/$)
IT Hardware	236,871	3,980,762	17,296,826	0.138	2.32	9.9
IT Professional Services	121,626	1,957,920	6,258,904	0.113	1.81	6.0
Software & Maintenance	110,502	1,791,718	5,846,534	0.066	1.07	3.6
Telecommunications and Voice Equipment	85,868	1,416,454	5,098,795	0.134	2.23	8.1
Professional, Administrative and Management Support	52,467	739,432	3,863,285	0.357	5.05	26.5
Networking Equipment	36,156	609,164	2,195,478	0.246	4.14	14.5
IT Maintenance Services	28,078	449,656	1,504,977	0.130	2.09	7.1
Office and Administration	2,562	41,997	148,138	0.284	4.55	19.0
Professional Development	1,761	31,945	98,426	0.079	1.44	4.5
Telecom Professional Services	348	5,530	16,845	0.126	2.05	6.7
Communications and Publications	151	2,597	10,817	0.251	4.48	21.0
Grand Total	**676,391**	**11,027,175**	**42,339,024**	**0.142**	**2.32**	**9.2**

Within these categories, a reduced series of **7 commodities contributes individually to more than 3% to total score** of each environmental indicator. More specifically the four following ones (in bold) make up **64% of impacts of procurement**. Decreasing the impact upstream their supply chain would be needed to reduced overall footprint of SSC procurements, in addition to reducing the volume of such procurement, whenever possible.

Commodity (GSIN)	GHG ($t CO_2eq$)	GHG (%)	Energy use (GJ)	Energy use (%)	Water use (m^3)	Water use (%)
Informatics Professional Services	119,412	17.7%	1,922,377	17.4%	6,135,678	14.5%
ADP Input-Output and Storage Devices	116,225	17.2%	1,953,010	17.7%	8,549,459	20.2%
ADP Software	106,539	15.8%	1,727,202	15.7%	5,625,399	13.3%
ADP Support Equipment	91,027	13.5%	1,529,600	13.9%	6,695,945	15.8%
Consulting Services	27,567	4.1%	387,249	3.5%	2,081,227	4.9%
Telecommunications - Voice Service	23,152	3.4%	379,054	3.4%	1,237,775	2.9%
Telecommunications - Satellite Services	21,778	3.2%	356,568	3.2%	1,164,357	2.8%
All other commodities	*170,691*	*25.2%*	*2,772,115*	*25.1%*	*10,849,184*	*25.6%*

ADP Input-Output and Storage Devices and ADP Support Equipment consist mostly (for 94% of procurements' value and impacts) in servers and equipment, parts and peripherals. Also, it is assumed that most of Informatics Professional Services are procurements related to data processing, hosting and similar services.

A different contribution analysis is also performed that allows identifying through which products and services purchased by SSC's suppliers most upstream life cycle impacts are generated. Any large contributors identified are those for which SSC should ask its suppliers to pay attention to

from its own supplies or in its own activities. Direct emissions is the direct contribution by the supplier itself. For example, in the figure below, close to 13.7% of GHGs from the 'Informatics Professional Services' are emitted by the 'Data processing, hosting and other information services' itself, while 7.3% come from its supplier of 'Office services', 5.2% from its 'Air transportation' expenses, etc.).

Upstream contributing commodities and direct emissions	Informatics Professional Services MPS51C000 Data processing, hosting and other information services
Direct emissions	13.7%
Office administrative services and head office services	7.3%
Air transportation services	5.2%
Paper, paperboard and waste	5.2%
Telephone apparatus and other communication equipment	4.9%
Electricity	3.7%
Rental of non-residential real estate	2.9%
Fees for the distribution of television and radio program ch	2.6%
All others goods and services	*54.6%*

Upstream contributing commodities and direct emissions	ADP Input-Output and Storage Devices and ADP Support Equipment MPG334100 Computers, computer peripherals and parts
Printed and integrated circuits and other electronic compo	18.3%
Computers, computer peripherals and parts	11.3%
Direct emissions	9.9%
Paper, paperboard and waste	8.4%
Electricity	4.7%
Truck transportation services	4.4%
Wholesale margins and commissions	4.3%
Iron and steel basic shapes and ferro-alloy products includi	3.7%
All others goods and services	*35.1%*

Upstream contributing commodities and direct emissions	ADP Software MPS511200 General purpose software
Direct emissions	11.6%
Office administrative services and head office services	7.3%
Paper, paperboard and waste	6.0%
Telephone apparatus and other communication equipment	5.7%
Air transportation services	5.6%
Electricity	3.7%
Fees for the distribution of television and radio program ch	3.0%
Rental of non-residential real estate	2.9%
All others goods and services	*54.0%*

Goods and services top-contributing to GHG in the supply chain for each of the four key commodities identified.

Based on the analysis, the following recommendations are made for the key procurements identified.

- *Computer, computer peripherals, and parts; Workstation and CPU*
  - Computer and semiconductor manufacturing facilities use large amounts of water. Sustainable procurements should consider if supplier facilities are in area where water scarcity, freshwater quality, and availability for human needs are a local concern. It may be requested for a hardware contract that the supplier demonstrates that he has implemented clean technologies towards low water consumption or has completed an Environmental Product Declaration (EPD) which addresses water issues.
  - The computer manufacturing industry and its direct supplier of electronic components is causing over 39% of GHG associated to computers and computer parts. Procurements should pay attention to the commitment of the suppliers as regards energy use, fossil energy use and associated GHG emissions.
- *Data processing, hosting, and other information services (including data centres services)*
  - Energy consumption (including electricity), and especially fossil energy use that cause direct GHG from the services provider is key to the environmental performance for such services. Suppliers should be favoured that i) are energy efficient; ii) are located in a region where the gridmix is low in fossil fuels and rich in renewable electricity (including hydroelectricity); iii) produce its own electricity form renewable sources out of the regional gridmix (e.g. wind, geothermal, photovoltaic, etc.).
- *Software*
  - Software production is among the commodities with the lowest GHG, energy use and water use intensities. This means that the important contribution of this group of

commodities to overall environmental score is due to SSC purchasing volume. Software development is a tertiary activity based on office work. Any environmental gains from such procurement (apart from reducing the purchased volume) could be obtained through asking suppliers to reducing building energy use, reducing office waste generations, etc.

This study is a high-level assessment, for pointing out the environmental “hot-spots” from thousands of contracts of very different nature. The partial carbon footprint, energy use and water use numbers are estimates and should therefore not be used outside of the context of this study. Noteworthy, due to the methodology and tool limitations, the estimates calculated does not include the use phase and the end of life of the goods purchased, at least systematically as explained above. The environmental picture of procurement is therefore partial only, particularly for durable goods that consume energy during their lifetime and for goods which end of life management can be a large source of impacts, especially GHGs.

Learnings from the current studies shows that Informatics Professional Services and IT Hardware such as servers and their equipment, both of which are found within data centers, are relevant candidates for more detailed LCA studies (built up from physical data instead of procurement values) which will cover life cycle stages not considered during the current study that can affect significantly the overall environmental score, especially the use stage and end-of-life stage of IT material or services that involves energy use (e.g. data centers). From such LCA studies, more refined recommendations, and possibly more specific environmental criteria/requirements, for these key categories of procurement could be derived and support SSC in its contribution to federal government's commitments to climate change and environmental protection.

1 Context of the study

In line with the federal government's commitments to climate change and environmental protection, Shared Services Canada (SSC) has to address the ecological and social aspects of the federal procurement under its authority – mostly information technology products and services – and seek to reduce their associated impacts, including, but not limited to, greenhouse gases emissions (GHG), water use and energy use. This study evaluates the partial life cycle GHG (embodied GHG or carbon footprint), cumulative water use and energy use associated with the procurement under the authority of SSC across Canada in order to identify those key procurement that cause the most impacts and on which it would be a priority to act (e.g. close monitoring of the procurement, adding targeted environmental criteria to calls for tender).

This study builds on and extends previous carbon footprint study conducted in 2018 and 2019 by the CIRAIG for Public Services and Procurement Canada (PSPC). For the current study, SSC asked the CIRAIG to apply the same methodology for estimating the carbon footprint of SSC procurement and to expand it to also cover energy and water consumption issues. SSC also asked first the CIRAIG for an update of the model it uses for the analysis.

2 Objectives and Scope of the study

2.1 Objectives

More specifically, the objectives are to:

I. Update the model used for the environmental assessment, namely *openIO-Canada,* which previous version was representative of the Canadian industry as of 2009, to the most recent year available.

II. Evaluate the life cycle GHGs, water use and energy use associated with the supply of the procurement contracted by SSC over the last three fiscal years (FY2017-2018 to FY2019-2020):
   i. Identify the categories of procurement (i.e. groupings of similar goods or services) that contribute most to each environmental indicator;
   ii. Analyze the results;
   iii. Make recommendations.

Comparing one to another the three years under study is not an objective of the study, nor is to analyze the results per individual client of SSC, i.e. departments and agencies within the federal government.

2.2 Scope of the study

This section aims to clarify what the environmental scores will refer to, especially in relation to the different stages of the life cycle of a purchased good or service, and also in relation to all the purchases that SSC can make.

2.2.1 Boundaries of the system studied

The study focuses on the goods and services purchased by SSC for its own account and for its client departments and agencies. Three fiscal years from April 1, 2017 to March 31, 2018, then 2018-2019 and 2019-2020 are studied. It should be noted that:

- Purchases made as part of business travel (transportation, accommodation, meal, etc.) are not addressed;
- Purchases made by government employees related to activities such as commuting to and from work, and daily meals are not addressed as well.

The annual amount of procurement can change from year to year. To smoothen this variability, the study covers the three fiscal years as a single time period.

Figure 2-1 shows how the life cycle of a product is broadly broken down into successive stages along its lifetime or the value chain.

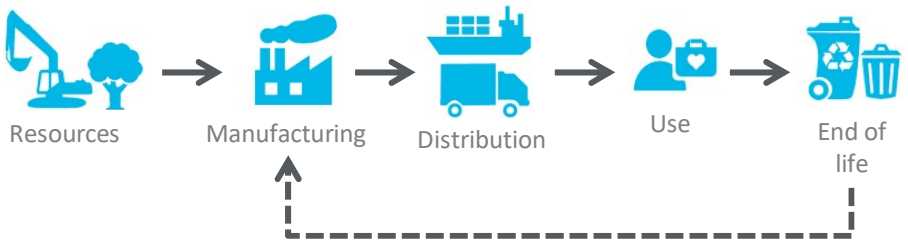
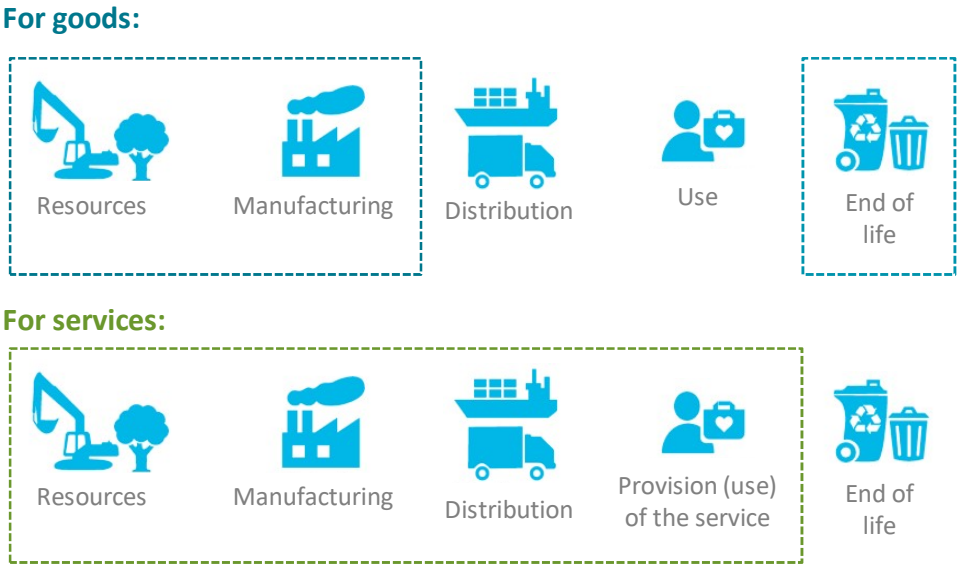


Figure 2-1 : Life cycle stages of a product.

Not all stages can be included when conducting a life cycle assessment depending on study's objectives, methodological aspects, and data availability. Here, even though it would be relevant to include the whole life cycle of procurement, only the stages presented in Figure 2-2 are considered for the environmental assessment of goods and services purchased. Therefore, **the environmental estimates in this study are partial over the life cycle**. Explanations are provided below.



*Note: Owing to some services purchased (e.g. a waste management service), the end of life of goods acquired during the year but **also in the past** may be partly accounted for.*

Figure 2-2 : System boundaries for goods (top) and for services (bottom).

For **goods**, the impact is assessed from cradle to the exit gate of the manufacturing plant. The distribution up to the user (i.e. the customer department) is not included for the following reasons:

i. information about the origin of the good and its specific destination are not necessarily known;

ii. the environmental model used to calculate the impacts, which is described below does not contain any default (even though generic) information for every good. This is a limitation of the model, and consequently of this study.

The use stage of goods purchased (e.g. electricity consumed by a computer, gasoline use and GHG from its combustion by a vehicle) is not included, because:

i. data from SSC about the procurement purchased do not contain enough descriptions and details about the goods in order to model their individual use stage (e.g. electricity consumption of a computer (power, use per day, lifetime), type of fuel and fuel consumption of a vehicle);
ii. The thousands of contracts evaluated (close to 9 200 over the three years) cannot be analyzed to attempt to model a representative use stage of each, even a generic one; Conversely, procurement are modeled after a grouping of individual contracts according to the GSIN code[1];
iii. Here again, the environmental model used to calculate the impact scores does not contain any default information (even though it would be generic) about the use of every good.

For **services**, the environmental model used to calculate the impacts includes the distribution and supply of the service, that is the provision of the service (Figure 2-2). For instance, an infrastructure repair service includes the movement of workers, the transport of materials up to the site, the use of the necessary machinery, the management of waste generated on the site. Direct GHG emissions, energy use and water use by the service provider are included. For example, during a construction service, the fuel consumed by the contractor's machinery is included and the GHGs from its combustion are therefore accounted for.

The **end of life of goods purchased or used in the provision of services** is not included. However, through some services purchased, the end of life of goods acquired the same year or also in the past can be indirectly considered for a part of them. Unfortunately, due to lack of detail and information on these services, it is difficult to link them to specific goods and to a specific year of procurement. This may be the case for services such as:

- Waste management;
- Numerous repair and maintenance services (e.g. of buildings, of data centres, of various civil infrastructures for transportation, for energy and other utilities supply, for communications, etc.) that include the repair or/and the decommissioning of the equipment or infrastructure, and may include as well the service of managing the end of life of the residues generated during the operation, at least a part of it (e.g. collection of electronic used parts, used cables, etc., and transport to recovery/recycling/landfilling).

[1] For its procurements activities, the federal government is using the Goods and Services Identification Number (GSIN) classification to identify and describe the generic commodities, but is transitioning to the use of UNSPSC, consequently both classifications appear in the tables.

3 Methodology

This chapter presents the methodology developed for the realization of the project. The method and the model used for assessing the environmental indicators are first explained, then the procurement data provided is described.

3.1 Environmental assessment methodology

The methodology is based on the **Environmentally Extended Input-Output analysis (EEIO)** derived from the Input-Output (IO) analysis commonly used in economics. EEIO is the choice solution in situations where traditional life cycle analysis (LCA), purely based on transformation processes relying on physical input and output data is less suitable. This is particularly the case when the system under study involves a large number of goods and services and where conducting a traditional LCA of each of them turns to be virtually impossible (because individual life cycle environmental data is not available in database[2] or would be difficult, time consumptive and costly to model – which is especially the case for services). With EEIO, the environmental impacts are evaluated from the **purchase value** of goods and services, which are classified according to their type, using a model that provides the impact scores per dollar of each good or service. Therefore, as compared to standard LCA, EEIO has the advantage to cover services in addition to goods, but the drawback is that it is rather generic due to the low granularity associated with the classification of the commodities. Nevertheless, EEIO is well suited for a "hotspot" analysis of procurement that contains thousands of highly variable transactions. More details on the EEIO basics and principles are presented in Appendix A.1.

3.1.1 EEIO model

The environmental assessment tool used is an update of *openIO-Canada*. *Open IO-Canada* is a Canadian model for Environmentally Extended Input-Output (EEIO) analysis first developed by CIRAIG in 2014 and then **updated for the current study**[3] with economic and environmental data representative of the **Canadian industry in 2016**. It is a multi-criteria tool which goes beyond GHG since it covers emissions of other pollutants (such as those published in Environment Canada's National pollutant release inventory – see Appendices A.1 and link below) and allows assessing other impacts than climate change, such as acidification, ecotoxicity, human toxicity, water withdrawal, etc. For the current study, it is used for GHG, water use and energy use assessments. *open IO-Canada* 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 good or service that would be imported is modeled with the tool as if it were produced in Canada.

The economic model of *openIO-Canada* distinguishes 234 different types of goods and services that cover all Canadian economic activities and for each of which a portion of life cycle emissions can be calculated, according to the boundaries presented in Figure 2-2. It should be noted that these goods and services are identified according to Statistics Canada's Input-Output Commodity Classification (IOCC, 234 codes) used for the national economic and environmental accounts,

[2] For instance, *ecoinvent* which is the most comprehensive physical life cycle inventory database, does not address services (www.ecoinvent.org)

[3] The model is made publicly available at https://github.com/CIRAIG/OpenIO-Canada

which is different from the GSIN classification used by the federal government for its procurement (about 5 000 codes).

The method and data used for the development of *openIO-Canada* 2016 are described in more detail in Appendix A.3 and at https://github.com/CIRAIG/OpenIO-Canada; the IOCC classification is presented in Appendix A.2; further **limitations of the analysis model** are listed in Appendix A.3.

3.1.2 GHG assessment

The partial carbon footprint or life cycle GHG emissions is assessed using the "IPCC 2007" method, considering the cumulative radiative forcing over a 100-year horizon. This method is based on the global warming potential (GWPs) published by the Intergovernmental Panel on Climate Change (IPCC) in 2007 for each GHG. The potential of each GHG to affect the climate is calculated in kilogram of carbon dioxide equivalent (kg CO_2eq), which is the reference unit for climate change impact. The GHGs considered by *openIO-Canada* model are those provided by Statistics Canada's Environment Accounts (CO_2, CH_4, and N_2O) as a dataset precalculated as CO_2eq (HFCs, PFCs, SF6 and NF3 are GHGs not considered in these accounts). The "IPCC 2007" GWPs used by Statistics Canada are still in line with those currently used for the National inventory report on GHG sources and sinks published by the federal government (25 and 298 kg CO_2eq/kg for CH_4 and N_2O, respectively). See Appendix A.3 for additional details.

It should be noted that more recent GWPs have been published by the IPCC ("IPCC 2013" GWPs) but they are not yet routinely implemented by Statistics Canada for the public release of the GHG national environmental accounts. A precalculated dataset of 2016 GHGs emissions using “IPCC 2013” GWPs has been requested to Statistics Canada but it was not provided in due time for this report. However, the change is expected to be limited to few percent only.

Lastly, it is important to keep in mind that the carbon footprint results represent potential and not actual environmental impacts. These are relative expressions that do not predict the final impact or risk on receiving environments and the exceeding of safety standards or margins.

3.1.3 Energy use assessment

The energy use data considered by *openIO-Canada* model are those provided by Statistics Canada's Environment Accounts. It is based on the annual use of energy products by industry, governments, institutions, and households. The following energy sources are covered: coal, natural gas, motor gasoline, diesel, aviation fuel, light fuel oil (including kerosene), heavy fuel oil, refinery fuel gas, coke oven gas, liquefied petroleum gases (including natural gas liquids), electricity, coke, steam, wood, and spent pulping liquor. The unit of measure is terajoule. Only uses of energy products for their energy content are considered; the use of energy products as material inputs is not included (e.g. oil products used to produce plastics).

3.1.4 Water use assessment

The water use data considered by *openIO-Canada* model are those provided by Statistics Canada's Environment Accounts. It considers the use of the natural resource input of water and of water accessed through municipal water supply or irrigation systems by industry, governments, institutions, and households. The unit of measure is thousand cubic metres.

3.2 Procurement data

3.2.1 Raw data from SSC

SSC provided the procurement data for the last three fiscal years in the form of a spreadsheet compiling 9 164 contracts of goods and services. These can be either initial contracts, amendments to these contracts, or amendments to contracts of a previous year. Other relevant information for each contract is: the amount (in Canadian dollars, taxes included), the GSIN commodity code corresponding to the good or service, a brief description of the commodity, the region of the supplier (Canadian province, state of United States, or else the unique code "0" for any other foreign country) and its name. All raw data is contained in the Excel appendix of this report. SSC also provided a mapping for grouping each procurement into 11 categories of procurement.

3.2.2 Processing of raw procurement data

In order to perform the assessment with *openIO-Canada*, several treatments on the raw procurement data provided by SSC had to be carried out. They are described below. It is recalled that the *openIO-Canada* environmental analysis model is based on Statistics Canada's IOCC Classification and uses basic price amounts as input data. The CIRAIG owns a mapping table that allows the crosswalk between the UNSPSC[4] and the IOCC classifications[5]. On the other hand, SSC procurement are still classified with GSIN codes. An incomplete GSIN-UNSPSC mapping table exists, partly elaborated by PSPC in 2016 and expanded by CIRAIG to make up for the missing GSIN codes.

3.2.2.1 Corrections to some miscoded procurement

About 30 contracts in SSC raw procurement data were spotted with likely wrong GSIN codes, as evidenced from contract short description and the vendor name. Among them, over than 20 were coded with GSIN 5154 "Concrete work". Further investigation by SSC allowed to provide a correct code for these procurement. The CIRAIG also corrected few remaining miscoded procurement based on others with same description field, same vendor and similar contract value.

It is worth noting that all 9 164 procurement were not inspected individually by CIRAIG for consistency in raw data between contract description and the GSIN code originally attributed. Miscoded procurement might still remain in the data that were further assessed that could affect the environmental results presented in this study.

All corrections are provided in the Excel appendix to the report.

3.2.2.2 GSIN re-mapping of some procurement

Because of the evolution of the GSIN classification, contracts in SSC raw procurement data display GSIN codes that were not yet listed in CIRAIG's own GSIN-UNSPSC-IOCC crosswalk table. A correspondence has been established for these 108 GSIN codes by CIRAIG. During the process, SSC also offered support by refining the GSIN coding of all procurement initially coded as GSIN 5150AJ "Workstations".

Re-mapping is provided in the Excel appendix to the report.

[4] United Nations Standard Products and Services Code (www.unspsc.org).
[5] Currently, the UNSPSC classification is not fully mapped to IOCC.

3.2.2.3 Exclusion of certain contracts

No contract was excluded from SSC raw data.

3.2.2.4 Multiannual contracts

Some contracts may relate to procurement that will be spread over several years. However, there is no raw data on how much of the total contract amount is allocated to each year of the period under study or excluded from that period. Even though it was possible to allocate an amount of year *n* over several years would imply that any future analysis for the year *n + 1, n + 2*, etc. be able to recognize the shares of the amount already allocated to previous years. It is recommended for future studies that continuity and traceability of the accounting (of actual shipments every year) is mapped to ensure that all shares are properly accounted for, and to avoid any risk of under- or over-estimating the carbon footprint. Such an accounting is not set up presently; for this study, we follow the rule **to allocate 100% of the amount of multi-year contracts to the year of their signature**.

3.2.2.5 Contract amendments

All contract amendments are included in the analysis, whatever its amount and the year of the original contract. So, it is assumed that an amendment with a positive value (respectively negative value) corresponds to the shipment of an additional quantity of goods or services (respectively a reduced quantity), and it is entirely allocated to the year of the amendment.

3.2.2.6 Sales taxes removal

openIO-Canada requires values as close as possible to a basic price. Hence, sales taxes must be removed from the amount provided with the raw data, where applicable. The following rules are considered, that have been used in previous studies for PSPC.

- Goods (GSIN with first letter N):
  a. Canadian supplier: sales taxes are applied, and the tax rate applied is the one applicable at the shipment address. For the study, it is considered that all shipments are made in the National Capital Region. A share of 80%-20% between Ontario and Québec is assumed to derive a tax rate of 13.395% to be used to remove taxes from the amount provided with SSC raw data.
  b. Non-Canadian supplier: For suppliers outside Canada, no tax has been added, so the amount provided with SSC raw data is free of sales tax.
- Services :
  a. Canadian supplier: sales taxes are applied, and the tax rate applied is the one applicable at the shipment address. For the study, it is considered that all shipments are made in the National Capital Region. A share of 80%-20% between Ontario and Québec is assumed to derive a tax rate of 13.395% to be used to remove taxes from the amount provided with SSC raw data.
  b. Non-Canadian supplier: For suppliers outside Canada, no tax has been added, so the amount provided with SSC raw data is free of sales tax.
- Construction work and services (GSIN beginning with 51):
  a. Canadian supplier: sales taxes are applied, and the tax rate applied is the one applicable at the shipment address. Hence, here again a tax rate of 13.395% is used to remove taxes from the amount provided with SSC raw data.

b. Non-Canadian supplier: There should be no supplier outside Canada for construction contracts.

4 Results and discussion

The first section of this chapter presents an economic overview of SSC procurement for the three years under study. Subsequently, the environmental score estimates associated with the partial life cycle of the procurement are presented and discussed.

4.1 Economic overview of SSC procurement

The contracts evaluated add up to $ 5.901 billion over the three fiscal years FY17-18 to FY19-20 (sales taxes included). Tax excluded, it is worth $ 5.217 billion. Software and maintenance, IT hardware and IT professional services are the top-3 categories making up to 80% of procurement value (Table 4-1). Software & Maintenance and IT Hardware account each for 30% of the procurement.

Table 4-1 : Value of SSC procurement, per category over FY17-18 to FY19-20

Category of procurement	Contract Value (tax included)	% of Total Contract Value
Software & Maintenance	$1,764,267,066	29.9%
IT Hardware	$1,764,250,323	29.9%
IT Professional Services	$1,166,118,457	19.8%
Telecommunications and Voice Equipment	$672,483,584	11.4%
IT Maintenance Services	$245,038,608	4.2%
Networking Equipment	$178,950,645	3.0%
Professional, Administrative and Management Support	$73,708,946	1.2%
Professional Development	$21,188,251	0.4%
Office and Administration	$11,757,175	0.2%
Telecom Professional Services	$2,737,026	0.0%
Communications and Publications	$913,402	0.0%
Grand Total	$5,901,413,483	100.0%

4.2 Overview of environmental scores of SSC procurement

Over the three years, the supply of goods and services purchased by SCC

- is emitting **676.4 kt CO_2eq GHG**
- is using **11 027 TJ energy** and
- is using **42.3 million cubic meters water**

The GHG figure is worth the annual emissions of driving over 147 thousand typical passenger vehicles (US EPA, 2018). The water use figure is worth the volume of 17 thousand Olympic swimming pools (2 500 m^3 each) or the annual residential water use by over 527 thousand Canadians (220 litres/person/day in 2017 - Statistics Canada, 2019). The energy use figure is equivalent to 1 808 thousand barrels of oil (6.1 GJ/barrel).

Table 4-2 presents the three environmental scores results for the 11 categories of procurement. **IT Hardware** procurement cause about 35% (GHG), 36% (energy use) and 41% (water use) of total impact, **IT Professional Services** 15% to 18%, while **Software & Maintenance** cause 14% to 16%

and **Telecommunications and Voice Equipment** 12% to 13% depending the environmental indicator.

Table 4-2 : Environmental performance of procurement, per category, over FY17-18 to FY19-20

Category of procurement	GHG (t CO2eq)	Energy use (GJ)	Water use (m3)
IT Hardware	236,871	3,980,762	17,296,826
IT Professional Services	121,626	1,957,920	6,258,904
Software & Maintenance	110,502	1,791,718	5,846,534
Telecommunications and Voice Equipment	85,868	1,416,454	5,098,795
Professional, Administrative and Management Support	52,467	739,432	3,863,285
Networking Equipment	36,156	609,164	2,195,478
IT Maintenance Services	28,078	449,656	1,504,977
Office and Administration	2,562	41,997	148,138
Professional Development	1,761	31,945	98,426
Telecom Professional Services	348	5,530	16,845
Communications and Publications	151	2,597	10,817
Grand Total	**676,391**	**11,027,175**	**42,339,024**

Translated into environmental performance per dollar of procurement (tax included), the results show how intensive some categories of procurement can be (Table 4-3) and that the most contributing categories are not necessarily the most intensive ones. Highly intensive categories involves a lot of consulting and business office services, which in turn involve important car transportation and travels, hence the large direct emissions of GHG and energy use for these activities. Recommendation would be to rationalize business travels, and to favour meeting through video-conferencing.

Table 4-3 : Environmental intensities of procurement, per category, over FY17-18 to FY19-20

Category of procurement	GHG intensity (kg CO2eq/$)	Energy use intensity (MJ/$)	Water use intensity (L/$)
IT Hardware	0.138	2.32	9.9
IT Professional Services	0.113	1.81	6.0
Software & Maintenance	0.066	1.07	3.6
Telecommunications and Voice Equipment	0.134	2.23	8.1
Professional, Administrative and Management Support	0.357	5.05	26.5
Networking Equipment	0.246	4.14	14.5
IT Maintenance Services	0.130	2.09	7.1
Office and Administration	0.284	4.55	19.0
Professional Development	0.079	1.44	4.5
Telecom Professional Services	0.126	2.05	6.7
Communications and Publications	0.251	4.48	21.0
Grand Total	**0.142**	**2.32**	**9.2**

Based on these results, a drill down to the level of the commodity (GSIN) is performed for the four above-mentioned categories of procurement (Table 4-4). As displayed, **very few commodities are causing most of the impact**:

- For IT Hardware
  - ADP Input-Output and Storage Devices (49% of IT hardware's impact)
  - ADP Support Equipment (37% of IT hardware's impact)
- For IT Professional Services

  - Informatics Professional Services (98% of IT Professional Services' impact)
  - Informatics Professional and Consulting Services - Maintenance Operations, Support
- For Software & Maintenance
  - ADP Software (96% of Software & Maintenance's impact)
  - Software Suppliers, Application, Business, Personnel Management, EDP
- For Telecommunications and Voice Equipment
  - Telecommunications - Voice Service (24-27% of Telecommunications and Voice Equipment's impact, depending on the indicator considered)
  - Telecommunications - Satellite Services (23-25% of Telecommunications and Voice Equipment's impact)
  - Telephones, Cellular (21-24% of Telecommunications and Voice Equipment's impact)

Seven commodities, and more specifically **the four following ones making up 64% of total impact of procurement**, are those of main concern. Decreasing the impact upstream their supply chain would be needed to reduced overall footprint of SSC procurements, in addition to reducing the volume of such procurement, whenever possible.

- **ADP Input-Output and Storage Devices**
- **ADP Support Equipment**
- **Informatics Professional Services**
- **ADP Software**

For 94% of procurements' value, ADP Input-Output and Storage Devices and ADP Support Equipment consist mostly in computer equipment, servers, parts and peripherals and Communications/Networking Equipment (see Table 4-5 and full table in the excel appendix file). These two GSIN commodities have thus been modelled within *openIO-Canada* with the IOCC commodity "Computers and computer peripheral equipment including parts". As regards the GSIN commodity Informatics Professional Services, in accordance with the description provided by SSC to CIRAIG about this type of procurement (because description is lacking in raw procurement data - see Table 4-5), the GSIN has been assign within *openIO-Canada* to the IOCC commodity "Data processing, hosting and other information services" since many of these professional services are associated to design, operation and maintenance of data centres.

Table 4-4 : Top contributing GSIN commodities for the main four categories of procurement (sorted on GHG contribution)

Category of procurement GSIN commodity	GHG (t CO_2eq)	GHG (% total)	Energy use (GJ)	Energy use (% total)	Water use (m^3)	Water use (% total)
IT Hardware	**236,871**	**35.0%**	**3,980,762**	**36.1%**	**17,296,826**	**40.9%**
ADP Input-Output and Storage Devices	116,137	17.2%	1,951,535	17.7%	8,542,998	20.2%
ADP Support Equipment	88,450	13.1%	1,486,289	13.5%	6,506,350	15.4%
Local Area Networks, Systems and Components	11,144	1.6%	187,602	1.7%	724,226	1.7%
ADP Central Processing Unit (CPU, Computer) Digital	9,440	1.4%	158,620	1.4%	694,370	1.6%
All other commodities	*11,700*	*1.7%*	*196,716*	*1.8%*	*828,882*	*2.0%*
IT Professional Services	**121,626**	**18.0%**	**1,957,920**	**17.8%**	**6,258,904**	**14.8%**
Informatics Professional Services	119,353	17.6%	1,921,424	17.4%	6,132,637	14.5%
Data Centre Services	1,184	0.2%	19,064	0.2%	60,845	0.1%
All other commodities	*1,089*	*0.2%*	*17,433*	*0.2%*	*65,422*	*0.2%*
Software & Maintenance	**110,502**	**16.3%**	**1,791,718**	**16.2%**	**5,846,534**	**13.8%**
ADP Software	106,539	15.8%	1,727,202	15.7%	5,625,399	13.3%
Software Suppliers, Application, Business, Personnel Management, EDP	2,308	0.3%	37,424	0.3%	121,887	0.3%
All other commodities	*1,654*	*0.2%*	*27,092*	*0.2%*	*99,248*	*0.2%*
Telecommunications and Voice Equipment	**85,868**	**12.7%**	**1,416,454**	**12.8%**	**5,098,795**	**12.0%**
Telecommunications - Voice Service	23,152	3.4%	379,054	3.4%	1,237,775	2.9%
Telecommunications - Satellite Services	21,778	3.2%	356,568	3.2%	1,164,357	2.8%
Telephones, Cellular	18,446	2.7%	310,526	2.8%	1,198,769	2.8%
Videoconferencing Equipment	6,202	0.9%	104,401	0.9%	403,033	1.0%
All other commodities	*16,290*	*2.4%*	*265,905*	*2.4%*	*1,094,861*	*2.6%*
All other categories	***121,524***	***18.0%***	***1,880,321***	***17.1%***	***7,837,965***	***18.5%***
Grand Total	**676,391**	**100.0%**	**11,027,175**	**100.0%**	**42,339,024**	**100.0%**

Table 4-5 : Description of top-contributing contracts for the top-7 contributing GSIN commodities, sorted by GHG (only contracts contributing above 1% of parent commodity GHG are displayed). Sums do not match totals since a cut-off is applied. Full table available in Excel appendix file.

Commodity (GSIN) Description of contract	GHG (t CO2eq)	% parent GHG	Energy use (GJ)	% gd total Energy use	Water use (m3)	% gd total Water use	# Contracts	Total Contract Value ($)	% parent contract value
Informatics Professional Services	**119,412**	**17.7%**	**1,922,377**	**17.4%**	**6,135,678**	**14.5%**	**425**	**$1,086,340,139**	**18.4%**
Description not provided	108,280	90.7%	1,743,163	15.8%	5,563,677	13.1%	106	$984,875,687	90.7%
Management Consulting	6,452	5.4%	103,871	0.9%	331,526	0.8%	56	$58,869,488	5.4%
Information Technology and Telecom Consultants	1,254	1.1%	20,188	0.2%	64,434	0.2%	75	$11,283,312	1.0%
ADP Input-Output and Storage Devices	**116,225**	**17.2%**	**1,953,010**	**17.7%**	**8,549,459**	**20.2%**	**800**	**$865,046,903**	**14.7%**
Computer Eqpt–Servers Incluant Parts&Peripherals	108,982	93.8%	1,831,307	16.6%	8,016,691	18.9%	664	$811,009,831	93.8%
Computer Equipment - Servers	4,956	4.3%	83,273	0.8%	364,534	0.9%	62	$36,879,518	4.3%
Computer Eqpt-Client Computing-Desktop/Portable	1,240	1.1%	20,844	0.2%	91,248	0.2%	20	$9,302,754	1.1%
ADP Software	**106,539**	**15.8%**	**1,727,202**	**15.7%**	**5,625,399**	**13.3%**	**570**	**$1,716,099,501**	**29.1%**
License/Maint fees Server Operating Sys & Software	99,580	93.5%	1,614,382	14.6%	5,257,950	12.4%	110	$1,604,390,949	93.5%
License/Maintenance fees for Client Software	4,309	4.0%	69,862	0.6%	227,535	0.5%	199	$68,658,436	4.0%
ADP Support Equipment	**91,027**	**13.5%**	**1,529,600**	**13.9%**	**6,695,945**	**15.8%**	**1340**	**$681,019,864**	**11.5%**
Computer Eqpt–Servers Incluant Parts&Peripherals	69,452	76.3%	1,167,054	10.6%	5,108,871	12.1%	890	$519,877,422	76.3%
Communications/Networking Equipment	15,095	16.6%	253,648	2.3%	1,110,365	2.6%	291	$113,109,023	16.6%
Computer Equipment - Servers	4,225	4.6%	70,991	0.6%	310,767	0.7%	40	$31,218,205	4.6%
Server Operating System and Utility Software	1,092	1.2%	18,355	0.2%	80,351	0.2%	5	$8,140,541	1.2%
Consulting Services	**27,567**	**4.1%**	**387,249**	**3.5%**	**2,081,227**	**4.9%**	**351**	**$67,641,844**	**1.1%**
Information Technology and Telecom Consultants	11,170	40.5%	156,914	1.4%	843,318	2.0%	111	$27,360,741	40.4%
Protection Services	6,244	22.7%	87,712	0.8%	471,401	1.1%	59	$15,371,483	22.7%
Management Consulting	5,714	20.7%	80,276	0.7%	431,433	1.0%	129	$14,031,002	20.7%
Description not provided	3,264	11.8%	45,854	0.4%	246,439	0.6%	7	$8,002,444	11.8%
Temporary Help Services	867	3.1%	12,179	0.1%	65,456	0.2%	25	$2,118,505	3.1%
Telecommunications - Voice Service	**23,152**	**3.4%**	**379,054**	**3.4%**	**1,237,775**	**2.9%**	**815**	**$196,266,040**	**3.3%**
Client Software	8,793	38.0%	143,973	1.3%	470,134	1.1%	4	$74,726,122	38.1%
Digital Chnnl Comm Svc for Combind Transmissn	7,801	33.7%	127,721	1.2%	417,064	1.0%	7	$65,862,440	33.6%
Voice Communications Services(incl Analog/Digital)	2,491	10.8%	40,785	0.4%	133,180	0.3%	577	$21,481,425	10.9%
Data Communications Services (incl Analog/Digital)	1,273	5.5%	20,837	0.2%	68,041	0.2%	35	$10,435,040	5.3%
Communications/Networking Equipment	1,261	5.4%	20,650	0.2%	67,432	0.2%	113	$10,678,687	5.4%
Other Business Services not Elsewhere Specified	433	1.9%	7,096	0.1%	23,171	0.1%	3	$3,683,004	1.9%
License/Maint fees Server Operating Sys & Software	356	1.5%	5,821	0.1%	19,008	0.0%	17	$3,010,619	1.5%
Server Operating System and Utility Software	262	1.1%	4,297	0.0%	14,030	0.0%	3	$2,239,952	1.1%
Telecommunications - Satellite Services	**21,778**	**3.2%**	**356,568**	**3.2%**	**1,164,357**	**2.8%**	**20**	**$189,047,268**	**3.2%**
Digital Chnnl Comm Svc for Combind Transmissn	21,686	99.6%	355,057	3.2%	1,159,422	2.7%	10	$188,246,455	99.6%
Grand Total	**676,391**	**100.0%**	**11,027,175**	**100.0%**	**42,339,024**	**100.0%**	**9164**	**$5,901,413,483**	**100.0%**

4.3 Environmental scores per commodities and contribution analysis

At the commodity level (GSIN), a reduced series of **7 commodities contributes individually to more than 3%** to total score in each environmental category (Table 4-6).

Table 4-6 : GSIN commodities contributing to more than 3% to each environmental score over the three years (sorted on GHG contribution)

Commodity (GSIN)	GHG (t CO_2eq)	GHG (% total)	Energy use (GJ)	Energy use (% total)	Water use (m^3)	Water use (% total)
Informatics Professional Services	119,412	17.7%	1,922,377	17.4%	6,135,678	14.5%
ADP Input-Output and Storage Devices	116,225	17.2%	1,953,010	17.7%	8,549,459	20.2%
ADP Software	106,539	15.8%	1,727,202	15.7%	5,625,399	13.3%
ADP Support Equipment	91,027	13.5%	1,529,600	13.9%	6,695,945	15.8%
Consulting Services	27,567	4.1%	387,249	3.5%	2,081,227	4.9%
Telecommunications - Voice Service	23,152	3.4%	379,054	3.4%	1,237,775	2.9%
Telecommunications - Satellite Services	21,778	3.2%	356,568	3.2%	1,164,357	2.8%
All other commodities	*170,691*	*25.2%*	*2,772,115*	*25.1%*	*10,849,184*	*25.6%*

Environmental intensities per dollar of procurement for these seven commodities are presented in Table 4-7. As a rule, the higher the intensity, the more attention should be paid to the environmental attributes of the commodity, e.g. the way the goods have been manufactured and/or the way the service is delivered. The intensity also reveals how the overall footprint of SSC procurement will be sensitive to every dollar of each commodity. For example, in terms of GHG, doubling the expenses on devices and equipment is worth a four times increase of expenses on software, meaning that a software solution might be more GHG effective than an alternative hardware solution with same performance (such as the increase of employee productivity, for instance)[6].

Table 4-7 : Environmental intensities of the top-contributing GSIN commodities (per dollar of procurement, tax included, over the three years)

Commodity (GSIN)	GHG intensity (kg CO2eq/$)	Energy use intensity (MJ/$)	Water use intensity (L/$)
Informatics Professional Services	0.110	1.8	5.7
ADP Input-Output and Storage Devices	0.134	2.3	9.9
ADP Software	0.063	1.0	3.3
ADP Support Equipment	0.134	2.2	9.8
Consulting Services	0.408	5.7	30.8
Telecommunications - Voice Service	0.117	1.9	6.3
Telecommunications - Satellite Services	0.116	1.9	6.2

The **upstream** contributors to life cycle GHG, energy use and water associated with the top-4 commodities are presented in Figure 4-1 to Figure 4-3, respectively, normalized per $ commodity purchased. Each contribution table displays the GSIN commodity name (e.g. Informatics

[6] We remind that energy efficiency of hardware during the use stage is not accounted for in the current modelling and in the intensities derived, neither the end-of-life stage. This can affect the whole life cycle performance of changing hardware and make this statement obsolete.

Professional Services), and the matching IOCC commodity used for the environmental modelling in *openIO-Canada* (e.g. MPS51C000 - Data processing, hosting and other information services).

The contribution analysis allows identifying through which products and services purchased by SSC's suppliers of these commodities most upstream life cycle impacts are generated. The contribution profile allows visualization of the top eight goods or services that contribute the most along their supply chain to the impact of the procurement. Any large contributors identified are those for which SSC should ask its suppliers to pay attention to. In such contribution profile, direct emissions represent GHGs emitted directly by the supplier of SSC (i.e. the product manufacturer or the service provider) or its own water use and energy use for the two other indicators. For example, for "Data processing, hosting and other information services" (first table of Figure 4-1), 13.7% of GHGs are due to direct GHG emissions by the provider of 'Data processing, hosting and other information services' itself, then 7.3% of GHGs come embedded with the life cycle of 'Office services' purchased by the provider, etc.

Direct GHGs from "Data processing, hosting and other information services" are most likely related to GHGs from fossil fuel combustion like natural gas in data processing centers (Figure 4-2 confirming that direct energy consumption is the first contributor (16.8%) of life cycle energy use for such services).

Upstream contributing commodities and direct emissions	Informatics Professional Services MPS51C000 Data processing, hosting and other information services
Direct emissions	13.7%
Office administrative services and head office services	7.3%
Air transportation services	5.2%
Paper, paperboard and waste	5.2%
Telephone apparatus and other communication equipment	4.9%
Electricity	3.7%
Rental of non-residential real estate	2.9%
Fees for the distribution of television and radio program ch	2.6%
All others goods and services	*54.6%*

Upstream contributing commodities and direct emissions	ADP Input-Output and Storage Devices and ADP Support Equipment MPG334100 Computers, computer peripherals and parts
Printed and integrated circuits and other electronic compo	18.3%
Computers, computer peripherals and parts	11.3%
Direct emissions	9.9%
Paper, paperboard and waste	8.4%
Electricity	4.7%
Truck transportation services	4.4%
Wholesale margins and commissions	4.3%
Iron and steel basic shapes and ferro-alloy products includi	3.7%
All others goods and services	*35.1%*

Upstream contributing commodities and direct emissions	ADP Software MPS511200 General purpose software
Direct emissions	11.6%
Office administrative services and head office services	7.3%
Paper, paperboard and waste	6.0%
Telephone apparatus and other communication equipment	5.7%
Air transportation services	5.6%
Electricity	3.7%
Fees for the distribution of television and radio program ch	3.0%
Rental of non-residential real estate	2.9%
All others goods and services	*54.0%*

Figure 4-1 : Top GHG contributors at the commodity level by suppliers, per $ purchased.

Upstream contributing commodities and direct emissions	Informatics Professional Services MPS51C000 Data processing, hosting and other information services
Direct emissions	16.8%
Other transportation equipment and related parts	6.3%
Pharmaceutical and medicinal products	6.2%
Medical, dental and personal safety supplies, instruments	5.1%
Sales of other government services	4.6%
Photographic, veterinary and other professional, scientific	3.6%
Fibre, yarn, thread and fabrics	3.1%
Crude oil (including synthetic) and bitumen	2.6%
All others goods and services	*51.6%*

Upstream contributing commodities and direct emissions	ADP Input-Output and Storage Devices and ADP Support Equipment MPG334100 Computers, computer peripherals and parts
Computers, computer peripherals and parts	18.3%
Direct emissions	13.4%
Other bus, taxi and passenger transportation services by ro	11.3%
Pharmaceutical and medicinal products	9.5%
Photographic, veterinary and other professional, scientific	4.5%
Alcoholic beverages for immediate consumption	3.9%
Non-depository credit intermediation and other services re	3.7%
Other membership services	3.6%
All others goods and services	*31.6%*

Upstream contributing commodities and direct emissions	ADP Software MPS511200 General purpose software
Direct emissions	14.8%
Pharmaceutical and medicinal products	7.1%
Other transportation equipment and related parts	6.4%
Medical, dental and personal safety supplies, instruments	5.9%
Sales of other government services	4.9%
Photographic, veterinary and other professional, scientific	3.7%
Fibre, yarn, thread and fabrics	3.2%
Crude oil (including synthetic) and bitumen	3.0%
All others goods and services	*51.0%*

Figure 4-2 : Top energy use contributors at the commodity level by suppliers, per $ purchased.

In the case of the water use indicator, for ADP devices and equipment, it is worth noting the large contribution of direct water use by the computer manufacturing industry itself, whereas there is no significant direct water use for the "Data processing, hosting and other information services" (Figure 4-3).

Upstream contributing commodities and direct emissions	Informatics Professional Services MPS51C000 Data processing, hosting and other information services
Photographic, veterinary and other professional, scientific	18.7%
Other transportation equipment and related parts	10.7%
Medical, dental and personal safety supplies, instruments	6.2%
Pharmaceutical and medicinal products	5.0%
Fibre, yarn, thread and fabrics	4.0%
Motor vehicle bodies, trailers and special purpose vehicles	3.6%
Crude oil (including synthetic) and bitumen	2.7%
Custom work services for forestry	2.5%
All others goods and services	*46.7%*

Upstream contributing commodities and direct emissions	ADP Input-Output and Storage Devices and ADP Support Equipment MPG334100 Computers, computer peripherals and parts
Direct emissions	19.3%
Photographic, veterinary and other professional, scientific	16.7%
Computers, computer peripherals and parts	15.8%
Other bus, taxi and passenger transportation services by ro	11.3%
Pharmaceutical and medicinal products	5.6%
Alcoholic beverages for immediate consumption	3.0%
Other plastic products	2.4%
Non-depository credit intermediation and other services re	2.3%
All others goods and services	*23.5%*

Upstream contributing commodities and direct emissions	ADP Software MPS511200 General purpose software
Photographic, veterinary and other professional, scientific	18.6%
Other transportation equipment and related parts	10.5%
Medical, dental and personal safety supplies, instruments	7.0%
Pharmaceutical and medicinal products	5.7%
Fibre, yarn, thread and fabrics	4.0%
Motor vehicle bodies, trailers and special purpose vehicles	3.6%
Crude oil (including synthetic) and bitumen	3.1%
Custom work services for forestry	2.7%
All others goods and services	*44.9%*

Figure 4-3 : Top water use contributors at the commodity level by suppliers, per $ purchased.

4.4 Recommendations by category of commodity

From the direct contribution analysis, recommendations can be identified to reduce the impacts associated from SSC procurement. These recommendations are not exhaustive since they result from the current analysis which scope is limited in term of coverage of life cycle stages and

environmental issues. Also, the low granularity of the analysis model limits the level of detail of these recommendations.

4.4.1 Computer, computer peripherals, and parts; Workstation and CPU

- Computer manufacturing and semiconductor manufacturing facilities use large amounts of **water** in the production process. Sustainable procurements should consider if supplier facilities are in area where water scarcity, freshwater quality, and availability for human needs are a local concern. It may be requested for a hardware contract that the supplier demonstrates that he (or its supplier if he is only a reseller of machines) has implemented clean technologies towards low water consumption in its manufacturing process or has completed an Environmental Product Declaration (EPD) which addresses water issues.
- The computer manufacturing industry and its direct supplier of electronic components (like printed and integrated circuits and other electronic components) is causing over 39% of GHG associated to computers and computer parts. Procurements should pay attention to the commitment of the suppliers as regards energy use, fossil energy use and associated GHG emissions.

4.4.2 Data processing, hosting, and other information services (including data centres services)

- Energy consumption (including electricity), and especially fossil energy use that cause direct GHG from the services provider is key to the environmental performance for such services. Suppliers that are energy efficient should be favoured.
- The electricity gridmix supplying the service provider governs the environmental impact of the electricity used. If the service provider is in a region where the gridmix is low in fossil fuels and rich in renewable electricity (including hydroelectricity), the GHG intensity can be significantly reduced.
- The supplier can beneficially produce its own electricity form renewable sources out of the regional gridmix (e.g. wind, geothermal, photovoltaic, etc.).
- Water use does not appear a key issue for such services since it displays a rather low/medium water use intensity (see Table 4-7) and not directly connected to the operations of the services supplier (Figure 4-3).
- Air transportation appears a non-negligible source of GHGs. Even though the analysis cannot reveal if this activity is related to the transportation of hardware equipment or to people travel, it can be requested to suppliers to favour rail and ship transportation instead of air transportation for material.

4.4.3 Software

Software production is among the commodities with the lowest GHG, energy use and water use intensities. This means that the important contribution of this group of commodities to overall environmental score is due to SSC purchasing volume. Software development is a tertiary activity based on office work. Any environmental gains from such procurement (apart from reducing the purchased volume) could be obtained through asking suppliers to reducing building energy use, reducing office waste generations, etc.

5 Limitations of the study

Before concluding, it is important to recall here the key limitations associated to this high-level, "hot-spot" analysis, environmental study.

1) In line with the objectives of the study, it is limited to the procurements under focus by SSC. The study does not cover the whole department organisation. On purpose, the following procurements are not addressed:

- Purchases made as part of business travel (transportation, accommodation, meal, etc.);
- Purchases made by government employees related to activities such as commuting to and from work, and daily meals are not addressed as well.

2) The environmental study does not systematically cover the whole life cycle of the commodities purchased. Therefore, it is called a partial environmental footprint study.

The analysis is "cradle-to-gate" (gate of the manufacturing plant) for goods. Thus, the footprint does not cover the whole life cycle of a good with respect to the impacts associated with its distribution, use during lifetime and end-of-life management. However, for services, it includes the delivery/provision of the service to the user. Owing to certain services purchased, the end-of-life of some goods acquired may be partly accounted for. This is the case for services such as, for instance, waste management services and repair and maintenance services (e.g. of IT hardware, of dedicated server rooms or data centres) that may include the decommissioning of the infrastructure or equipment and the management of the resulting waste.

3) Contracts are not assessed individually. Rather, the environmental assessment is performed per category of procurements according to the GSIN classification, as entered by SSC when contracts are filed. Hence, the subsequent carbon footprint modelling is limited by:

- The intrinsic level of precision of the GSIN classification (i.e. its granularity) and the accuracy of the GSIN code that has been attributed;
- Then, by the accuracy of the two crosswalk tables used to go, first, from GSIN to UNSPSC codes and then from UNSPSC to IOCC codes in order to map the GSIN to the environmental assessment model which is based on the IOCC classification (which has also its own lack of granularity).

The expected replacement of the GSIN classification by the UNSPSC classification by SSC will alleviate the limitation. The lack of accuracy of the IOCC classification will remain.

4) The environmental assessment considers imported commodities as produced domestically.

openIO-Canada is representative of Canada's domestic economic activities only and does not consider interactions with foreign countries. Any good or service that would be imported is modeled with the tool as if it were produced in Canada, with a Canadian average electricity gridmix.

Considering these limitations, the environmental scores estimated should be considered with caution. However, the relative positioning of categories of procurement can be estimated as robust. The "hot spots" categories identified as the largest contributors to the impacts of procurement may then deserve a further and deeper assessment, e.g. with other life cycle assessment tools, to identify key procurement criteria related to the commodity itself or to its supplier.

6 Conclusion

For all its customers in Canada, SSC manages annually thousands of IT related procurements. Over the last three years period, this is about 9 200 contracts, for about $ 5.9 billion. The partial life cycle GHG emissions, water use and energy use of these procurements have been assessed, from cradle to the gate of the manufacturing plant (for goods) or up to the delivery to the customer (for service), for the last three fiscal years (FY17-18 to FY19-20). The three environmental scores are assessed from every contracts' value using an input-output assessment model (namely *openIO-Canada*) that was specifically updated for the study and is representative of the Canadian economy as of 2016. The environmental scores of all procurement over the three years are as follows, per category of procurement:

Category of procurement	GHG (t CO2eq)	Energy use (GJ)	Water use (m3)	GHG intensity (kg CO2eq/$)	Energy use intensity (MJ/$)	Water use intensity (L/$)
IT Hardware	236,871	3,980,762	17,296,826	0.138	2.32	9.9
IT Professional Services	121,626	1,957,920	6,258,904	0.113	1.81	6.0
Software & Maintenance	110,502	1,791,718	5,846,534	0.066	1.07	3.6
Telecommunications and Voice Equipment	85,868	1,416,454	5,098,795	0.134	2.23	8.1
Professional, Administrative and Management Support	52,467	739,432	3,863,285	0.357	5.05	26.5
Networking Equipment	36,156	609,164	2,195,478	0.246	4.14	14.5
IT Maintenance Services	28,078	449,656	1,504,977	0.130	2.09	7.1
Office and Administration	2,562	41,997	148,138	0.284	4.55	19.0
Professional Development	1,761	31,945	98,426	0.079	1.44	4.5
Telecom Professional Services	348	5,530	16,845	0.126	2.05	6.7
Communications and Publications	151	2,597	10,817	0.251	4.48	21.0
Grand Total	**676,391**	**11,027,175**	**42,339,024**	**0.142**	**2.32**	**9.2**

The top-7 commodities (GSIN classification) contributing to the environmental scores at more than 3% of the total, for each three indicators, are:

Commodity (GSIN)	GHG ($t CO_2eq$)	GHG (% total)	Energy use (GJ)	Energy use (% total)	Water use (m^3)	Water use (% total)
Informatics Professional Services	119,412	17.7%	1,922,377	17.4%	6,135,678	14.5%
ADP Input-Output and Storage Devices	116,225	17.2%	1,953,010	17.7%	8,549,459	20.2%
ADP Software	106,539	15.8%	1,727,202	15.7%	5,625,399	13.3%
ADP Support Equipment	91,027	13.5%	1,529,600	13.9%	6,695,945	15.8%
Consulting Services	27,567	4.1%	387,249	3.5%	2,081,227	4.9%
Telecommunications - Voice Service	23,152	3.4%	379,054	3.4%	1,237,775	2.9%
Telecommunications - Satellite Services	21,778	3.2%	356,568	3.2%	1,164,357	2.8%

This study is a high-level assessment, for pointing out the "hot-spots" from the environmental scores of thousands of very different procurements. These scores numbers are: i) estimates, ii) for partial life cycle, and iii) should therefore not be used outside of the context of this study. Most important is the capacity of the analysis to spot the commodities that contribute the most to the total impact, so as to identify where priorities and efforts should be put on in order to contribute efficiently to the reduction of the environmental footprint of government procurement. Thus, a limited series of 4 different key commodities has been identified. Wherever possible, efforts should first be made to reduce or rationalize the volumes of these procurements. This is not always possible, obviously, especially when large projects (e.g. data centre, deployment of a new inter-department management IT system) must be implemented. This is probably easier for more regular procurement over time and across departments. Actions at this level should help reduce spending and the total annual carbon footprint.

Another area of action for SSC is to develop specific environmental criteria/requirements for these key categories of procurement in its call for tenders. The few recommendations developed for the 4 categories can help to point out the issues that should be addressed by these requirements.

Seeking for more detailed and specific criteria, combining other sources of information and more refined and detailed life cycle assessment studies could then:

I. Improve and refine these recommendations;
II. include aspects not covered within this high-level assessment, like:
    - environmental concerns other than GHG, energy and water use, like – but not limited to – metal and mineral resources depletion, human toxicity and ecotoxicity issues (in relation to electronic waste management)
    - life cycle stage not covered within the current study that can affect significantly the overall environmental score, especially the use stage and end-of-life stage of IT material or services that involves energy use (like data centres).

Learnings from the current studies shows that Informatics Professional Services and IT Hardware such as servers and their equipment, both of which are found within data centers, are relevant candidates for more detailed LCA studies.

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Appendix A.1:
Environmentally Extended Input-Output analysis (EEIO)

Principles and use of EEIO analysis (in French)

La méthodologie proposée pour l'étude repose sur **l'analyse environnementale Entrées-Sorties (ES-E)** dérivée de l'analyse économique Entrées-Sorties (ES). L'analyse ES-E est couramment utilisée pour réaliser des analyses environnementales dans des situations où l'ACV traditionnelle[7] est peu -ou moins- adaptée. C'est particulièrement le cas lorsque le système à l'étude implique de très nombreux produits et services et que réaliser l'ACV de chacun d'eux pour modéliser le système n'est finalement pas possible (données individuelles non disponibles ou difficilement accessibles, fardeau de travail trop élevé). Typiquement, l'analyse ES-E est utilisée pour évaluer les impacts de toute une nation (Hertwich & Peters 2009; Huppes et al. 2006), d'une région (Erickson et al. 2010; Larsen & Hertwich 2011) ou d'une ville (Larsen & Hertwich 2010; Wiedmann et al. 2015), y inclus les échanges commerciaux entre ces économies (Norman et al. 2007 ; Hertwich & Peters 2009; Wiedmann et al. 2015; Kanemoto et al. 2016). Elle est aussi adaptée à l'évaluation des multiples activités et approvisionnements d'organisations telles que les corporations (p.ex. Huang et al. 2009), les universités (Baboulet & Lenzen 2010; Thurston & Eckelman 2011; Larsen et al. 2013; Townsend & Barrett 2015; Gómez et al. 2016) ou les services publics et les gouvernements (Minx et al. 2009 ; Wiedmann & Barrett 2011; Larsen & Hertwich 2011; Alvarez & Rubio 2015 ; Kjaer et al. 2015). L'analyse ES-E est aussi utilisée conjointement à l'ACV traditionnelle, en phase d'analyse préliminaire car, tout comme l'ACV traditionnelle, elle permet d'identifier les sources d'impact le long des chaines d'approvisionnement et aussi de discerner les responsabilités entre fournisseurs et consommateurs. Aussi, la taille des systèmes qu'elle permet d'analyser rend la méthode adaptée pour supporter les politiques publiques liées à la consommation, par exemple lorsqu'il s'agit d'identifier des priorités d'actions par catégories de produits et services (voir Minx et al. 2009; Tukker 2006; Huppes et al. 2006).

Les paragraphes qui suivent introduisent brièvement les principes généraux de l'analyse ES et de son extension à l'analyse environnementale ES-E. Puis, le modèle d'analyse développé pour l'étude est présenté.

L'analyse Entrées/Sorties économique

Les analyses ES considèrent l'entièreté de l'économie comme un ensemble d'acteurs regroupés en industries (ou secteurs) qui s'achètent et se vendent des biens et services (« produits »). Des tableaux ES monétaires sont construits à partir des données des agences de statistiques nationales. Ces tableaux ES sont des inventaires comptables nationaux, et se réfèrent à une année. La consommation «finale» de produits par les ménages et les gouvernements, ainsi que les imports et exports sont représentés dans des tableaux à part. Tout autre flux qui ne peut être considéré comme un échange de produits est représenté dans des extensions; pour une analyse économique, cela se résume typiquement à la valeur ajoutée, notamment le paiement des salaires et les profits

Les tableaux ES sont généralement construits symétriques de façon à décrire quels produits servent à la production de quels produits (**Z**, voir Figure 7-1). Autrement dit, on élimine les

[7] Par la suite, il est entendu par « ACV » la méthode traditionnelle d'analyse du cycle de vie utilisant des processus unitaires dont l'inventaire est exclusivement en données physiques. L'inventaire est généralement tronqué par l'application d'un seuil de coupure (p.ex. les intrants représentant moins de 1% en masse du total des entrants du processus sont exclus de l'inventaire partant du principe que leur contribution ne sera pas significative à l'impact) ou par l'exclusion de certaines activités (p.ex. le transport des employés sur leur lieu de travail). *Ecoinvent* est un exemple reconnu de base de données de type « ACV ».

industries de la représentation de l'économie, et on se concentre sur l'interdépendance entre les différents produits.

Un tableau ES est ensuite normalisé par rapport à la production totale de chaque produit. Chaque colonne constitue donc une sorte de « recette de cuisine » pour produire 1$ d'un produit (Leontief, 1970). La matrice des flux **Z** devient alors la matrice des coefficients techniques (**A**). Cette dernière est utilisée ensuite dans les modèles d'analyse ES à l'aide de la matrice de Leontief ($\mathbf{L}=(\mathbf{I}-\mathbf{A})^{-1}$) qui introduit l'approche **cycle de vie**. En multipliant un vecteur de demande finale de produits (p.ex. la demande des ménages) par **L**, on calcule la production totale **du «berceau au consommateur»** requise pour chaque produit afin de satisfaire la demande. Ce modèle dit « des quantités » se retrouve au cœur de toute analyse ES et aussi de l'ACV traditionnelle. L'analyse ES et l'ACV partagent donc les mêmes fondements mathématiques et bon nombre de présuppositions.

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

Figure 7-1 : Tableau non normalisé d'entrées-sorties (exemple fictif simplifié de 3 produits).

*La colonne «Électricité» compile les flux des différents produits (**Z**) et la valeur ajoutée (**va**) dédiés à la production d'électricité dans l'économie ; la rangée «Électricité» dénombre la consommation d'électricité dans la production des différentes commodités (**Z**) et par les consommateurs finaux (**h**). Les sommes des rangées et des colonnes se doivent d'être égales (**x=x'**).*

Analyse ES multirégionale : En combinant les tableaux de tous les pays disponibles, et en réconciliant leurs déclarations d'importations et d'exportations, on peut développer un tableau global du monde entier où chaque pays est représenté explicitement, et chaque industrie utilise des intrants domestiques et importés. La compilation de tableaux ES multirégionaux est une tâche passablement ardue, réalisée par des experts du monde académique, mais leur utilisation n'est pas plus compliquée ensuite que celle d'un tableau ES national. De tels tableaux ouvrent la voie à des analyses où la provenance des produits peut être considérée.

Les tableaux ES sont typiquement publiés tous les 5 ans par les agences statistiques nationales, et avec un délai de quelques années. L'analyste doit donc gérer cet aspect de la temporalité à l'aide d'indices de prix pour corriger au besoin l'inflation ou la déflation (voir annexe A.4).

L'analyse Entrées/Sorties environnementale (ES-E)

L'analyse ES calcule en $ la production totale (du « berceau au consommateur ») requise pour une consommation finale donnée. Une des principales applications de l'analyse ES-E est plutôt de calculer **les émissions totales pour une consommation donnée**. Pour ce faire, on ajoute des extensions environnementales aux données d'inventaire de l'économie. Mathématiquement, on compile et on traite les extensions environnementales de la même manière que la valeur ajoutée présentée plus haut à la Figure 7-1. Les tableaux ES-E sont donc les tableaux ES enrichis d'une matrice de flux environnementaux exprimés en unités physiques, comme des émissions à l'air de kg CO_2 ou de kg SO_2, des prélèvements de m^3 d'eau, de kg de pétrole brut, etc. Chaque colonne, c'est-à-dire chaque processus de production et activité de services (cf. Figure 7-1) possède donc l'inventaire de ses intrants de l'environnement (ressources naturelles prélevées) et ses émissions directes à l'environnement (polluants émis à l'air, l'eau ou au sol). Certains tableaux ES-E fournissent également les émissions de la phase d'utilisation des produits, sous forme d'émissions directes des ménages par $ d'achat de chaque produit (p. ex., CO_2 émis par $ d'achat d'essence automobile).

Les extensions environnementales peuvent être ajoutées aux tables économiques par les agences statistiques elles-mêmes, mais elles sont alors souvent limitées aux GES et à quelques ressources. Les modèles les plus complets sont plutôt développés par le monde académique. Les ressources impliquées sont très importantes, autant pour collecter les données disponibles que pour le travail d'estimation des données manquantes, de mise à l'échelle, et de contrôle qualité (identification de biais, cohérence des totaux, etc.). Ceci explique la disponibilité somme toute réduite de bases de données pour l'analyse ES-E (i.e. tableaux ES-E), nationales comme multirégionales. Il est très important de noter que, bien qu'une analyse ES-E assure la prise en compte exhaustive des activités économiques impliquées, la couverture des enjeux environnementaux n'est que partielle si l'inventaire contenu dans les tableaux est incomplet. Un modèle d'analyse ES-E, s'il est jugé comme suffisamment détaillé et complet, peut être utilisé conjointement à une ACV pour guider la collecte de données et la modélisation dans une phase exploratoire préliminaire à l'ACV traditionnelle (Bretz & Frankhauser 1996; Huang et al. 2009).

Appendix A.2: Input-Output Commodity Classification (IOCC), 2016, level link 1961, used in *openIO-Canada*

IOCC code and description used in *openIO-Canada* model v2.0 (2016 data)

Source: Statistics Canada's National Accounts

Note: IOCC 2016 differs slightly from IOCC 2009 used in *openIO-Canada* v1.0. Differences are highlighted in file « **Pi533_SSC Procurements_Appendix.xlsx** » provided with the final report. Tab "Support mapping" and also Tab "Issues".

ENE113003	Fuel wood
ENE211102	Natural gas
ENE211103	Natural gas liquids and related products
ENE2111A0	Crude oil (including synthetic) and bitumen
ENE212100	Coal
ENE221100	Electricity
ENE221303	Steam and heated or cooled air or water
ENE324111	Gasoline
ENE324112	Diesel and biodiesel fuels
ENE32411A	Other fuels
ENE32B000	Coke, other coke oven and solid fuel products
IMG11B000	Imputed farm products
IMS5311A0	Imputed rental of owner-occupied dwellings
IMS541502	Own-account software design and development services
IMS541702	Own-account research and development (except software development)
IMS551001	Holding company services (imputed)
MPG111AA0	Fresh vegetables and fruits and other crop products
MPG111AB0	Grains and oilseeds
MPG111C00	Cannabis plants, seeds and flowering tops
MPG112A00	Live animals
MPG113A00	Logs, pulpwood and other forestry products
MPG114000	Fish, crustaceans, shellfish and other fishery products
MPG11C000	Other farm products
MPG212210	Iron ores and concentrates
MPG212220	Gold and silver ores and concentrates
MPG212230	Copper, nickel, lead and zinc ores and concentrates
MPG212290	Radioactive and other metal ores and concentrates
MPG212396	Potash
MPG21239B	Diamonds and other non-metallic minerals
MPG2123A0	Stone, sand, gravel, clay and refractory minerals
MPG23A000	Residential construction
MPG23B000	Non-residential building construction
MPG23C100	Transportation engineering construction
MPG23C200	Oil and gas engineering construction
MPG23C300	Electric power engineering construction
MPG23C400	Communication engineering construction
MPG23C500	Other engineering construction
MPG311100	Animal feed
MPG311200	Milled grains and oilseeds
MPG311300	Refined sugar and confectionary products
MPG311400	Fruit and vegetable juices and preserved fruits and vegetables
MPG311500	Dairy products
MPG311600	Meat products
MPG311700	Prepared and packaged seafood products
MPG311B00	Other miscellaneous food products
MPG312110	Bottled water, soft drinks and ice
MPG312120	Beer
MPG3121A0	Wine and distilled liquor
MPG312200	Tobacco products
MPG312300	Cannabis products (except plants, seeds and flowering tops)
MPG31AA00	Fibre, yarn, thread and fabrics
MPG31AB00	Carpets, textile furnishings and other textile products
MPG31B000	Clothing, footwear and accessories
MPG3211A0	Hardwood and softwood lumber and treated wood products
MPG321900	Wood windows and doors, wood containers and other wood products
MPG321A00	Wood chips, veneer and plywood, reconstituted wood products and wood waste
MPG322101	Wood pulp
MPG322200	Converted paper products
MPG322A00	Paper, paperboard and waste
MPG323001	Printed products
MPG3241C0	Other refined petroleum and coal products
MPG325101	Petrochemicals
MPG3251A0	Other basic chemicals

MPG325200	Plastic resins, rubber and synthetic filaments
MPG325300	Chemical fertilizers, pesticides and other agricultural chemicals
MPG325400	Pharmaceutical and medicinal products
MPG325500	Paints, coatings and adhesive products
MPG325600	Soaps, cleaning compounds, perfumes and toiletries
MPG325900	Chemical products, n.e.c.
MPG326103	Plastic and foam building and construction materials
MPG326107	Motor vehicle plastic parts
MPG326200	Tires, rubber and plastic hoses and other rubber products
MPG326A00	Other plastic products
MPG327300	Cement, ready-mixed concrete and concrete products
MPG327AA0	Other non-metallic mineral products
MPG327AB0	Glass and glass products including waste and scrap
MPG331200	Iron and steel pipes, tubes and rolled and drawn steel products
MPG331300	Bauxite, aluminum oxide and aluminum products including alloys
MPG331406	Basic and semi-finished products of non-ferrous metals and alloys (except aluminum)
MPG3314B0	Unwrought precious metals including alloys and gold as store of value
MPG331500	Ferrous and non-ferrous metal castings
MPG331A00	Iron and steel basic shapes and ferro-alloy products including scrap
MPG331B00	Other miscellaneous unwrought non-ferrous metals including alloys and scrap
MPG332400	Metal containers, boilers and tanks
MPG332C00	Hardware, wire products and turned products
MPG332E00	Structural, ornamental, architectural and other fabricated metal products
MPG333B00	Industry specific machinery
MPG333C00	General purpose machinery
MPG334100	Computers, computer peripherals and parts
MPG334200	Telephone apparatus and other communication equipment
MPG334400	Printed and integrated circuits and other electronic components
MPG334A01	Audio and video equipment and unrecorded media
MPG334AB0	Navigational, measuring, medical and control instruments
MPG335200	Household appliances
MPG335A00	Electrical equipment and components
MPG336111	Passenger cars
MPG336112	Light-duty trucks, vans and sport utility vehicles (SUVs)
MPG336120	Medium and heavy-duty trucks and chassis
MPG336200	Motor vehicle bodies, trailers and special purpose vehicles
MPG336310	Motor vehicle gasoline engines and engine parts
MPG3363A0	Motor vehicle parts except engines
MPG336403	Aircraft parts and other aerospace equipment
MPG3364A0	Aircraft and aircraft engines
MPG336500	Railway rolling stock and parts
MPG336600	Ships, boats and personal watercraft
MPG336900	Other transportation equipment and related parts
MPG337A00	Household furniture and furniture related products
MPG337B00	Office and institutional furniture including fixtures
MPG339100	Medical, dental and personal safety supplies, instruments and equipment
MPG339900	Miscellaneous manufactured products
MPG5111C0	Published products including newspapers, periodicals and books (print and electronic)
MPS115300	Support services for forestry
MPS115A00	Support services for crop and animal production
MPS11X000	Custom work services for forestry
MPS21311A	Support services for oil and gas extraction (except exploration)
MPS21311B	Support services for mining and quarrying (except exploration)
MPS21A000	Mineral and oil and gas exploration
MPS221200	Natural gas distribution
MPS2213A0	Water and sewage
MPS23D000	Repair construction services
MPS31A006	Textile and fabric finishing and coating services
MPS323A00	Support services for printing and contract printing services for publishers
MPS332800	Coating, engraving, heat treating and similar metal processing services
MPS3X0000	Custom work manufacturing services (except printing, finishing textiles and metals)
MPS410000	Wholesale margins and commissions
MPS453BL0	Retail margins - cannabis products (licensed)

MPS453BU0	Retail margins - cannabis products (unlicensed)
MPS481000	Air transportation services
MPS482000	Rail transportation services
MPS483000	Water transportation services
MPS484000	Truck transportation services
MPS485100	Urban transit services
MPS486000	Transportation services by pipeline
MPS488006	Freight transportation arrangement and customs brokering services
MPS488A00	Support activities for air transportation and aircraft maintenance and repair services
MPS488B00	Rail, water, road and other transportation support, maintenance and repair services
MPS48C000	Other bus, taxi and passenger transportation services by road
MPS493000	Warehousing and storage services
MPS49A000	Postal and courier services
MPS4AB000	Retail margins (except cannabis), sales of used goods and commissions
MPS5111B0	Advertising space in published printed products and licensing fees to distribute or reproduce
MPS511200	General purpose software
MPS512A00	Recorded movies, television programs, videos, music and audio works
MPS512B00	Motion picture and sound recording services
MPS515A02	Fees for the distribution of television and radio program channels (affiliation payments)
MPS515B00	Advertising air time on television and radio
MPS517001	Fixed telecommunications services (except Internet access)
MPS517002	Mobile telecommunications services
MPS517003	Cable, satellite and other program distribution services
MPS517004	Fixed Internet access services
MPS51C000	Data processing, hosting and other information services
MPS522A00	Non-depository credit intermediation and other services related to credit intermediation
MPS523003	Portfolio management services
MPS523A00	Investment banking, security brokerage and securities dealing services
MPS523B00	Investment counselling, holding company, and other financial investment and related activities
MPS5241A0	Life insurance and accident and sickness insurance services
MPS5241B0	Automotive, property, liability and other casualty insurance services
MPS524200	Brokerage and other insurance related services
MPS526000	Trusteed pension fund services, mutual funds (cost of services) and other similar services
MPS52B000	Banking, credit unions and other depository credit intermediation services - explicit charges
MPS52X001	Deposit intermediation services indirectly measured (FISIM)
MPS52XA00	Loan intermediation services indirectly measured (FISIM)
MPS531101	Rental of residential real estate
MPS531102	Rental of non-residential real estate
MPS531A00	Real estate brokerage and other services related to real estate
MPS532100	Motor vehicle rental and leasing services
MPS532A03	Commercial and industrial machinery and equipment (except office equipment) rental and leasing services
MPS532A09	Rental and leasing services of other goods
MPS532AA0	Computer equipment, office machinery and equipment rental and leasing services
MPS533000	Licensing of rights to non-financial produced intangible assets (except software and other copyright licensing)
MPS541100	Legal services
MPS541200	Accounting, tax preparation, bookkeeping and payroll services
MPS541300	Architectural, engineering and related services
MPS541400	Specialized design services
MPS541501	Custom software design and development services
MPS541503	Computer systems design and related services (except software development)
MPS541600	Management, scientific and technical consulting services
MPS541701	Research and development services
MPS541800	Advertising, public relations and related services
MPS541900	Photographic, veterinary and other professional, scientific and technical services
MPS561300	Employment services
MPS561400	Business support services
MPS561500	Travel arrangement, reservation and planning services
MPS561600	Investigation and security services
MPS561700	Services to buildings and dwellings
MPS561A00	Facilities and other support services
MPS562000	Waste management and remediation services
MPS5D0000	Office administrative services and head office services
MPS610001	Tuition and similar fees for elementary and secondary schools

MPS610002	Tuition and similar fees for colleges and C.E.G.E.P.s
MPS610003	Tuition and similar fees for universities
MPS61A000	Tuition and similar fees for trade, technical and professional training and other educational services
MPS621100	Physician services
MPS621200	Dental services
MPS621A01	Other health practitioner services
MPS622000	Hospital services
MPS623000	Nursing and residential care services
MPS624001	Child day-care services
MPS62B000	Other health and social assistance services
MPS713200	Gambling (net wagers)
MPS713A00	Amusement and recreation services
MPS71AA00	Admissions to live sporting events and performing arts performances
MPS71AB00	Other arts and entertainment services
MPS721100	Room or unit accommodation services for travellers
MPS721A00	Other accommodation services
MPS722001	Prepared meals
MPS722002	Alcoholic beverages for immediate consumption
MPS811100	Motor vehicle repair and maintenance services
MPS811A00	Repair and maintenance services (except for buildings and motor vehicles)
MPS812A01	Hair care and aesthetic services
MPS812B00	Miscellaneous personal and personal care services
MPS813000	Other membership services
MPS814000	Private household services
MPS9A0000	Sales of other services by Non-Profit Institutions Serving Households
MPS9B0000	Sales of other government services
NGS611100	Elementary and secondary school services provided by governments
NGS611200	Community college and C.E.G.E.P services provided by governments
NGS611300	University services provided by governments
NGS611A00	Other educational services provided by governments
NGS622000	Hospital services provided by governments
NGS623000	Residential care facility services provided by governments
NGS911100	Defence services
NGS911A00	Other federal government services
NGS912000	Other provincial and territorial government services
NGS913000	Other municipal government services
NGS914000	Other aboriginal government services
NNP610000	Educational services provided by Non-Profit Institutions Serving Households
NNP621000	Ambulatory health care services provided by Non-Profit Institutions Serving Households
NNP624000	Social assistance services provided by Non-Profit Institutions Serving Households
NNP710000	Arts, entertainment and recreation services provided by Non-Profit Institutions Serving Households
NNP813100	Religious services
NNP813930	Labour organization membership services
NNP813AA0	Grant-making, civic, and professional and similar organization services
NNP999999	Other services provided by Non-Profit Institutions Serving Households

Appendix A.3:
openIO-Canada model and data (v2.0; 2016)

A) updated *openIO-Canada* model development

Step 1: Downloading the economic tables

Canadian National Input Output Tables (IOT) for 2016 were downloaded via the Statistics Canada website (https://www150.statcan.gc.ca/n1/pub/15-602-x/15-602-x2017001-eng.htm). The Link 1961 (L61) level of aggregation was chosen to avoid dealing with undisclosed data that cannot be published by Statistics Canada at higher level of detail for confidentiality reason.

The CA_SUT_C2016_L61.xlsx Excel file contains the information required to compile the IOTs. This information is separated in two matrices called Supply (V) and Use (U). The Supply table describes the quantities (in CAD$) of commodities supplied by the different industries in Canada. The Use table describes the quantities of commodities purchased by the different industries as well as by the final demand (e.g., Canadian households). Purchases from the final demand (Y) however, are separated from the Use table.

From these tables, the total amount of each commodity's output ($q = \sum_i V_i$) as well as the total amount of each industry's output ($g = \sum_j U_j$) can be extracted.

Step 2: Building the IOT

To transform Supply & Use tables into a square IOT there are multiple models (or constructs) that can be applied. To select which model to use, the level of classification must first be chosen. It is possible to generate a square industry x industry IOT or a square product x product IOT. For our purposes we selected the product level, because our goal is to study the impact of products and not industries. There are therefore 3 models applicable:

- product technology assumption
- industry technology assumption
- hybrid technology assumption

We chose to go with the industry technology assumption as both the product and industry technology assumptions are more mainstream than the hybrid technology assumption and because the industry technology assumption does not introduce negative values.

The square product-by-product technology matrix (A) is therefore obtained using the following equation:

$$A = U \cdot \hat{g}^{-1} \cdot V^t \cdot \hat{q}^{-1}$$

Step 3: Linking the IOT to emissions

Greenhouse gases (GHG):

The physical flow accounts of GHG of 2016 provided by Statistics Canada (https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810009701) were connected to the IOT. In these accounts, the GHG emissions are directly linked to the L61 classification used by the Supply and Use tables used previously. GHGs emissions are therefore provided for industries and not products. To allocate GHG emissions to products, the economic share of an industry's output was used. In other words, the more a product was produced by an industry, the more it is held responsible for the emissions of that industry. The following equation were thus used to change the matrix of GHG emissions from industries (F^i) to products (F^p):

$$F^p = F^i \cdot V^t \cdot \hat{g}^{-1}$$

This conversion step will also be performed for the other environmental flows. In the rest of the methodology, F^p will simply be called F. F will contain all environmental flows (i.e., GHG, energy use and water use).

Energy use:

The physical flow accounts of energy use of 2016 provided by Statistics Canada (https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810009601) were connected to the IOT. The energy use account shares the exact same format (L61) as the GHG account. The exact same steps were therefore performed to link the energy use flows to the IOT.

Water use:

The physical flow accounts of energy use of 2015 provided by Statistics Canada (https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810025001) were connected to the IOT. Unfortunately, data on water use is currently only available until 2015. The water use accounts follow a higher-level classification than the IOT, e.g., emissions are available from Agriculture but the IOT separates Agriculture into Crops and Animals. The use of water from Agriculture must thus be split between the cultivation of crops and the breeding of animals. We thus rely on the market share of these services to allocation the water use, i.e., if 90% of sales in Agriculture come from the sales of crops, then 90% of water use is allocated to the cultivation of crops.

Step 4: Calculating emissions per $ of product purchased

To determine the normalized emissions per dollar, we first calculate the inverse of Leontief (L):

$$L = (I - A)^{-1}$$

where I is the identity matrix. The inverse of Leontief determines the total amount needed of each commodity to produce 1$ of a product. We then multiply the inverse of Leontief by our emissions matrix (F) that we normalize:

$$normalized\_emissions = F \cdot \hat{q}^{-1} \cdot L$$

B) ENVIRONMENTAL DATA

Greenhouse gases coverage (2016 data)

The data from Statistics Canada on GHG emissions used in this model only covers three gases: CO_2, CH_4 and N_2O. HFCs, PFCs, SF6 and NF3 are GHGs not considered in Statistics Canada accounts. The "IPCC 2007" GWPs used by Statistics Canada are still in line with those currently used for the National inventory report on GHG sources and sinks published by the federal government (25 and 298 kg CO_2eq/kg for CH_4 and N_2O, respectively) What is more, the emissions data is only made available as an aggregate Carbon dioxide equivalent (CO_2e) and use global warming potentials (GWP) of 25 and 298 for CH_4 and N_2O, respectively (IPCC 2007, 100-year time horizon). The following sources are covered: “combustion of fossil fuels and biomass; non-combustion uses of fossil fuels; industrial processes; agricultural soils; livestock manure and enteric fermentation”. Emissions from landfill gas is not included. CO_2 from biomass combustion is not excluded, even though this CO_2 from biogenic source can also be absorbed through biomass production.

More information:

https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5115

Data source:

https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810009701

Energy use coverage (2016 data)

The energy use data considered by openIO-Canada model are those provided by Statistics Canada's Environment Accounts. It is based on the annual use of energy products by industry, governments, institutions, and households. The following energy sources are covered: coal, natural gas, motor gasoline, diesel, aviation fuel, light fuel oil (including kerosene), heavy fuel oil, refinery fuel gas, coke oven gas, liquefied petroleum gases (including natural gas liquids), electricity, coke, steam, wood, and spent pulping liquor. The unit of measure is terajoule. Only uses of energy products for their energy content are considered; the use of energy products as material inputs is not included (e.g. oil products used to produce plastics).

More information:

https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5115

Data source:

https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810009601

Water use coverage (2016 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.

More information:

https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5115

Data source:

https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810025001

See also other environmental data and mode limitations of *openIO-Canada* v1.0 at http://www.ciraig.org/en/open_io_canada/known_limitation.html

Appendix A.4: Sectoral inflation rates to be used with IOCC commodities used in *openIO-Canada*

Source: Statistics Canada.

Price indices:

- IPPI: Industrial producer price index
- CPI: Consumer price index

The appendix is included in file « **Pi533_SSC Procurements_Appendix.xlsx** » provided with the final report. Tab “Price”

Appendix B:
GSIN – UNSPSC mapping table

The appendix is included in file « **Pi533_SSC Procurements_Appendix.xlsx** » provided with the final report. Tab « nibs-gsin_unspsc »

Appendix C:
UNSPSC – IOCC L61 mapping

The appendix is included in file « **Pi533_SSC Procurements_Appendix.xlsx** » provided with the final report. Tab « UNSPSC-IOCC-13_08_2019 »