Preliminary Resource Recovery Report Card and Gaps Assessment for Canada

Final Report

Prepared for:
Natural Resources Canada
Lands and Minerals Sector and Canadian Forest Service

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Executive Summary

In January 2020 NRCan contracted with Kelleher Environmental to research and prepare a resource recovery scoping study and preliminary circular economy report card for Canada. The results of this contract with Kelleher Environmental, a reflection of what is currently known about Canada's CE performance, could be presented at the WCEF (World Circular Economy Forum) which was scheduled for fall, 2020 in Toronto but has been delayed due to covid 19.

The main objective of the work is to provide an estimate for the recovery and recycling of selected materials in Canada, using data from published sources (secondary data sources). The study report includes a gap analysis and assessment for future work needed to refine the preliminary estimates and collect additional data to fill in identified information gaps.

Three categories of materials are of interest to the study:

- **Materials** that are typically recycled such as paper, ferrous metals, non-ferrous metals, glass, plastics, food and yard waste, lumber, wood and drywall.
- **Products** such as auto hulks, tires, electronics, appliances and batteries that are typically recycled to recover metals and plastics, and
- **Industrial residuals** that are typically recovered and utilized rather than disposed. These include CCP (coal combustion products), steel making residuals, wood ash and foundry sand.

The recovery and recycling data assembled for the *Preliminary CE Report Card* were drawn from most recent reports and studies that are publicly available. Data were also provided to the Kelleher team by NRCan staff. The bulk of the project work involved reviewing reports, articles in trade journals, websites, the internet and other sources of information, which quantify current recycling efforts in Canada for the materials, products and industrial residuals.

NRCan staff supported the Kelleher team by contacting industry associations with requests for data and reports and by providing relevant in-house data. NRCan also provided the Kelleher team with export and import data for the target study materials, where they existed.

The quantities of selected materials recycled in Canada in or near 2018 identified in this study research are summarized by material in the Table ES.1.

The total amount material recovered and/or recycled in the categories covered in this study is estimated to be over 22.3 million tonnes. The largest amount in this total identified to date is in the steel industry, which uses 6.7 million tonnes of scrap steel, exports 5.1 million tonnes and recycles 2.9 million tonnes of residues. Scrap paper also accounts for significant amounts recycled in Canada. All of these totals may include some double counting and this needs to be resolved through additional research and analysis.

The evidence assembled for this report is a clear indication that Canada's economy contains many circularities. While policies and regulations may drive some of the recovery/recycling activities quantified in this report, gains in resource and energy efficiencies supported by positive economic factors may have a greater influence. In other words, since business seeks to minimize cost and maximize profit, process residuals discarded may contain some value and therefore may represent a double loss: the cost of waste disposal plus foregone revenue.

The study identified a number of gaps in the data which should be filled through additional research.

Table ES.1: Summary of Selected Materials Recycled or Reused in Canada (2018)

Material	Exported (tonnes)	Imported (tonnes)	Reused or Recycled (tonnes)	Notes
Scrap Paper	2,000,000	1,400,000	3,600,000	Used in Canada (2014)
Scrap Steel	5,100,000	3,340,100	6,700,000	steel/ferrous metal used in Canada (2018) 4,800,000 tonnes purchased 1,900,000 tonnes internal scrap
Aluminum	553,420	104,900	104,900	No data on recycled – assume imported value
Lead	4,480	5,590	129,500	Secondary lead amount from NRCan
Copper	162,810	109,720	109,720	No data on recycled – assume imported value
Zinc	10,690	250	250	No data on recycled – assume imported value
Nickel	9,581	29,040	29,040	No data on recycled – assume imported value
Glass			380,000	WMIS (2016)
Glass (Deposit Return Programs)			200,000	309, 100 tonnes deposit-return systems –some is additional to WMIS value – degree of double counting not known, so allowance of 200,000 tonnes included but this may be an underestimate
Plastic			442,000	Deloitte (2019)
Food and Yard			2,670,000	WMIS (2016)
Tires			440,000	CATRA (2018)
Electronics			106,900	EPRA and ARMA (2018)
White Goods			330,800	WMIS (2016) May be counted in metals above
Small and outdoor appliances			5,300	BC only
Batteries (post-consumer)			5,000	
Batteries (lead acid)				129,500 lead already counted in metals
Lumber/Wood			283,000 272,000 2,000,000	CR&D Pallets Biomass power
Drywall			106,000	
Coal combustion products (CCP)			1,306,000 181,000 214,000 40,000	Fly ash Bottom ash Flue gas desulphurization Bottom ash
Steel making residues			1,500,000 820,000 450,000 110,000 29,000	Blast Furnace slag Steel making slag sold off site On-site recycling On-site reuse EAF to zinc recyclers
Wood ash			54,700 52,500	Soil amendment (from pulp and paper sector) Other beneficial use (from pulp and paper sector)
Total Identified To Date for Canada	7,840,981	4,989,600	22,340,810	

1 Introduction

1.1 Background

The "circular economy" (CE) promotes three main principles:[1]

- Designing out waste and pollution;
- Keeping products and materials in use; and
- Restoring natural systems.

NRCan is the federal department mandated to create a "sustainable resource advantage" for the benefit of all Canadians. In January 2020 NRCan contracted with Kelleher Environmental to research and prepare a resource recovery scoping study and preliminary circular economy report card for Canada. The results of this contract with Kelleher Environmental, a reflection of what is currently known about Canada's CE performance, could be presented at the next World Circular Economy Forum (WCEF). The event was originally scheduled for Toronto in fall, 2020, but is being rescheduled due to covid-19.

The information collected through the research will be a resource document for NRCan staff and other interested parties and stakeholders to easily understand the quantified material stream data and through additional research where needed identify the complete scope of circular economy activities in Canada.

[1] Ellen MacArthur Foundation

2 Scope and Approach

2.1 Objective and Project Scope

The main objective of the work is to provide an estimate for the recovery and recycling of selected materials in Canada, using data from published sources (secondary data sources). The study report includes a gap analysis and assessment for future work needed to refine the preliminary estimates and collect additional data to fill in identified information gaps.

Three categories of materials are of interest to the study:

- **Materials** that are typically recycled such as paper, ferrous metals, non-ferrous metals, glass, plastics, food and yard waste, lumber, wood and drywall.
- **Products** such as auto hulks, tires, electronics, appliances and batteries that are typically recycled to recover metals and plastics, and
- **Industrial residuals** that are typically recovered and utilized rather than disposed. These include CCP (coal combustion products), steel making residuals, wood ash and foundry sand.

The report is presented in three separate parts (1 to 3) as shown in Table 1, with each part addressing the material categories described above.

Table 1: Materials, Products and Industrial Residuals of Interest to the Preliminary Resource Recovery Report Card Study

Main Section of Report	Preliminary Resource Recovery Report Card Category	Addressed in This Study
PART 1	Materials	Paper Metals (ferrous and non-ferrous) Glass Plastics Food and Yard Waste Lumber/wood Drywall
PART 2	Products	Auto Hulks Tires Electronic Waste White Goods (Large Appliances) Small Appliances Batteries
PART 3	Industrial Residuals	Coal Combustion Products (CCP) EAF (Electric Arc Furnace) Dust Wood Ash Foundry Sand

2.2 Approach

The target baseline year for the study data is 2018 but this will vary according to the availability of data.

This assessment was limited to a review of publicly available literature and contact with selected key people in relevant industry associations. It was accepted at the outset of the project that in some cases and for some materials, only older data would be used.

The recovery and recycling data assembled for the project were drawn from most recent reports and studies that are publicly available. The bulk of the project work involved reviewing reports, articles in trade journals, websites, the internet and other sources of information.

NRCan staff supported the Kelleher team by contacting industry associations with requests for data and reports and by providing relevant in-house data.

NRCan also provided the Kelleher team with export and import data for the target study materials, where they existed.[2] However, export and import information was not available for small trade flows such as electronic waste (for example). Even large volume materials like coal combustion products (e.g. fly ash) are combined with a mix of unrelated materials because the value of these materials do not reach a certain threshold established via the *Harmonized Commodity Description and Coding System,* which is maintained by the World Customs Organization.

The Kelleher team consulted with the Canadian Steel Producers Association (CSPA), the Canadian Association of Recycling Industries (CARI), Paper and Paperboard Packaging Environment Council (PPEC), and Automotive Recyclers of Canada to identify sources of information available on quantities of scrap collected and processed in Canada and definitions used in the industry for recycled material flows.

The Kelleher team also contacted other industry associations such as the Canadian Foundry Association to determine if they collect reliable annual quantity data for specific material streams recycled. Where the data were not collected or available, this is noted as a gap for future research.

2.3 Report Structure

For each material, product or industrial residual stream assessed in this assignment, a separate section of the *Preliminary* CE *Report Card* document presents the following information:

- The data sources identified and reviewed;
- Which data sources were used to develop recycling quantity estimates; and,
- Any assumptions used to extrapolate from reported data.

Sources are presented in brief reference format with author and date throughout the text. Additional materials are presented in the other report appendices. Footnotes are used to reference information presented in tables and figures, with full references in Appendix A

[2] All trade data contained in this report was provided by NRCan staff via the Statistics Canada Trade Retrieval and Aggregation System 2.0

Findings of the research are summarized in the following sections:

- Paper and paper packaging are addressed in Section 3.
- Metals (ferrous and non-ferrous) are addressed in Section 4.
- Glass, plastic and food and yard waste are addressed in Sections 5, 6 and 7, respectively.
- Lumber and drywall waste are addressed in Sections 8 and 9 respectively.
- Auto hulks are addressed in Section 10.
- Tires, electronics and batteries are addressed in Sections 11, 12 and 13, respectively.
- Industrial residuals (including coal combustion products (CCP), steel making residuals, wood ash and foundry sand are addressed in Section 14.
- Section 15 identifies gaps in the data, which should be addressed in future studies.

Additional material is presented in a series of appendices.

PART 1: MATERIALS WHICH ARE TYPICALLY RECYCLED IN CANADA

The sections in Part 1 address a number of materials which are typically recycled in Canada. These include:

- Paper
- Metals (ferrous and non-ferrous)
- Glass
- Plastics
- Food and Yard Waste
- Lumber/wood
- Drywall

3 Paper

3.1 Paper Recycling Process

Recycling of paper refers to the process whereby used printed paper (e.g. newspapers, magazines, flyers, etc.) and packaging (cardboard, boxboard, etc.) are collected, processed and sent to mills for incorporation into new paper products, or into other industrial processes to produce a variety of products such as insulation etc.

However, paper cannot be recycled indefinitely. After repeated processing, the fibres become too short for the production of new paper. This is why some virgin fibre is added to the pulp recipe for various paper products.

Three categories of paper are used as recycled feedstock in paper and paperboard mills:

- *Mill broke* is paper trimmings and other paper scrap from the manufacture of paper, and is recycled in a paper mill;
- *Pre-consumer waste paper* is a material which left the paper mill but was discarded before it was ready for consumer use; and,
- *Post-consumer waste paper* is material discarded after consumer use, such as old corrugated containers (OCC), boxboard (used in shoe boxes, cereal boxes, etc.), magazines, and newspapers.

The numbers in this report are for post-consumer paper waste mostly.

The paper collected for recycling in Canada typically goes to MRFs (material recycling facilities) where it is processed to eliminate contaminants such as plastics. The processed paper is baled for sale to paper mills each of which require different recycled feedstock. Some paper mills that produce newsprint only accept recycled newsprint. Other mills that produce corrugated cardboard can accept either newsprint, corrugated cardboard, boxboard or sometimes mixed paper as feedstock, and some mills can accept any grade of paper as recycled feedstock. The demand for all of these recycled paper materials as feedstock depends on the price of virgin pulp. When virgin pulp is expensive, paper and paperboard mills will take the time and effort to decontaminate recycled paper as the costs of clean up and residue disposal are justified by the cheaper purchase price for recycled paper. Where the price of virgin pulp is attractive, it is easier for mills to use virgin pulp that has a higher quality than recycled paper feedstock.

The sale of recycled paper to mills is usually managed by paper brokers. The recycled paper is sold to Canadian mills, US mills or sometimes to mills in South Korea or China. In 2018, the Chinese government significantly tightened up quality standards on recycled paper imported with the introduction and enforcement of the “China Sword” policy. As a result, the amount of Canadian recycled paper being sold to China has reduced to a modest amount.

3.2 Amount of Paper Recycled in Canada

Table 2 summarizes information on paper recycling in Canada collected by Statistics Canada every two years through their Waste Management Industry Survey (WMIS).

Table 2: Paper Recycling In Canada (WMIS Survey) 2008 to 2016

Paper Type Recycled	2008	2010	2012	2014	2016
Newsprint	1,129,609	N/A	N/A	N/A	N/A
Cardboard and boxboard	1,381,298	N/A	N/A	N/A	N/A
Mixed paper	927,069	N/A	N/A	N/A	N/A
All paper fibres recycled and reported through WMIS	3,437,976	3,246,679	3,355,667	3,574,929	3,566,789

Prior to 2010, WMIS collected data separately for three categories of recycled paper: newsprint; cardboard and boxboard, and mixed paper. From 2010 onwards, these categories were collapsed into one broad category (all paper fibres). Table 2 shows that the total amount of paper recycled in Canada has ranged from 3.2 to 3.6 million tonnes per year.

Where paper is processed through MRFs (material recycling facilities[3]) the amounts are captured in WMIS. However, direct business-to-business recycling (e.g. a paper recycling company sending their own truck directly to large retailers to collect cardboard) is not captured.

The year 2016 is the most recent for which data are available from WMIS. The survey includes many entities that recycle paper, including municipalities that recycle through residential collection programs. Discussions with Statistics Canada staff indicated that paper materials from beverage container deposit/return programs are included in the WMIS totals for some provinces and programs but not for others. Clarifying the extent to which materials from deposit return systems are included in the WMIS is noted as a research gap.

More detailed data on paper recycled in Canada by province is presented in Appendix B. This is either data for 2018, or the latest year for which data were available from annual reports published by extended producer responsibility (EPR) or stewardship programs for printed paper and packaging and also from deposit/return programs for beverage containers which handle small amounts of paper packaging sent for recycling. For some EPR or deposit/return programs the most recent year for which data are available is 2016 or 2017.

Kelleher Environmental contacted PPEC (Paper & Paperboard Packaging Environmental Council) to determine if any good data were available on the amount of additional paper recycled via direct business-to-business activity. PPEC collects detailed per company shipments for paper packaging mills (which are the major paper recyclers in Canada) and reported that the packaging mills shipped 2,114,487 tonnes of recycled board (this refers to cardboard and boxboard created as an end product using various recycled papers as feedstock) in 2018[4]. . At a 10% wastage rate (i.e. to account for removal of contaminants or process losses) this would mean that about 2,349,430 tonnes (110% of the 2,114,487 tonnes of finished product) of recycled paper were used in packaging mills in Canada in 2018 to create the 2,114,487 tonnes of finished product. PPEC is in the process of collecting information from non-packaging mills that use recycled paper to produce paper products with recycled content in order to provide a more complete picture of recycled paper totals.

Information provided to NRCan by the Pulp and Paper Products Council is presented in Table 3. Information was provided back to 1980 but data from 2010-2014 was considered of most relevance to the current study. The table shows that in 2014 (the most recent data available) an estimated 4.2 million tonnes of paper were recovered in Canada. A reported 2 million tonnes were exported. Canadian mills used a reported 2.7 million tonnes of recycled

[3] In this context, a MRF receives materials from municipal sources, especially residential but possibly commercial and light industrial as well.
[4] The PPEC Executive Director commented that paper shrinks when it's recycled so that 100 tonnes supplied to a mill becomes approximately 90 tonnes shipped to a new customer.

paper feedstock, so the gap (500,000 tonnes) was assumed in this study to be filled using imported paper. Section 3.3 explains the export and import of recyclable paper from 2016 to 2018. Export and import data for 2014, or updated data for 2015 to 2018 from PPPC are needed to carry out a proper mass balance. This information is noted as a data gap in Section 15 of the report.

Table 3: Paper Recycled in Canada, 2010 to 2014 (thousands of tonnes)[5]

YEAR	Domestic Receipts	Recyclable Paper Exports	Recovered Paper from Domestic Sources (Domestic Receipts plus Recyclable Paper Exports)	Canadian Paper & Board Consumption	Recovered Paper Consumption	Paper & Board Production
2010	2,426	1,745	4,171	6,046	3.444	12,669
2011	2,345	2,052	4,397	5,991	3.284	12,060
2012	1,957	2,341	4,298	6,040	2.651	10,755
2013	2,130	2,155	4,285	5,974	2.700	11,165
2014	2,123	2,078	4,201	5,849	2.745	11,095

3.3 Imports and Exports of Recycled Paper

Table 4 presents data on recycled paper imports and exports to Canada. The trade in recycled paper is generally north-south rather than east-west and is based on how close the mills are to where the recycled material was processed. As an example, recycling programs in Alberta or BC often sell their paper to mills in Washington and Oregon states; polycoat containers from Western Canada are sold to companies such as ICF International and shipped to manufacturing plants in South Korea, Thailand, and Japan for recovery and production of tissue paper; paper from Manitoba is sometimes sold to markets south of the border; mills in Eastern Canada often import paper for their operations.

The table shows that in the years 2016 to 2018 imports of recycled paper to Canada reached 1.4 million tonnes in 2018. Meanwhile, exports of recycled paper from Canada were about 2 million tonnes in 2018, down from 2.5 million tonnes in 2016 and 2017.

[5] Source: Pulp and Paper Products Council

Table 4: Trade Data for Recovered Paper Commodities 2016-2018 (Tonnes)

	Imports			Exports		
Recycled Paper Category	**2016**	**2017**	**2018**	**2016**	**2017**	**2018**
Other paper or paperboard made mainly of bleached chemical pulp not coloured in the mass. High-grade deinking paper and paperboard.	150,676	160,268	140,616			
Other paper or paperboard made mainly of bleached chemical pulp not coloured in the mass. Other.	2,667	4,413	7,889			
Paper or paperboard made mainly of mechanical pulp (for example newspapers journals and similar printed matter). Newsprint waste.	83,445	28,503	46,190			
Paper or paperboard made mainly of mechanical pulp (for example newspapers journals and similar printed matter). Other.	65,756	60,531	125,790			
Pulps of fibres derived from recovered (waste and scrap) paper or paperboard.	19,115	18,539	15,736	6,351	3,096	4,795
Recovered (waste and scrap) paper or paperboard. Of other paper or paperboard made mainly of bleached chemical pulp not coloured in the mass.				77,254	97,177	68,958
Recovered (waste and scrap) paper or paperboard. Of paper or paperboard made mainly of mechanical pulp. Other.				60,584	33,093	13,934
Recovered (waste and scrap) paper or paperboard. Of paper or paperboard made mainly of mechanical pulp. Newsprint.				460,874	620,965	298,287
Recovered (waste and scrap) paper or paperboard. Of unbleached kraft paper or paperboard or of corrugated paper or paperboard.				1,031,350	893,139	816,680
Recovered (waste and scrap) paper or paperboard. Other including unsorted waste and scrap.				948,040	879,388	797,731
Recovered (waste and scrap) paper or paperboard. Other including unsorted waste and scrap.	203,859	226,037	346,499			
Waste and scrap of paper or paperboard. Of unbleached kraft paper or paperboard or of corrugated paper or paperboard.	257,117	319,947	730,715			
Total Recycled Paper Imports and Exports By Year	**782,635**	**818,238**	**1,413,435**	**2,584,453**	**2,526,858**	**2,000,385**

3.4 Summary of Paper Recycling Data

Data on paper recycling amounts in Canada have been compiled from different sources for different years. Even though it is a somewhat an “apples and oranges” analysis, a mass balance has been developed to get a sense of the amounts of scrap paper and recycled paper utilization that might be involved, using different years of data, but assuming the values will be similar in some cases in 2018. Updating these figures to a 2018 baseline is noted for further research in Section 15.

Recognizing that imports, exports and utilization change significantly from one year to another, the various sources have been combined to create an approximate 2018 mass balance which can be updated by NRCan as more quantity data are assembled and clarified. The values used for the 2018 mass balance presented in Figure 1 are discussed below.

- 3.57 million tonnes (rounded to 3.6 million tonnes) of paper are recycled in Canada (WMIS, 2016). This does not capture direct business to business paper recycling.
- PPPC indicate that 4.2 million tonnes of paper were recycled in 2014 (the most recent year for which data are available). It was assumed for the 2018 mass balance calculations that this amount was the total paper collected and processed for recycling within Canada in 2018 in order to create the Figure 1 mass balance.
- The difference between 4.2 million tonnes reported by PPPC for 2014 and 3.6 million tonnes reported by WMIS (about 0.6 million tonnes) could be direct business to business paper recycling (quantifying this amount is identified as a data gap in Section 15).
- A reported 2.0 million tonnes of recycled paper were exported from Canada to markets in the US and overseas in 2018.
- If the 4.2 million tonne figure from PPEC is considered a good baseline for the 2018 mass balance (as it is recognized that the 2016 WMIS survey includes some of the same sources), subtracting exports from the total collected leaves 2.2 million tonnes (of the original 4.2 million tonnes) available for use in Canada in 2018.
- A reported 1.4 million tonnes of recycled paper were imported to Canada in 2018.
- PPPC reports that 2.745 million tonnes (rounded to 2.7 million tonnes) of recycled paper were used in Canadian mills (packaging as well as non-packaging) in 2014.
- PPEC reports that 2.1 million tonnes of packaging made from recycled paper were shipped by Canadian packaging mills in 2018. The amount of recycled paper required to make this amount of packaging is estimated at 2.3 million tonnes to account for 10% process residues.
- The amount of scrap paper used by non-packaging mills (producing printed papers) in 2018 has not been identified to date and is identified as a data gap in Section 15.

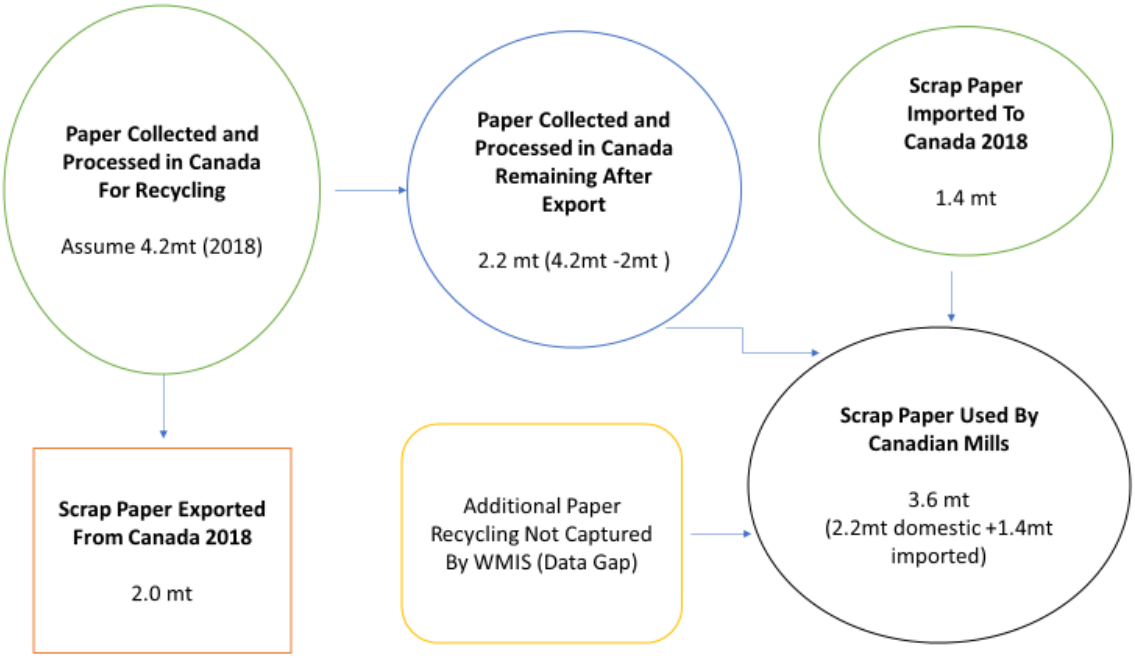


Figure 1: Preliminary Flow Chart for Recycled Paper in Canada (2018)

Figure 1 presents a preliminary schematic of the flow of recycled paper in Canada in 2018 based on the information collected in this section. While the export and import data are for 2018, other values have been estimated based on various assumptions and sources discussed earlier in this section. The figure shows an estimated 3.6 million tonnes of scrap paper being used in Canadian mills in 2018 based on a mass balance which uses a baseline of 4.2

million tonnes of scrap paper collected and processed in Canada. All of these numbers need to be verified through additional research.

4 Scrap Metals (Ferrous and Non-Ferrous)

This section addresses the recycling of metals in Canada including ferrous metals (steel, based on iron) and non-ferrous metals such as copper, aluminum, zinc and lead. Of these metals, scrap steel accounts for by far the highest amount of metal recycled. There is a robust secondary lead business in Canada, and smaller amounts of scrap copper, zinc and aluminum are used in Canada. A report prepared for NRCan by Resourceful Paths (2018) indicated that with the rise of Chinese smelting and refining capacity, many copper, zinc and nickel operations in Canada face a somewhat uncertain future which has led to consolidation, closing of some mines, smelters and refiners, and the relocation of some recycling operations (e.g. copper) to countries where the parent company is located.

4.1 Scrap Steel

The steel industry is a large industry in Canada and uses as much secondary (scrap) steel as possible since it has a number of benefits, including lower energy requirements. Some steel facilities with EAF (electric arc furnaces) operate on 100% recycled steel feedstock from auto hulks and building materials supplied by metal shredders (described in Section 10). Depending on design and operating procedures, basic oxygen furnaces (BOF) can also use scrap steel (see www.steel.org).

The Canadian Steel Producers Association (CSPA) represents 10 companies with 13 facility locations across Canada, shown in Table 5.

Table 5: Steelmaking Facilities in Canada (2020)

Company Name	Location of Steelmaking Facilities	Brief Description
Algoma Steel	Sault Ste Marie, ON	Integrated mill (blast furnaces and BOF furnaces)*
AltaSteel	Edmonton, AB	EAF mill
ArcelorMittal Dofasco	Hamilton, ON	Integrated (blast furnaces and BOF furnace) and EAF mill
ArcelorMittal Long Products Canada	Contrecoeur, QC	DRI (Direct Reduced Iron) with EAF mill
Evraz	Regina, SK	EAF mill
Gerdau	Selkirk, MB; Whitby & Cambridge, ON	EAF mills
Ivaco	L'Orignal, ON	EAF mill
Rio Tinto Fer et Titane (RTFT)	Sorel-Tracy, QC	Iron/titanium production and BOF furnace
Stelco	Hamilton & Nanticoke, ON	Integrated mill (blast furnace and BOF furnaces)
Tenaris	Sault Ste Marie, ON	Tube mill

The CSPA companies represent all carbon steel production in Canada. A survey of CSPA members was carried out by CSPA staff in support of this project and results of the survey are used in this section to identify the flow of scrap steel in Canada.

The Canadian steel industry produced 13.6 million tonnes of steel in 2018. A reported 4.8 million tonnes of purchased scrap was used in addition to 1.9 million tonnes of internally generated scrap for a total of 6.7 million tonnes of scrap steel. The purchased steel scrap includes scrap from the steel industries downstream customers such as fabricators and manufacturers, as well as ferrous scrap recovered from end-of-life products (see Section 10 for a description of metal shredders and auto hulk processing). Internally generated steel scrap is generated in primary operations (e.g. steelmaking) or in finishing operations (e.g. hot or cold rolling).

Table 6 shows imports and exports of steel scrap to and from Canada for 2016 to 2018 obtained from the TRAGS database by NRCan staff. The table shows that amount of steel scrap exported from Canada has varied from a low of 3.6 million tonnes in 2016 to 5.1 million tonnes in 2018, with most of the exported steel going to the US. Imported scrap steel amounts of increased steadily from 1.8 million tonnes in 2016 to 3.3 million tonnes in 2018. As with other commodities the import and export of scrap steel is related to the location of facilities which use the scrap steel as feedstock. In some parts of the country, it is more cost efficient to import scrap steel from the US rather than transport it across Canada.

Table 6: Canadian Imports and Exports of Scrap Steel, 2016 to 2018 (tonnes)

EXPORTS	2016	2017	2018
US	2,799,002	3,173,338	3,561,268
Other Countries	834,328	1,328,590	1,565,611
Total	**3,633,330**	**4,501,928**	**5,126,879**
IMPORTS			
US	1,841,825	2,255,553	3,330,099
Other Countries	5,367	9,681	9,968
Total	**1,847,192**	**2,265,234**	**3,340,067**

Information on metals (both ferrous and non-ferrous) recycled as reported through the 2016 Statistics Canada WMIS as well as in most recently available EPR and deposit-return program reports is summarized in Appendix C.

Figure 2 presents a flow chart for scrap steel in Canada based on information provided by CSPA as well as import and export data provided by NRCan.

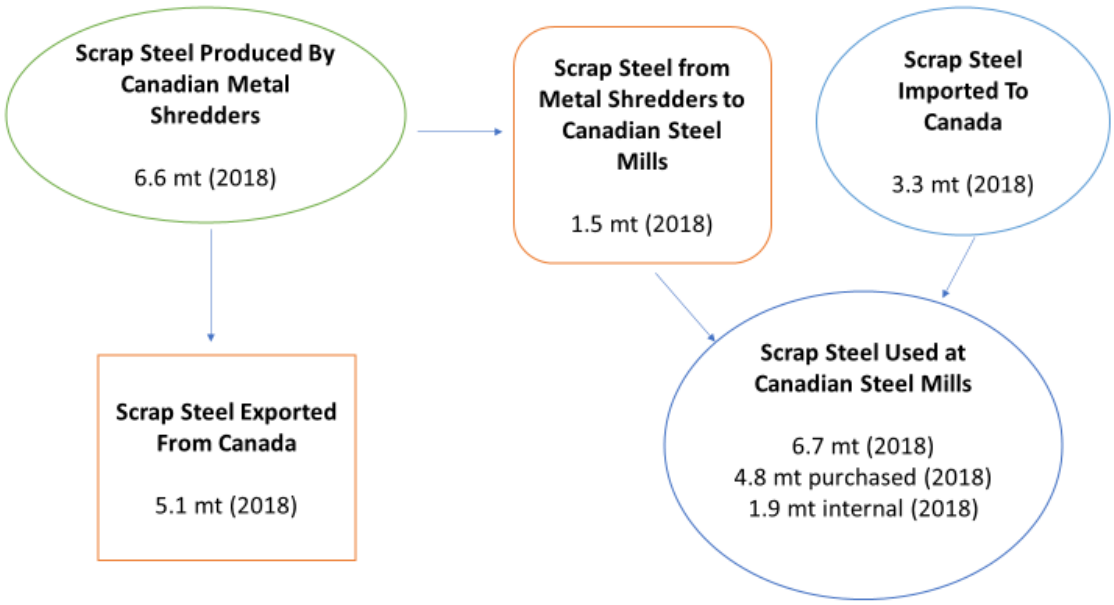


Figure 2: Flow of Scrap Steel in Canada (2018)

The estimated amount of scrap steel produced by metal shredders is based on the following assumptions (all figures for 2018):

- Canadian steel mills purchased 4.8 million tonnes (mt in the figure) of scrap steel;
- A reported 3.3 million tonnes of scrap steel were imported, therefore 1.5 million tonnes of scrap steel came from domestic sources - Canadian metal shredders (to make up 4.8 million tonnes);
- A reported 5.1 million tonnes of scrap steel were exported from Canada in 2018;
- Total Canadian production of scrap steel was therefore estimated at 6.6 million tonnes (1.5 million tonnes sent to Canadian steel mills and 5.1 million tonnes exported).

4.2 Scrap Lead

The NRCan website reports that 129,508 tonnes of secondary lead metal (from recycled lead) was produced in Canada in 2018, down slightly from 151,921 tonnes in 2017 (NRCan website Lead Facts). Table 7 presents data on export and import of lead to and from Canada. The amounts of scrap lead exported and imported are modest, ranging from exports of about 1,450 to 4,480 tonnes and imports ranging from 5,035 to about 5,600 tonnes for the years 2016 and 2018 respectively. These values indicate that most of the scrap lead used in Canadian facilities is sourced domestically.

Table 7: Canadian Imports and Exports of Scrap Lead, 2016 to 2018 (tonnes)

EXPORTS	2016	2017	2018
US	503	610	586
Other Countries	946	1,568	3,895
Total	1,449	2,178	4,480
IMPORTS			
US	4,984	3,666	5,328
Other Countries	50	75	265
Total	5,035	3,741	5,592

Figure 3 shows the amount of primary and secondary lead used in Canadian lead smelting operations from 2008 to 2018. The table shows that in the years 2008 to 2018 the total amount of primary and secondary lead combined as remained between 250,000 to 270,000 tonnes/year. Of this total, between 100,000 and 130,000 tonnes/year are from primary sources and 130,000 to 150,000 tonnes are from secondary (recycled) sources.

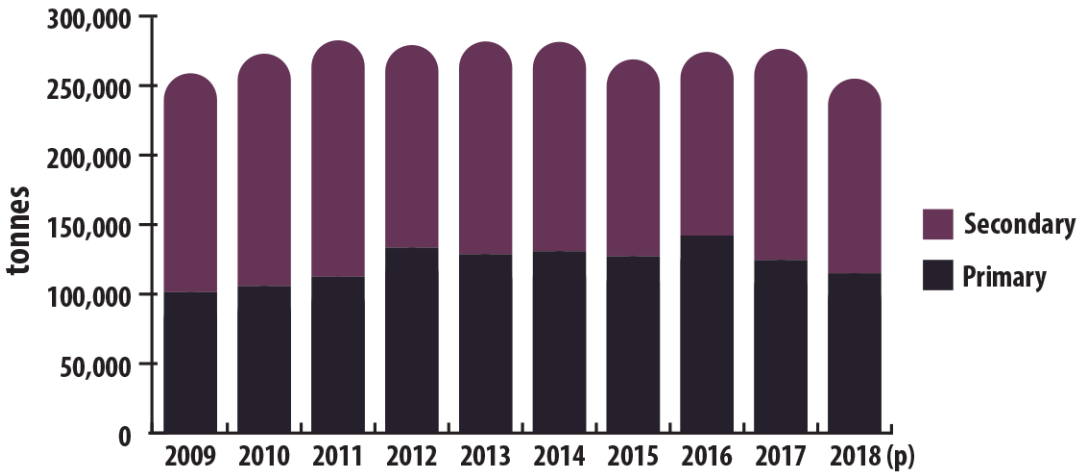


Figure 3: Primary and Recycled Lead Used in Canadian Lead Smelters 2008-2017[6]

The recycling process for lead acid batteries is discussed in more detail in Section 12.

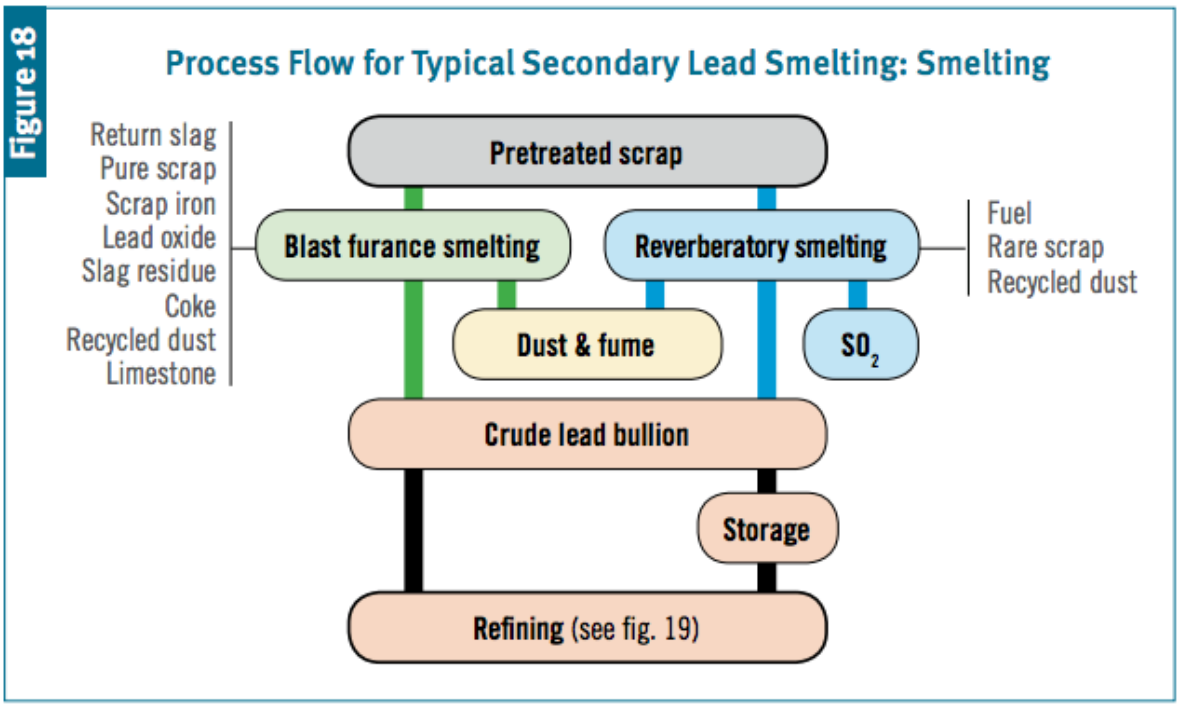
[6] Natural Resources Canada website. "Lead facts."

In Canada, the lead recycling industry is very consolidated. There are currently five secondary lead processing plants: one in BC, one in Ontario, and three in Quebec. Most or all of these smelters also have refining operations on site. In addition, secondary lead is processed at three primary smelters, one in BC and two in New Brunswick. Table 8 shows the secondary lead smelters in Canada.

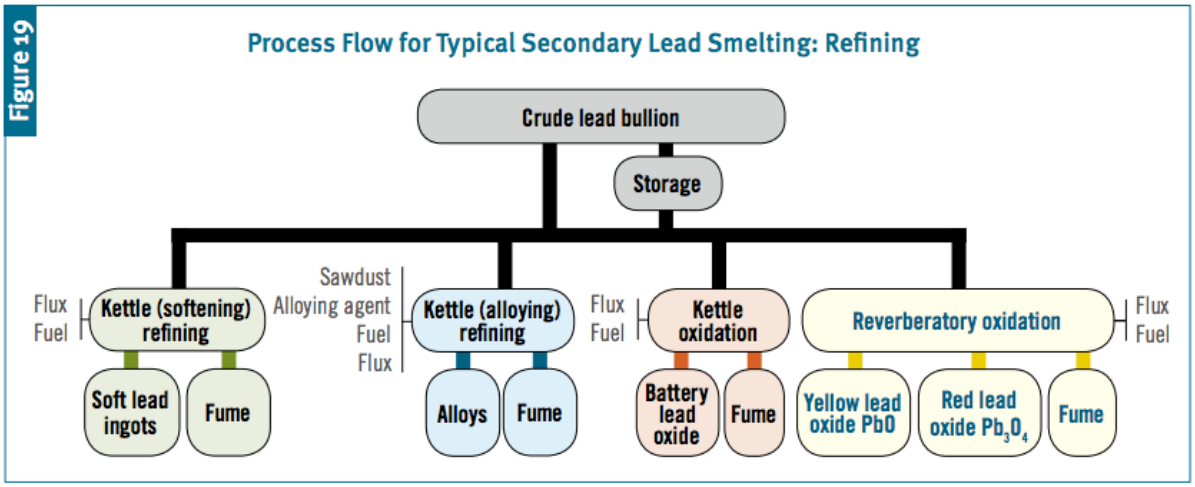
Table 8: Secondary Lead Smelters in Canada (CEC, 2016)

Facility Name	Location	Description
Metalex Products Ltd.	Richmond, BC	All other miscellaneous manufacturing
Teck Trail Operations	Trail, BC	Non-ferrous metal (except aluminum) smelting and refining
K.C. Recycling Ltd.	Trail, BC	Collector and battery breaker
Tonolli	Mississauga, ON	Non-ferrous metal rolling, drawing, extruding, and alloying
Newalta	Ste-Catherine, QC	Non-ferrous metal foundries
Glencore – Brunswick Smelter	Belledune, NB	Non-ferrous metal (except aluminum) smelting and refining . Closed end of 2019.

The process flow diagrams for typical secondary lead smelting and refining operations are presented in Figure 4. The smelting figure shows how the operation starts with pre-treated lead scrap (the lead acid battery specific process is described in more detail in Section 12).



Source: Adapted from US Environmental Protection Agency. 1995. *Compilation of air pollutant emission factors. Volume 1: Stationary Point and Area Sources.* Fifth Edition. Chapter 12: Metallurgical Industry. <www.epa.gov/ttn/chief/ap42/ch12/final/c12s11_2010.pdf>



Source: Adapted from US Environmental Protection Agency. 1995. *Compilation of air pollutant emission factors, Volume 1: Stationary point and area sources.* Fifth Ed. Chapter 12: Metallurgical Industry. <www.epa.gov/ttn/chief/ap42/ch12/final/c12s11_2010.pdf>.

Figure 4: Typical Flow of Materials Though Secondary Lead Smelting Operations (CEC, 2016)

4.3 Scrap Aluminum

Aluminum is used in a variety of applications and sectors, including construction, the electrical and electronics industries, packaging (e.g. for beverage containers), and the automotive and transportation industry. Construction and demolition waste as well as wastes from various industrial sources are significant sources of scrap aluminum. Aluminum is also recycled through municipal curbside recycling programs which collect items like beverage cans, aluminum baking trays, and pie pans. Aluminum beverage cans are also recycled through deposit return systems which are in place in most provinces.

Because of its very high value, scrap aluminum is recovered for recycling wherever feasible, and various scrap metal brokers and collectors will collect bins containing aluminum from businesses across Canada.

Recycling of aluminum has many benefits. The Aluminum Association (based in the US) states that secondary aluminum production saves more than 90% of the energy and generates just 8% of the greenhouse gas emissions (GHGs) associated with primary aluminum production. More than 90% of aluminum used in the automotive and construction sectors is recycled[7]and aluminum cans contain an average of 73% recycled content. (The Aluminum Association).

The NRCan website states that there are currently 10 primary aluminum smelters in Canada (one in BC, the other nine in Quebec). In fact, there are actually nine because Rio Tinto merged two sites (Arvida and AP60). There is also one alumina refinery, located in Saguenay, Quebec (NRCan website Aluminum Facts). The location and estimated annual processing capacities of these facilities are shown in Figure 5. To help inform the research for this report, discussions were initiated by NRCan with the Aluminium Association of Canada (AAC) which represents primary producers of aluminum (Alcoa, Rio Tinto and Alouette). The AAC confirmed that the primary producers do not use aluminum scrap purchased from outside sources. They only re-melt their own process residuals (such as rejected cast outputs, offcuts from products, etc.).

[7] Natural Resources Canada website "Aluminum Facts"

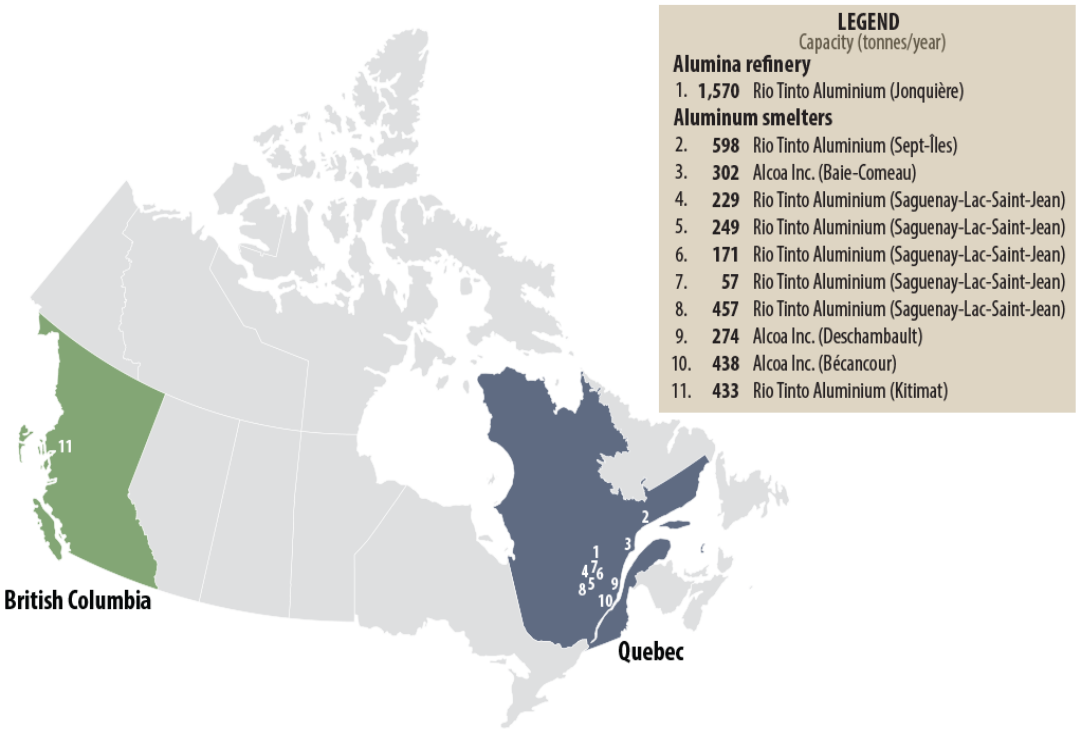


Figure 5: Aluminum Smelter and Refinery Location and Capacity in Canada[8]

AluQuebec, the Quebec cluster which has an inventory of 49 businesses working in secondary aluminum processing might absorb some aluminum scrap (NRCan website "Aluminum Facts"). No information is available at this time so the extent to which aluminum scrap is absorbed by this sector is an information gap and included in Section 15.

Export and import trade in aluminum for Canada are presented in Table 9 which shows that 553,400 tonnes of aluminum scrap were exported by Canada to the US and other countries in 2018, and that exports of aluminum scrap from Canada were over 500,000 tonnes in each of the last three years. The exported aluminum is collected and processed in Canada for recycling but end markets were located mostly in the US, some in China and to a small extent in other countries. The table also shows that over 100,000 tonnes of aluminum scrap have been imported to Canada each year from 2016 to 2018. This scrap aluminum is incorporated into manufacturing in Canada. The amount of scrap aluminum which is collected and processed domestically in Canada and used in Canadian operations is not known and is identified as an information gap in Section 15 of this report.

[8] Natural Resources Canada website . "Aluminum Facts."

Table 9: Canadian Imports and Exports of Scrap Aluminum, 2016 to 2018 (tonnes)

EXPORTS	2016	2017	2018
US	360,319	371,881	382,434
China	101,751	129,984	117,334
Other countries	39,618	40,913	53,650
Total	**501,688**	**542,779**	**553,417**
IMPORTS			
US	112,798	109,609	102,398
China	37	1	9
Other countries	3,852	5,699	2,505
Total	**116,687**	**115,309**	**104,911**

Aluminum cans collected in BC's deposit program were sold and shipped to re-melt Novelis facilities in Kentucky or New York (United States) and turned back into sheet stock for new cans (Encorp Pacific, 2018). Those collected in Alberta's beverage container program are sent to Novelis and Schupan Recycling in Indiana or Michigan (Alberta Beverage Container Recycling Corporation, 2018).

AAC and AluQuébec are researching aluminum scrap metal flow and identifying the players involved. AAC confirmed in communications with NRCan staff as part of the project research that the majority of Canadian aluminum scrap is sent to large re-melting operations in the US as there are limited casting centres in Canada. ACC anticipate a continuing trend towards more secondary aluminum processing capacity in the US, which has almost no primary aluminum production.[9]

Appendix D summarizes the data for aluminum recycled in Canada in 2018, or the latest year for which data was available for EPR and deposit return programs, which collect large numbers of aluminum beverage containers. Also included in the Appendix D table are data from the 2016 StatsCan WMIS, which shows the aluminum and copper diverted from both the residential and non-residential sectors as a combined figure of 88,575 tonnes, most of which is assumed to be aluminum.

An estimated 73,500 tonnes of aluminum were collected through beverage container deposit programs in Canada in 2016. Verifying the amount of other scrap aluminum used in Canada is identified as an information gap for further study.

4.4 Scrap Copper

Copper is one of the few materials that do not degrade or lose their chemical or physical properties in the recycling process. In 2014, the International Copper Study Group estimated that more than 30% of the world's copper consumption came from recycled copper. Canada has an established copper recycling industry, recovering much of it in the Quebec-based smelter in Rouyn-Noranda and in the refinery located Montreal (NRCan website "Copper Facts").

Exports and imports of copper scrap for 2016 to 2018 obtained from the TRAGS database are presented in Table 10.

[9] E-mail communication with Anik Dubuc, AAC, 6th March, 2020

Table 10: Canadian Imports and Exports of Scrap Copper, 2016 to 2018

EXPORTS	2016	2017	2018
US	65,492	100,855	88,941
China	79,295	70,585	37,921
Other Countries	16,261	13,819	35,952
Total	**161,048**	**185,259**	**162,814**
IMPORTS			
US	75,131	93,591	103,412
China	46	25	25
Other Countries	1,744	7,140	6,284
Total	**76,921**	**100,757**	**109,720**

Exports of scrap copper from Canada varied from 161,048 tonnes in 2016 to 162,814 tonnes in 2018, with a higher export value of 185,259 tonnes in 2017. Imports of scrap copper were 76,921 tonnes in 2016 and 100,757 tonnes in 2017. Imports totalled 109,720 tonnes in 2018, the year used for the baseline of this study.

In 2018, refined copper production was 304,000 tonnes in Canada. Based on a recycled content rate of about 30% in the refined product, an estimated 101,000 tonnes of recycled copper would have been used by Canadian operations. Given that 109,720 tonnes of scrap copper were imported to Canada in 2018, at least this amount, and possibly an additional amount source domestically was used in copper production in 2018. The total amount of scrap copper used from domestic sources is an information gap identified in the study research.

The Horne Smelter in Rouyn-Noranda is a custom copper smelter which uses both copper concentrates and precious metal-bearing recyclable materials as its feedstock to produce a 99.1% copper anode. The anode is sent to the Canadian Copper Refinery (the only copper refinery in Canada) in Montreal, Quebec where it is converted into 99.99% copper cathodes which are sold to end-markets globally. The Horne smelter has a total reported processing capacity of 840,000 tonnes/year (Glencore). Glencore's website states that the Horne Smelter in Rouyn-Noranda is now the only copper smelter in Canada, because in 2015-18 Vale's Copper Cliff Sudbury smelter was converted to process nickel concentrate.

Vale's Copper Cliff Smelter in Sudbury, Ontario used to produce 95,000 tonnes/year of nickel, copper and cobalt in matte. The smelted and granulated matte used to be transported by rail to Québec City, then shipped overseas to Nikkelverk in Norway for refining into pure metals (Sudbury Integrated Nickel Operations). No data could be found through the study research on the tonnes of scrap copper used at this facility, although it may have stopped accepting scrap copper completely due to its conversion to a nickel facility.

The 2016 WMIS combines tonnes of copper and aluminum recycled into one figure: 88,575 tonnes in 2016. The copper in this total is expected to be minor and would come mainly from building materials (copper pipes and fittings). The percentage of the total that is copper is not known.

Stewardship Ontario reported 25,595 tonnes of scrap metal collected by municipalities in the Province in 2018. A very small amount of this total could be copper piping from construction and demolition projects but no information is available with which to refine this estimate.

Identifying the amount of scrap copper produced and recycled in Canada is identified as a research gap in this study.

4.5 Scrap Zinc

In 2018, mined zinc production in Canada totaled 266,600 tonnes. About 37% of this was mined in Manitoba, followed by Quebec (28%), Ontario (23%), and New Brunswick (11%). Canada's refined production of zinc in 2018 was 695,566 tonnes (Natural Resources Canada Zinc Facts).

Table 11 presents information on Canadian imports and exports of scrap zinc for the years 2016-2018.

Table 11: Canadian Imports and Exports of Scrap Zinc, 2016 to 2018

EXPORTS	2016	2017	2018
US	7,795	7,684	8,381
Other Countries	3,909	2,289	2,306
Total	11,704	9,973	10,687
IMPORTS			
US	212	146	254
Other Countries	1	0	0
Total	213	146	254

On a global scale, over 60% of zinc produced each year goes to protecting steel from rust and corrosion through galvanizing. About 17% of it goes into die casting, and another 9% is used in brass (International Zinc Association, 2017). The remainder goes into other manufacturing uses, such as zinc sheet in buildings and chemical compounds such as Zinc Oxide, used in fertilizers, paint, rubber and pharmaceuticals (and notably zinc used in these ways is not recoverable). Where zinc is used in applications with long effective lifetimes, such as galvanizing and rolled zinc, these products may stay in service up to 100 years.

Globally, the International Zinc Association (IZA) estimates that 45% of available zinc at the end-of-life is recovered and recycled. For developed regions like North America, the recycling rates are much higher, and in some cases can exceed 95% for products such as zinc sheet roofing and brass.

At the end of its useful life, zinc can be recycled without deteriorating. Approximately 25%-30% of global zinc is reported to be supplied from recycled materials. The 25% is value is from the NRCan website while the 30% was taken from a report by IZA.

On the basis of production of 651,584 tonnes of zinc products and 25% to 35% coming from zinc scrap (the lower 25% value is used for this study), and if Canada had similar rates to the global average, an estimated 162,900 tonnes of zinc scrap would be recycled in Canada. However, there is a limited zinc-based industry in Canada and many zinc operations have closed in the last 20 years (Resourceful Paths, 2018). Zinc containing products are collected and processed based on scrap availability, metal composition (e.g. purity, alloy, etc.) and ease of processing (International Zinc Association. 2015). Zinc can be recycled from scrap generated from galvanized steel production, waste materials generated during manufacture and installation, and waste from end-products such as batteries.

4.6 Scrap Nickel

NRCan reports that Canada produced an estimated 180,000 tonnes of nickel in concentrate from mines located in Newfoundland and Labrador, Quebec, Ontario, and Manitoba, as well as 133,200 tonnes of refined nickel at four refineries located in Fort Saskatchewan, Alberta; Thompson, Manitoba; Sudbury, Ontario, and Long Harbour, Newfoundland. In terms of trade, Canada exported 115,000 tonnes of unwrought nickel in 2018, valued at $2.1 billion (NRCan website "Nickel Facts").

The Nickel Institute estimates that around 68% of all nickel available from consumer products is recycled (up from 63% in 2000); another 15% enters the carbon steel loop. Around 17% ends up in landfill, mainly in metal goods and in e-waste.

A Nickel Institute study (2002) estimates that globally about 35% of nickel is made from recycled feedstock. On the basis that Canada produces 133,200 tonnes of refined nickel, and assuming the global average 35% value, an estimated 46,600 tonnes of recycled nickel could be used in Canadian nickel operations.

Exports and imports of scrap nickel for 2016 to 2018 from the TRAGS database are presented in Table 12.

Table 12: Canadian Exports and Imports of Scrap Nickel, 2016 to 2018 (tonnes)

EXPORTS	2016	2017	2018
US	6,150	8,300	9,413
Other Countries	238	164	169
Total	6,387	8,464	9,581
IMPORTS			
US	20,300	24,004	27,145
Other Countries	1,204	2,630	1,897
Total	21,504	26,634	29,041

The number should be verified in the future through additional studies, rather than applying global averages to annual production, which generates a preliminary estimate for this study.

4.7 Scrap Metal Summary

Table 13 summarizes available data on the amount of scrap metal recycling in Canada. The activity is a combination of:

- Scrap metal collected in Canada and used within Canada in manufacturing activities;
- Scrap metal imported to Canada and incorporated into manufacturing in Canada; and,
- Scrap metal collected in Canada and exported.

In some cases, specifically for copper, zinc and nickel, sufficient information could not be found during the study research to develop reliable estimates. Applying global values to Canadian industry production resulted in values which were not considered reliable. Therefore for these three metals in particular only imported values for these metals are included in the total recycled until a more reliable estimate can be developed through a survey.

Table 13: Summary of Metals Recycling Information for Canada in 2018 (tonnes)

Metal	Exports	Imports	Used for manufacturing in Canada	Comments
Iron and Steel	5,126,879	3,340,067	6,700,000	CSDA Member survey March, 2020 4,800,000 purchased and 1,900,000 internal scrap
Aluminum	553,417	104,911	104,911	Based on imports only and excludes domestically recycled scrap. Actual likely higher
Copper	162,814	109,720	109,720	Based on imports only and excludes domestically recycled scrap. Actual likely higher
Lead	4,480	5,592	129,508	NRCan value
Zinc	10,687	254	254	Based on imports only and excludes domestically recycled scrap. Actual likely higher
Nickel	9,581	29,041	29,041	Based on imports only and excludes domestically recycled scrap. Actual likely higher
Total	5,867,858	3,589,585	7,073,434	

5 Glass

Table 14 summarizes data on tonnes of glass collected for recycling in Canada in 2018, or the most recent year for which data was available. This includes glass collected through beverage container deposit return programs and printed paper and packaging (PPP) EPR programs. Also included in the table are data from the 2016 WMIS, which includes total tonnes of glass recycled from both residential and non-residential sources.

Table 14: Glass Recycled in Canada (2016 and 2018) (tonnes)

Province	Source	EPR (tonnes)	Deposit Return Program (tonnes)	WMIS (2016) (tonnes)
British Columbia	Recycle BC (2018)	15,162		
	Encorp Pacific (2018)		77,520	
	WMIS (2016)			113,955
Alberta	Alberta Beverage Container Recycling Corporation (2018)		55,819	
	WMIS (2016)			N/A
Saskatchewan	Multi Material Stewardship Western (2018)	N/A		
	Deposit Program (2018)		N/A	
	WMIS (2016)			N/A
Manitoba	Multi Material Stewardship Manitoba (2018	12,433		
	WMIS (2016)			8,435
Ontario	Stewardship Ontario 2020 Pay In Model (PIM) (2018)	78,076		
	The Beer Store (2018)		149,886	
	WMIS (2016)			120,076
Quebec	Recyc Quebec (2018-2019)	N/A		
	Recyc Quebec (2018-2019)		22,262	
	WMIS (2016)			55,000
PEI	WMIS (2016)			223
Nova Scotia	WMIS (2016)			3,264
Newfoundland	Deposit Program (2018-19)[10]		2,778	
	WMIS (2016)			N/A
Northwest Territories	Deposit Program (2018-19)		868[11]	
Northwest Territories, Yukon, and Nunavut	WMIS (2016)			648
Total For Canada	WMIS (2016)	**105,671**	**309,133**	**379,960**

The 2016 WMIS states that 379,960 tonnes of glass were recycled in Canada in 2016.

Research for this study identified that 309,133 tonnes were recycled by deposit return programs and 105,671 tonnes were recycled through EPR programs. Statistics Canada staff confirmed that glass tonnes from some, but not all deposit return programs are included in the WMIS. It is likely that the EPR program glass is included in the WMIS data as the programs have municipal involvement. Deposit-return systems are run by separate entities only some of which provide data to WMIS. Given the lack of specific data for Alberta and Saskatchewan, and the lack of detail on which EPR and deposit return glass is counted in WMIS, the amount of glass recycled could be as high as 794,764 tonnes if not double counting takes place between EPR, deposit return and WMIS data. A value of 200,000 tonnes of additional glass from deposit systems was used in this study, as it was considered reasonable that significant

[10] Personal communication with Gordon Wall, Multi-Material Stewardship Board.
[11] 338 tonnes refillable glass (ISB); 510 tonnes non-refillable

amounts of glass are collected in deposit refund systems and are not captured in the WMIS survey. Clarifying the potential for double counting glass is identified as a research need in Section 15.

Glass bottle manufacturing plants are only in Ontario and Quebec, with other forms of recycling found in Western Canada (reflective paint additives and fiberglass insulation manufacturers) (Ackerman et al 2018).

Examples of how glass is managed after collection are listed below (and are subject to change):

- Glass collected through the Recycle BC program is shipped to Abbotsford to be processed into new bottles and to Quesnel to be made into sandblast materials;
- Glass containers collected via the deposit program in BC were processed in BC and shipped to
    - a manufacturing plant that produces fiberglass insulation in Alberta;
    - a facility that produces new glass bottles in Seattle, USA;
    - a facility that manufactures sandblasting materials in Quesnel, BC; and
    - municipal sites that use crushed glass as an aggregate substitute.
- Glass bottles recovered in Alberta's deposit return program are sent to Vitreous Glass where they are used in the manufacture of fiberglass. Approximately 95% of the glass is recycled with 5% including caps, corks and dust (Alberta Beverage Container Recycling Corporation, 2018)
- Clear cullet from the Prairie provinces (including 15,000 tonnes/year from SARCAN in Saskatchewan) is purchased by Potters Industries, a leading producer of engineered glass materials (Ackerman et al, 2018).
- Glass collected in Ontario's deposit return program
    - Non-standard refillable bottles are separated from Industry Standard Bottles and returned to their brewers for reuse.
    - Non-refillable glass bottles are crushed and used to make new glass.

Incorporating recycled glass into glass manufacturing is usually part of making containers because recycled cullet lowers the melting point of the entire batch, which can mean significant energy savings and reduced carbon footprint (Ackerman et al, 2018). However, because glass is a very heavy material, for many recycling programs the costs of shipping glass-to-glass plants is not worth it so glass is often used locally, often as an aggregate substitute. Other end-uses for collected glass can include alternate landfill cover, road base, and sandblast medium. Some is also landfilled with other waste.

6 Plastic

A comprehensive report on plastic waste was carried out for the federal government in 2019 (Deloitte and ChemInfo 2019) Key findings from the report are summarized in this section.

The report concluded that about 3.3 million tonnes of plastic waste are generated in Canada each year. The amount recycled varies by plastic use (e.g. packaging versus construction, etc.) with a 23% diversion rate identified for plastic packaging where about 1.5 million tonnes is produced and 347,000 tonnes are recycled. Table 15 shows 308,000 tonnes of automotive plastics diverted, but this value is adjusted to zero in a later table in the Deloitte report (presented as Table 16 in this report).

Table 15: Plastic Waste Diversion Rate in Canada Broken Down by Sector 2016 (Deloitte and Cheminfo, 2019)

Sector/Source	Plastics Discarded (Tonnes)	Diversion Rate (%)	Plastics Diverted (Tonnes)
Construction	175,000	11	19,000
Electronic and Electrical Equipment	214,000	16	34,000
Packaging	1,542,000	23	347,000
Textile	235,000	5	11,000
Automotive	309,000	100	308,000
White goods	130,000	64	83,000
Agriculture	45,000	9	4,000
Other plastics	617,000	-	-
Total for Canada	**3,268,000**	**25**	**807,000**

Table 16 presents the information from the Deloitte report in more detail and adds a “value recovery rate” to the plastic waste diversion analysis. Deloitte defines “value recovery rate” as the “share of plastic that is ultimately value recovered whether through chemical or mechanical recycling from diverted and disposed waste or through thermal recovery, divided by plastics in waste collected.” In Table 16, the total plastics recovered is identified as 442,000 tonnes, which is considered the number that should be used in this report.

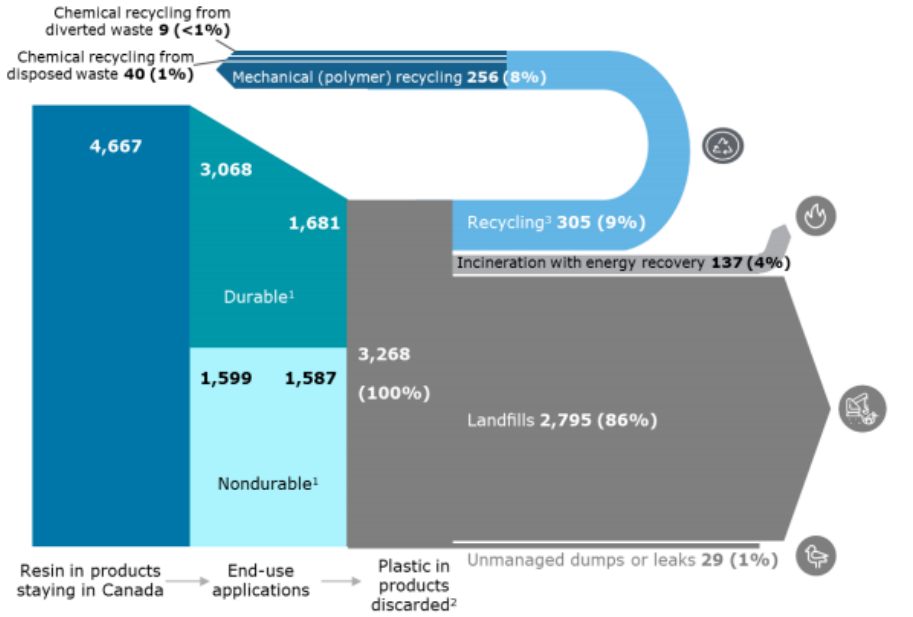
Table 16: Diversion Rate, Recycling Rate, and Value Recovery Rate by Source of Plastic Waste, 2016[12]

Sector/Source of Plastic Waste	Plastics Discarded (Tonnes)	Diversion Rate (%)	Recycling Rate (%)	Value Recovery Rate (%)	Plastics Recovered (Tonnes)
Packaging	1,542,000	23	15	21	327,000
Electronic and Electrical Equipment	214,000	16	13	15	33,000
Agriculture	45,000	9	5	10	5,000
Automotive	309,000	100	-	-	-
White goods	130,000	64	-	5	7,000
Construction	175,000	11	1	6	11,000
Textile	235,000	5	-	7	17,000
Other plastics	617,000	-	-	7	43,000
Total for Canada	**3,268,000**	**25**	**8**	**13**	**442,000**

Figure 6, which is taken directly from the 2019 Deloitte report, illustrates Canadian resin flows in 2016. As shown in the figure:

- An estimated 4.667 million tonnes of plastics were introduced to the market as both domestic and imported products.
- Of this total, 3.068 million tonnes were in durable products and 1.599 million tonnes were in non-durables.
- An estimated 3.268 million tonnes of plastics in products were discarded as waste in Canada.
- An estimated 9% of these plastics were recycled (mechanically or chemically) and 4% were sent for energy recovery.
- The remaining 2.795 million tonnes (86%) were sent to landfill or lost to the environment (unmanaged dumps or leaks estimated to be 1%).

[12] Deloitte and Cheminfo (2019)



[1] Durable applications with an average lifetime >1 year will end up as waste only in later years; given market growth and increase share of plastics in durable applications (e.g., construction, cars) plastics waste generated today is less than what is being put in the market that same year. On the contrary nondurable applications go almost straight to waste.

[2] 1,587 thousand metric tons of mixed plastic waste from nondurable applications plus 1,681 thousand metric tons of mixed plastic waste from production in previous years.

[3] Output recycling rate, after taking into account process losses.

Figure 6 Canadian Resin Flows (thousands of tonnes per year) 2016[13]

Other more detailed sources of plastics recycling efforts in Canada are presented in Appendix E, which summarizes data on tonnes of plastic collected for recycling in EPR and deposit return programs in Canada in 2018, or the most recent year for which data was available.

[13] Deloitte and Cheminfo (2019)

7 Food and Yard Waste

Organics (food and yard waste) make up about 35% to 40% (Environment Canada, 2013) of residential waste and 11% of industrial, commercial and institutional (IC&I) waste, although the organic content of waste from some IC&I establishments (e.g. restaurants) is much higher than 11%. There are a number of initiatives at both the provincial and municipal levels across Canada to increase organics diversion. For example:

- Nova Scotia and Prince Edward Island have implemented provincial level landfill and disposal bans for organic materials for both residential and IC&I sectors;
- Several municipalities (e.g. Metro Vancouver, Regional District of Nanaimo) have implemented disposal bans on organics targeting residential and/or IC&I sectors;
- The Ontario government is planning to initiate a ban on organic waste disposal in landfills starting in 2022, as noted in the province's *Food and Organic Waste Framework* that was released in 2017, and has also proposed recovery targets.
- Quebec's *Residual Materials Management Policy* plans to implement a similar organics disposal ban.

Diversion of organics has many benefits including conservation of landfill space, reduced acid generation in landfills (and metal precipitation in leachate), and conservation of organics that can be used as a soil amendment. The preservation of landfill space is especially relevant today as available space in existing landfills becomes increasingly scarce and as the process of siting new landfills becomes more challenging. Proper organic waste management can also play a significant role in the mitigation of greenhouse gas emissions because methane from the decomposition of organics in anaerobic landfills is avoided.

The Commission for Environmental Cooperation (CEC, 2017) report on organic waste management in Canada, the US and Mexico is the best (most recent) source of information currently available on organic waste diversion in Canada. The report estimated that there is potential for a reduction of up to 3.4 million metric tonnes of carbon dioxide equivalent ($MTCO_2e$) annually from organic waste diversion in Canada. Additional GHG benefits can be realized if the biogas produced from organic wastes is captured as a source of energy, as this displaces the need for fossil fuel energy sources, such as coal, oil and natural gas (Ontario Waste Management Association et al, 2015).

In addition to the environmental benefits, the diversion of organics away from disposal offers a number of economic benefits. Biogas production, for example, can generate a new revenue stream for farmers and municipalities, and create new jobs. A 2013 report by Kelleher Environmental for the Canadian Biogas Association (Kelleher et al, 2013) estimated that realizing the full potential of biogas development could lead to up to 1,800 separate construction projects with a capital investment of $7 billion and economic spin-off of $21 billion to the Canadian economy.

WMIS identifies that over 2.6 million tonnes of organic materials were diverted from disposal in Canada in 2016. Appendix F presents a breakdown by province and territory of organics (food and yard waste) collected and diverted across Canada. Note that WMIS data does not capture the following organic waste diversion activities:

- food and animal wastes used in rendering plants to make protein meals and fat products
- food wastes or other wastes sent to farms for use as animal feed or bedding
- agricultural waste (including livestock manure and offal) processed via land application or on-site anaerobic digestion

The 2017 CEC report states that there are more than 200 composting facilities processing municipal organics in Canada, of which eight are anaerobic digestion facilities. Table 17 presents information on the processing capacities of composting facilities in both Western and Eastern Canada. As shown in the table, Canada's composting facilities

have about 4.1 million tonnes of available approved processing capacity. They currently accept around 2.6 million tonnes annually, therefore 64% of the overall capacity was utilized in 2017.

Table 17: Organics Processing Capacities of Composting Facilities in Canada (Tonnes)[14]

	Western Canada	Eastern Canada	Total
Accepted	940,000	1,700,000	2,640,000
Capacity	1,800,000	2,300,000	4,100,000
Percentage	52%	74%	64%

Composting facilities may accept four different types of feedstock, including yard waste, residential source separated organics (SSO), IC&I organics, and biosolids from wastewater treatment plants. About 81% of the facilities accept yard waste, 35% accept SSO, 14% accept IC&I organics, and 15% accept biosolids.

Table 18: Feedstock Material Accepted at Compost Facilities in Canada[15]

Feedstock	Number of Facilities Accepting Feedstock	Percent of Total
Yard waste	166	81.4%
Residential SSO	72	35.3%
IC&I organics	28	13.7%
Biosolids	31	15.2%

Leaf and yard waste is generally composted, whereas food waste from residential and IC&I sources is typically processed in an anaerobic digester (AD). Unlike leaf and yard waste, which has low biogas yields, food waste generally produces 100 cubic meters of biogas per tonne processed. Biogas can be captured and used to generate electricity on-site, sold to utilities as renewable energy, converted to vehicle fuel, or treated to produce renewable natural gas (RNG). AD also has a much smaller footprint than composting facilities.

[14] Cant, M. 11 April 2018.
[15] Commission for Environmental Cooperation. 2017.

8 Lumber and Wood

8.1 Reuse and Recycling of Wood Wastes

Management options for wood waste include:

- Reuse;
- Recycling into other products such as mulch, animal bedding, etc. and
- Use as a biofuel.

Recycled wood has a lower moisture content than new wood (approximately 20% as compared to virgin wood at 60-70%) making it a better choice for certain applications as it is cheaper and no drying is required. The low moisture content makes recycled wood ideal for bio-fuel applications (hog fuel) where energy is created through the burning of wood fuel. Another advantage of a lower moisture content is that for the same weight of wood purchased less of the cost includes moisture. The lower moisture content of recycled wood also means higher durability.

Various uses of recycled wood include:

- The manufacture of chipboard, medium-density fibreboard (MDF) or OSB (Oriented Strand Board);
- Chipboard and fibreboard products are used in construction and furniture making (e.g. MDF kitchen cabinets);
- Chipped and/or shredded wood is used in the following applications:
  - composting operations where the wood provides a carbon source to maintain the correct carbon to nitrogen ratio for biological activity.
  - landscaping operations as mulch.
  - animal and poultry bedding.
  - forest trails, running tracks or other ground cover products.

The Canadian Wood Waste Recycling Business Group (CWWR) has identified three core business activities that support the growth of the Canadian wood recycling industry, which is part of the circular bioeconomy. These are:

- **Barn wood:** The business of reclaiming used wood into a barn wood inventory retail business platform. Inventory is sold as recycled renewable building products. There are about 80 barn wood business operations in Canada. Lumber is recovered from old structures, prepared by removing old fasteners, inventoried, priced and then retailed to the public. In some cases, reclaimed lumber is offered by big box retailers at premium prices over new material.
- **Remanufacturing:** The business of creating a remanufacturing business platform, using a small portable wood sawmill. This includes sawmilling, kiln drying, planning and/or milling the wood product and stocking an inventory of recycled, renewable building products.
- **Reprocessing:** The business of creating a small portable reprocessing business platform, using the process of grinding, screening and/or shredding used end-of-life wood, which is sold as recycled wood product for developing reuse markets.

Wood recovered in good condition from beams, window frames, doors, partitions, and other fittings can be reused. This wood is typically recovered through deconstruction activities, and requires no processing. Wood salvaged from deconstruction that is high quality has a good market value for special reuse (i.e. furniture, cabinets, and floorings).

The wood waste stream from Construction, Renovation & Demolition (CR&D) activities is highly variable in both quantity and quality. There are differences in the amount and composition of the wood in the demolition waste stream, with contaminated wood (e.g. painted, varnished, treated, containing cement) posing limitations for reuse and recycling. Other building materials (such as fasteners, drywall, insulation, etc.) as well as paint or chemical wood treatments such as chromated copper arsenate (CCA) for insect control and other preservatives are often present in the demolition wood waste stream.

Processing of wood waste from CR&D sites occurs across Canada in either stand-alone or integrated mixed CR&D processing operations.

Treated wood is generally separated from clean wood waste during the recycling stage, whether on site or at a processing facility. However, distinguishing clean wood from wood treated with wood preservatives or painted wood for separation is challenging.

Once the wood is separated from other CR&D materials, it is chipped into different sizes to meet market specifications for different buyers.

Each wood waste processor has its own criteria for accepting wood waste. Usually wood waste processors look for wood that is free of contaminants such as dirt, rock, concrete, plastic, metal, and other contaminants, which can damage wood waste processing equipment. Some processors will accept loads with contaminants, but charge a higher fee to cover the costs of separation.

Typically, wood that is recycled must be free of chemicals, including paint, stain, waterproofing, creosote, pentachlorophenol (PCP), petroleum distillates, and pressurizing treatments. Many processors will not accept wood with CCA treatment or lead paint. Separation of treated wood from clean wood relies on visual inspection at different points along the wood waste processing system. The most common method for identifying treated wood from clean wood is through colour, because CCA treated wood will have a green tint.

Examples of wood waste recyclers in Canada, and the end markets where wood waste is used:

- **Ecowaste (formerly Urban Wood Waste Recyclers in Vancouver)**: Metro Vancouver banned wood waste at disposal locations, which led to the development of a robust wood recycling industry. Ecowaste purchased Harvest Power's CR&D Wood Processing assets in December 2018. Prior to September 2019 the company processed clean CR&D wood through a temporary grinding operation. In September 2019 they commissioned a mini-MRF (a mechanical material recycling facility) with a capacity of 100,000 tonnes/year. Outputs include biofuel products for district and process energy customers. A future Phase III (full sized MRF) is planned to handle mixed CR&D waste loads with a capacity of 240,000 tonnes/year (Metro Vancouver, 2019).
- **Alberta Waste and Recycling, AB**: This company accepts a wide range of wood waste (e.g. includes pallets, construction lumber, plywood and laminated veneer lumber with no metal larger than nails, no treated lumber). Generators are charged a fee of $95/tonne to drop off the wood waste, which is chipped for use as feedstock for roofing material, landscaping chips and compost.
- **Biofuels Recycling Centre, AB:** This facility accepts, sorts and shreds wood waste into chips. The shredded wood waste is used as biofuel at the Dapp Power plant facility north of Westlock, AB. Other end uses include landscape mulch, animal bedding, and oilfield remediation. The by-product (wood ash) from the biofuel plant is used by local area landowners as a soil conditioner.

- **PSI Technologies Inc., SK***:* Based in Saskatchewan, this facility accepts and shreds wood waste to produce a mulch for landscaping and erosion control purposes.
- **CountryWide Recycling** outside Hamilton, Ontario accepts wood waste and its total capacity for all CR&D waste including wood is reportedly 800 tonnes/day.
- **Halifax C&D Recycling (HCD):** The majority of the wood products that HCD receives is clean wood, laminated wood and lightly painted/stained wood. Most of this material is processed, pre-ground and used to make animal bedding. The remainder of the clean wood products are sold to Brooklyn Energy in Liverpool, NS for use as hog fuel to produce steam and power. HCD also produces approximately 1,200 tonnes per year of wood that is ground to a specific sizing and then screened if necessary to provide bio filter for the local composting facilities run by Miller Waste and Otter Lake. Pressure treated, heavily painted and creosote wood is processed and ground to a 3" minus material and sent to Otter Lake Landfill where it is used as daily landfill cover material. This material is also used at HCD's Three Corners CR&D Landfill in Antrim for daily cover, berm building and road construction.

Lumber and wood wastes are generated from the following sources in Canada and are discussed in Sections 8.2, 8.3 and 8.4.

- Construction and demolition activities;
- Wood pallets (logistics/shippers); and,
- Forest product industry residuals.

8.2 Wood from Construction, Renovation and Demolition (CR&D) Projects

A detailed report on materials generated and recycled from construction, renovation and demolition (CR&D) activities in Canada was produced for Environment Canada (now Environment & Climate Change Canada or ECCC) in March, 2015 (Kelleher Environmental et al, 2015). The report was used by Canadian Council of Ministers of the Environment (CCME) for CR&D policy development but has not been released publicly. This is the most comprehensive assessment of CR&D waste management activities in Canada in recent times, but quantities may be slightly out of date as much of the work was carried out in 2014, using 2010 data.

The report estimated that CR&D sites across Canada generate about 1.3 million tonnes of wood waste annually. Of this total:

- About half (49%) was estimated to be clean wood, suitable for a number of uses;
- An estimated 23% was engineered wood;
- An estimated 20% was painted wood; and,
- An estimated 8% was wood treated with preservatives and other chemicals.

The report research estimated that about 283,000 tonnes of wood wastes were recycled from CR&D projects annually in Canada, so the remainder was presumably disposed.

The Ontario Resource Productivity and Recovery Authority (RPRA) reports that 52,963 tonnes of wood were collected by municipalities (likely at drop-off sites) in 2018. A similar level of data is not available for the other provinces.

8.3 Wood Waste from Pallets

There are over 80 wooden pallet recyclers in Canada,[16] and many CR&D processing facilities also accept wooden pallets for recycling. Examples include:

- **ECCO Recycling & Energy Corporation** are involved in wood pallet recycling and charge a tipping fee of $34.50/tonne.
- **Blue Planet Recycling** defines clean wood as solid wood, lumber or pallets that are unpainted, not stained, and free of glue. Composite woods (painted, MDF or laminates) are also accepted, but at a higher cost as these materials are more difficult to recycle. Clean wood is first ground in a mulching machine and all metals are removed. The shredded wood is then recycled into items such as landscape mulch, hog fuel, compost or raw material for wood products.

In 2011, an estimated 47.4 million wooden pallets were recovered in Canada. Of these, 32.6 million were returned to service as pallets. The remaining 14.8 million pallets were recycled[17].

The Canadian Wood Pallet & Container Association (CWPCA) reports that the 48 inch by 40 inch pallet is the dominant size of pallet in the market,[18] and the weight of this size of pallet is reported at 33-48 lbs.[19] An average weight of 40.5 lbs (18.4 kg) was applied to 14.8 million pallets recycled to estimate recycling of 272,000 tonnes of wood waste by the Canadian wood pallet industry.

8.4 Mill Residues from the Forest Products Industry

A report by the Standing Committee on Natural Resources – *Value Added Products in Canada's Forest Sector* dated May, 2018 indicates that the forest sector generated 12 million cubic metres of wood residue and it was used primarily to generate low carbon electricity. Assuming a density of wood at the low end of the range of 170-300 kg/m^3, an estimated 2 million tonnes of wood residue are used for energy production annually in Canada.

A report prepared for NRCan in March 2017 identified 364 bioheat facilities across Canada (Torchlight Bioresources, 2017). Of this total, 75 were small (between 50-149 kW). A reported 70% were < 1MW. The report noted that wood pellets and wood chips dominate this market. Locations of these facilities are presented in Figure 7 (taken directly from the Torchlight report). Management of ash from bioheat facilities is discussed in Section 14 of this report.

[16] Naturespackaging.org
[17] https://www.garbagebinrentals.ca
[18] https://cdn.ymaws.com/www.palletcentral.com/resource/resmgr/interpal/cwpca.pdf
[19] https://www.palletconsultants.com/blog/pallet-weight-and-capacit

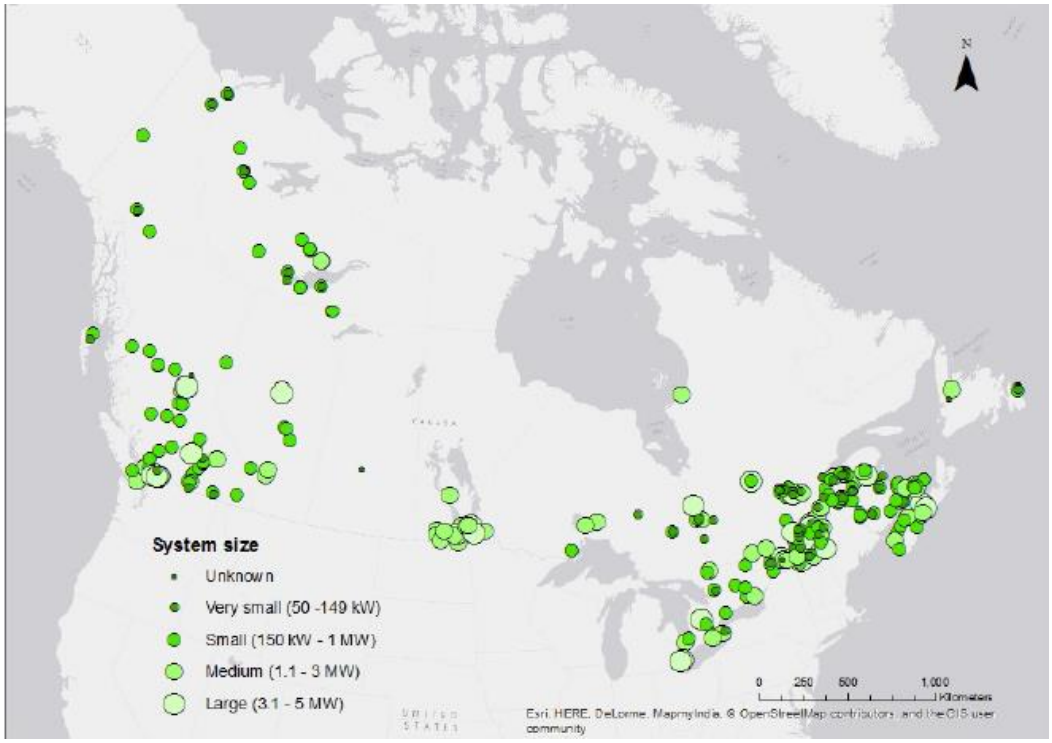


Figure 7: Location of Canadian Bioheat Projects by Capacity (2016)

8.5 Summary of Wood Waste Recycling

Table 19 presents an estimate of the amount of wood wastes recycled in Canada annually by source. The table shows that an estimated 283,000 tonnes are recycled from CR&D sites, an estimated 272,000 tonnes are recycled from wood pallets and an estimated 2 million tonnes of mill residues are used for biomass power.

Table 19: Summary of Wood Wastes Recycled in Canada Annually (tonnes)

Wood Waste Source Recycled or Reused	Tonnes/Year
CR&D Projects	283,000
Wood Pallets	272,000
Mill Residues	2,000,000
Total for Canada	**2,555,000**

9 Drywall

Drywall is a common building material in Canada, and it is used in a wide range of construction and renovation projects. It is also known as gypsum, gyprock or sheetrock. Where CR&D activities occur, old drywall is removed from structures or off-cuts are generated when new drywall is installed. In both cases, source separation and special collection present an opportunity for recovery and recycling (where local programs and facilities exist).

Several processing methods are used for preparing gypsum drywall for recycling. Many of these operate using some type of grinder followed by a screening system; a dust collection system is typically included for the fine particles of drywall dust generated during the processing. Standard size reduction devices (e.g. tub grinders,) which are employed at many waste treatment facilities can be used to process drywall. Trommel screens are frequently used as screening devices, and have been used as stand-alone operations where drywall is both separated from the paper and size reduced. Small, mobile grinders can used at the point of "waste" generation with the objective of applying size-reduced gypsum directly at the same site.

New West Gypsum and Recycle Gypse Quebec Inc. are the two main companies involved in drywall recycling in Canada.

New West Gypsum Recycling operates three drywall recycling facilities in Canada (in New Westminster, BC; Calgary, Alberta and Oakville, Ontario) as well as around the world). NWGR's recycling facilities are capable of processing an average of 25 tonnes of blended wet and dry gypsum drywall material per hour. Current capacity for each plant is reported at 100,000 metric tonnes annually. The New West Gypsum drywall recycling process involves the following steps:

- Inbound wet and dry loads of waste wallboard product are delivered to the plant's tipping floor and hand-cleaned (pre-sorted) to separate metal, plastic and other debris;
- The gypsum waste is loaded into a large feed hopper, which feeds the waste onto a sorting belt where a quality control agent can sort through the material;
- A conveyor belt then moves the material under an electromagnet, which removes ferrous metal fragments;
- The material is then conveyed to an enclosed processing area where the paper lines are separated from the gypsum core;
- The recycled gypsum is sold to drywall manufacturers, where it is blended with virgin or synthetic gypsum to make wallboard;
- The paper is further processed prior to recycling for use in a wide variety of applications, such as composting, fuel, and building materials; and,
- Where possible, any metals collected enter a separate recycling stream.

The New West Gypsum drywall recycling process yields about 94% gypsum, 6% paper and less than 1% other materials (e.g. wood, metals) most of which are recycled. Recycle Gypse Québec Inc., QC operates a similar process.

A report to Environment Canada (Kelleher et al, 2015) is the most current source of information on drywall recycling numbers in Canada. The report estimates that 106,030 tonnes of drywall were recycled in Canada in 2010 and about 298,300 tonnes of drywall were disposed.

PART 2: PRODUCTS

The sections that follow address a number of products which are typically recycled in Canada. These items are multi-material in nature and so they require additional processing to separate the recoverable materials from those that may have to be disposed. For the purposes of this report, and because they are collected and recycled across Canada, the following products were selected:

- Auto Hulks
- Tires
- Electronic Waste
- White Goods (Large Appliances)
- Small Appliances
- Batteries (Lead Acid and Small/Consumer)

10 Auto Hulks

End-of-life vehicles are one of the most significant sources of scrap steel in Canada. About 1.6 million vehicles are scrapped in Canada each year, depending on economic conditions (Cheminfo, 2014). At an average weight of 4,000 lbs (1,818 kg) and at 50% steel, each scrapped vehicle produces about 909 kg (0.9 tonnes) of scrap steel, as well as some other metals. Therefore, 1.6 million scrapped vehicles would produce approximately 1.44 million tonnes of scrap steel; 1.2 million vehicles would yield 1.08 million tonnes of scrap steel. Figure 8 presents a schematic developed by the Ontario Automotive Recyclers Association (OARA) illustrating how vehicles flow through the end-of-life process, which includes dismantlers, parts sellers, brokers and metal shredders. The metal shredders process end-of-life vehicles, household appliances and other primarily ferrous metals collected by scrap yards and scrap metal dealers and brokers. Once shredded, the ferrous scrap material is sold to steel mills and foundries for the production of steel products.

The following terms appear in the figure in abbreviated format: ELV – end-of-life vehicle; ODS – ozone depleting substances; and, OARA – Ontario Automotive Recyclers Association.

The metal values for auto hulks and parts ensures that an estimated 95% of vehicles are currently collected for recycling and re-use. Of this, approximately 83% of a typical end-of-life vehicle, by weight, will be reused or recycled when it is properly dismantled (OARA). The remaining end-of-life vehicles are reportedly in stockpiled junkyards, and a very small number are abandoned or illegally dumped.

Most end-of-life vehicles go through auto dismantlers where reusable parts are removed for resale. Many of the hulks are crushed prior to shredding, and most are shredded prior sorting and separation. When processing auto hulks, shredders typically produce various metals for remanufacturing and automotive shredder residue (ASR):[20]

- Ferrous metals: sheet steel, steel, cast iron (70%);
- Non-ferrous metals: aluminum, copper/brass, and others (6%); and.
- ASR (24%).

[20] https://greenvehicledisposal.com/what-is-an-end-of-life-vehicle/

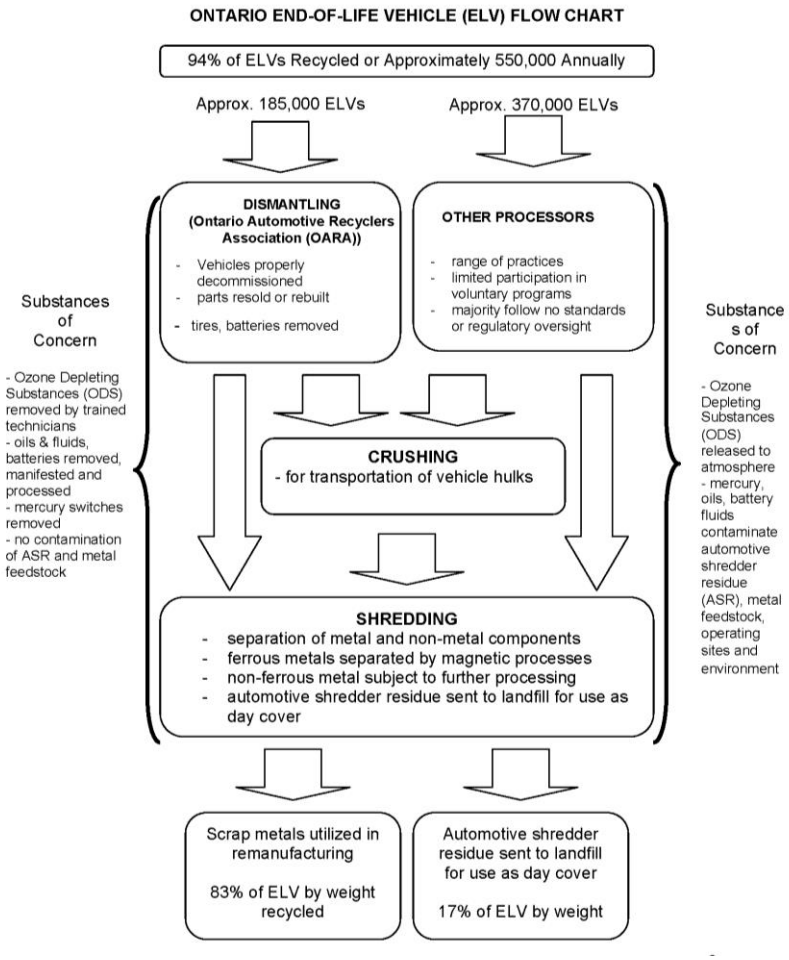


Figure 8: Flow of End-of-life Vehicles through Shredding System[21]

While ferrous metals make up most of what is recovered, other materials, items or products targeted for capture include non-ferrous metals (aluminum, copper, lead); rubber from tires; lead acid batteries (LABs); any precious metals in the catalytic converter, oxygen sensors; operating fluids (gas, oil, windshield washer fluid, antifreeze); parts that are re-used directly, as well as parts that are collected for remanufacturing.

As the auto market moves to an increasing percentage of electric vehicles, the composition of end-of-life vehicles will change. The metal content of electric vehicles (EVs) is different than current internal combustion engine (ICE) vehicles. They contain more copper, lithium, nickel, manganese, cobalt, aluminum (for light-weighting) and potentially more plastics than ICE vehicles. However, given that EVs have a lifespan of 8 years or more and are still a very small percentage of the auto fleet in Canada today, it will be a number of years before this impact will be seen at the metal shredders.

Auto shredder residue (ASR) contains a combination of shredded glass, foam and various plastics. Based on the figures of 1.6 million automobiles shredded and between 200-280 kg of ASR generated per vehicle (based on ChemInfo, 2014), a total of between 320,000 and 448,000 tonnes of ASR is generated annually in Canada. The composition of ASR can differ considerably depending on the shredding and post-shredding process that is used, and

[21]Ontario Automotive Recyclers Association (OARA). "Effective and Efficient End-of-Life-Vehicle Environmental Management in Ontario." Available at https://oara.com/wp-content/files/OARA-ELVIS-White-Paper.pdf

this is mainly because of differences in processing and sorting efficiency. Table 21 presents the approximate composition of ASR.

Table 20: Composition of Auto Shredder Residue (ASR)[22]

Material	Amount in ASR (%)
Plastics polyurethane foam, polyester, polypropylene, polyvinyl chloride, styrene, polyethylene, acrylic	15-25%
Inert Material gravel, sand, dirt, etc.	15-25%
Paper/wood	15-25%
Glass	10-15%
Rubber	10-15%
Moisture	10-15%

ASR is generally used as a day cover for landfills. The Gerdau (auto-shredder) facility in Oshawa, Ontario has its own landfill. This is mostly due to the high pollutant content as well as of the lack of cost-effective sorting technologies suitable for separating valuable materials from the ASR (ChemInfo, 2014). On 12thFebruary, 2020 Environment and Climate Change Canada (ECCC) announced funding through the Plastics Innovation Challenge[23] to support ASR research.

While there are hundreds of businesses involved in the initial processing of auto hulks, there are fewer crushing operations and even fewer shredding operations.[24] Table 22 lists the shredding facilities currently in operation in Canada, with information on their processing capacity in cases where it was available.

Some of the capacity information in the table comes from a confidential 2007 research study Kelleher Environmental carried out for the Ontario Power Authority, and some additional information from CARI (Canadian Association of Recycling Industries). Many of the companies identified at the time have been bought out by companies such as American Iron and Metal (AIM), EVRAZ or others.

Triple M as an example handles over 2.7 million tonnes of ferrous and 270,000 tonnes of nonferrous scrap each year and operates 26 locations in 10 Canadian provinces, 20 U.S. states and five Mexican states.

The company's four shredding plants (Brampton, Hamilton and Sault Ste. Marie, Ontario) process more than 545,000 tonnes/year of infeed material.[25] The state-of-the-art nonferrous downstream separator in Hamilton, Ontario processes 270,000 tonnes per year of shredder residue, recovering "zorba" (aluminum), "zurik" (stainless steel) and insulated copper wire and reducing the amount of shredder residue disposed. The company also processes over 17,500 tons of insulated wire per year at the chopping line in Brampton.

Clarifying the status, location and capacity of metal shredders is identified as a research need in Section 15.

[22] https://greenvehicledisposal.com/what-is-an-end-of-life-vehicle/
[23] https://www.ic.gc.ca/eic/site/101.nsf/eng/00001.html
[24] https://autorecyclers.ca/wp-content/files/National_ELV_EMS_approach.pdf
[25] https://www.recyclingtoday.com/article/triple-m-metals-canada-profile

Table 21: Locations and Capacities of Large Canadian Metal Shredders

Province	Site Name	Operator/Owners	City	Available Information on Capacity (March, 2020)
BC	Schnitzer Steel (was Steel Pacific)	Schnitzer Steel Industries	Victoria	ND
BC	Schnitzer Steel (was Amix)	Schnitzer Steel Industries	Surrey	
BC	Richmond Steel Recycling Ltd.	Sims Group + Nucor Steel	Richmond	ND
Alberta	Calgary Metal	EVRAZ Group	Calgary	ND
Alberta	Navajo Metals	EVRAZ Group	Calgary	800-900 t/d[26]
Alberta	Genalta Recycling	EVRAZ Group + AltaSteel	Sherwood Park	ND
Saskatchewan	Wheat City Metals Inc.	EVRAZ Group	Regina	ND
Manitoba	Gerdau Ameristeel (Selkirk)	Gerdau Ameristeel	Selkirk	40,000 t/y (2007)
Manitoba	General Scrap	EVRAZ Group	Winnipeg	40,000 t/y (2007)
Ontario	AIM Recycling Ottawa East	American Iron & Metal Company Inc.	Ottawa	140,000 t/y (2007)
Ontario	Zalev Brothers Ltd.	Ferrous Processing & Trading Co.	Windsor	80,000 t/y (2007)
Ontario	Gerdau Ameristeel (Whitby)	Gerdau Ameristeel	Whitby	140,000 t/y (2007)
Ontario	Glenview Iron & Metal Ltd.	Glenview Iron & Metal Ltd.	Smiths Falls	ND
Ontario	Lakehead Scrap Metals	EVRAZ Group	Thunder Bay	40,000 t/y (2007)
Ontario	Kimco Steel Sales Ltd.	Kimco Steel Sales Ltd.	Kingston	ND
Ontario	Triple M Metals Inc.	Triple M Metals Inc.	Sault St. Marie	ND
Ontario	POSCOR	Triple M Metals Inc.	Hamilton	All Triple M locations together 545,000 t/y
Ontario	Triple M Metals Inc.	Triple M Metals Inc.	Brampton	See above
Ontario	Triple M Metals Inc.	Triple M Metals Inc.	Hamilton	See above
Quebec	American Iron & Metal Company Inc.	American Iron & Metal Company Inc.	Montreal-Est	Possibly 140,000 t/y (2007)
Quebec	American Iron & Metal Company Inc.	American Iron & Metal Company Inc.	Levis	50 tonnes/hour
Quebec	Les Industries Associees de l'Acier Ltee	Les Industries Associees de l'Acier Ltee	Ville Ste-Catherine	> 80,000 tonnes/year[27]
Quebec	Fers et Metaux Recycles Ltee, Div. La Prairie	AccelorMittal Canada	La Prairie	ND
Quebec	Sidbec Feruni Inc.	AccelorMittal Canada	Contrecoeur	140,000 t/y (2007)
Quebec	Quebec Metal Recycle SNF	American Iron & Metal Company Inc.	Laval	140,000 t/y (2007)
Quebec	Quebec Metal Recycle SNF	American Iron & Metal Company Inc.	St-Augustin-de-Desmaures	140,000 t/y (2007)
Quebec	Total Metal Recovery	Total Metal Recovery	Laval	
New Brunswick	Arcelormittal Montreal Inc	AccelorMittal Canada	Scoudouc	ND

[26] https://www.gccarra.ca/ward-9-newsroom/2018/2/evraz-navajo-metals-and-lynnwood-ridge-update
[27] http://asiriva.com/

Most shredders have begun to install secondary recovery units to target non-ferrous metals (like aluminum, copper, and brass) which have high values.

Triple M processes ASR from other shredders (especially the smaller ones) to recover these nonferrous metals.

There are a number of smaller shredding facilities that have recently come online or are scheduled to open in the near future. One example is John Ross & Sons, a Halifax, Nova Scotia based company, which recently purchased A&S Scrap Metal's facility in PEI, and is planning to install an auto-shredder at their PEI location.[28] Other examples include Dartmouth Metals in Halifax and Trenton Salvage in Quinte West, Ontario. These mini-shredders are cheap to put in, run and get approvals, and their aim is to intercept enough cars before they go to the traditional shredders to extract more value, although they rely on the bigger shredders to process their shredder residue. Another company that has recently entered the shredding scene in Canada is Norshred Inc., which received Ontario Ministry approval to operate a mobile de-pollution and shredding unit for end-of-life vehicles.[29]

[28]Sandoval (2019)
[29] Email correspondence Maria Kelleher and Steve Fletcher, OARA, February, 2020

11 Tires

Programs for collecting and recycling used tires are run by different EPR organizations in different provinces across Canada. There are differences between provinces in terms of how collected tires are reported and what types and sizes of tires are included in each program. Manitoba and Ontario's programs, for example, are the most comprehensive and include all tire types, except for aviation tires. The programs in New Brunswick, Nova Scotia, and Newfoundland cover passenger/light truck tires and medium truck/bus tires. Large industrial, forestry and mining tires are not generally included in these programs and are managed by the companies involved.

Appendix G contains data on the tonnes of tires collected across Canada through tire stewardship programs in 2018/19. Some programs report tires recovered in tonnes, while others report only in units. In order to convert from units to tonnes, a conversion factor of one passenger tire equivalent (PTE) to 10 kg was used.

Table 22 summarizes 2018 provincial data on tire recycling published by CATRA, a national association of tire recycling agencies in the provinces and territories in Canada. The table shows that 439,509 tonnes of tires were collected. A total of 461,434 tonnes of tires were recycled (some additions from stockpiles in previous years), and 26,036 tonnes of tires were used as fuel (TDF). In some cases the diversion rate is calculated as greater than 100% because of carryover of collected tires from previous years

Table 22: Available Data on Tire Collection, Recycling, and End-Uses in Canada, 2018[30]

	Collected (Tonnes)	Recycled (Tire Derived Product - TDP) (Tonnes)	Energy Recovery (Tire Derived Fuel - TDF) (Tonnes)	Diversion Rate (TDP + TDF)/Collected (%)	8 Year Average (%)
British Columbia	51,419	39,437	10,793	98%	96%
Alberta	67,875	67,611	0	100%	102%
Saskatchewan	21,675	17,057	0	79%	116%
Manitoba	18,177	15,972	33	88%	96%
Ontario	156,518	210,704	0	135%	113%
Quebec	91,851	83,601	8,249	100%	94%
NB	10,845	10,845	0	100%	100%
Nova Scotia	11,982	14,272	0	119%	104%
Newfoundland & Labrador	5,929	990	4,939	100%	100%
Prince Edward Island	2,625	332	2,022	90%	97%
Yukon	613 (estimate)	613 (estimate)	0	100%	100%
Northwest Territories	N/A	N/A	N/A	N/A	N /A
Nunavut	N/A	N/A	N/A	N/A	N/A
Total for Canada	439,509	461,434	26,036	111%	104%

[30] Canadian Association of Tire Recycling Agencies (2018)

Table 23 summarizes the various uses for recycled tires in 2017. These include: crumb (32%); molded (27%); tire derived aggregate (11.5%); mulch (6.4%); blasting mats (2.8%), and tire derived fuel or TDF (9.5%).

Table 23: 2017 National Recycling and TDF Uses (CATRA, 2018)

TDF Use	Tonnes	% of Total
Crumb	146,844	32.4%
Molded	122,768	27.1%
Tire Derived Aggregate (TDA)	51,969	11.5%
Mulch	29,017	6.4%
Steel/Fibre	40,660	9.0%
Blasting Mats	12,776	2.8%
Other	5,968	1.3%
Tire Derived Fuel (TDF)	42,960	9.5%
Total	**452,962**	

Information from Table 23 is presented in graphical format in Figure 9 and shows that crumb rubber is the largest end market for recycled scrap tires in Canada.

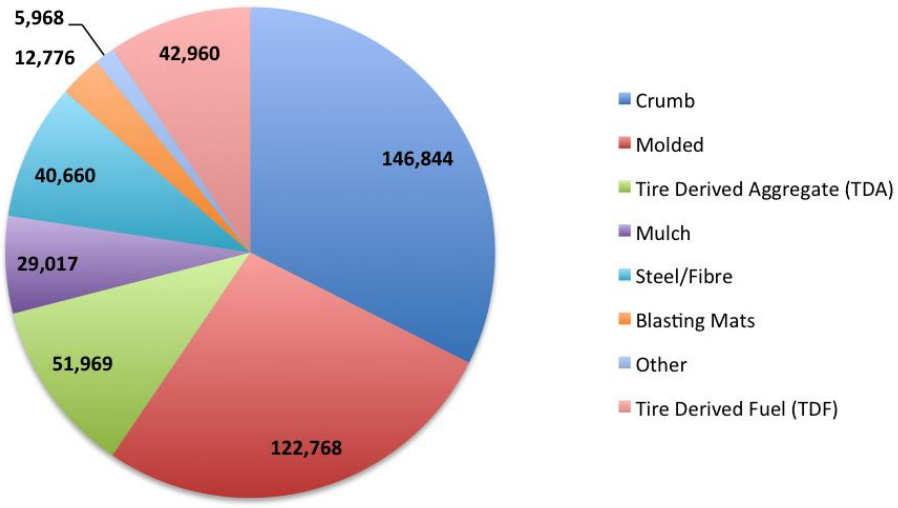


Figure 9: 2017 National Recycling & TDF Uses (Tonnes)

Crumb rubber is used in a variety of products such as athletics' surfaces and fields, agricultural and equestrian mats, playground and other safety surfaces, patio blocks, and more. When combined with molded products, which also incorporate crumb rubber, the two categories represent close to 60% of Canada's used tire market. Molded products are made from buffing dust (rubber particles removed from a tire carcass during retreading) and include products such as ramps, sidewalk curbing, and landscaping forms (CATRA, 2018).

Following crumb rubber and molded products, TDA is deployed in civil engineering applications using a variety of sizes of shredded rubber. Examples include lightweight fill material for road and landfill construction, septic tank leach fields, and alternative daily cover for landfills. When used in appropriate applications, TDA's special characteristics (e.g. light-weight, compressibility, high permeability) can reduce construction costs. Mulch, which represents about 6% of Canada's recycled tire products, is used exclusively in landscaping applications. The processing of crumb rubber from waste tires also produces steel and fibre by-product streams (9%). Very little

market demand has been identified for the fibre, and so most of it ends up in landfills or is used in energy from waste facilities. Steel is generally recycled and sold as a product to an end use market. Tire derived fuel (TDF), which represents just under 10% of Canada's end-products, is generally consumed by cement or other industrial kilns as a supplementary fuel (CATRA, 2015). TDF may include whole tires or tires processed into shreds or chips, whichever satisfy the specifications of the end-user (NERC, 2019).

12 Batteries

This section presents available information on the recycling of batteries in Canada. This includes both lead-acid batteries and consumer (or small, portable) batteries. While "consumer" batteries are also used extensively in commercial, institutional and industrial settings, no information could be found on recovery rates for these batteries and so these are excluded from the report, but this lack of data is identified in Section 15.

12.1 Lead Acid Batteries

NRCan reports that in 2018, 129,508 tonnes of secondary lead metal (from recycled lead) was produced in Canada, down slightly from 151,921 tonnes in 2017. Lead acid batteries are the main source of secondary lead in Canada, and a mature secondary lead smelting and refining business exists here.

Lead acid batteries (LABs) are used for a variety of applications:

- **Starting Lighting and Ingition (SLI)** batteries are commonly used to start and run engines for automobiles, motor bikes, etc. and are designed to deliver sporadic current spikes. Starting batteries have a large number of thin plates containing lead in a sponge-like material. This provides a very large surface area, but if deep cycled (discharged down as low as 20% of full charge), this sponge will quickly be consumed and fall to the bottom of the cells. Automotive batteries will generally fail after 30 to 150 deep cycles, while they may last for thousands of cycles in normal starting use (2-5% discharge).
- **Deep cycle** batteries are designed to be discharged down as much as 80% time after time, and have much thicker lead plates than SLI batteries.
- **Marine batteries** have a lead sponge plate which is coarser and heavier than that used in SLI batteries.
- **Industrial deep cycle batteries,** sometimes called forklift, traction or stationary batteries, are used where power is needed over a longer period, and are designed to be deep cycled, or discharged down as low as 20% of full charge (80% DOD, or Depth of Discharge). These batteries are used in forklifts, golf carts, and floor sweepers. Deep cycle batteries have much thicker plates than automotive batteries.

The most recent National Recycling Rate Study (2014-2018) commissioned by Battery Council International (BCI) reports that lead-acid batteries have a recycling rate of 99% in the US. The value is expected to be similar in Canada because of the high value of lead and similar (even integrated) end-of-life vehicle management systems.

The recycling of lead-acid batteries provides a critical supply of lead to the battery industry and is economically and environmentally superior to obtaining it from virgin ore, as it reduces the need to mine new lead and diverts batteries from disposal. Processing secondary lead requires less than half the energy than producing lead from ore (International Lead Association).

Table 24 presents information on the average weight of different LABs depending on the category.

Table 24: Weight of Different Lead Acid Batteries[31]

Lead Acid Battery (LAB) Type	Typical Weight (kg)
Starting, Lighting, and Ignition	2-50
Motive	15 - 1,250
Stationary	2 - >10,000

Table 25 presents the typical composition of lead acid batteries as a percentage of total weight.

Table 25: Lead Acid Battery Composition

Component	Typical Lead Acid Battery Composition (CBA)
Lead	65%
Sulphuric Acid (H_2SO_4)	16%
Paper, Plastic, Carbon	10%
Metals (non-lead)	4%
Other Materials (non-metallic)	5%

LABs have a high value at end-of-life due to the inherent worth of lead (the lead refining industry is described in Section 4). As a result, the majority of LABs are recycled (close to 100%) and are collected in a reverse distribution system. Manufacturers deliver new LABs to retail and IC&I customers and pick-up the spent LABs at the same time. Used LABs are brought back to the distributor's warehouse where they are either recharged, refurbished, or declared obsolete. LABs that cannot be refurbished are sent to recycling and smelting facilities in Canada and the US (for more detail, see Section 4). Table 26 summarizes information provided by BCI on how the average LAB is recycled. The table shows that all elements of the LAB are recycled:

- Lead goes back into ingots;
- Electrolytes (sulphuric acid) are recycled and used in other industries;
- The polypropylene cases and other plastic are recycled back into various plastic products.

[31] Canadian Battery Association "Types of Lead Acid Batteries."

Table 26: How Various Components of Lead-Acid Batteries are Recycled[32]

Material	Description	Fate
Metals	99% of lead is recovered during the smelting process	Lead ingots are sold as a commodity on the open market.
	1% of lead from the secondary smelting process is not recovered and is contained in dross. Dross can be sent to primary smelters for further processing.	
	Antimony and calcium are used to provide strength within the lead plates	Remain as an alloy of the lead after smelting.
Electrolytes	Sulphuric acid is recovered and sold as an input to another manufacturing process.	Recycled and sold as a commodity.
Plastics	The polypropylene case provides structure to most batteries. Stationary batteries have a clear casing made of acrylic.	About 70% of the plastic is recycled and used to make new battery casings. Acrylic casings are not recyclable and are burned for energy recovery.
	Within each battery, plastic separators are used to isolate the positive and negative plates.	The Plastic Separators are burned at the smelters for energy recovery creating an oxygen free environment during the smelting process.

Table 27 presents information on the average amount of lead in different types of lead-acid batteries. The weight of lead is the primary driver in the recovery of LABs in Canada and elsewhere.

Table 27: Average Weight of Lead in Different Batteries

Battery Type (Automotive)	Average Lead Weight (lbs)	Average Lead Weight (kg)
Passenger car & light truck	23.5	10.7
Truck & heavy duty truck	25.7	11.7
Tractor	34.1	15.5
Marine & RV	28.8	13.1
General utility	8.4	3.8
Golf car and floor scrubber	40.4	18.4
Motorcycle	4.8	2.4
Aircraft	40.0	18.2
Military	47.0	21.4
Miscellaneous and others	25.0	11.4

Figure 10 provides a schematic representation of the lead-acid battery recycling process. SLAB in the figure refers to spent lead acid batteries.

[32] Canadian Battery Association (2017)

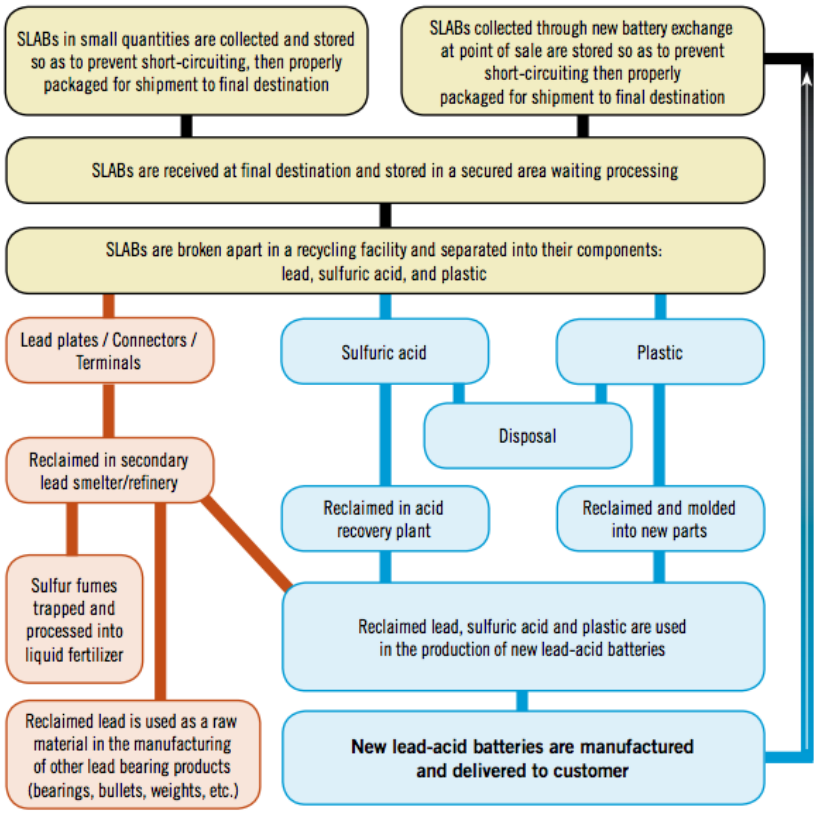


Figure 10: Schematic of Lead Acid Battery Recycling[33]

Canada does not have federal level laws pertaining to the collection of spent lead-acid batteries. However, there are a number of provincial level take-back programs in place, such as the lead-acid battery stewardship programs in British Columbia, Manitoba, Nova Scotia, and Prince Edward Island that are run by the Canadian Battery Association (CBA). All recovered lead-acid batteries collected by CBA members are sent to recycling and smelting facilities that have valid permits and/or approvals. These provinces require the battery industry to report annually on the amount of lead acid batteries collected. Table 28 summarizes the information available on tonnes of lead-acid batteries collected in these four provinces, for the most recent year for which data was available. The table shows that these four provinces together collected a reported 34,525 tonnes of LABs. BC and Manitoba require the stewardship agencies to split out the totals by battery type. The reported numbers show that most of the weight collected is SLI batteries.

[33] Commission for Environmental Cooperation (2016)

Table 28: Lead-Acid Batteries Collected in Stewardship and EPR Programs in Canada (2017 or 2018) (Tonnes)[34]

Province	Battery Type	Collected (tonnes)
British Columbia (2018)		**24,211**
SLI	21,339	
Motive	2,800	
Stationary	71	
Manitoba (2017)		**6,219**
SLI	6,060	
Motive	127	
Stationary	32	
PEI (2017)		**181**
New Brunswick (2017)		**2,523**
Nova Scotia (2017)		**1,390**
Total for Canada		**34,525**

The value of approximately 129,508 tonnes of lead recycled in Canada (in Section 4) is the number most relevant to this study. The number and weight of LABs collected is higher as the batteries not only contain lead, but also electrolyte and plastic, but lead accounts for most of the weight.

12.2 Consumer (Small, Portable) Batteries

Consumer batteries include both rechargeable (nickel cadmium (NiCd), nickel metal hydride (NiMH), lithium-ion (Li-ion), and small-sealed lead-acid (SSLA/Pb) and single-use (lithium primary, alkaline and carbon zinc) batteries. Generally, a weight cut-off of either 2 kg or 5 kg is used to delineate consumer/small/portable batteries from other batteries in regulations which mandate recycling.

In Canada, the regulations governing recycling of consumer batteries vary from province to province. For those that impose regulatory requirements for consumer battery recycling, producers are obligated to join a recognized stewardship program to ensure that batteries are properly managed at the end of their useful life.

Call2Recycle is the official battery stewardship program in BC, Manitoba, Quebec, and most recently in Prince Edward Island (PEI) where the agreement was formalized in 2018 for implementation April 1, 2019. In addition to the regulated programs, Call2Recycle operates a voluntary program in New Brunswick under a memorandum of understanding (MOU) and is the official battery collection and recycling program for the Federal Government, with approximately 200 new Federal Government collection locations introduced in 2018.[35] Call2Recycle Canada, Inc. has collected batteries from Federal Government locations since 2014 when the program signed a five-year contract as

[34] Canadian Battery Association (2018)
[35] Call2Recycle (2018)

the preferred battery recycling service provider. Since then, Call2Recycle has collected more than 300 tonnes of batteries from Federal Government department locations across all 10 provinces (Call2Recycle, 2019).

Call2Recycle also operates a voluntary battery program in the Northwest Territories through a partnership with the territorial government's electronics recycling program. Single-use alkaline batteries and rechargeable batteries are accepted for recycling at electronics recycling depots and collection events. Since the launch of the program, the NWT has shipped 1.6 tonnes of batteries to Call2Recycle for recycling (Government of the Northwest Territories, 2018).

In the province of Ontario, the recycling of single-use batteries is mandated under regulation. These batteries are recovered as part of Stewardship Ontario's *Municipal Hazardous and Special Waste (MHSW)* Program, known to consumers as the Orange Drop Program.

Table 29 presents data on the tonnes of consumer batteries (single-use and rechargeable) collected in Canada in 2018, or the most recent year for which data was available. The total is about 5,000 tonnes/year. British Columbia and Manitoba's annual reports provide a breakdown of collections by chemistry, whereas the other programs only report on totals.

Table 29: Consumer Batteries Collected in Canada in 2018 (tonnes)

Province[36]	Battery Chemistry	Collected (tonnes)	Designated Batteries Collected (tonnes)
British Columbia	*Ni-Cd*	40	
	Ni-MH	17	
	Li-ion	30	
	SSLA	31	
	Total rechargeable batteries	117	
	Alkaline and zinc carbon	506	
	Lithium	11	
	Mercury	0.04	
	Total single-use batteries	517	
	Total consumer batteries		**635**
Manitoba (2018)	*Ni-Cd*	7	
	Ni-MH	3	
	Li-ion	8	
	SSLA	4	
	Total rechargeable batteries	23	
	Alkaline and zinc carbon	80	
	Lithium	4	
	Total single-use batteries	83	
	Total consumer batteries		**106**
Ontario			**2,964**
Quebec			**1,186**
PEI			**28**
New Brunswick			**79**
Northwest Territories			**N/A[37]**
Total for Canada			**4,997**

[36] All values for 2018 from provincial Call2Recycle reports except for Ontario (Stewardship Ontario 2018 report) and Government of Northwest Territories (2017-2018).
[37] Since February 2016, the NWT has shipped 1.6 tonnes of batteries to Call2Recycle for recycling. No tonnage data for 2018 is available.

13 Electronic Waste, Small Appliances and White Goods

Electronic waste generally refers to products such as laptops and desktop computers, mobile/smart phones, printers, fax machines, audio-visual equipment and televisions. Small appliances refer to portable (light-weight) kitchen and bathroom appliances and gadgets. White goods refer to larger appliances such as fridges and stoves. All of these products contain a combination of metals, plastics and glass, and must be dismantled and processed before the constituent materials can be recycled. Each of these product groupings are recycled through different networks across Canada, described in this section.

13.1 Electronic Waste

With the exception of Nunavut, all provinces and territories in Canada have regulated programs for the collection and recycling of electronic and electrical waste. Producers are obligated under regulation and are responsible for putting recycling systems in place and either paying for them or ensuring the collection of sufficient funds to pay for proper recycling. The Electronic Products Recycling Association (EPRA) runs most of these programs across Canada. The exceptions are Alberta where the electronics stewardship program is run by Alberta Recycling Management Authority, and Yukon and Northwest Territories where the programs are operated by the territorial government.

In terms of program scope, there are significant differences across Canada regarding the types of electronics accepted for recycling in regulated EPR programs. Ontario and BC are the only provinces that collect cell phones as part of the program, and there are now five provincial programs that collect microwaves. Of all provinces, Alberta's program is the most limited in scope, although a potential Phase 2 electronics program would expand the list of designated products to include small household appliances, power tools, audio visual equipment and telecom equipment.

The general categories of electronic products accepted for recycling in different provincial EPR programs are presented in Table 30. Nova Scotia expanded its product categories on 1st January 2020, and will be implementing a corresponding landfill ban for these products effective 1st March 2020.

Table 30: Designated Electronic Products Accepted for Recycling by Stewardship and EPR Programs in Canada (as of January 2020)[38]

Product Category	BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL	YK	NWT
Desktop Computers	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Large Battery-Powered Ride-On Toys	✔											
Portable Computers	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Small Battery-Powered Ride-On Toys	✔											
Display Devices ≤ 29" All-in-one (AIO) computers	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Display Devices 30-45" All-in-one (AIO) computers	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Display Devices ≥ 46" All-in-one (AIO) computers	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Desktop Printers	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Floor Standing Printers	✔	✔	✔	✔	✔				✔			✔
Computer Peripherals	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	
Personal/Portable Audio/Video Playback and/or Recording Systems	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	
Electronic Toys	✔											
Home Audio/Video Playback and/or Recording Systems	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	
Home Theatre in a Box	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	
Vehicle Audio and Video Systems	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	
Non-Cellular Telephones and Answering Machines	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	
Cellular Devices and Pagers	✔			✔	✔	✔	✔	✔	✔	✔	✔	
Countertop Microwave Ovens			✔	✔				✔	✔		✔	
IT and Telecom Equipment	✔											

Table 31 shows that a total of 106,882 tonnes of electronics were recycled in electronic stewardship programs across Canada in 2018 and summarizes data on the tonnes of electronic waste collected by province and territory.

[38] EPRA (2020)

Table 31: Electronics Collected in EPR and Stewardship Programs in Canada, 2018 (tonnes)

Province/ Territory[39]	Designated Electronics Collected (tonnes)
British Columbia	16,815
Alberta (2018-19)	10,111
Saskatchewan	2,344
Manitoba	3,024
Ontario	47,711
Quebec	21,387
New Brunswick	861
Nova Scotia	3,169
Prince Edward Island	458
Newfoundland & Labrador	796
Yukon (2018-19)[40]	119
Northwest Territories (2018-19)[41]	87
Total	**106,882**

The major players (with multiple facilities) recycling end-of-life electronics in Canada are:

- eCycle Solutions: Airdrie (Alberta), Chilliwack (British Columbia), Mississauga (Ontario), Salaberry-de-Valleyfield (Quebec)
- Quantum Lifecycle Partners (GEEP and Shift Recycling merged into Quantum Lifecycle Partners): Barrie (Ontario), Calgary (Alberta), Edmonton (Alberta), Montreal (Quebec), Toronto (Ontario), Vancouver (British Columbia)
- FCM Recycling: Vancouver (British Columbia), Halifax (Nova Scotia), Cornwall (Ontario), Montreal (Quebec)
- KC Recycling Ltd.: Trail (British Columbia)
- Exner E-waste processing Inc.: Manitoba (website not working February, 2020. May not be active)
- Carrefour Environnement Usine NB: Edmunston (New Brunswick) (website states capacity 6,000 tonnes/year Feb, 2020)
- ADL Process Inc.: Toronto (Ontario)
- Evolu-TIC Outaouais: Gatineau (Quebec)
- Valoritec: Gatineau (Quebec)
- 100 ENV Inc.: Montreal, Quebec
- COM2 Recycling Solutions: Mississauga (Ontario)
- Greentec: Cambridge (Ontario)
- Electronic Recycling Association (ERA).

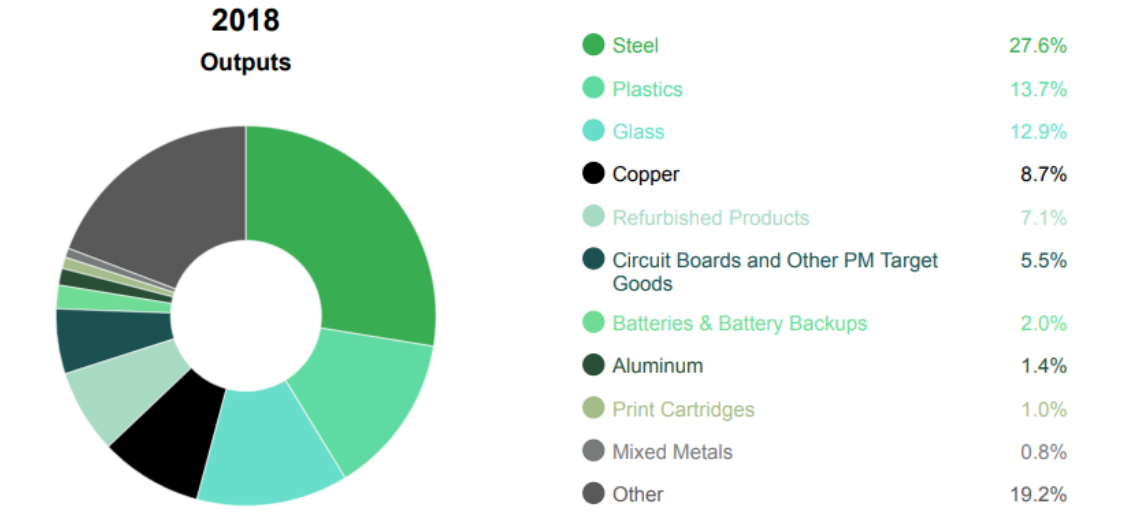
E-waste collected by EPRA and other programs is brought to central facilities where it is tested to see if there is a reuse application. The battery is removed (for safety reasons), and components such as casings not suitable for reuse/resale are sent to a shredder where plastics and metals are separately recovered.

[39]References for all values except Alberta are from Electronic Products Recycling Association (2018).
[40] Personal communication with Jennifer Dagg and Jolene Jacobs at Environment Yukon
[41] Personal communication with Taylor Mackey, Recycling Coordinator at NWT's Department of Environment and Natural Resources. September 25, 2019

Canada's *Electronics Reuse and Refurbishment Program* (ERRP)[42] encourages recycling facilities to reuse and refurbish as many electronics as possible. For products that are in working condition, several of the companies mentioned above will refurbish them for donation or resale. Quantum Lifecycle Partners, for example, offers a variety of reuse solutions, including 'wholesale remarketing' (where they refurbish, repair and resell the equipment) as well as employee purchase and charitable donation programs. Greentec, eCycle Solutions, and COM2 Recycling Solutions also offer ITAD (IT Asset Disposition) services. These services typically include data wiping and hard drive destruction; a diagnostic evaluation to identify whether the item is too damaged to obsolete to be repaired; and a refurbishment to repair and upgrade the asset.

Figure 11 presents information on the output from one electronics processor (Greentec) as an example.

[42] Care of Electronic Products Recycling Association (https://rqp.ca/wp-content/uploads/2014/01/ERRP-EN.pdf)



Additional Breakdown

"Other" Sub-Categories

Sales and Finished Goods "Other" Category	2018 kg of Category	% of 2018 Sales and Finished goods "Other" Category Mass (kg)
Other Non-Program Waste	23547.34	1.71%
Other	142152.68	10.30%
CRT Display	91263.69	6.61%
Portable Computers	118558.16	8.59%
Printers and Peripheral Devices	35784.81	2.59%
Small Appliances		
Computer Peripherals	9680.11	1%
Hazardous Materials	19479.07	1%
Flatscreen Display	78031.95	6%
Desktop/Server Computers	1445.15	0.10%
Computer Components	53494.42	3.87%
Waste	778350	56.38%
Cellular Devices	15397.65	1.12%
Non-Cellular Telephones	12832.58	0.93%
Desktop Computers	91.17	0.01%
Printer Cartridges	526.62	0.04%
TOTALS	1380635.04	100.00%

"Refurbished Goods" Sub-Categories

Sales and Finished Goods "Refurbished Goods" Category	2018 kg of Category	% of 2018 Sales and Finished Goods "Refurbished Goods" Category Mass (kg)
Printer Cartridges	336075.89	65.46%
WIP Refurb Stock	5507.97	1.07%
Portable Computers	132428.56	25.80%
Desktop/Server Computers	34169.57	6.66%
Computer Peripherals		
Refurbished Goods		
Cellular Devices	590.63	0.12%
Networking Devices	1263.25	0.025%
Batteries and Battery Backup Systems	2560.08	0.5%
Computer Components	781.99	0.15%
TOTALS	513377.94	100.00%

"Circuit Boards and Precious Metal Target Goods" Sub Categories

Circuit Boards and Precious Metal Target Goods" Category (%)	2018 kg of Category	% of 2018 Circuit Boards and Precious Metal Target Goods" Category (%) Mass (kg)
Circuit Boards	374335.26	94.14%
Computer Components	253.10	0.06%
Networking Devices	16336.13	4.11%
Shredded Circuit Boards	2039.35	0.51%
Processors	3084.88	0.78%
Other	1579.86	0.4%
TOTALS	397628.59	100.00%

Figure 11: Fate of Electronic Waste Processed by Greentec, 2018[43]

[43] ttps://greentec.com/wp-content/uploads/2019/10/Greentec-Sustainability-Report-2018.pdf

A report on critical raw materials and the circular economy (European Commission (2018) identified the electronics industry as a key sector in the use and recycling of critical raw materials. Figure 13 (from the 2018 report) shows the critical materials that are found in electronics including batteries marked in green.

ANTIMONY	FLUORSPAR	NATURAL GRAPHITE	TANTALUM
BARYTE	GALLIUM	NATURAL RUBBER	TUNGSTEN
BERYLLIUM	GERMANIUM	NIOBIUM	VANDIUM
BISMUTH	HAFNIUM	PHOSPHATE ROCK	PLATINUM GROUP METALS
BORATE	HELIUM	PHOSPHORUS	HEAVY RARE EARTH ELEMENTS
COBALT	INDIUM	SCANDIUM	LIGHT RARE EARTH ELEMENTS
COKING COAL	MAGNESIUM	SILICON METAL	

Figure 12: Critical Metals Found in Electronic Waste and Batteries

13.2 White Goods (Large Appliances)

White goods refer to large appliances such as fridges, stoves, freezers, washers, dryers, etc. Regulations requiring the proper removal and management of ozone depleting substances (ODS) have increased the cost of managing freezers, fridges and air conditioners, but they are still recycled at high rates because of their metal content.

The 2016 Statistics Canada Waste Management Industry Survey (WMIS) reports that 330,820 tonnes of white goods were diverted across Canada in 2016. A breakdown by province is shown in Table 32.

Table 32: White Goods Diverted Across Canada, by Province, 2016 (tonnes)

Province/Territory	Tonnes Diverted
British Columbia	20,493
Alberta	9,365
Saskatchewan	1,995
Manitoba	N/A*
Ontario	11,739
Quebec	276,767
New Brunswick	N/A*
Nova Scotia	1,412
Prince Edward Island	6,325
Newfoundland & Labrador	N/A*
Yukon, Northwest Territories, and Nunavut	N/A*
Total	**330,820**[44]

*Data suppressed to meet the confidentiality requirements of the Statistics Act

To date, BC is the only province in Canada to regulate the management of white goods through EPR. This program for end-of-life major household appliances is operated by the Major Appliance Recycling Roundtable (MARR), and was established in 2012. The BC regulation covers the list of 17 appliances/product categories shown in Appendix H. Examples include air conditioners, dehumidifiers, clothes washers and dryers, dishwashers, built-in ovens, freezers, and refrigerators.

[44] Total includes data suppressed because of confidentiality

As of the end of 2018, there were 293 locations in BC that accepted major appliances for recycling. Many retailers offer customers a delivery/take-back option when a new appliance is purchased; appliances picked up in this way are generally delivered to a drop-off site although some retailers report that appliances might also go to a refurbisher.

MARR reports that there are currently two mechanical processing facilities in BC that receive and shred end-of-life products, including white goods. Materials recovered from white goods include metal (both ferrous and non-ferrous scrap), plastics, and other small amounts of material like glass, rubber, and foam. Before shredding takes place, products undergo decommissioning to remove ODS (ozone depleting substances) and other halocarbons. Shredded material is sorted and metals are separated from other materials. According to MARR, an estimated 74% of the materials are recycled (mostly ferrous and non-ferrous metal), while the remaining 26% is sent to landfill.[45]

Table 33 summarizes information available on the number of white goods collected in BC's stewardship program in 2018 (a reported 597,025 units), as well as a reported tonnage figure (37,868 tonnes), which was calculated by applying a unit weight (kg) to each product category.

Table 33: Large Appliances Collected in BC, 2018 (tonnes)[46]

Large Appliance	Units Collected	Unit Weight (kg)	Tonnes Collected
Full-size refrigerators & wine coolers/beverage centres	96,558	129.0	12,456
Compact refrigerators & wine coolers/beverage centres	35,470	25.1	890
Freezers	28,313	79.5	2,251
Room air conditioners	29,598	20.2	598
Portable air conditioners	29,598	53.0	1,569
Dehumidifiers	13,908	26.2	364
Clothes washer	56,012	61.9	3,467
Clothes dryers/steam cleaners	61,054	53.4	3,260
Ranges	67,550	80.4	5,431
Range hood & downdrafts	10,421	33.1	345
Built-in ovens	52,827	59.4	3,138
Built-in & over-the-range microwave ovens	22,567	25.0	564
Surface cooking units	3,833	23.4	90
Dishwashers	72,416	45.3	3,280
Food waste disposers	13,185	5.2	69
Trash compactors	861	66.0	57
Electric beverage dispensers	2,853	13.6	39
Total	**597,025**		**37,868**

13.3 Small Appliances, Power Tools and Other EPR Materials in BC

[45] Major Appliance Recycling Roundtable (MARR) (2018).
[46] ibid

BC is the only province with an EPR program for small appliances and power tools. The Canadian Electrical Stewardship Association (CESA) runs both programs. Appendix I provides a list of product categories and examples of products captured by the CESA small appliances recycling program which initially collected eleven product categories in October 2011 and expanded to 17 categories in July 2012.

In 2018, CESA collected 5,092 tonnes of regular products. In addition to this material, 2,957 pieces of large exercise equipment and 1,479 pieces of large power tools were collected. Unlike regular CESA products, these very large products are not managed through the program's recycling process. Table 34 shows the percent of weight processed by material commodity in 2018.

Table 34: Materials Processed by BC Small Appliance Program (2018)

Material Commodity	% of Total Tonnage Processed	Tonnes	Downstream Flow
Ferrous steel	52.5%	2,673	Production, Processing
Plastics	27.3%	1,390	Production, Non-processing
Aluminum	1.5%	76	Production, Processing
Wire and cables and string lights	4.2%	214	Refining, Non-Processing
Copper	2.3%	117	Processing, Refining, Non-processing
Glass	2.0%	102	Processing, Refining
Circuit boards	2.3%	117	Refining
Rechargeable batteries	1.2%	61	Processing, Non-Processing
Paper based materials	0.5%	25	Processing
Non-rechargeable batteries	0.1%	5	Processing, Non-Processing
Heating oil	0.5%	25	Processing, Recovery, Landfill
Waste to landfill	5.6%	285	Landfill disposal
Total Processed (tonnes)		**5,092**	

The BC EPR program for electric outdoor power equipment (EOPE) launched on July 1, 2012 and is managed by the Outdoor Power Equipment Institute of Canada (OPEIC). Four categories of outdoor power equipment are covered in the program: hand-held, walk-behind, free-standing, and lawn tractors. These categories include battery powered (mostly lithium-ion) and electric powered products and are summarized in Appendix I.

OPEIC state that there is a well-established reuse market for EOPE and that the repair and reuse of EOPE products that are not at the end of their functional life is facilitated through a number of channels, including re-selling web sites (e.g. Kijiji, Facebook Buy and Sell sites), charitable organizations, and trade-ins on new EOPE purchases.[47]

The 2012 stewardship program plan that was submitted to the Ministry for regulatory approval estimated that between 30,000 to 40,000 electric-powered OPEs were retired annually in BC, or approximately 150 to 200 tonnes.[48]

[47] OPEIC (2018).
[48] Outdoor Power Equipment Institute of Canada (2012).

PART 3: RESIDUALS

The sections in Part 3 address a number of industrial residuals which are produced in Canada and are reused or recycled where practical and economically viable. The residuals selected for this report include:

- Coal Combustion Products
- Steel Making Residuals
- Wood Ash
- Foundry Sand

14 Industrial Process Residuals

This section addresses selected industrial residuals that are produced in relatively large volumes, are of a relatively consistent quality and composition and are believed to be reused and recycled to various extents. Capturing the amount of these residuals directed to productive use is an important part of quantifying the circular economy efforts in Canada (especially given the large resource extraction part of the economy). Four industrial process residuals are addressed in this section:

- Coal combustion products (CCP);
- Electric Arc Furnace (EAF) Dust;
- Wood Ash; and,
- Foundry Sand.

Many other industrial process residuals are directed to productive use. Quantification of these beneficial use activities is identified as a research gap in Section 15.

14.1 Coal Combustion Products (CCP)

Coal combustion products (CCP) refers to materials such as fly ash, bottom ash and flue gas desulphurization (FGD) gypsum generated at coal generating stations. These large quantities of solid materials are reused where possible mostly in construction, predominantly in the cement or concrete industries or in construction related products such as drywall. The location of coal mines and coal power plants across Canada is shown in Figure 13.

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Figure 13: Coal Mines and Coal Power Plants in Canada (2018)[49]

The most recent comprehensive information on CCP utilization in Canada is from a paper by Anne Weir (former Executive Director at the Association of Canadian Industries Recycling Coal Ash) (Weir, A. (2013). Figure 14 shows

[49]Government of Canada (December 2018). "A Just and Fair Transition for Canadian Coal Power Workers and Communities."

CCP usage in Canada from 1997 to 2011. The figure shows that total CCP usage was about 1.7 million tonnes in 2011, the most recent year for which this level of data is available.

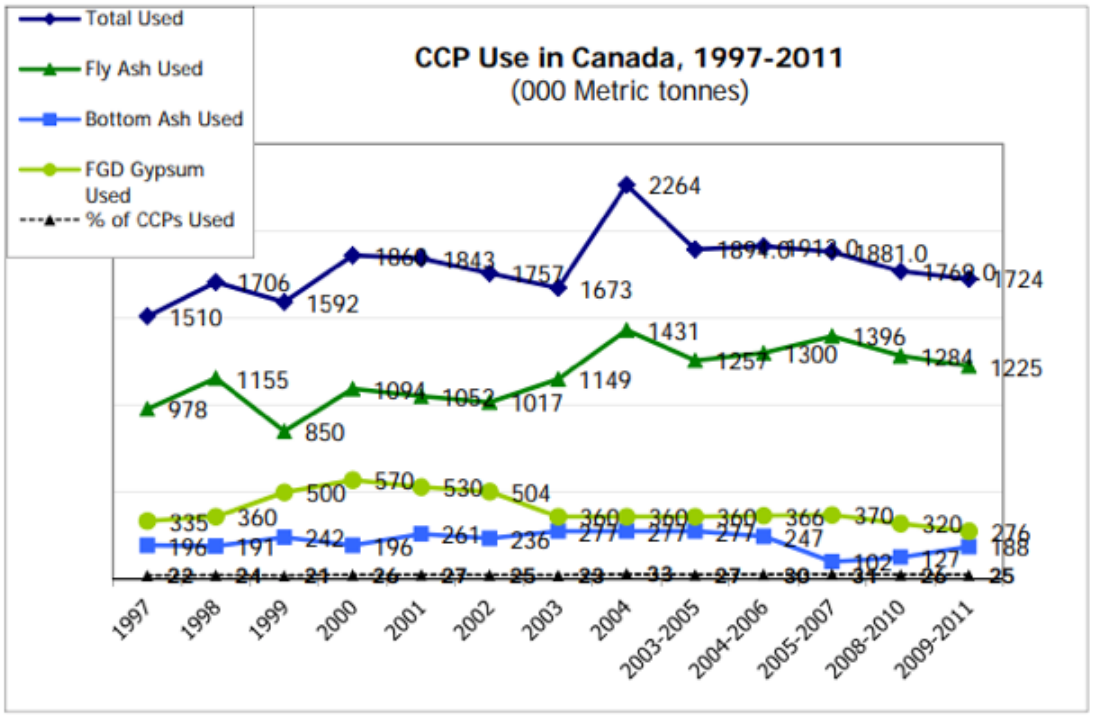

Figure 14: Coal Combustion Products (CCP) Utilization in Canada, 1997 to 2011[50]

NRCan used to administer a survey quantifying "Coal Combustion Products Production and Use" but 2012-13 was the last year the survey was carried out. As a result, and since that time, the beneficial use of CCP is no longer tracked.

Table 35 presents the average production and utilization of CCP in Canada for the years 2011-2013. The table shows that about 6.2 million tonnes of CCP were produced on average in these years. Most of the CCP produced (about 4.1 million tonnes) was fly ash. Bottom ash made up about 1.7 million tonnes of the CCP produced. About 215,000 tonnes were flue gas desulphurization gypsum, and 186,000 tonnes were fluidized bed ash and bottom ash. In total approximately 1.74 million tonnes of CCP were reused/recycled and 5 million tonnes were disposed.

The 1.3 million tonnes of fly ash which were recycled/reused were directed to the following applications:

- 814,000 tonnes in the concrete/grout industries;
- 367,000 tonnes in the cement industry;
- 70,000 tonnes used in the mining industry;
- 34,000 tonnes were used for waste stabilization and specialty uses such as mineral filler and "flowable" fill; and,
- 20,000 tonnes used as road base.

[50] ibid

Most of the 1.7 million tonnes of bottom ash which were produced were disposed, however, approximately 130,000 tonnes were used in the cement industry and 47,000 tonnes were used as road base or sub-base;

Virtually all of the FGD dust produced (about 215,000 tonnes) was reused in the wallboard industry.

An estimated 186,000 tonnes of fluidized bed ash and bottom ash were produced. About 40,000 tonnes of this material was used in the cement industry.

Table 35: Average Production and Use of Coal Combustion Products (CCPs) in Canada (2011-2013)[51]

	Fly Ash (000 tonnes)	Bottom Ash (000 tonnes)	Flue Gas Desulphurization Gypsum (000 tonnes)	Fluidized Bed Ash and Bottom Ash (000 tonnes)	Total CCPs (000 tonnes)
PRODUCTION					
Produced	4,081	1,708	215	186	6,190
Disposed / Stored	3,118	1,705	1	186	5,010
Removed from Disposal	15	--	--	--	15
USE (DOMESTIC)					
Cement	367	130	2	39	538
Concrete / Grout	814	0	0	0	814
Mining Applications	70	0	0	0	70
Roadbase / Subbase	20	47	0	0	67
Wallboard	0	0	212	0	212
Waste stabilization and specialty uses such as mineral filler and flowable fill as well as other uses	34	4	0	0	38
TOTAL USE	**1,306**	**181**	**214**	**40**	**1,740**
Percentage Utilization by Material (%)	32%	12%	100%	22%	28%

Appendix J presents more detailed information on CCP usage by existing coal fired generating stations found in trade journals, internet searches and websites of currently operating coal fired generating stations.

In December, 2018 the Government of Canada announced final regulations to phase-out traditional coal-fired electricity by 2030 as part of a greenhouse gas/climate change target to have 90% of electricity from non-emitting sources by 2030.[52] The announced phase out is projected to cut carbon pollution from the electricity sector by an estimated 12.8 million tonnes. This announcement also means that the production of CCP will be phased out over the next ten years.

[51] Natural Resources Canada, September 15th, 2014

[52] https://www.canada.ca/en/environment-climate-change/news/2018/12/canadas-coal-power-phase-out-reaches-another-milestone.html

14.2 Steel Making Residues

The CSPA (Canadian Steel Producers Association) has ten member companies with 13 facility locations across Canada, presented in Table 36.

Table 36: Canadian Steel Producers Association Membership and Facility Locations

COMPANY NAME	Location of Steelmaking Facilities	Brief Description
Algoma Steel	Sault Ste Marie, ON	Integrated mill (blast furnaces and BOF furnaces)
AltaSteel	Edmonton, AB	EAF mill
ArcelorMittal Dofasco	Hamilton, ON	Integrated (blast furnaces and BOF furnace) and EAF mill
ArcelorMittal Long Products Canada	Contrecoeur, QC	DRI (Direct Reduced Iron) with EAF mill
Evraz	Regina, SK	EAF mill
Gerdau	Selkirk, MB; Whitby & Cambridge, ON	EAF mills
Ivaco	L'Orignal, ON	EAF mill
Rio Tinto Fer et Titane (RTFT)	Sorel-Tracy, QC	Iron/titanium production and BOF furnace
Stelco	Hamilton & Nanticoke, ON	Integrated mill (blast furnace and BOF furnaces)
Tenaris	Sault Ste Marie, ON	Tube mill

CSPA companies represent all carbon steel production in Canada. Information on how steel making residues are managed was obtained from through a survey of CSPA membership carried out in March, 2020. The survey results are presented in Table 37.

Table 37: Management of Steel Making Residues in Canada (2020)

Steel Making Residue Material	Typical Practices	Amount Reused or Recycled (2018)
Fly Ash Management	Fly ash production at boilers is minimal (~<10 tonnes across the sector).	
Pollution Control Device Residues	The steel sector has many different kinds of pollution control devices (e.g. bag houses, water treatment, flue dust collectors, etc.) in which various residuals are collected. This data varies across facilities and could not be assembled during the March 2020 survey. It is possible to recycle/sell iron bearing by-products such as mill scale (removed by water in the hot rolling mill). Mill scale sold (recycled) was ~0.26 million tonnes in 2018. Other by-products that may be sold include iron pellet fines, blast furnace flue dust and kish.[53]	260,000 tonnes of mill scale sold. Data on other materials could not be collected
Blast Furnace Slag	The sector produced 1.44 million tonnes of blast furnace slag in 2018. Blast furnace slag is either granulated or pelletized. If slag processing facilities are unavailable, then the slag may be air cooled. In 2018, ~1.50 million tonnes of blast furnace slag were sold to the cement industry (to be used in the production of cement). About 0.09 million tonnes were stored on site in 2018. The slag inventory from a previous year may be sold in a subsequent year.	Approx. 1,500,000 tonnes of blast furnace slag sold to cement industry.
Steelmaking Slag	The sector produced 1.73 million tonnes of steelmaking slag in 2018. Steelmaking slag includes slag from BOF furnaces, EAF furnaces and also from ladle metallurgical furnaces (used in some facilities as a step after the steelmaking furnace). Steelmaking slag is typically managed by an on-site third-party processor to cool and crush the slag. The slag is generally processed through a metallics recovery plant that removes metals (for recycling) and screens the slag to size. About 0.82 million tonnes of slag were sold and re-used off site in 2018 in the cement industry, the steel industry (for use in furnaces), for road construction, mixed in with asphalt and in the manufacture of insulation. About 0.45 million tonnes were recycled on-site into the ironmaking and steelmaking processes (integrated mills). About 0.11 million tonnes were reused on-site (various uses), and about 0.30 million tonnes were stored in 2018. Note that slag inventory from a previous year may be sold in a subsequent year.	820,000 tonnes of slag sold and reused off site to cement industry, steel industry, road construction, or manufacture of insulation. 450,000 tonnes recycled on-site 110,000 tonnes reused on site.
Electric Arc Furnace (EAF) Dust	Electric arc furnace (EAF) dust is a by-product of the steelmaking industry. Composition of the dust varies depending on the feedstock, but usually includes iron, zinc, lead, and small amounts of other slag making compounds. About 101,000 tonnes of EAF dust were produced in 2018. Of this total, about 70,000 tonnes were put into on-site storage (specialized cells) or secure landfill disposal. About 29,000 tonnes were shipped to recycling facilities in the U.S. – either American Zinc Corporation (http://azr.com/) or Steel Dust Recycling (http://steeldust.com/). About 2,000 tonnes were recycled on-site back into the steelmaking process.	29,000 tonnes of EAF dust sent to recycling

14.3 Wood Ash

Wood, or biomass, ash is created when forest biomass (i.e., tree tops and branches, bark, wood chips, and sawdust) is burned to produce bioenergy. As the biofuel industry expands, so will the volume of wood ash generated as a by-product of the biomass combustion process. Wood ash is an excellent source of lime and potassium for promoting plant growth. It also provides many of the trace elements that plants need.

[53] Kish is "graphite formed on the surface of molten iron that contains a large amount of carbon" (Collins online dictionary)

IEA Bioenergy (2018) estimates that Canada produces at least 1 million tonnes per year of wood ash, based on total contributions from pulp and paper mills and wood/forest biomass ash (Cherian,2019).

Table 38: Available Data on Wood Ash Production in Canada, Various Years[54]

Jurisdiction	Year	Annual Wood Ash Production (Tonnes)	Notes
Canada – pulp & paper mills only	2013	420,000	Dry weight[55]
Alberta – wood ash	2015	59,639	Dry weight[56]
British Columbia – forest biomass ash	2014	235,449	Dry weight[57]
Quebec	2007	200,000	Reported as 300,000 tonnes wet weight.[58] Calculated as 200,000 dry weight (assuming 33% moisture content)
Total		Not known	Double counting of wood ash from pulp and paper mills with wood ash from other sources likely. Actual total not known until surveys of other provinces completed and data for Quebec, BC and Alberta are updated.

Table 40 summarizes the results of a recently completed survey of Canadian pulp and paper mills, which provides some relevant data on annual production of wood ash from pulp and paper facilities in Canada, as well as data that was collected for BC, Alberta, and Quebec in different years (2013-2015). It should be noted that the data from Quebec is reported in wet tonnes rather than dry tonnes, so a 33% moisture content of wood ash was used to convert the total to dry tonnes. While incomplete, the table indicates that the amounts of wood ash are substantial, and likely up to or greater than 1 million tonnes/year, although the extent of double counting between the pulp and paper mill total and the provincial totals is not known.

Some biomass ash is used as soil amendment – its lime and phosphorous content is valuable for this purpose. Some is also used at pulp and paper mills on a small scale for other beneficial purposes (soil stabilization, road stabilization, solidification of waste, and as a neutralizing agent). Table 40 shows that about 55,000 tonnes of biomass ash were used as a soil amendment in Canada in 2013.

[54] Cherian, C., and S. Siddiqua (2019).
[55] Elliott, A. and T. Mahmood (2015).
[56] G. Dinwoodie, Land Reclamation Specialist - Alberta Environment and Parks, Land Policy Branch, personal communication, September 2016
[57] Nishio, G. (2016).
[58] Hébert, M. and B. Breton (2008).

Table 39: Management and Disposal of Boiler Ash Generated in Canadian Pulp and Paper Mills in 2013[59]

Utilization	Quantity (Tonnes)	Proportion of the 296,200 tonnes of ash produced by survey respondents at Canadian pulp & paper mills (%)
Landfill	183,100	62%
Soil amendment (direct application or in compost)	54,700	18%
Other beneficial use	52,500	18%

The use of wood ash as a soil amendment is largely under provincial and territorial jurisdiction and therefore varies significantly across Canada. The level of government support for the practice also varies from one province/territory to another. In Alberta, soil application of wood ash is fairly common because of Alberta guidelines which encourage the use of wood ash as a liming agent. Soil application of wood ash produced at co-generating plants (i.e. not associated with pulp and paper mills) is also standard practice in Quebec, where high landfill disposal fees have been implemented to encourage waste diversion. In Nova Scotia, the utilization of wood ash as a fertilizer and liming agent on farmland is encouraged by the provincial government through subsidies given to agricultural producers. The practice has become so popular that available wood ash supplies often run out.[60] In some jurisdictions, wood ash is treated as a hazardous waste and landfilled.[61]

Table 40 summarizes the use of wood ash as a soil amendment in selected Canadian provinces and territories. MB, NWT, NU, ON, PEI, SK, YK, and NFLD do not allow this practice. The table shows that this practice is more common on agricultural soils than on forest soils in the provinces that permit this practice.

Table 40: Use of Wood Ash as a Soil Amendment in Selected Provinces in Canada62

		Common Uses of Applied Ash	
Province/Territory	**Ash used as a soil amendment?**	**Purpose**	**Site Type**
Alberta	Yes	Liming	Agriculture
British Columbia	Yes	Liming	Agriculture/Forestry
New Brunswick	Yes	Fertilizing/Liming	Agriculture
Nova Scotia	Yes	Fertilizing/Liming	Agriculture
Quebec	Yes	Liming	Agriculture/Forestry

Research for this study could not find comprehensive information on how wood ash is managed in Canada. Research is needed to quantify total wood ash generation in Canada and the extent to which the wood ash is directed to beneficial purposes. This is identified as a research need in Section 15.

14.4 Spent Foundry Sand

Canada's foundry industry includes large, medium, and small foundries that serve a number of markets and industries, including the automotive sector, construction, agriculture, forestry, mining, pulp and paper, heavy industrial machinery and equipment, etc. (Canadian Foundry Association website).

Foundry sand is a high-quality silica sand or lake sand that is bonded and used to form molds for ferrous and non-ferrous metal castings.[63] Prior to use, this sand material is uniformly graded. Once used, however, the material

[59] Sources: Hébert, M. and B. Breton (2008) and Elliott, A. and T. Mahmood (2015).
[60] Natural Resources Canada, Canadian Forest Service (2016).
[61] ibid.
[62] Natural Resources Canada, Canadian Forest Service (2016).
[63] U.S. Department of Transportation, Federal Highway Administration.

usually contains metal from the casting and oversized mold and core material containing partially degraded binder. Used or spent foundry sand can also contain some leachable contaminants, including metals (cadmium, lead, copper, zinc, chromium and nickel) that are absorbed by the sand during the molding process and casting operations.[64]

There are two types of foundry sand: green sand and chemically bonded sand. Green sand is the most commonly used molding media by foundries and consists of 85-95% silica, 0-12% clay, 2-10% carbonaceous additives, and 2-5% water. In contrast, chemically bonded sand contains of 93-99% silica and 1-3% chemical binder. [65]

A March 2017 article in the International Journal of Scientific and Research Publications identifies a number of beneficial uses of spent foundry sand, including[66]:

- **Structural fill** used as support for structures such as roadways, parking lots, buildings, and pieces of equipment.
- **Manufacturing another product** as a raw material in the manufacture of other products such as asphalt, cement, concrete, grout, lightweight aggregate, bricks, and roofing material.
- **Soil manufacturing and amendment** to produce horticultural soils, topsoil, potting soil, and turf mixes
- **Landfill uses** as daily cover for an active landfill or for road construction within an active cell
- **Pipe bedding and backfill for trenches** created by the installation of storm and sewer lines
- **Rock wool** as an effective source of silica in rock wool, which is commonly used to reinforce other materials such as building material insulation

NRCan (2006) estimated that 351,000 to 585,000 tonnes of spent foundry sand were discarded or available for recycling in Canada annually. Given substantial changes in most heavy industries in Canada since that time, the situation could be considerably different today. The 2006 NRCan report states that reclamation and reuse of foundry sand within the molding operation was a standard practice at that time. Some spent foundry sand was also used as an aggregate substitute and could be used as a silica source for some applications, although its high content of fine particles limited its use to particular applications. Industries which used spent foundry sand as a silica source included: aggregates and building materials (particularly fill applications), the cement industry and the mineral wool products industry. Some spent foundry sand was supplied to the asphalt and cement industry as a feedstock after screening to remove large pieces. There were limits to the amount that could be blended into these operations.

The Canadian Foundry Association was contacted as part of this study research. However, given the Covid 19 situation which emerged in March 2020, it was not possible to contact industry members to confirm current practice. A survey of this sector is identified as future research in Section 15.

[64] U.S. Department of Transportation, Federal Highway Administration
[65] Jadhav, S.S., et al (2017)
[66] ibid.

15 Summary and Gaps

15.1 Summary of Quantities Recycled

The quantities of materials recycled in Canada in or near 2018 identified in this study research are summarized by material in Table 41.

Table 41: Summary of Identified Materials Recycled in Canada Annually (tonnes)

Material	Exported (tonnes)	Imported (tonnes)	Reused or Recycled (tonnes)	Notes
Scrap Paper	2,000,000	1,400,000	3,600,000	Used in Canada (2014)
Scrap Steel	5,100,000	3,340,100	6,700,000	steel/ferrous metal used in Canada (2018) 4,800,000 tonnes purchased 1,900,000 tonnes internal scrap
Aluminum	553,420	104,900	104,900	No data on recycled – assume imported value
Lead	4,480	5,590	129,500	Secondary lead amount from NRCan
Copper	162,810	109,720	109,720	No data on recycled – assume imported value
Zinc	10,690	250	250	No data on recycled – assume imported value
Nickel	9,581	29,040	29,040	No data on recycled – assume imported value
Glass			380,000	WMIS (2016)
Glass (Deposit Return Programs)			200,000	309, 100 tonnes deposit-return systems –some is additional to WMIS value – degree of double counting not known, so allowance of 200,000 tonnes included but this may be an underestimate
Plastic			442,000	Deloitte (2019)
Food and Yard			2,670,000	WMIS (2016)
Tires			440,000	CATRA (2018)
Electronics			106,900	EPRA and ARMA (2018)
White Goods			330,800	WMIS (2016) May be counted in metals above
Small and outdoor appliances			5,300	BC only
Batteries (post-consumer)			5,000	
Batteries (lead acid)				129,500 lead already counted in metals
Lumber/Wood			283,000 272,000 2,000,000	CR&D Pallets Biomass power
Drywall			106,000	
Coal combustion products (CCP)			1,306,000 181,000 214,000 40,000	Fly ash Bottom ash Flue gas desulphurization Bottom ash
Steel making residues			1,500,000 820,000 450,000 110,000 29,000	Blast Furnace slag Steel making slag sold off site On-site recycling On-site reuse EAF to zinc recyclers
Wood ash			54,700 52,500	Soil amendment (from pulp and paper sector) Other beneficial use (from pulp and paper sector)
Total For Canada Identified To Date	**7,840,981**	**4,989,600**	**22,340,810**	

The total amount material recovered and/or recycled is estimated to be over 22.3 million tonnes. This excludes potential glass from deposit-return programs, which is estimated at 308,100 tonnes in 2018. There is some double

counting with the WMIS (2016) total, therefore an allowance of 200,000 tonnes is included in Table 42 but needs to be verified through future research. The largest amount in this total identified to date is in the steel industry, which uses 6.7 million tonnes of scrap steel, exports 5.1 million tonnes, imports 3.3 million tonnes of scrap and recycles 2.9 million tonnes of residues. Scrap paper is also recycled in significant quantities, with 2 million tonnes exported, 1.4 million tonnes imported, and an estimated 3.6 million tonnes used in Canadian mills. This value needs to be updated through additional research. All of these totals may include some double counting and they need to be resolved through additional research and analysis.

The evidence assembled for this report is a clear indication that Canada's economy contains many circularities. While policies and regulations may drive some of the recovery/recycling activities quantified in this report, gains in resource and energy efficiencies supported by positive economic factors may have a greater influence. In other words, since business seeks to minimize cost and maximize profit, any discard of process residuals that contain some value may represent a double loss: the cost of waste disposal plus foregone revenues.

Given that waste diversion activities save on GHG emissions, the large amount of material reused, recovered, recycled or composted in Canada results in significant GHG emission reductions. These should be quantified as part of future research activities.

15.2 Gaps in Available Data

The research identified gaps in the available data for each material studied. These were noted throughout the text. Some gaps where the amount of material involved is potentially significant are listed below. In all cases, a survey of the industries involved would quantify the materials.

Wood Ash: While incomplete, the table in Section 14 indicates that the amounts of wood ash produced are substantial and likely greater than 2 million tonnes/year. Management pathways for the wood ash are not known and need to be identified through additional research

Agricultural Waste: The WMIS survey does not capture the following organic waste diversion activities:

- food and animal wastes from rendering plants used to make protein meals and fat products;
- food wastes or other wastes sent to farms for use as animal feed or bedding; and,
- agricultural waste (including livestock manure and offal) processed via land application or on-site anaerobic digestion.

Foundry Sand Utilization: It was not possible to confirm the current practices for foundry sand utilization, therefore follow up with the Canadian Foundry Association is needed to contact industry members to confirm current practice and seek quantities.

Scrap Paper Amounts: All scrap paper amounts for one baseline year are needed to obtain a reliable estimate of how scrap paper and recycled paper flows through the Canadian system.

Amounts of Aluminum Recycled in Canada: No information is available at this time regarding the extent to which aluminum scrap is absorbed by this sector in Canada. The aluminum imported is absorbed domestically but some domestically collected aluminum may also be absorbed by industry in Canada.

Scrap Copper, Zinc and Nickel: The extent to which scrap copper, zinc and nickel are absorbed in Canadian facilities is not known, although there is trade data showing exports and imports for each metal.

Recycling of Batteries from the IC&I Sector: Significant amounts of batteries are used by the IC&I sector. Neither recycling practices nor quantities are known.

Deposit-Return System and EPR Program Tonnages: The extent to which WMIS includes tonnes recycled by deposit return systems for beverage containers and also materials collected in EPR programs needs to be clarified The materials involved in deposit return programs are mostly aluminum, glass and some plastic. EPR programs address a wide range of materials.

Metal Shredder Capacity: Research or a survey should be carried out to identify the capacity and throughput of metal shredders in Canada (in tonnes/year).

15.3 Potential for Circular Economy Survey

This report proposes one broad suggestion – that a *Circular Economy Survey* be developed in partnership with Statistics Canada to fill in a number of the gaps identified through the project research. Many of the identified gaps could be addressed if such a survey were designed and administered.

For many of the materials examined (e.g. scrap metal "consumed" in Canada (that is, re-melted); scrap paper used by paper industries, etc.) the number of companies involved in the use of scrap feedstock is not extensive, and these companies are already likely surveyed by Statistics Canada for other reasons. Therefore, adding a few questions to existing surveys, or creating new surveys should be explored. For instance, only 13 large BOF and EAF facilities in Canada and less than 100 iron and steel foundries use scrap steel; and less than 30 paper recycling companies use scrap paper in Canada. The proposed point of measurement is where material transformation (i.e. melting or hydro-pulping) occurs, not at the collection point.

As an example, while Section 3 of this report shows that good data exists on paper recycled through MRFs (which capture most residential recycling and some commercial recycling), the paper collected directly by paper companies from large retail establishments is not captured through the WMIS survey. It is believed that this data was likely captured through information provided by the Pulp and Paper Products Council (an international organization with an office in Montreal) to NRCan but the most recent data is for 2014.

A Circular Economy survey could be developed that includes all facilities in Canada that are known to use (or "consume") any appreciable amount of scrap materials. Suggested questions include:

- How much scrap or "secondary" material (please specify) did you use in your manufacturing operation last year?
- How much of this total did you receive directly from businesses that produce scrap materials suitable for you to incorporate into your manufacturing processes? and, if relevant;
- How much of this total was imported from foreign sources?
- What residuals do you produce at your site?
- Are any of these residuals recycled or reused either in our own operation or elsewhere (please specify).

The Circular Economy Survey should include materials such as CCP (coal combustion products) which are directed to a variety of different uses, including to the cement and concrete industry. The recycling of wood wastes would need to be captured by a survey of wood waste generators and recyclers, as wood wastes are used in a number of end markets including as biofuel, animal bedding and compost amendment among other uses.

15.4 Metrics for Measuring Circular Economy Activity in Canada

Since the Circular Economy is a global concept, and since many other countries are developing or implementing policies and programs to advance it, there is a pressing need to determine how CE performance should be measured and reported. This raises a few questions. What qualifies as circular? How should energy recovery be treated? How can double-counting be avoided? Which country gets the "credit" for recovered materials if collection and processing take place on different sides of an international border? In address these questions, it is recommended that the Government of Canada engage with other governments and entities (UNEP, OECD, WCEF, etc.) to ensure that CE measurements between different countries are standardized or at least comparable.

Regarding the final outcome of this *Preliminary Resource Recovery Report Card and Gaps Assessment*, the metric total tonnes recycled in the Canadian Circular Economy (22.3 million tonnes from Table 42) divided by Canada's population (37 million in 2018[67]) suggests that the Canadian economy recovers or recycles about 600 kg per cap per year. This simple metric would enable comparisons with other countries if they were to adopt the same approach. The denominator for the calculation could be total solid waste generated, rather than population. As a first step, it would be necessary to determine the feasibility of assembling total waste data, but that was beyond the scope of this report. Given the complexity of what is counted in the denominator for waste studies, a metric related to population is easier to apply as population data are readily available for all countries.

[67] https://www150.statcan.gc.ca/n1/pub/12-581-x/2018000/pop-eng.htm

Appendix A: List of References

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Appendix B: Details of Paper Recycling By EPR and Deposit Return Programs in Canada by Province and Territory

All of the data that could be found on paper recycling at the provincial level is presented in Table 42. The information is taken from EPR (extended producer responsibility) program annual reports, and may already be included in the 2016 WMIS data, therefore it is possible that some double counting is involved. Deposit return program materials are shown separately in the table as these may not be included in the WMIS totals (to be confirmed with Statistics Canada). Because of the uncertainty regarding double counting, the WMIS 2016 total was used in the report.

The information in the table shows the amounts of different types of paper materials (polycoat, cardboard, boxboard, newsprint, etc.) recycled by province, and where available, by territory. The data is taken from the most recent reports available, generally 2017 or 2018 EPR and deposit-return program annual reports submitted to provinces or territories and/or generally posted on EPR organization websites. All 2016 WMIS[68] references come from the same source and are not footnoted in the table. For Yukon, Nunavut and NWT, data in the table are shown as N/A, since the information is suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 42: Paper Recycled in Canada by Province and Source, 2018

Province and Date	Reference and Recycled Paper Type	EPR Programs (tonnes)	Deposit Return Programs (tonnes)	WMIS (2016) (tonnes)
British Columbia	Recycle BC EPR Program[69] (2018)	120,267		
	Deposit Program[70] - *Polycoat (drink box & gable top)*		1,797	
	WMIS (2016)			**603,485**
Alberta	Deposit Program *Gable top cartons & tetra-pak (2018)*		4,891[71]	
	WMIS (2016)			**259,442**
Saskatchewan	Multi-Material Stewardship Western EPR Program (2018)	N/A[72]		
	Deposit Program		N/A	
	WMIS (2016)			**51,881**
Manitoba	Multi-Material Stewardship Manitoba (MMSM) EPR Program[73] (2017)			
	Newsprint	20,165		
	Magazines and catalogues	3,347		
	Telephone books	882		
	Other printed paper	2,762		
	Total printed paper	27,156		
	Corrugated cardboard	11,632		
	Boxboard	8,730		
	Gable top cartons	1,076		

68 Statistics Canada. 2016 Waste Management Industry Survey.
69 Recycle BC 2018 Annual Report
70 Encorp Pacific 2018 Annual Report
71 ABCRC 2018 Annual Report
72 MMSW 2018 Annual Report only provides data on total tonnes of PPP collected, which was 42,352 tonnes in 2018.
73 MMSM 2018 Annual Report only provides data on 2017 supplied and collected tonnes. 2018 data will be available in their 2019 annual report, which is not yet posted.

	Paper laminates	973		
	Aseptic containers	383		
	Total paper-based packaging	22,794		
	WMIS (2016)			**89,993**
Ontario	Stewardship Ontario EPR Program[74] (2018)			
	Newsprint (Canadian Newspaper Association and Ontario Community Newspaper Association Reporting)[75]	88,435		
	Newsprint (Newspapers who are not members of either Canadian Newspaper Association or Ontario Community Newspaper Association)[76]	101,940		
	Magazines and catalogues	40,292		
	Telephone books	1,364		
	Other printed paper	33,277		
	Total printed paper	265,307		
	Corrugated cardboard	190,045		
	Boxboard	102,024		
	Gable top cartons	7,258		
	Paper laminates	4,029		
	Aseptic containers	1,693		
	Total paper-based packaging	305,048		
	Deposit Program[77] – (Corrugated/Boxboard) (2018)		18,946	
	WMIS (2016)			**1,327,911**
Quebec	Eco-Entreprises Quebec EPR Program (2018-19)	N/A[78] Could be 459,020[79]		
	WMIS (2016)			**1,107,000**
New Brunswick	WMIS (2016)			**30,297**
PEI	WMIS (2016)			**10,457**
Nova Scotia	WMIS (2016)			**54,276**
Northwest Territories	Deposit Program[80] **(T**etra pak & gable top) (2017-2018)		120 (2017/2018) 32 (2018/2019)[81]	
Northwest Territories	WMIS (2016)	N/A		N/A
Yukon	WMIS (2016)	N/A		N/A
Nunavut	WMIS (2016)	N/A		N/A
Total for Canada	WMIS (2016)			**3,566,789**

74 Stewardship Ontario 2020 PIM Data
75 Consolidated numbers are reported for all members of CNA (Canadian Newspapers Association) and OCNA (Ontario Community Newspapers Association) combined.
76 Newspapers that are not members of either CNA or OCNA report tonnes separately
77 The Beer Store 2018 Stewardship Report
78 Recyc Quebec 2018-19 Annual Report states that total tonnes collected, of all materials, was more than 97,000 tonnes in 2018. No breakdown of collection by material. The 2018 report contains a footnote next to that number which cites 3 sources including Recyc-Quebec, StatsCan, and the 'Institut de la statistique du Quebec.
79 Eco-Entreprises Quebec's 2018 Annual Report states that 778,000 tonnes of materials were recovered through municipal programs. It also states that between 2015 and 2017, paper and cardboard represented 59% of what was in residential curbside recycling bins.
80 NWT 2017-18 Annual Report
81 https://www.ntassembly.ca/sites/assembly/files/td_51-192.pd

Appendix C: Information on Metal Recycling From WMIS (2016), EPR and Deposit Return Programs

Table 43 shows the data collected on metal recycling through Statistics Canada's biennial Waste Management Industry Survey (2016), as well as through EPR and beverage container programs. The amount of metal recovered through these channels is small relative to the amount of metal recovered via metal shredders (see Section 10).

Table 43: Reported Ferrous Metal Recycled By Province in Canada, 2016 and Through Deposit Return and EPR Programs in Canada in 2018

Province	Source	EPR (Tonnes)	Deposit Return (Tonnes)	WMIS (2016) (Tonnes)	Metal Description
British Columbia	Recycle BC EPR Program[82] (2018)	8,837			
	Deposit Program[83] (2018)		250		Bi-metal
	WMIS (2016)			58,342 55,791 114,133	Ferrous metal Mixed metal Total metal
Alberta	Deposit Program[84] (2018)	292			Bi-metal
	WMIS (2016)			33,286 23,072 56,358	Ferrous metal Mixed metal Total metal
Saskatchewan	WMIS (2016)[85]			3,452	
Manitoba	MMSM EPR Program[86]	2,391 118 113 2,622			Steel and food beverage cans Steel aerosols Other steel containers Total steel
Ontario	Stewardship Ontario EPR Program[87] (2018)	26,252 1,200 217 27,670 25,595[88]			Steel food and beverage cans Steel aerosols Steel paint cans Total steel Scrap metal
	Deposit Program[89] (2018)		182		Secondary steel packaging
Quebec	EEQ EPR Program[90] (2018-19)	23,340			
	Deposit Program[91]		17,403		
	WMIS (2016)			213,676	

[82] Reported as metal, not split out between ferrous and non-ferrous. Recycle BC 2018 Annual Report
[83] Encorp Pacific 2018 Annual Report
[84] ABCRC 2018 Annual Report
[85] No data on MMSW EPR Program or deposit program for 2018
[86] MMSM 2018 Annual Report only provides data on 2017 supplied and collected tonnes. 2018 data will be available in their 2019 annual report, which is not yet posted
[87] Stewardship Ontario 2020 PIM Data.
[88] 2018 Ontario RPRA Municipal Datacall. Scrap metal includes both ferrous and non-ferrous metal. No breakdown is provided but most of the weight is assumed to be ferrous
[89] The Beer Store. 2018 Stewardship Report
[90] Recyc Quebec 2018-19 Annual Report states that total tonnes collected, of all materials, was more than 97,000 tonnes in 2018. No breakdown of collection by material. Eco-Entreprises Quebec's 2018 Annual Report states that 778,000 tonnes of materials were recovered through municipal programs. It also states that between 2015 and 2017, metal represented 3% (23,340 tonnes) of what was in residential curbside recycling bins.
[91] Recyc-Quebec

New Brunswick	WMIS (2016)			1,505 811	Ferrous metal Mixed metals
Nova Scotia	WMIS (2016)			4,244	
PEI	WMIS (2016)			8,722 1,867	Ferrous metal Non-ferrous metal
Newfoundland	WMIS (2016)			1,093[92]	
	Northwest Territories (2017-18) - Deposit Program			11 (2018/19)[93]	Bi-metal
Northwest Territories, Yukon, and Nunavut	WMIS (2016)			N/A	
Total for Canada	WMIS (2016)			**491,536**	

[92] NFLD's deposit program numbers because those were aluminum containers, which are non-ferrous
[93] https://www.ntassembly.ca/sites/assembly/files/td_51-192.pdf

Appendix D: Aluminum Recycling Data by Province for EPR and Deposit Return Systems and Reported by WMIS (2016)(Combined with Copper)

Table 44: Reported Data on "All Metal" (Aluminum and Copper) from 2016 WMIS and Aluminum Recycled in EPR and Beverage Container Deposit Systems in 2018[94] [95]

Province	Source	EPR (tonnes)	Deposit Return System (tonnes)	WMIS (2016) Reported Aluminum and Copper
British Columbia	(2018) – Recycle BC EPR Program[96]	8,837		
	(2018) - Deposit Program[97]		5,202	
	WMIS (2016)			**15,037**
Alberta	(2018) - Deposit Program[98]		12,973	
	WMIS (2016)			N/A
Saskatchewan	(2018) MMSW EPR Program[99]	N/A		
	(2018) - Deposit Program[100]		N/A	
	WMIS (2016)			N/A
Manitoba	(2017) – MMSM EPR Program[101]			
	Aluminum food & beverage cans	1,641		
	Other aluminum packaging	154		
	Total aluminum	**1,795**		
Ontario	(2018) – Stewardship Ontario EPR Program[102]			
	Aluminum food & beverage Cans	11,032		
	Other aluminum packaging	128		
	Total aluminum	**11,159**		
	(2018) – Deposit Program[103]		13,683	
	WMIS (2016)			**18,789**
Quebec	(2018-19) – EEQ EPR Program	N/A		
	(2018) - Deposit Program[104]		17,403	
	WMIS (2016)			31,737

[94] N/A indicates data suppressed to meet the confidentiality requirements of the Statistics Act

[95] All metal; aluminum percentage not known but likely small or minimal

[96] Recycle BC. 2018 Annual Report

[97] Encorp Pacific (Canada). 2018 Annual Report.

[98] Alberta Beverage Container Recycling Corporation. 2018 Annual Report.

[99] Multi Material Stewardship Western. 2018 Annual Report.

[100] In its 2018-2019 annual report, SARCAN states that the return rate for aluminum beverage cans is 97% but it does not provide data on the number or weight of those containers.

[101] Multi Material Stewardship Manitoba. 2018 Annual Report.

[102] Stewardship Ontario 2020 PIM Data.

[103] The Beer Store. 2018 Stewardship Report.

[104] Recyc-Quebec. "Tableau des ventes et de la recuperation des contenants consignes (biere et boissons gazeuses)."

New Brunswick	WMIS (2016)			855
Nova Scotia	WMIS (2016)			189
PEI (2016)			1,018	1,514
Newfoundland	(2018-19) - Deposit Program[105]			
Newfoundland	WMIS (2016)			N/A
Northwest Territories	(2017-18) - Deposit Program[106]			
	Aluminum	171		
Northwest Territories, Yukon, and Nunavut	WMIS (2016)			251
Total for Canada		72,241		88,575 aluminum and copper combined[107]

[105] Personal communication with Gordon Wall, MMSB.
[106] Government of Northwest Territories. 2017-2018 Waste Reduction and Recovery Program Annual Report.
[107] 70,252 tonnes not suppressed and 18,323 tonnes suppressed data

Appendix E: Detailed Information on Plastics Recycling by EPR and Deposit Return Programs and Plastics Processors

Table 45 summarizes data on tonnes of plastic collected for recycling in EPR and deposit return programs in Canada in 2018, or the most recent year for which data was available. This includes tonnes of plastic collected through beverage container deposit return programs as well as printed paper and packaging (PPP) EPR programs, which include plastic packaging, and are therefore mostly consumer/residential related quantities. Plastic packaging is commonly used to protect, preserve, store and transport products, and is the main category in terms of the end market for plastic products. It regroups films (including plastic bags), bottles and other items for sectors including food and beverage, healthcare, consumer packaged goods, and cosmetics and personal care among countless other applications.

Plastics from packaging (e.g., films, bottle, non-bottle rigid) represents 1,542,000 tonnes or 47% of all plastic waste generated in Canada in 2016.

Also included in the table are data from the 2016 StatsCan WMIS, which includes total tonnes of plastic recycled from both residential and non-residential sources.

Table 45: Reported Plastics Recycled in EPR and Deposit Return Programs in Canada in 2018 and by Statistics Canada in 2016

	Province	EPR Program Plastics (tonnes)	EPR Collected (tonnes)	Deposit Return Program (tonnes)	WMIS (2016) Plastics Totals
British Columbia	Recycle BC EPR Program (2018)[108]				
	Rigid plastic	22,865			
	Flexible plastic	3,762			
	Total EPR plastics		26,627		
	Deposit Program (2018)[109]			10,719	
	WMIS (2016)				65,851
Alberta	Deposit Program (2018)[110]			20,192	
	WMIS (2016)				33,591
Saskatchewan	MMSW EPR Program (2018)[111]		N/A		
	(2018-19) - Deposit Program			N/A	
Saskatchewan	WMIS (2016)				6,506
Manitoba	MMSM EPR Program (2017)[112]				
	PET bottles	4,482			
	HDPE bottles	2,773			
	Plastic film	105			
	Other plastics	3,516			
	Total plastics		10,876		
Manitoba	WMIS (2016)				7,315
Ontario	Stewardship Ontario EPR Program (2018)[113]				
	PET bottles	38,597			
	HDPE bottles	15,611			
	Plastic film	5,321			
	Plastic laminates	1,333			
	Polystyrene	995			
	Other plastics	31,438			
	Total plastics		93,295		
	Ontario (2018) – Deposit Program[114]				
	PET packaging		959		
	Mixed plastic packaging		1,016		
	Total plastic packaging		1,975		
Ontario	WMIS (2016)				120,335
Quebec (2018-19)	EEQ EPR Program[115]		N/A		
	(2018) - Deposit Program[116]			4,813	
Quebec	WMIS (2016)				137,235
New Brunswick	WMIS (2016)				1,455
PEI	WMIS (2016)				781
Nova Scotia	WMIS (2016)				7,738
Newfoundland	Deposit Program (2018-19)[117]			2,394	

	Newfoundland (2016 WMIS)				N/A
Northwest Territories (2017-18)	Deposit Program (2017-2018) [118]			130	
Northwest Territories, Yukon, and Nunavut	WMIS (2016)				N/A
Total for Canada	WMIS (2016)				**382,097**

[108] Recycle BC. 2018 Annual Report.
[109] Encorp Pacific. 2018 Annual Report.
[110] Alberta Beverage Container Recycling Corporation. 2018 Sustainability Report.
[111] Multi Material Stewardship Western's 2018 Annual Report only provides data on total tonnes of PPP collected, which was 42,352 tonnes in 2018.
[112] Multi Material Stewardship Manitoba's 2018 Annual Report only provides data on 2017 collected tonnes. 2018 data will be available in their 2019 annual report, which is not yet posted.
[113] Stewardship Ontario 2020 PIM (Pay in Model) Data.
[114] The Beer Store. 2018 Stewardship Report.
[115] Recyc Quebec's 2018-19 Annual Report says that total tonnes collected, of all materials, was more than 97,000 tonnes in 2018. No breakdown of collection by material.
[116] Recyc-Quebec
[117] Personal communication with Gordon Wall, MMSB.
[118] Government of the Northwest Territories. 2017/2018 Waste Reduction and Recovery Program Annual Report.

Plastics from packaging (e.g., films, bottle, non-bottle rigid) represents 1,542,000 tonnes or 47% of all plastic waste generated in Canada in 2016.

Examples of how plastic collected in deposit return programs (and which is reasonably clean when collected) is recycled include:

- More than 98% of plastics collected in BC remain in BC, with a local end-market in Metro Vancouver
- Plastic containers collected in BC's beverage container deposit program were sold to end markets in British Columbia and shipped to their two separate facilities in BC and AB to be cleaned and pelletized to become new raw material for manufacturers of various plastic products including new containers, strapping material and fibres.
- Stand-up pouches made of layers of plastic and aluminum foil, as well as the laminated plastic bags used inside bag-in-a-box containers were shipped to a manufacturing company in South Korea for production into composite decking.

Table 46 summarizes polyethylene terephthalate (PET) recycling services provided by four significant plastics recyclers in Canada, showing whether they purchase PET materials as bottles (and are therefore recyclers which accept materials from deposit systems or municipal programs in Canada). PET is a strong and lightweight plastic that is widely used to make packaging for food and beverage products, especially soft drinks, juices and water. PET is also widely used for packaging salad dressings, peanut butter, cooking oils, mouthwash, shampoo, liquid hand soap, etc.[119]

Table 46 PET Market Summary, Canada[120]

Recycler	Location	PET Bottles	Ground PET Bottle Flake	PET Bottle Pellets	PET Thermoform Bales
Merlin Plastics Supply, Inc. (Canada)	Delta, BC	P	S		P
Plastrec Inc. (Canada)	Joliette, QC	P	S/P	S	P
Soleno Recycling (Canada)	Yamachiche, QC	S	S		
Tomra (Canada)	Baie D'Urfe, QC	P	S		
S = Sell **P = Purchase**					

[119]PET Resin Association. "An Introduction to PET."
120 Plastic Action Centre. "Canada Plastic Recycling Markets."

Table 47 summarizes recycling services provided by five polyethylene (high density are HDPE and low density are LDPE) and polypropylene (PP) recycling companies in Canada, showing the specific plastic grades they buy or sell.[121]

Table 47 Polyethylene and Polypropylene Market Summary, Canada

Recycler	HDPE Ground Bottle Flake	HDPE Pellets	LDPE Flake and/or Pellet	HDPE Injection Bulky Rigid	Mixed Bulky Rigid Plastics	HDPE Natural Bottles	HDPE Coloured	PP Bales	PP Flake and/or Pellet	Tubs and Lids (Thin Wall Packaging)	1-7 Bottles & ALL Rigid Plastics	1-7 Bottles & ALL Other	Any Post-Consumer PE	Any Post-Consumer PP
EFS-Plastics Inc. (Canada) Listowel, ON		S	S	P	P	P	P	P	S	P	P	P	P	P
Fraser Plastics Ltd. Canada Maple Ridge, BC	S/P	S		P	P	P	P	P	S	P			P	P
Merlin Plastics Supply Inc (Canada) Delta, BC	S	S	S			P	P	P	S	P	P	P	P	P
Plastrec Inc (Canada) Joliette QC														
Soleno Recycling (Canada) Yamachiche, QC	S/P	S/P		S/P	S/P	S/P	P		S/P	S/P	P		P	

Table 48 summarizes the recycling services available for plastic film in Canada.[122]

Table 48: Plastic Film Market Summary, Canada

Recycler	Location	HD and LD Retail Bag Bales	MRF Curbside Film Bales	PE Retail Mix Film Bales	PE Ag Film Including Mulch Bales	PE Ag Film (Excl. Mulch Bales)	PE Clear Film	LDPE Coloured Film Bales	LDPE Flake and/or Pellets	LDPE Furniture Mix Film Bales
EFS-Plastics Inc. (Canada)	Listowel, ON	P	P	P			P	P	S	P
Fraser Plastics Ltd. Canada	Maple Ridge, BC									
Merlin Plastics Supply Inc (Canada)	Delta, BC	P	P	P	P	P	P	P	S	P
Soleno Recycling (Canada)	Yamachiche, QC		S/P							
Tomra (Canada)	Baie D'Urfe, QC									

[121]Plastic Action Centre. "Canada Plastic Recycling Markets." Available at https://plasticactioncentre.ca/directory/canadian-plastic-recycling-markets/

[122] ibid.

The Deloitte report states that:

> *Mechanical recycling is currently the main value recovery option utilized in Canada. The vast majority of post-consumer mechanical recycling economic activity occurs at approximately 10-11 facilities across Canada, which typically (but not exclusively) produce resins and/or flakes of multiple resins. These facilities primarily recycle PET, HDPE, LDPE and polypropylene, which almost exclusively originate from packaging. The main challenges faced by mechanical recycling operations include the continued low prices of virgin resins, low bale quality received from some municipalities resulting in higher operating costs and lower profitability, the prevalence of poor design decisions (from a recyclability standpoint) on behalf of brand owners, and increasing costs to transport bales from various municipalities to the recycling facility.*

Figure 15 shows that most of the plastic recovered for recycling in Canada is either PET or high density polyethylene (HDPE). Both of these resins have high value markets.

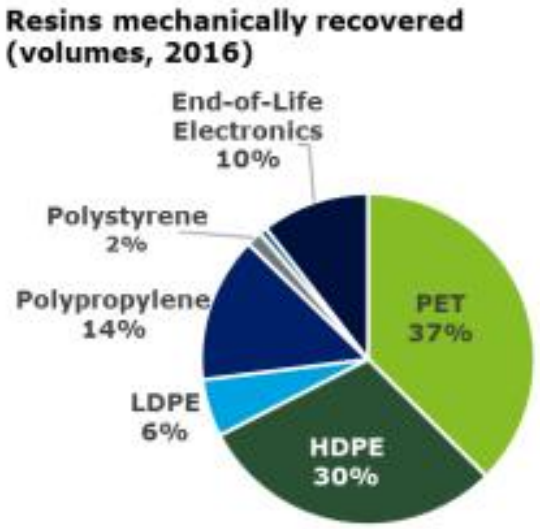

Figure 15: Plastic Resins Recycled in Canada, 2016[123]

[123] Deloitte and Cheminfo (2019)

Appendix F: Organic Waste Diversion Data by Province

With the exception of Ontario which collects data on organics collection through the Resource Productivity and Recovery Authority (RPRA)'s annual Municipal Datacall, all of the information in Table 49 from the Statistics Canada 2016 WMIS.

Table 49: Organics Collected in Canada and Diverted from Disposal (WMIS, 2016)

Province	Tonnes Collected	Organic Material Details	WMIS (2016)
British Columbia (2016 WMIS)			592,294
Alberta (2016 WMIS)			239,431
Saskatchewan (2016 WMIS)			31,329
Manitoba (2016 WMIS)			51,824
Ontario (2018 RPRA Municipal Datacall)[124]	461,512 66,880 2,436 11,596 555,304 **1,097,730**	Yard waste Leaves Christmas trees Bulky yard waste Household organics Total organics	
Ontario (2016 WMIS)			1,133,603
Quebec (2016 WMIS)			268,000
Newfoundland (2016 WMIS)			401
PEI (2016 WMIS)			20,181
Nova Scotia (2016 WMIS)			156,603
New Brunswick (2016 WMIS)			97,958
NWT, Yukon, and Nunavut (2016 WMIS)			3,990
Total for Canada			**2,595,614**

[124] Resource Productivity and Recovery Authority 2018 Datacall; only Ontario records the quantity of Christmas trees collected.

Appendix G: Tire Recycling Data from EPR Programs

This appendix provides some additional detail on tire recycling by province in 2018, or the most recent year for which data are available. While most tire program annual reports include performance data on publicly available web sites, the format of these reports vary, with some containing more detail than others. The way in which programs report on the final disposition of collected tires also varies. For example:

- BC provides a breakdown of the tonnes of processed tires that are converted into new products or sent to energy recovery or landfill.
- Tire Stewardship of Saskatchewan reports on the total weight of scrap tires that are converted into different products like shred, crumb, waste steel, and manufactured products.
- PEI's program operator, the Island Waste Management Corporation, simply states that a certain number of tonnes were shipped for recycling and/or as a fuel source, with no further breakdown or detail on end-fate of the material.
- Prior to moving to its new EPR regime, Ontario Tire Stewardship used to report on tonnes recovered, reused, actual input to recycling, material losses and disposal, recycled rubber, recycled steel, recycled fibre and total tonnes recycled, etc. The new Tires Regulation requires producers to submit an annual report to the RPRA (Resource Productivity and Recovery Authority) that contains information on the number and calculated weight of tires, for each tire type, that were reused and retreaded; the weight of processed materials, by material type, that resulted from the processing of tires; a list of the types of products and packaging that were made with the processed materials; and the number and calculated weight of processed materials that were land disposed, incinerated, used as a fuel or fuel supplement, or stored, stockpiled, or otherwise deposited on land.

Table 50 presents reported data on the tonnes of tires collected across Canada through tire stewardship programs in 2018 at a more detailed level. Some programs report tires recovered in tonnes, while others report only in units. In order to convert from units to tonnes, a conversion factor of one passenger tire equivalent (PTE) to 10 kg was used. The table shows that 435,167 tonnes of tires were collected in provinces across Canada in either 2018 or 2019 (the most recent year for which data are available). This value is somewhat different to the CATRA total because of slightly different reporting periods.

Table 50: Tonnes of Tires Collected for Recycling in Canada, 2018

Province	Tire Types Reported	Collected in Sub-Categories (tonnes)	Collected (tonnes)
British Columbia (2018)[125]	Passenger light truck tires	33,068	
	Medium truck tires	17,416	
	Large agricultural tires	546	
	Off-the-Road (OTR) tires	389	
	Total tires		51,419
Alberta (2018-19)[126]	Passenger Light Truck Tires (PLTT) and Specialty, Industrial, and Other (SIO) tires	40,394	
	Medium truck tires	21,987	
	Off-the-Road (OTR) tires	5,230	
	Total tires		67,611
Saskatchewan (2018)[127]			17,058
Manitoba (2018)[128]			18,177
Ontario (2018)[129]	Passenger light truck tires	102,826	
	Medium truck tires	35,786	
	Off-the-Road (OTR) tires	17,903	
	Total tires		156,515
Quebec (2018-19)[130]	Automobile tires	68,600	
	Truck tries	21,997	
	Forklift tires	791	
	Small tires	465	
	Total tires		91,851
New Brunswick (2018)[131]			12,217
Nova Scotia (2018-19)[132]			13,000
Prince Edward Island (2018-19)[133]			2,425
Newfoundland & Labrador (2018-19)[134]			4,370
Yukon (2018-19)			524
Total for Canada			**435,167**

[125] Tire Stewardship BC 2018 Annual Report.
[126] Alberta Recycling 2018-2019 Annual Report.
[127] Tire Stewardship of Saskatchewan 2018 Annual Report.
[128] Tire Stewardship Manitoba 2018 Annual Report.
[129] Tire Stewardship Ontario 2018 Annual Report.
[130] Recyc Quebec 2018-19 Annual Report.
[131] Recycle NB 2018 Annual Report.
[132] Divert NS 2018-19 Annual Report.
[133] Personal communication with Heather Myers at the Island Waste Management Corporation (IWMC).
[134] Personal communication with Glenda Melvin at Multi-Material Stewardship Board (MMSB).

Appendix H – List of Products Included in BC's Large Appliances Recycling Program

Table 51: Products Included in BC's Large Appliances Recycling Program

Product Category
1. Full-Size Refrigerators & Wine Coolers/Beverage Centres
2. Compact Refrigerators & Wine Coolers/Beverage Centres
3. Freezers
4. Room Air Conditioners
5. Portable Air Conditioners
6. Dehumidifiers
7. Clothes Washers
8. Clothes Dryers / Steam Cleaners
9. Ranges
10. Range Hoods and Downdrafts
11. Built-In Ovens
12. Built-In and Over the Range Microwave Ovens
13. Surface Cooking Units
14. Dishwashers
15. Food Waste Disposers
16. Trash Compactors
17(a) Electric Cold Beverage Dispensers
17(b) Electric Hot Beverage Dispensers

Appendix I: Canadian Electrical Stewardship Association (CESA) and OPEIC List of Products in BC EPR Programs

Table 52: List of Product Categories Collected in BC's CESA Program

Product Category
1. Kitchen Countertop – Motorized Appliances
2. Kitchen Countertop – Heating Appliances
3. Kitchen Countertop – Heating Appliances (coffee/tea)
4. Microwave Ovens
5. Time Measurement & Display Devices
6. Weight Measurement
7. Garment Care Appliances
8. Air Treatment Appliances
9. Personal Care Appliances
10. Full-size Floor Cleaning Appliances
11. Smaller Floor/Surface Cleaning Appliances
12. Test and Measurement Tools
13. Hand-Held Power Tools (Corded and Cordless)
14. Bench-Top, Demolition and Free-Standing Power Tools
15. Sewing/Textile Machines
16. Exercise Machines
17. Sports, Leisure, Arts, Crafts & Hobby Devices
18. Designated Very Small Items

Table 53: Categories of Electric Outdoor Power Equipment (EOPE) Covered by OPEIC's Stewardship Program in BC[135]

Hand-Held EOPE	Walk-Behind EOPE	Free-Standing EOPE	Electric Lawn Tractor
Brush cutter/lopper	Lawn mower	Mulcher	Lawn tractor
Chain saw	Snow thrower/snow blower	Pressure washer	
Garden sheer	Tiller/cultivator	Wood chipper/shredder	
Garden sprayer/insect fogger/weed steamer	De-thatcher	Wood splitter	
Ice drill	Walk-behind sprayer		
Lawn blower/vacuum	Edger/trimmer		
Lawn scarifier/de-thatcher	Lawn aerator		
Pole saw/pole pruning saw	Walk-behind blower/vacuum		
Post hole digger			
Stick edger			
Tiller			
Trimmers (grass, hedge, split-boom, etc.)			

[135] BC Stewardship Plan for Electric Outdoor Power Equipment. February 2018.

Appendix J: CCP Usage and Selected Canadian Coal Fired Power Plants

More detailed information on CCP usage by existing coal fired generating stations found in trade journals, internet searches and websites of currently operating coal fired generating stations is summarized below.

Genesee Generating Station, Alberta:[136] Coal from the Genesee Mine generally contains between 13-20% ash. Approximately 99.5% of the ash is recovered and put into permanent storage or sold for industrial uses. By using this ash in cement (instead of kilning limestone), coal-fired power plants reduce the greenhouse gas emissions of the combined industries by using the ash waste as their feedstock. Coarse sand-like fragments called bottom ash fall to the bottom of the boiler and have to be continuously removed. This by-product of burning coal is often sold as a substitute for gravel as a sub-base for road construction. Bottom ash from Genesee was used in the construction of the ring road, Anthony Henday Drive, and under the turf base of Commonwealth Stadium. A portion of the bottom ash is transported and stored in licenced ash landfills within the Genesee Mine. Fly ash is a dust-like by-product formed from coal combustion with a consistency similar to talcum powder. Fly ash from Genesee Unit 1 and Unit 2 is separated from the flue gas using an electrostatic precipitator (ESP). Fly ash is sold to the cement industry for use as an additive in the manufacturing of Portland cement. Fly ash from Genesee Unit 1 and 2 has been used in concrete for construction of airport runways, roads and building construction. Unsold ash is transported and stored in licenced landfills within the Genesee Mine.

H.R. Milner Generating Station, Alberta:[137] Bottom ash is sluiced to dewatering bins and is then hauled by truck to an off-site ash storage area. Fly ash is transferred to a fly ash silo and is then hauled by truck to the ash disposal site.

Boundary Dam Power Station, Saskatchewan:[138] In February 2012, SaskPower entered into a 10-year agreement with Lehigh Hanson Materials Limited (Lehigh), which gives Lehigh the exclusive rights to market fly ash from Boundary Dam. SaskPower looked for a company that could help maximize fly ash sales, given the increased storage capacity and the steady demand for the high quality of fly ash that comes from Boundary Dam.

Shand Power Station Estevan, Saskatchewan:[139] In November 2018, SaskPower and Lehigh signed an agreement to give Lehigh exclusive rights to market Shand Power Station fly ash. Lehigh has had rights to market Boundary Dam fly ash since 2012.

Belledune Generating Station, New Brunswick: One of its by-products is synthetic gypsum. Fly ash is used in a product that replaces Portland cement, production of which releases significant amounts of CO_2. A reported 98% percent of the fly ash is recycled.[140] The plant produces approximately 100,000 tons of low calcium fly ash each year. Around half is sold and the other half put into a landfill adjacent to the plant.[141]

136 Capital Power. "Capital Power Corporation's Genesee Generating Station."
137 Milner Power Inc. "Milner Generating Station."
138"Estevan fly ash facility opens." August 29, 2012. Yorkton This Week.
139SaskPower. November 26, 2018. "SaskPower, Lehigh Sign Agreement to Boost Fly Ash Sales." News Release.
140 Port of Belledune. Spring 2014. "Message from the President & CEO."
141 Coe, J. Spring/Summer 2017. "Alkali silica reaction at the Mactaquac Dam." Atlantic Concrete Association's Ready Mix News

Nova Scotia Power: NS Power owns all of the generation stations in the province (Lingan; Point Aconi; Point Tupper; Trenton), and its website states "When possible, we sell ash produced by our thermal generating stations to be used for other purposes. Fly ash, for example, can be used as a substitute for cement in concrete."[142]

Examples of how fly ash from coal combustion was reused (from a 2010 Triton Environmental Consultants report to Environment Canada[143]) include:

- ATCO Power's Battle River Generating Station in Alberta sells its fly ash to ASHCOR technologies to reuse in the cement industry and unsold flash and all bottom ash are disposed of at designated ash disposal sites.
- At Capital Powers' Genessee Generating Station, fly ash is handled dry and landfilled or sold and bottom ash is handled wet and landfilled.
- TransAlta Utilities' Sundance Generating Station sells much of its fly ash and the remaining is returned to the mine.

[142] Nova Scotia Power. "How We Make Electricity."
[143] Triton Environmental Consultants Ltd. June 2010. "Control of Mercury Emissions to Air." Report to Environment Canada.