BASELINING FOR
A CIRCULAR
TORONTO

MATERIAL FLOW ANALYSIS

Technical
Memorandum #2

May 14th, 2021

This report represents the second output of a research project between Circle Economy, David Suzuki Foundation and the City of Toronto. It seeks to build on existing Toronto data (material, emissions, and energy flows) and strategies that support circular economy goals (i.e. Long Term Waste Management Strategy, TransformTO, Toronto's Food Strategy, and Toronto's Resilience Strategy etc.). Following the completion of the Landscape Analysis in August 2020, this report serves to provide an in depth understanding of the current material flows for three key sectors – waste management, construction and food systems.

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The City of Toronto has taken on a leading role among Canadian cities in recent years by actively pursuing the topic of circular economy, and exploring how to take practical steps away from linear “take-make-dispose” approaches. As part of the Long-Term Waste Management Strategy, the City of Toronto is working towards an aspirational goal of zero waste and making Toronto the first municipality in the Province of Ontario with a circular economy. In order to do so, the City is developing strategies and programs (i.e. establishing a Circular Economy Working Group), engaging in multiple networks (e.g. the National Zero Waste Council (NZWC) and the Ellen MacArthur Foundation) and establishing various circular economy initiatives (e.g. formalization of a city-focused extended producer responsibility policy, investment in infrastructure to turn organic waste into renewable natural gas, development of a ‘Circular Procurement Implementation Plan and Framework’, etc.). The City’s efforts are being recognized internationally.[1]

This research project will seek to build on existing Toronto strategies that support circular economy goals (e.g. Long-Term Waste Management Strategy, TransformTO, Toronto’s Food Strategy, and Toronto’s Resilience Strategy etc.). In addition, this research project will help to inform the development of City policies and actions, and will also help to identify circularity goals that cannot be met by the City alone. The aim of the research project is to use data to understand circularity in key sectors and identify where intervention is required. This will link to existing City strategies in order to guide future actions and provide a robust ability to monitor progress. The project has been divided into four main tasks, which are described as follows:

TASK 1: START-UP AND CONSULTATION

The start-up and consultation phase (conducted in Quarter 1 of 2020) was used to gather information from key staff at the City of Toronto and the Toronto Region and Conservation Authority, and to help establish necessary support for the process to follow. The objective of this task was to ensure the direction of this baseline circularity analysis is aligned with parallel initiatives of the Circular Economy and Innovation Unit and other City-led initiatives. Documentation of the discussions and exercises from the start-up and consultation phase can be found in the kick-off report.

TASK 2: LANDSCAPE ANALYSIS

A Landscape Analysis was used to understand the existing state of Toronto’s socio-economic and policy context as it relates to circular economy themes. The main results of the Landscape Analysis helped to inform the decision on which three sectors would be analyzed further to optimise the beneficial impacts of circular economy solutions, in alignment with the City’s other strategic priorities. To this end, sectors were compared based on their contribution to factors like employment, Gross Domestic Product (GDP) and environmental impact, as well as their strategic importance. This exercise also provided insights on household spending, policies and legislation influencing waste management in Toronto, and current circular initiatives led by local businesses and community groups. The Landscape Analysis identified three sectors for the more detailed material flow and ‘business as usual’ analyses in Task 3. The City of Toronto undertook stakeholder engagement to validate and further refine the recommendations. Through this work, the following three sectors were identified for further study: Waste Management, Construction and Real Estate, and the Food System.

TASK 3 (A & B): MATERIAL FLOW ANALYSIS (MFA) & BUSINESS AS USUAL (BAU) ANALYSIS

To understand where the circular economy can have the most beneficial impact in each of the three selected sectors, an MFA was conducted for each of the three sectors to identify opportunities to close material cycles (see Glossary). The MFA provides visual maps of how water, energy, biomass, metals, and minerals are consumed within the sectors, and how these materials subsequently flow out of the sectors in the form of wastes and emissions. Looking ahead, the BAU analysis anticipates what the material consumption and waste generation patterns for the three sectors could be in 10 years time if left unchanged (subject only to economic growth and population growth). This provides a useful baseline to compare the impact of various alternative circular economy scenarios relative to one another. The MFA and BAU are the subjects of this document.

TASK 4: IDENTIFICATION OF KEY CONSIDERATIONS

In order to chart a path toward a circular economy, the researchers will reflect on the insights and outcomes of the previous Tasks, and draw on their expertise and experience from other cities to identify key considerations in transitioning Toronto towards a circular economy.

2 SUMMARY OF LANDSCAPE ANALYSIS

The Landscape Analysis was a fundamental part of the overall circular baseline assessment conducted to achieve a shared understanding of Toronto's current situation, including the character of its local economy, policy context, consumption behaviours and existing circular economy initiatives. The analysis showed that the City of Toronto has embraced circular economy thinking in much of its work, and is pursuing a number of ambitious waste management initiatives found in the Long-Term Waste Management Strategy and TransformTO, the City's climate action strategy. The City's approach provides a strong signal of circular ambition to both residents and businesses, and establishes an enabling environment for greater circularity.

Given the City's role regarding solid waste collection and disposal, it is not surprising that many of its circular efforts to date have focused at the end of various value chains – managing products at the end of their useful life and diverting resources away from disposal to more valuable uses/processes. However, a comprehensive circular economy approach considers not only waste management but the upstream processes and decisions necessary to avoid generating waste in the first place. This requires the involvement of a broad range of actors from within the municipal government and outside it, whose efforts are aligned toward shifting specific resource flows from linear to circular. When identifying which resource flows to focus on and which actions to prioritise, an overview of the magnitude of these flows in relation to one another provides a useful starting point. The Material Flow Analyses (MFAs) in this report aim to provide such an overview to facilitate understanding of the City of Toronto's urban metabolism (see Glossary), and inform the City about which actions it could take to encourage or support circularity in priority sectors. These insights can also be used to guide the City on how it might work with other stakeholders to achieve impact beyond its mandates.

The Landscape Analysis concluded by recommending potential sectors for further investigation via MFA. These sectors were proposed based on:

- Where can visibility and awareness be built? What projects could the City quickly develop that build awareness, engage the local business community and test practical circular economy approaches?
- Where are some 'quick wins' to address the biggest impacts? What are some of the biggest impacts that can be addressed, like embodied carbon (see Glossary), pollution, value loss, or diversion from landfill?
- How could strategic priorities be further reinforced? What new perspectives could a circular economy bring to Toronto's current policy goals and ambitions?

The proposed sectors were further discussed by project stakeholders, and three sectors were chosen for further investigation. It was agreed that the MFAs should focus on (1) Waste Management, (2) Construction and Real Estate and (3) the Food System.

It is important to note that "Construction and Real Estate" were presented as one sector in the Landscape Analysis due to economic data classifications; however, the Real Estate sector is not represented in the Material Flow Analysis due to data limitations and discrepancies. Many data sources fail to capture material flows from the Real Estate sector alone and better capture the material flows associated with the Construction and Demolition sector. That said, the Real Estate sector is less relevant in terms of material consumption and waste generation because its resource consumption is mainly related to utilities rather than finite raw materials. Focusing on Construction-related activities captures the vast majority of the relevant materials flows within Toronto. The Real Estate sector is a significant contributor to Toronto's economy, and could be a key enabler for circular economy solutions in the Construction sector as a whole.

The Food System was the final selection made by project stakeholders, which was an evolution from the original recommendation of "Consumer Goods" by the researchers in the Landscape Analysis. This change was brought about through stakeholder consultation where project stakeholders expressed that a food-specific focus would provide added-value. The researchers evolved their recommendation to highlight food as one specific aspect of consumer goods.

A sectoral Material Flow Analysis (MFA) provides a holistic view of the material throughput of a sector, and has been used in this report to gain greater insights into the current circular state of the three sectors identified by the researchers and approved by the City of Toronto at the end of the Landscape Analysis. MFAs examine how resources (including but not limited to energy, biomass, minerals, and metals) are consumed, processed and disposed of within each sector. MFAs are based on estimates of the volumes of the material, waste, emission or other key impacts associated with certain material flows. The objective of this task is to visually map the flows of materials through the city to more easily explain the baseline level of circularity of the identified sectors, and identify where intervention may be possible to make linear flows more circular.

The data used to prepare an MFA is collected from a wide variety of sources, both from government and non-governmental sources. MFAs only offer a static 'snapshot' of resource flows through a given sector or area of the economy. The accuracy with which an MFA can depict local realities is highly dependent on the quality, format, age and availability of the data. In some cases, national or provincial data may have to be adapted to represent the city scale, and in other cases, older data may have to be used that doesn't necessarily reflect recent developments. Based on data availability, only some material flows have been selected in this analysis (major resource groups and CO_2 emissions). While the MFAs in this report were prepared using the best data available, the MFAs should not be viewed as complete and comprehensive representations of the resource metabolism for each sector. The MFA provides a system-level overview and is not intended to present detailed information on specific business processes or operations.

When reading this document, please note that it is directional in nature and not intended to provide technical guidance, specific policy recommendations or an implementation plan for the City of Toronto. The figures presented in this report are based on rounded numbers and are not intended to replace reporting requirements for the City of Toronto. Further research to address the data gaps identified through this project will be required in order to make informed regulatory or policy changes to enhance circularity in Toronto.

Definition of sectors

In this document, the researchers present MFAs for three sectors, defined as follows:

- **Waste Management** encompasses the waste flows from the Residential; Industrial, Commercial, and Institutional (IC&I) (see Glossary); and Construction & Demolition (C&D) sectors. The focus of this sector is not limited to waste currently managed by the City of Toronto. To provide a holistic view, it includes both waste generated within the city boundaries and managed by the City itself, and waste managed outside of the City's waste management services.
- **Construction** is defined based on the North American Industry Classification System NAICS code 23.[2] It includes construction of new buildings as well as the demolition and renovation of built structures. Activities undertaken by private households are not included.
- **Food System** refers to the complex web of activities involving the production, processing, transport and consumption of food products by both residential and non-residential sources.

Please note that the MFAs of these three sectors are not exclusive of each other. There is overlap between the Construction MFA and the C&D waste that is included in the Waste Management MFA, as well as the Food System MFA and the biomass material flow in the Waste Management MFA.

The MFAs for each of the three sectors are visualised in summary graphics called Sankey diagrams that depict the material flows as different colour lines moving from left (their entry into the sector) to right (their exit from the sector). A high-level interpretation of the MFAs is provided, along with an analysis of the main challenges for each sector. These challenges indicate areas where significant negative, waste-related impacts exist, or where value is being lost along the supply chain. In other words, the areas where circular economy approaches could be most suitable for developing solutions or potential opportunities for impactful interventions.

3.1. BUSINESS-AS-USUAL (BAU) ANALYSIS

In order to better understand the implications of the current material flows resulting from the MFAs, a 'business as usual' (BAU) analysis is provided at the end of each sector. Each BAU analysis forecasts future material consumption and waste generation patterns for the three selected sectors if left unchanged, based on projected GDP growth and population growth. This provides a useful baseline to compare alternative (circular economy) scenarios. The estimation of material consumption and waste generation projects the status quo 10 years into the future.

In the case of the Waste Management sector, this research only models waste generation and not material consumption. Providing an analysis of projected material consumption within the Waste Management sector would require an economy-wide assessment of the consumption of most goods and services, as this sector collects and processes goods that are consumed in all parts of the economy. Modelling future consumption patterns at this scale is beyond the scope of this analysis.

It is important to note that the BAU analysis in this study is a simple future projection. While projections can indicate direction, they cannot be used to measure actual future developments as there are a myriad of other dynamics that will come into play. They also do not take into account challenges with business as usual (e.g. inequitable access to resources or services) that may change over time as a result of policies and other interventions. Further work will be required to refine these projections if they are to be used as a baseline for measuring progress.

4.1. DATA AVAILABILITY

In order to provide the most comprehensive picture, the MFA builds on different available data sources. The data used is the most recent available data that the researchers had access to and is expressed in total amount per year. Due to the scarcity and uncertainty of data, particularly in regard to waste collected by the private sector, a separate methodology guide (Appendix A) and data inventory document (Appendix B) have been created to accompany this report. All studies, reports, and calculation methods are discussed in more detail in those two documents.

Where direct local or regional data is not available, numbers are drawn from two large databases:

- **Exiobase** provides estimates for volumes of input and waste materials on a national level per sector (and sub-sector), based on applying a transfer coefficient to reported material/product used in production and consumption, and adding a lifetime distribution function to forecast the expected waste generation for the following years after entering the economy. Exiobase numbers are scaled down by using labour data for each sector on the Canadian versus the municipal level. While Exiobase has the advantage of providing national data specific for Canada, its drawback is that the data is from 2011, and thus may provide a dated representation of current volumes of input and waste materials.
- **Statistics Canada** produces statistics that help Canadians better understand their country — its population, resources, economy, society, and culture. In addition to conducting a Census every five years, there are about 350 active surveys on virtually all aspects of Canadian life. Data from this agency is extracted and downscaled from national to city level based on labour and/or population data, depending on the nature of the data.

All data points shown in the MFA diagrams have been rounded to the nearest hundred to indicate that they are the results of estimations by the researchers following the methodology and data sources reported in Appendix A.

The analysis does not capture the effects of the COVID-19 pandemic. The majority of data and information used in the MFA analysis were collected prior to the onset of the pandemic. Analysis and interpretation are therefore restricted to pre-pandemic conditions. Although the MFA may only provide a pre-COVID-19 snapshot in time, this does not negate its value for forward-looking strategic and policy planning. Instead, it will provide a baseline of circularity based on the actions and interventions possible in the time before the pandemic, in contrast to what the City of Toronto may elect to do to a highly disrupted system, as part of post-pandemic recovery planning.

4.2. SYSTEM BOUNDARIES

The scope of the MFA focuses on the direct inputs into a sector and the waste that is generated by that sector and processed in Toronto by the City of Toronto itself or other actors. However, while waste may be generated within the municipal boundaries of Toronto, many recycling and landfilling activities occur outside of the city itself. For example, although the City-owned Organic Processing Facilities (OPFs) are located within Toronto, their down-stream aerobic composting facilities to convert digestate to compost are located outside of the city boundaries. For this reason, these treatment processes are included in the MFA. Where possible, movements across the municipal border are documented, including import of goods, but also the export of waste products and the sale of recycled materials to secondary international markets. Furthermore, it is important to note that not all processes and possible material 'leakages' are modelled within the system, such as illegal dumping and scavenging. The omission of such processes and sources of material 'leakage' is a result of very scarce or absent data often due to the nature of the activities.

4.3. MATERIAL CATEGORIES AND PRODUCTS

Where possible and relevant to each given sector, the material flows represented in these MFAs are categorised by energy, biomass, minerals and chemicals, metals, and operating emissions. Where data is available, some material flows are more tailored to the specific sector. For instance, for the Waste Management sector, recyclables constitute a separate material flow as defined below. The material flows include raw materials as well as finished products. They depict annual material use and waste production, using 2019 as the baseline year. Where 2019 data is not available, the most recent sources available are used instead. Each source and corresponding data year are listed in Appendix A. For each material flow category, efforts are made to visually depict as detailed a breakdown of flows as possible. In cases where detailed breakdowns would have made the Sankey diagrams difficult to read, the breakdowns are described in the text.

The material flow categories that are used in this report are general in nature. Materials are examined in a given sector according to its specific relevance, thus all material flow categories may not be present in all sector analyses. The specific material flow categories that are used in this report include:

Biomass [tonnes]
The amount of vegetable and animal products originating from agriculture and forestry, as well as prepared meals and food products. This category also encompasses products like wood, yard waste, and food waste. The City of Toronto collects residential food waste, pet waste, diapers and sanitary products, and other organics via the City's 'Green Bin Organics Program'. Yard waste is also included in this material flow, although it is collected separately by the City.

Emissions [t CO_2-eq]
The combined total of all greenhouse gas emissions (GHGs) produced by a sector, converted into tonnes of carbon dioxide equivalent.[4,5]

Minerals and Chemicals [tonnes]
The solid materials that are present in nature and products such as clay and bricks. This category also includes chemical compositions and oil-based products such as plastics and rubber. This material flow category mainly refers to materials used by the construction sector.

Metals [tonnes]
The amount of raw and processed metals and products, varying from iron ores to paper clips. Some metals are accepted in the City of Toronto's 'Blue Bin Recycling Program'. The City also recovers metal through curbside collection of bulky goods and at its drop off depots. Due to low data availability, scrap metal salvaging activities within Toronto are not quantitatively considered in the analysis of this material flow.

Mixed Materials [tonnes]
The aggregated total in this flow includes textiles, multi-layered materials, products made up of multiple materials, and other mixed materials.[3] Diversion program participation rates are never 100%. As such, this stream also includes materials that could potentially be captured in other categories, including Biomass and Recyclables that are not separated at source. The City of Toronto does offer separation for some components of this material flow (i.e. furniture and large appliances, household hazardous waste, electronic waste, etc.).

Recyclables [tonnes]
The amount of products that are processed in order for their source materials to be reused in new products. For materials handled by the City of Toronto, this category primarily represents materials collected via the City's single-stream collection system called the 'Blue Bin Recycling Program'. Some recyclables are also accepted at City-owned transfer stations. For privately-handled waste streams, this category includes materials like paper, plastic, glass, ferrous and non-ferrous materials, commonly recycled via existing recycling technologies.

Energy [TJ]
The amount of energy consumed by a specific economic activity during its operations.[6]

Management of solid waste is expressed according to two categories: diversion and landfill.

Diversion (from landfill)
Waste processing methods like recycling, composting, anaerobic digestion (see Glossary), and others (i.e. reuse, repair, upcycle, etc.) aimed at preventing waste from reaching landfills.[7]

Landfill
Disposal of resources within an engineered landfill site. Not only is all material value lost, landfilling waste also has high emissions implications in terms of transportation and the emission of methane from decomposing biomass, and can potentially impact human and ecosystem health if not managed as per regulatory guidelines.[8] As cities use up existing landfill sites, new landfill sites or sites to manage residual waste will be required. There are challenges siting new landfills in Ontario which can take many years to plan and develop, which further underscores the importance of preserving existing landfill capacity by diverting resources from disposal.

5 WASTE MANAGEMENT SECTOR MFA

Waste management is at the centre of many of Toronto's circular economy efforts, and there are a number of initiatives with the aspirational goal of 'zero waste'. Today, Canadians are amongst the highest waste producers in the world, with a total waste generation of about 708kg per capita in 2018.[9] The results of the MFA show that Toronto registers lower numbers, with citizens generating about 579kg of waste per capita.[10] Nevertheless, the City of Toronto's climate action strategy, TransformTO, has identified that the waste management sector is a significant emitter of greenhouse gases.[11] Considering the negative impacts of solid waste generation in terms of both environmental pollution and emissions, there is an urgent need to revolutionise the current state of the sector. However, data on waste generation is limited, particularly for the Industrial, Commercial, and Institutional (IC&I) and Construction and Demolition (C&D) sectors. As the waste management sector plays such a pivotal role in achieving a circular economy, the MFA was conducted to better understand the relative volumes and movement of waste from City-serviced and non-City-serviced sources and which data gaps persist.

System boundaries and data considerations

- This study aims to consider all the main flows of solid waste within Toronto managed by either the City of Toronto or by private waste management services. It considers Municipal Solid Waste (MSW)[12] (i.e. recyclables and organic materials, as well as other mixed materials) generated by residential, IC&I sources, and by the C&D sector. The study also considers other waste sources managed by the City of Toronto, such as street litter and special events.
- The recycling waste flow considers all materials for which processing technologies currently exist. Recyclable materials collected via the 'Blue Bin Recycling Program' include glass, plastics (film, rigid and foam), paper and metals from household products and packaging. This flow also considers other materials that are not currently collected by the 'Blue Bin Program' but are processed by existing recycling technologies.
- The estimates of IC&I and C&D waste are based on the 2018 Waste Management Industry Survey published by Statistics Canada. Tonnage data provided by the City of Toronto is from 2019 and is indicated with an asterix (*) in the MFA diagram.

- All data for this MFA is derived from a combination of municipal level data, and provincial and national studies. All studies, reports, and calculation methods are documented in the reference list in the annex of this report (Appendix B), and their usage is explained further in the methodology document (Appendix A).
- It is important to note that, while waste numbers from sources served by City waste management services are collected and provided by the City of Toronto for the purpose of this analysis, waste data relating to non-residential sources (IC&I and C&D) are calculated based on different sources and based on a number of assumptions (see Appendix A for more information).

5.1. MATERIAL FLOWS OVERVIEW

The results of the MFA show that Toronto is estimated to annually generate over 2.1 million tonnes of waste, of which about 40% comes from residential sources, 41% from IC&I sources, and almost 18% from C&D activities. Waste emissions in 2017 were approximately 1.5 million tCO_2e accounting for about 10% of all community-wide emissions.[13] The City of Toronto handles around 44% of this waste, while the rest is managed by private waste management services. Almost all of the IC&I and C&D waste is handled by private haulers, with the exception of a relatively small number of commercial establishments served by the City. Some IC&I waste from private sources is also accepted at City-owned transfer stations and at the City landfill.[14]

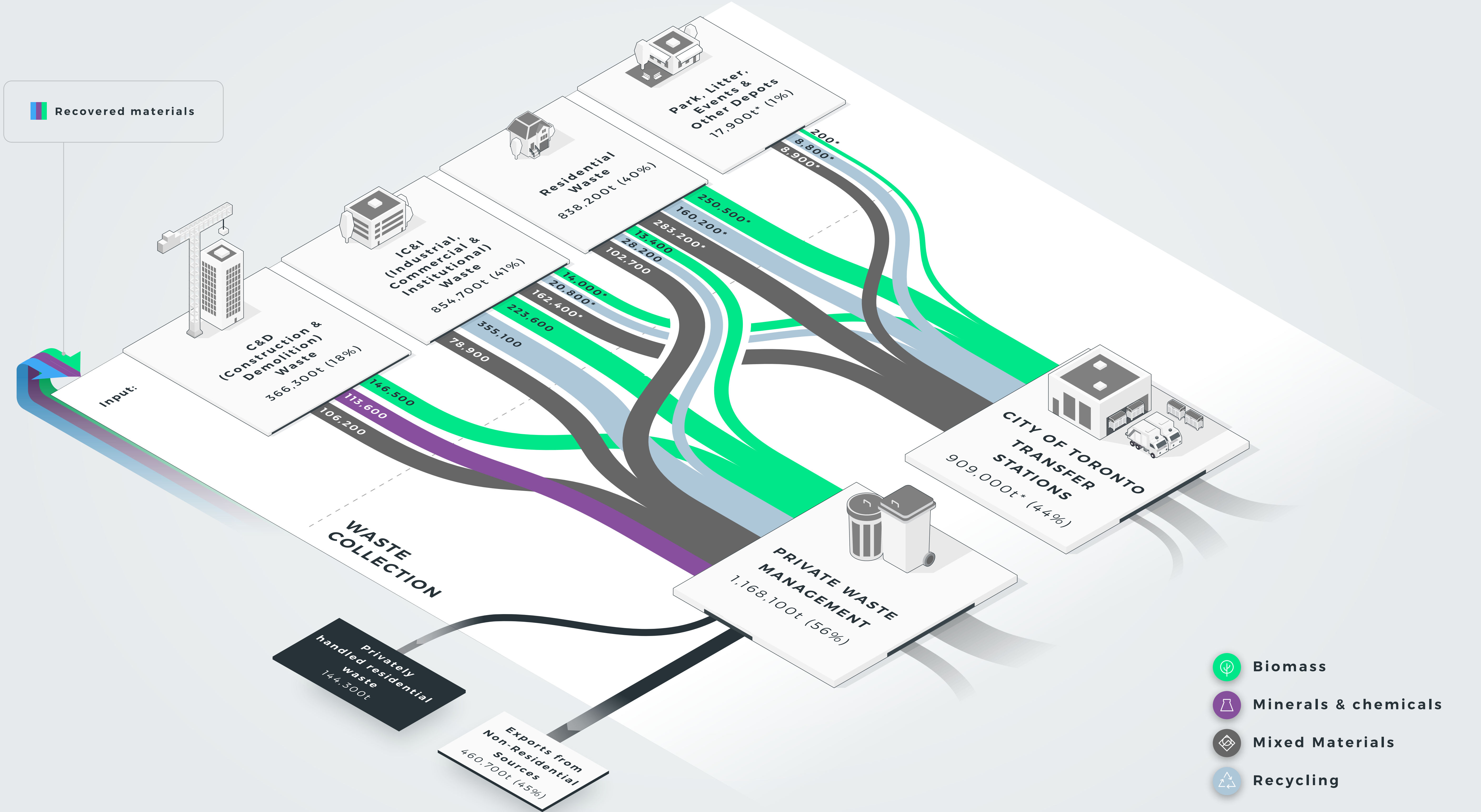
The City of Toronto offers one of the most comprehensive integrated waste management systems in North America and manages over 900,000 tonnes of waste each year. Waste management and diversion programs in the city have evolved to a complex system of collecting source-separated materials, including Blue Bin recycling, Green Bin organics, garbage, yard waste, oversized (i.e. mattresses) and metal items, electronic waste, and household hazardous waste, as well as a range of other items. All waste collected by the City is consolidated at seven City-owned transfer stations, from where it is sent to a materials recovery facility (MRF), organic processing facilities, or landfills. Through these different diversion programs, the City of Toronto is able to divert almost 399,900 tonnes of residential waste from landfill via its integrated waste management system, and achieve a residential diversion rate of 53%.[15] In residential areas, waste separation and diversion from landfill is influenced by the type of dwelling, with single family-homes achieving 64% diversion, and multi-residential achieving just 28% diversion in 2019. The City of Toronto's 53% residential diversion rate is higher than the national average (27%),[16] but in line with provincial (49.7%)[17] and European (47%)[18] diversion rates for municipal solid waste (MSW).[19] In general, Ontario, followed by Quebec, are the provinces that divert the most waste in Canada.[20]

The City of Toronto is also actively investing in minimizing its carbon footprint through investments to generate Renewable Natural Gas (RNG) from biogas and landfill gas (LFG). The City-owned Green Lane Landfill currently features a hydraulic trap design, leachate collection system, leachate treatment plant, LFG collection system, enclosed flares, and stormwater control system to protect the site from environmental harm.[21] Additionally, the City has identified potential RNG production opportunities at four locations: its two anaerobic digestion (organics processing) facilities (Dufferin and Disco Road) and two of its landfill sites. Toronto's first RNG facility has recently been built at the Dufferin facility and is ready to start commissioning. Current estimates suggest that the Dufferin RNG facility will produce approximately 3.3M m3/yr of RNG. Pre-design work is underway to install similar technology at the Disco Road facility, which is currently using 8% of biogas to generate heat, while the rest is being flared. Disco Road is expected to generate 4.6M m3/yr of RNG, starting in 2022. The City of Toronto is currently exploring opportunities to utilize landfill gas, with generating RNG being a top contender, first at its operating landfill, Green Lane Landfill, and shortly following at the closed Keele Valley Landfill. The City has estimated that both landfill projects will be concluded by 2025. Should the City choose to move forward with generating RNG at these sites, the Green Land Landfill and the Keele Valley Landfill are estimated to generate 27.66M m3/yr and 20M m3/yr, respectively.[22]

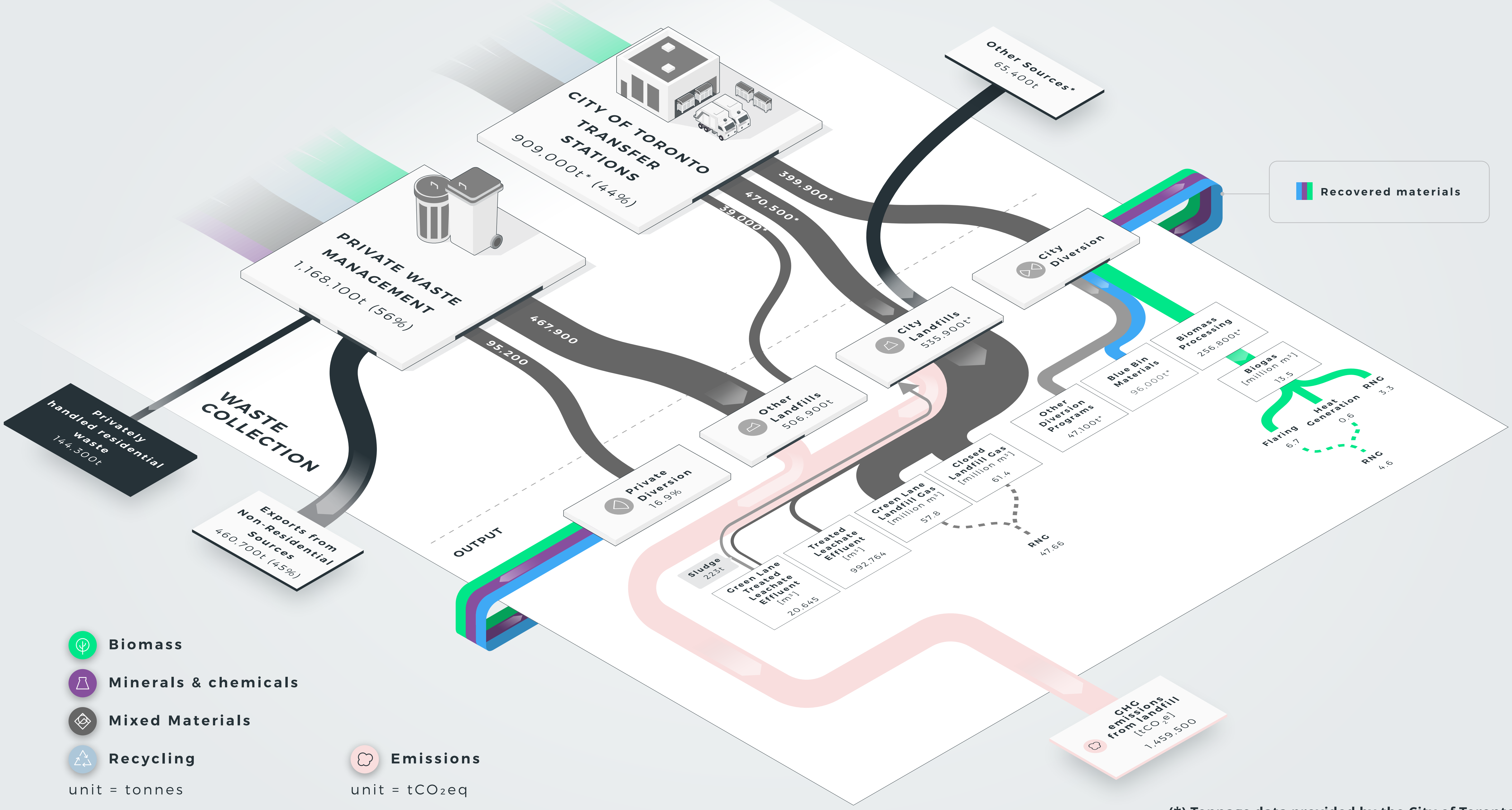
The City of Toronto's RNG portfolio is one of the first of its kind in Canada and North America and will allow the City to reduce fuel costs for its fleet of waste collection trucks and significantly reduce its carbon footprint. Toronto City Council has also approved a strategy to blend the RNG produced at the Dufferin RNG facility with the natural gas that the City purchases to fuel vehicles and heat buildings. This will create a low-carbon fuel blend and allow the City to reduce greenhouse gas emissions across the organization.

By contrast, the non-residential sector (IC&I and C&D waste - excluding waste from multi-residential buildings) served by private haulers is estimated to generate around 1.2 million tonnes of waste, while diverting only 16.9% of the total waste stream, based on 2016 provincial average (as shown in the MFA diagram).[23] The private sector makes use of privately-owned landfills, but also of capacity provided by municipally-owned and operated landfill sites. Moreover, while the City of Toronto stopped exporting waste to Michigan at the end of 2010, it is estimated that the private sector still exports 40-45% of Ontario`s IC&I waste (including C&D), mostly into the states of Michigan, Ohio, and New York in the USA.[24] For the purposes of the material flow analysis, the researchers have assumed 45% of privately handled, non-residential waste is exported.

WASTE MANAGEMENT SECTOR MFA



(*) Tonnage data provided by the City of Toronto



Biomass

Minerals & chemicals

Mixed Materials

Recycling

unit = tonnes

Emissions

unit = tCO_2eq

Future projections

(*) Tonnage data provided by the City of Toronto

Residential waste

The City currently provides waste management services to all single-family homes and two-thirds of Toronto's more than 676,000 multi-residential units.[25] As shown by the MFA diagram, in 2019 the City collected around 693,900 tonnes of waste from residential sources. Based on 2019 data provided by the City of Toronto, approximately 36% (~250,500 tonnes) of the residential waste handled by the City are collected through biomass management programs such as the Leaf and Yard Waste and Green Bin organics programs, and 23% (~160,200 tonnes) via the current Blue Bin recycling program. In 2019, a total of 399,824 tonnes (53%) of residential waste was diverted from landfill through various diversion programs.[26]

The goal set by the Long Term Waste Management Strategy in 2016 is to achieve a 70% diversion rate by 2026. While single-family homes show a high diversion rate (64%), potentially in line with the 2026 target, multi-residential units (apartments and condominiums) served by the City show much lower waste diversion rates (28%).[27] However, a recent study by the City suggests that there may be somewhat limited opportunities to significantly improve multi-residential diversion based on the contents of the waste stream. The City's study determined that the multi-residential garbage stream does not contain enough high-value recyclables that are currently accepted in the Blue Bin program to make a substantial increase in diversion solely through the recovery of recyclables.[28] The difference in diversion between multi-family and single-family dwellings may be due to different consumption patterns rather than improper disposal behaviour (i.e., recyclables being incorrectly disposed of in the garbage).

The remaining third of multi-residential units in Toronto are served by private haulers. Multi-residential waste is included as an IC&I source under Ontario Regulation (O. Reg) 103/94, and because municipalities are not required to provide services to IC&I sources, multi-residential buildings can choose their service provider. The City of Toronto does not provide different levels of service to different customers. If multi-residential condominium boards or property management companies opt for City collection services, they are required to participate in the City's waste diversion programs if they want to receive garbage collection and pay a utility rate that covers the cost of all waste services (includes collection, processing and disposal, overhead and public goods).

All multi-residential buildings are regulated under Ontario Regulation 103/94 (O. Reg. 103/94 – Source Separation Programs) which requires them to offer a source separation program for recyclables (including materials collected in the local municipal Blue Box recycling program), but not for organics. City-serviced multi-residential buildings, however, are required to comply with Municipal Code Chapter 844 – Residential Collection, which requires source separation and participation in all City waste diversion programs including the Green Bin Organics Program. As a result of the difference in program participation requirements between the Provincial regulation and City bylaw, multi-residential buildings may choose to opt out of City services to simplify their waste system down to two major streams (e.g. garbage and recycling). Furthermore, opting out of City collection services can be less expensive, but it also limits access to (and subsequent participation in) diversion programs resulting in less circular waste management outcomes than are currently achieved through the City's integrated waste management system.

Data on how multi-residential waste served by private haulers is being handled is virtually impossible to gather. According to Toronto's Solid Waste Management Services Division, the City is "unable to control — or even know — how Toronto's privately contracted waste is treated or where it ends up".[29] Thus, privately managed residential waste is depicted as a 'black box' in the MFA diagram. Information on how this type of waste flows within Toronto, how it is treated, or where it goes is not available. Therefore, the 'black box' flows out of the system boundaries of the MFA after collection.

Total waste generation and composition of privately managed multi-residential buildings were calculated assuming it would correspond to waste generation and composition of City-served multi-residential buildings, for which data was provided directly from the City of Toronto. There is no reason to believe that the different type of collection would influence the quantity or type of waste generated. However, it is assumed that the majority of non-City served multi-residential buildings do not offer organics diversion, and thus the modelling provided for non-City served multi-residential waste likely overstates actual diversion occurring, because it represents diversion potential rather than actual waste separation happening at source.[30]

IC&I waste

Municipalities in Ontario are not obligated or mandated to provide waste management services to the Industrial, Commercial and Institutional (IC&I) sector. The results of the MFA highlight that only about 23% of the waste stream generated by IC&I sectors is collected by the City under certain circumstances (i.e. small commercial businesses, City of Toronto agencies and corporations, non-profit organizations, charities, religious institutions, schools, etc.).[31] Moreover, the MFA shows that the total waste generated by this sector (excluding C&D waste) is estimated to be around 854,700 tonnes per year.[32] Most of the waste in the IC&I waste stream has been documented to originate from three main IC&I sectors: hospitality (accommodation and restaurants), retail and healthcare - sources that are not currently frequently served by the City.[33] City services offer waste separation services to eligible small IC&I enterprises. However, to increase diversion rates of small IC&I enterprises in the future, additional diversion opportunities that are sufficiently flexible to accommodate changing IC&I waste streams and customer accessibility will be needed.[34]

The majority of IC&I waste generated in Toronto is handled by private waste management services. Much of the IC&I waste could be diverted through recycling or organics processing. Materials that are disposed of from the IC&I sector are mostly paper (35%), food (24%), plastic (11%), wood (8%), metals (6%), glass and yard waste (2% each), and other mixed materials (12%) like textiles, electronics, and multi-layered materials.[35] Most of these materials (e.g. paper, food, and plastics) can be diverted from landfill, when appropriate infrastructure and collection systems are in place. Similarly, clean wood[36] can be readily recycled into construction materials or mulch or used as fuel. Although recycling materials categorized as 'other' are more difficult to recycle, some material such as textiles and electronics can be donated or refurbished.

The City of Toronto, for example, manages small quantities of textiles, electronics, etc., likely indicating that donation schemes or retail take-back programs may be managing a portion of this material. There is also evidence in other circular cities that beneficial uses can be found for these materials, particularly through new business ventures. Ultimately, to further understand the diversion potential in IC&I sectors, and inform and identify the necessary infrastructure and systems to support maximal diversion rates, more robust data on waste quantities and characterization is required.

While there is a lack of Toronto-level data on non-residential waste diversion, Ontario-level data shows that privately handled non-residential waste (IC&I and C&D combined) registers a much lower diversion rate (16.9%)[37] than residential waste (53%). Non-residential waste collection currently operates on a business-to-business, fee-for-service structure, where the costs of waste diversion are not offset by government programs.[38] For the majority of materials, this means disposal in landfill is the least costly option. In the residential sector, provincial public policy initiatives and public acceptance for diversion programs have been prominent drivers to reduce pressure on landfills. The same did not occur in the IC&I sector. Greater focus and attention on establishing mechanisms such as disposal bans and extended producer responsibility schemes could increase waste diversion in the IC&I sector. Some of these efforts are already underway in the Province (see Challenge #1 Section 5.2).[39]

C&D waste

Construction and Demolition (C&D) materials consist of the debris generated during the construction, renovation and demolition of buildings, roads and bridges. The results of the MFA show that, in Toronto, this type of waste is estimated to account for 18% of total waste flows (~366,300 tonnes) and it is almost entirely handled by private haulers. The City of Toronto is a municipal waste utility and does not have the infrastructure to manage the vast amount of C&D waste that is generated in the city. However, the City does divert limited quantities of C&D materials (such as drywall, metal and porcelain) from residential renovations.

Based on U.S. statistics, construction activities constitute only 10% of C&D waste, while demolition accounts for more than 90% of total debris from the construction sector.[40] The majority of C&D waste is wood (40%), the rest is construction materials like Old Corrugated Cardboard/Containers (OCC), metals, concrete, plastic, drywall, and asphalt roofing, together accounting for just over 30%. About 29% of C&D waste is categorized as other mixed materials like brick, aggregates (e.g. sand, gravel, crushed stone), yard waste, textiles, carpet, flooring, household hazardous waste, and furniture.[41,42]

Only 9% of diverted material from the non-residential sector is C&D waste.[43] Given its contribution to the overall waste stream, reducing the amount of C&D materials disposed of in landfills is crucial. Focusing on wood alone could have major benefits. Clean wood can be easily recycled and repurposed if appropriate and stable secondary markets to make diversion programs financially viable exist. For example, wood and wood chips can be used for construction and landscaping materials (4.4% of construction inputs are wood and wood products). Ontario Regulations 102/94 requires waste audits to be conducted before the beginning of C&D projects and after to show how much waste has been generated, potentially providing great insights on how to better manage resources. Despite being in place for over 25 years, ensuring compliance with this regulation has been challenging, and the issue regarding the lack of detailed data on construction material flows persists (see Challenge #1 Section 6.2).[44]

Wastewater management

The wastewater flow was not included in the MFA diagram, which focuses exclusively on solid waste. Nevertheless, many resources are embedded in wastewater flows and are worth mentioning. The level of circularity in Toronto's wastewater system is relatively high. All municipalities in Ontario treat sewage water,[45] and the City of Toronto owns four wastewater treatment facilities. In 2019, these facilities treated a total of 424 million m3 of sewage water (42.8% residential and 52.5% from IC&I) and 195,000 tonnes of biosolids, a beneficial resource containing essential plant nutrients and organic matter.[46] The output of biosolid processing is recycled as fertilizer and soil amendment. Moreover, anaerobic digestion is used to process biosolids to produce biogas, made up predominantly of methane. Biogas is used as a supplementary fuel for wastewater treatment facility needs, including process and space heating, thereby reducing facility operating costs and carbon footprint.[47] None of the City's biosolids have been disposed of to landfill since 2016. The Highland Creek Treatment Plant is the only facility that still incinerates all of its biosolids (59,650 tonnes) and generates about 5,000 tonnes of ashes that are disposed of in the City's Green Lane Landfill.[48]

5.2. CHALLENGES

CHALLENGE #1: Jurisdictional and regulatory limitations and data gaps

There is very limited data available on how and where privately handled waste is treated and/or disposed of, whereas data on municipal waste services provided by the City of Toronto was recent and of a good quality. In Toronto, waste management companies privately negotiate contracts with more than 2,000 multi-residential buildings, with IC&I establishments and with C&D businesses. It is not possible to know what these private agreements cover, as they do not require the use of municipal transfer stations and the City landfill, or adherence to the City's waste related bylaws. Moreover, private waste management companies are not required to disclose their facilities or data to the City. Available data on privately handled waste is inconsistent across reports, in many cases due to different methodological approaches and selected scopes. Residential waste from multi-unit buildings, for example, falls under the definition of IC&I in O.Reg. 103/94, creating further data gaps and confusion around IC&I waste. Retrieving data about privately handled waste is even more challenging given the fact that the private sector exports almost half (45%) of Ontario`s IC&I waste (including C&D). Export flows are calculated based on different sources[49] that need to be retrieved from different institutions and waste management departments of the countries the waste is exported to, which are often not publicly available.

For the purpose of this analysis, the most recent and accurate data sources were selected. The waste management MFA broadly relies on three estimates regarding residential, IC&I and C&D waste streams, but few mechanisms exist to validate the data, the scale of waste and its impact.

Since 1994 various regulations have been developed at the Provincial level with the goal of increasing diversion of residential, IC&I and C&D waste from disposal,[50] but compliance has so far been a challenge, complicating the data picture of C&D waste (under O. Reg. 102/94), as well as multi-residential waste (under O. Reg. 103/94).[51] At the same time, the City of Toronto does not have a reliable means to collect data and monitor waste streams managed outside of the Integrated Waste Management System operated by Solid Waste Management Services Division, and it has limited authority to intervene in the collection, processing and disposal of waste managed by other actors.

Jurisdictional and regulatory limitations and data gaps were identified as challenges in the Long Term Waste Management Strategy adopted in 2016, and they persist today. Private waste management services are often cheaper, as buildings on private collection may not choose to voluntarily participate in all diversion programs (as City serviced buildings do), opting only for garbage and recycling collection (in compliance with O. Reg. 103/94) to avoid additional costs to separate, collect and manage other waste streams. With the rising number of Torontonians living in condominium and apartment buildings that can opt for private waste collection, there is a risk that the growing number of privately negotiated contracts may lead to less circular waste management outcomes than are currently achieved through the City's integrated waste management system. For example, the City is consistently working to address contamination through a variety of interventions; however, the same consistent approach to address contamination may not be occurring in multi-residential buildings served by private waste management operations. The uneven participation effort and enforcement results in lower diversion outcomes from non-City serviced locations.

Building a circular economy in Toronto will require diversion and resource recovery from all waste streams. This work will not be limited to the materials managed by the City of Toronto, but also waste materials being generated within Toronto and managed by the private sector. In the Long Term Waste Management Strategy, the City of Toronto considers various approaches on how local policies could influence non-residential waste generators like the IC&I and C&D sectors. Additional updates and measures to increase control and mandate diversion over IC&I and C&D waste might come from the final developments of the Provincial government's Strategy for a Waste-Free Ontario: Building the Circular Economy and/or the Made in Ontario Environment Plan.[52] However, the changing policy landscape (i.e. the Food and Organic Waste Policy Statement, transition of waste diversion programs to Extended Producer Responsibility etc.) and the limited organics processing capacity in Ontario have significant implications for the types of strategies that are viable at this time (see Challenge #2 below).

Still, some waste management responsibilities are outside of the City's control and are therefore subject to uncertainty and risk with respect to external parties making changes that can impact the City's system. The City of Toronto is in the process of determining what leadership actions it could take to enable the adoption of circular business models and initiatives in the private and not-for-profit sectors.

CHALLENGE #2: Changes in recycling waste streams, end markets, consumer products and packaging, and the policy landscape

Contamination rate

Contamination has historically been an issue in the recovery of recyclables, for the City of Toronto and other waste operators and jurisdictions. The percentage of non-recyclable material in recyclable waste streams significantly reduces the effectiveness of waste diversion. First, contamination significantly increases the cost to process recyclables. Secondly, contamination has a direct impact on the quality, and subsequently the value, of recyclables entering the commodity markets. The Blue Bin Program is impacted by high contamination rates, mainly because organics and other non-recyclable materials are often incorrectly disposed of in Blue Bins.[53]

Due to a multitude of factors including changes in the end-market standards, rapid changes in packaging, misleading labelling and advertising, the contamination rate in the City of Toronto's Blue Bin Recycling Program has been increasing over time, despite best efforts from the City to mitigate against this. In 2017, the overall contamination rate in Blue Bin was about 25%.[54] Increasing contamination rates has cost the City millions in processing fees and lost revenue from recycling sales.

The pressure to decrease contamination comes from a variety of sources. The City has a strong commitment to achieve a 70% residential waste diversion rate by 2026. Private recycling processors in Canada do not accept materials contaminated with food waste and other foreign matter and/or charge municipalities higher rates for more contaminated materials, thus increasing costs for the City.[55] Additionally, external actors like foreign importers of recyclable materials (e.g. China) have imposed bans and restrictions on the acceptance of recyclable materials.[56]

End market stability

In general, the City of Toronto is still able to market most recyclables. However, the long-term stability of suitable end markets for many materials remains an ongoing risk.[57] For plastics in particular, the market for recovered material can be significantly impacted by external factors. Plastic recycling export may be influenced by changes to international agreements, like the new Basel Convention requirements for transboundary shipments of plastic scrap and waste—accepted by Canada and other 187 countries, and taking effect on January 1, 2021.[58] Plastics may also be subject to changes given new national policies like the Ocean Plastics Charter, laying the groundwork to ensure plastics are designed for reuse and recycling, and through the federal Action Plan on Zero Plastic Waste.[59] Finally, government policies requiring the inclusion of post-consumer resins in plastic products may increase the viability of low-value plastics recycling. On the other hand, lower virgin resin costs may have a significant negative impact on the economic viability of plastics recycling (particularly for the low-value film and expanded polystyrene).

Business cases for infrastructure investment to support a circular economy must factor the viability and stability of end markets for recovered materials into the analysis, as they are a necessary requirement for effective recycling.

Changing consumer products and packaging

Another issue is the changing nature of consumer products and packaging, and the uncertainty around the City's role in the management of these materials might change as a result. At a federal[60] and provincial level,[61] there seems to be a desire to use compostable plastic products and packaging as a way to reduce the amount of single-use plastic used in Canada. Compostable plastics may be an alternative to conventional plastics with material characteristics that are less likely to contribute to plastic pollution in the environment, especially in relation to the food packaging industry. However, these products are still relatively new and require more research.

The sustainability performance of many compostable polymers is still under scrutiny by the scientific community, and there is significant uncertainty on how compostable products and packaging would be processed and/or managed. Since compostable plastics only constitute a minor share of global plastic production, waste management systems have not yet adapted to identify or deal with them, meaning that they could end up in landfills or incinerated.[62] If recycled with conventional plastics, then, compostable biopolymers may damage the whole recycling process and further increase contamination rates in recycling waste streams.[63] Current sorting technologies cannot distinguish between compostable and conventional plastics, increasing the likelihood of contamination in plastic bales and threatening the viability of recovery and recycling.

To contribute to the circular economy, compostable plastics need to be separated from conventional plastics and processed as organics. However, there are many different types of bioplastics—each with different requirements for decomposition—and no clear internationally-recognized label to distinguish between compostable plastic products and help consumers to correctly dispose of them. Even when labelled, information can be misleading as products may be certified as biodegradable under certain conditions, but are not recognised as such by municipal processing technologies.[64] Finally, many compostable products are certified under laboratory conditions that are not achievable in municipal solid waste facilities (e.g. retention time, temperature requirements). Promotion and education, and product labelling reflective of the local municipality's capabilities is needed to reduce consumer confusion and ensure proper disposal.

The City's Green Bin Program was developed to process food waste and some primarily fibre-based packaging and products. As such, the City's organics processing infrastructure does not produce the appropriate conditions for the majority of compostable plastic material to break down, which results in their presence being considered contamination. Similar to recycling, including infrastructure for contamination removal increases processing costs, and adds cost to dispose of the contaminated material as garbage. The robust pre-processing systems at the City's anaerobic digestion facilities (designed to remove contaminants and plastic bags) remove compostable plastics from the anaerobic digestion feedstock. As such, compostable plastics are processed twice by the City – first through Green Bin collection, then hauled to landfill for residual disposal – which costs the City and its ratepayers.

Changing policy landscape

The landscape for municipal recycling is changing, and with uncertainty comes risk as well as opportunity. Ontario's existing waste diversion programs are transitioning to an Extended Producer Responsibility model (EPR).[65] Extended producer responsibility agreements incentivize producers to manufacture their goods with end-of-life management in mind. In Canada, these types of arrangements helped to promote the diversion of just over 105,000 tonnes of electronic products from Canada's landfills in 2018, climbing 10-fold from around 10,000 tonnes recycled in 2004 since first measured by Statistics Canada.[66]

In Ontario, tires, beverage and alcohol containers, batteries, as well as electrical and electronic equipment and Municipal Hazardous or Special Waste (MHSW) either already started transitioning to EPR models or will do so in 2021.[67] Due to the transition of several waste diversion programs to EPR regulations under the Resource Recovery and Circular Economy Act, 2016, there is uncertainty about the scope and nature of the role that the City of Toronto will play in managing the designated materials. Contamination and designated materials that are found in the municipal waste streams (e.g. garbage and organics) will remain a consideration under the EPR model. However, the nature of the risks to the City is changing as the City's role with respect to the largest waste diversion program (Blue Box program) changes. Moreover, the transition of the Blue Box program to EPR may have an impact on the level of service that City of Toronto customers currently receive if service levels and materials currently accepted in Toronto's Blue Bin program are not included in the new common collection system that producers of packaging, paper, and product-like packaging will be responsible for implementing province-wide by 2026.

The federal government is also considering including the introduction of an integrated waste management system harmonized at the national level to improve plastic recycling and generate stable markets for recycled plastic content.[68] However, there may not be clarity on impact or opportunities for the City of Toronto for some time, making it challenging to plan for comprehensive circular economy strategies in recycling. This work also appears to be focused on plastics, which is only one grouping of material currently accepted in the City of Toronto's Blue Bin program.

CHALLENGE #3: Opportunities and constraints for enhanced material recovery

The City of Toronto offers one of the largest and most comprehensive integrated waste management systems in North America. Diversion programs in the City of Toronto collect source-separated materials for Blue Bin recyclables, Green Bin organics, Leaf and Yard waste, electronic waste, large appliances, scrap metal, tires, and Household Hazardous Waste (HHW). Additionally, the City offers the collection of other mixed materials (i.e. books, clothing, small households items, ceramics, mattresses, residential drywall, etc.) and accepts waste drop-offs during Community Environment Days. Still, there are several materials that are not collected or diverted by the City of Toronto.

The circular economy often implies the recovery of a much broader and more ambitious range of materials than is traditionally considered divertible in municipal waste operations, and for which there are no stewardship programs in Ontario. Even so, many materials currently not diverted by the City of Toronto have shown high recovery potential, based on successes in other jurisdictions, material composition (i.e. presence of traditionally high-value components like metals), and other factors. Examples include textiles, leather, wood, and plastic residues from organics pre-processing. This reveals an important challenge for the City, considering the economic value creation potential from waste diversion. For example, in Ontario, every 1,000 tonnes of waste diverted from landfill could generate up to seven full-time jobs, $360,000 in wages and more than $700,000 in Gross Domestic Product (GDP).[69] However, different diversion strategies may come at a cost to the City of Toronto utility rate. While revenues and benefits are unlikely to be recovered by the utility directly, it can also be challenging to measure the direct impact of certain circular economy interventions (and the corresponding investment required by the municipality) to realize these benefits. To achieve a circular economy, value recovery for all waste material streams should be evaluated and optimised over time.

Textiles, rubber, leather and wood

These materials only constitute 5% of total residential waste and are often included in “residual MSW” - defined as any fraction of municipal waste remaining after the source separation of waste fractions such as food and yard waste, recyclables, and other items.[70] In Canada, 10kg of textiles, 9kg of rubber and leather, and 76kg of wood per capita were disposed of as residual MSW in 2016.[71] There is high potential to divert these materials flows from residual waste and direct them to reuse, upcycling or recycling following the waste hierarchy. In Ontario, these materials do not have stewardship programs, as some materials do not have known or reliable markets available to either the City of Toronto or other actors to recycle these materials. Recycling, however, might not be the only solution to enhanced material recovery. For example, the majority of textiles in Toronto are reused, not recycled.

Textiles are a key example where many innovative precedents for recovery exist, but where the technical, market, and trade considerations associated with recovery make the prospect challenging for municipalities. Data on the percentage of used textiles being disposed of in landfills in Canada is limited. However, the City of Toronto has conducted a number of waste audits in single-family homes (2012-2018) and multi-residential buildings (2014-2015) and found that, on average, respectively, textiles make up 2.1% (16 kg/household/year) and 4.2% (29 kg/household/year) of total waste by weight (found in garbage, Blue Bin recycling, and Green Bin organics). These results illustrate that textiles make up a relatively small portion of total residential waste. If the City collected and diverted this quantity of textiles, it would increase the residential waste diversion rate by less than 1%.[72] At the same time, less than 1% of Canadian post-consumer textile waste is truly recycled (i.e. chemically deconstructed into fibres to be used to make new textiles), often because markets are extremely limited and the costs far outweigh manufacturing with virgin fibres. Alternative actions can be taken to address the issue beyond end-of-life recycling, such as new business models for clothing rentals or sharing economy programs. In addition to the City’s own Community Reduce and Reuse[73] programs that promote reuse, repair and share, there are many initiatives already active to divert textiles from landfills, such as thrift stores, donation programs, community swaps, and some more recent retail take back initiatives for textiles.[74,75,76]

In order to further advance textile reduction and diversion efforts, the City is continuing to research best practices found in other jurisdictions and educate about textile waste and reduction and reuse, as well as exploring opportunities for innovative service delivery partnerships with textile collectors.[77] With strong demand for “fast fashion”, additional and enhanced communications on textile waste will be pivotal to divert textiles from landfill.

Organics and food waste

The amount of food and organic waste currently being sent to disposal has a high social, environmental and economic costs. In landfills, organic waste breaks down in a low- to no-oxygen environment that produces methane—a gas with about 20 times the greenhouse effect of carbon dioxide.[78] Organic waste in Ontario landfills are contributing over 4.6 megatonnes of greenhouse gas emissions released in the atmosphere (including 3.4 megatonnes from solid waste disposal).[79] Currently, the City of Toronto Green Bin program serves predominantly residential customers. Expanding organic and food waste processing capacity under a circular economy framework has numerous potential recovery and regenerative outcomes.

The main barrier to expanding organics collection to additional customers is the limited processing capacity in Ontario, which considerably inhibits diversion in both public and private sectors. Further, there are considerable financial barriers to generating participation in enhanced diversion programs. The costs of participating in the program may be an issue for some small organizations, particularly those that operate on low margins. Finally, as already mentioned, participation in the Green Bin Program, unlike the Blue Bin Program, is not currently required by any provincial regulations, reducing the incentive to divert organics, as the full program costs are borne by the ratepayer.

Despite these barriers, cities across the nation are actively taking steps to increase diversion of organic waste and increase organic processing capacity.[80] The City of Toronto is currently in the preliminary planning stages to construct and commission a third anaerobic digestion facility to manage its projected organic processing needs. Finally, the Province of Ontario is revising its Food and Organic Waste Policy Statement to clarify and expand the categories of food and organic waste and update direction on the management of compostable products and packaging.[81] The policy revision may impact the feedstock going to organics processing facilities and have implications for the City’s organics processing infrastructure.

5.3. BAU PROJECTIONS

The 'business as usual' (BAU) analysis aims to analyse the current and future material flows resulting from the MFA analysis and show how they will develop in time if no action is taken. The BAU analysis forecasts future material consumption and waste generation patterns for the three selected sectors considered in this report. Providing an analysis of projected material consumption within the Waste Management sector, however, is challenging as it would require an economy-wide assessment of consumption patterns. Because the Waste Management sector collects and processes goods that are consumed in all other parts of the economy, modelling future consumption patterns at this level would require in-depth modelling capabilities that are out of the scope of this analysis. For this reason, in the case of the Waste Management sector, this research only models waste generation and not material consumption.

Modelling waste generation has other advantages and the City of Toronto already actively monitors waste generation data. Waste projections are a key element in any City planning process as it allows decision makers and planners to identify the long-term needs of the system and effectively plan their City's waste management programs and support the achievement of a 70% residential waste diversion target. The latest waste projections forecast to 2040 was undertaken in 2019 and focused on the residential sector.[82] The present analysis complements the already existing City projection efforts by providing an overview of waste tonnes which are both within the City's control and not within the City's control (Figure 1). The data presented here could allow the City for adjustments to waste projection projects and for acknowledging the impact of tonnes managed outside of the City's services. The total waste flow was subdivided into 3 main categories: Residential, IC&I, and C&D waste. Residential waste projections are calculated based on anticipated GDP and population growth, IC&I and C&D waste based on GDP growth. It is important to note that waste generation is likely to be influenced by numerous factors in addition to GDP, population, and employment trends. These factors include a changing sectoral composition (i.e. increase in financial and professional services), changing consumer habits influencing composition and volumes of waste streams, and an evolving regulatory landscape. Using this simple model as an indication, by 2030, Toronto might generate over 2.5 million tonnes of waste material from residential and non-residential sources per year, if no waste reduction takes place.[83]

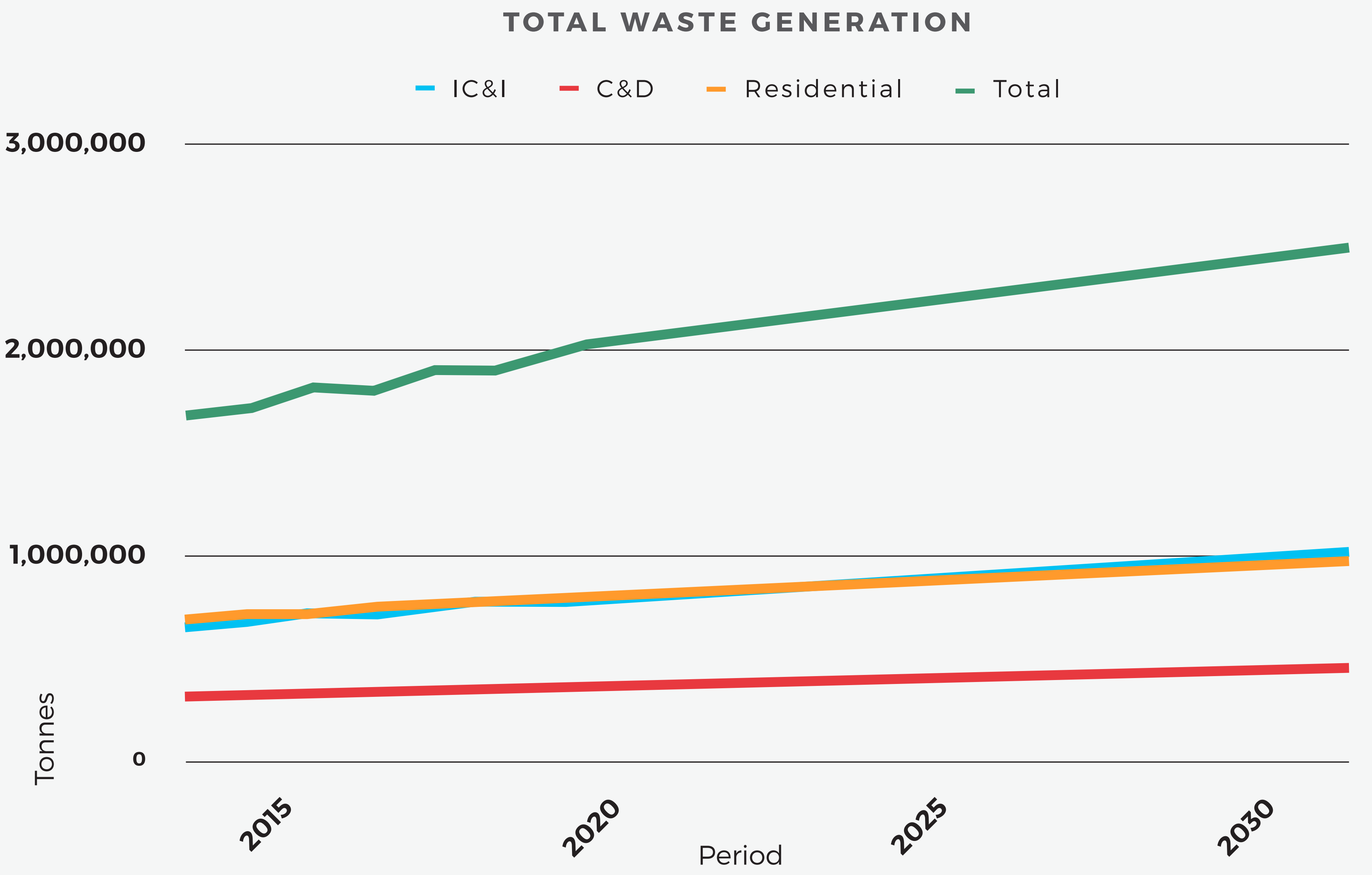


Figure 1. Projected total waste generation for Residential, IC&I, and C&D sources, solely based on anticipated GDP and population growth

6 CONSTRUCTION SECTOR MFA

The construction sector and its related activities are noteworthy contributors to Toronto's GDP (21.3%) and have experienced above-average annual employment growth rates since 2014.[84] This sector also represents one of the most material- and energy-intensive sectors in most economies. Building materials are largely generated from extractive industries as opposed to secondary sources, which contributes to a significant environmental footprint. Moreover, according to United Nations Environment figures, buildings and the construction sector accounted for 39% of global energy and process-related CO_2 emissions in 2018, and 11% of this was attributable to the manufacturing of building materials like cement, steel and glass.[85]

This sector is important in achieving a circular economy in Toronto because of the amount of construction activity in the city, the expected future growth of the sector, and the high resource-intensity of the sector. The sector has a significant environmental impact in terms of resource extraction, energy and water use, GHG emissions and waste generation. Construction and demolition (C&D) waste makes up one of the largest solid waste streams in Canada.[86] Some businesses in the sector are already involved in initiatives that explore circular economy approaches (e.g. design for modularity and disassembly), and there is a good policy framework (e.g. The Toronto Green Standard, and other measures adopted in the City) that can also be built upon to encourage more circular resource management in the sector.

For these reasons, the researchers and the City of Toronto have selected this sector for further analysis via MFA. This analysis will provide a clearer and more granular understanding of the material flows within Toronto to help the City prioritise areas for intervention. Focusing on this sector could generate significant impact reductions, considering the embodied emissions associated with extracting and manufacturing construction materials, and the fact that these materials are typically landfilled rather than reprocessed and reused.

System boundaries and data considerations

- Input materials are downscaled from Exiobase national-level data based on labour data, with the exception of energy use, which is derived from Statistics Canada.
- Emission data for the full life cycle of buildings at the city-level is difficult to obtain. National emissions from the Construction sector are estimated using Exiobase data on the total emissions of 'Construction' (NAICS 23) and the emissions

from 'Re-processing of secondary construction material into aggregates' (downscaled to Toronto level using labour data). This data is limited and only accounts for operating emissions (i.e. energy and fuel use, transport, running offices, plants, etc.) of the construction sector and the emissions during aggregate production. It does not represent the emissions from waste treatment and disposal, and lifecycle/embodied emissions of input materials due to lack of data.

- The estimated total C&D waste is based on the 2018 Waste Management Industry Survey published by Statistics Canada.
- All other data is derived from municipal-level data and/ or literature reviews of provincial and national studies. All studies, reports, and calculation methods are documented in the reference list in the annex of this report (Appendix B) and in the methodology document (Appendix A).

6.1. MATERIAL FLOWS OVERVIEW

Material consumption

The construction sector is highly resource-intensive and its material flows add to the stock in the built environment that remain in the city for decades (or even centuries). Material consumption for the construction sector in Toronto is calculated based on material inputs downscaled from Exiobase based on labour data (with the exception of energy use, which is derived from Statistics Canada). The results of the MFA show that Toronto's construction sector uses more than 17 million tonnes of materials each year. Minerals and chemicals make up, by far, the largest share of material inputs, with the over 16 million tonnes consumed representing about 94% of the total material inputs of the sector. Mostly, this flow of material includes stones, aggregate materials (i.e. inert materials that resists compressive load like sand, clay, gravel, etc.), concrete and other non-metallic mineral products.[87] The dominance of minerals and chemicals as inputs into Toronto's construction sector is comparable to European cities like Prague and Basel.

Based on Exiobase data, it is estimated that around 92% of materials used by the construction sector in Canada originate within national borders, and only 8% of materials are imported from other countries. Canada is richly endowed with minerals and is one of the world's largest producers of minerals and metals. In 2016, 200 mines and 7,000 quarries produced more than 60 minerals and metals worth $41 billion.[88] Most mining-related activity takes place in Ontario and neighbouring regions.

More than two-thirds (68%) of the buildings in Toronto are reserved for residential use.[89] The remaining third of buildings are used by the IC&I sector (28%) and infrastructure (i.e. for utility and transportation) (7%). Different materials profiles were not taken into account in the MFA for lack of granular data, but it is important to note that the environmental impact of different types of buildings is associated with their material profiles. Because of its high strength-to-weight ratio, more steel is used for tall buildings and large industrial facilities rather than for low-rise residential buildings (for which wood is the primary component), thus, contributing to higher embodied emissions for these construction projects. The environmental impact of buildings also relates to their energy use during construction activity.[90] As shown in the MFA, energy use in residential construction is lower than for infrastructure or other non-residential projects.

End of life

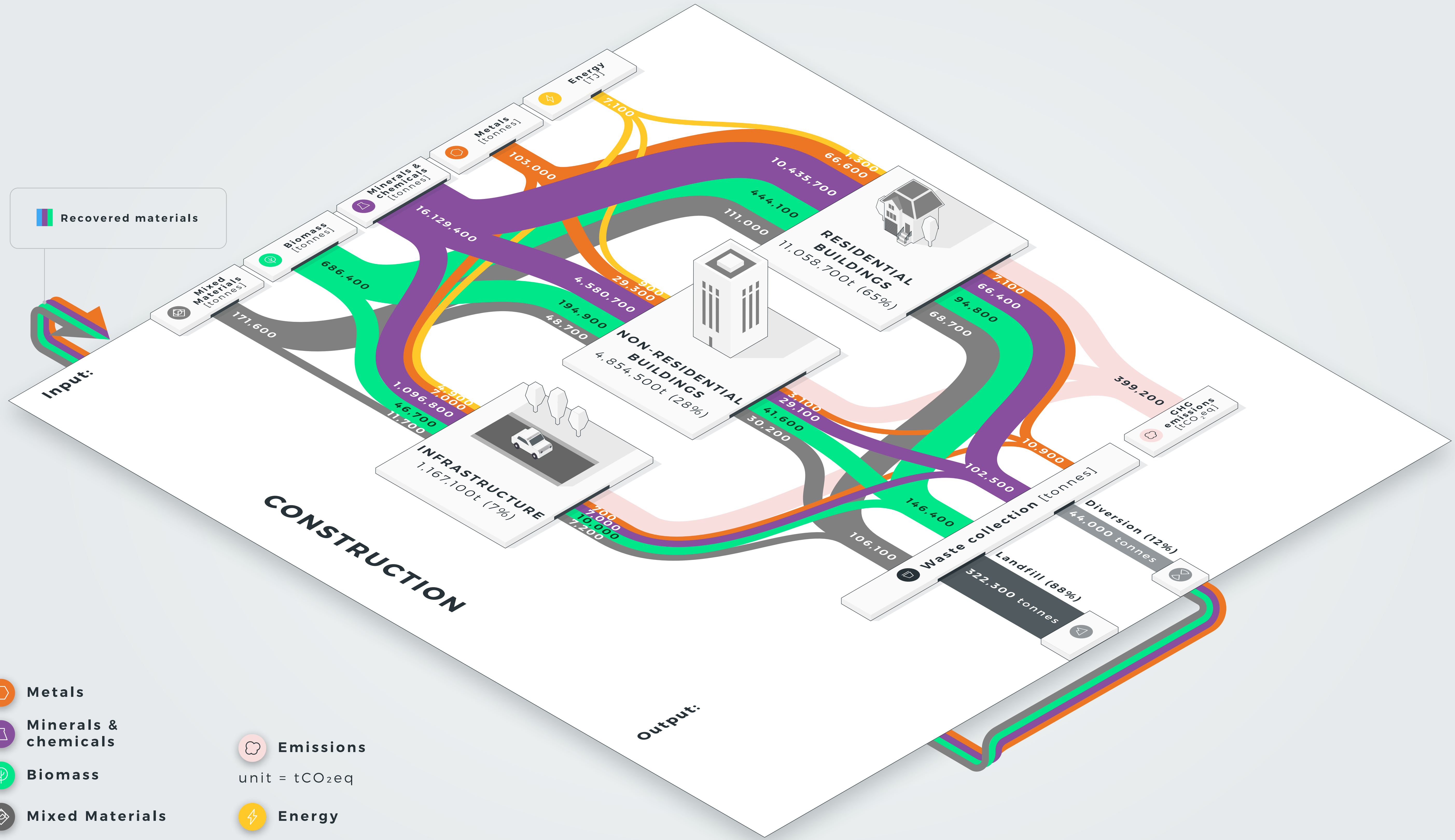
C&D waste generation in Toronto is estimated at 366,300 tonnes per year. This estimate is derived from Ontario-level data as more granular data at city-level is not available. In Ontario, 6.1 million tonnes of waste were generated by the "non-residential" (including both IC&I and C&D waste) in 2018. As reported in the Long Term Waste Management Strategy of the City of Toronto, typically 30% of non-residential waste is C&D material.[91] The C&D sector shows a diversion rate of 12%, equivalent to around 44,000 tonnes, meaning that around 322,300 tonnes of construction materials are disposed of in landfill per year.[92] However, studies report that over 75% of what the construction industry generates as waste has a residual value, and therefore could be recycled, salvaged and/or reused.[93]

C&D waste is typically disposed of at municipal, private or sometimes specialized landfills, both within the province and in other neighboring countries.[94] Some landfills in Ontario are designated as "dry" landfills suitable for disposal of C&D waste only, as this waste does not contain any wet organic material. Recycling of C&D waste is provided by private waste management companies and regulated via the provincial 3Rs Regulations (Reg. 101/94 to 103/94) and two other regulations (Reg. 102/94 and 103/94) under the Environmental Protection Act. Materials that must be separated for recycling include cardboard, brick and Portland cement concrete, steel, clean drywall (not painted), and wood (not including painted or treated wood or laminated wood).[95] Moreover, the Ontario Waste Management Association (OWMA) reports existing recycling possibilities for metals, ferrous and non-ferrous slag and asphalt.[96]

The diversion rate for C&D waste in Ontario is much lower than in Europe, where a mandatory target for 70% recovery of C&D waste was set for 2020.[97] However, C&D waste recycling has increased in recent years as the economic argument is strengthening. For example, drywall is being increasingly separated at the source so that it can be recovered and purchased for new construction projects.[98]

Biomass represents the single largest flow of waste generated from the sector, making up for 40% (~146,400 tonnes) of the total waste generated by mass. This is likely due to the significant quantities of wood (clean, engineered, treated and painted) generated by demolition activities, that usually represent 90% of debris generated by the C&D sector.[99] Other construction materials like asphalt roofing (10%), drywall (9%), concrete (4%), and packaging materials like corrugated cardboard (1%) and plastics (4%), make up for the second largest waste flow, totaling 102,500 tonnes (28%). Metals constitute only 3% of waste. The remaining 29% of C&D waste is made up of other mixed materials such as brick, aggregates (e.g. sand, gravel, crushed stone), mixed paper, yard waste, carpet, flooring, household hazardous waste and furniture.[100]

CONSTRUCTION SECTOR MFA



Metals

Minerals & chemicals

Biomass

Mixed Materials

unit = tonnes

Emissions

unit = tCO_2eq

Energy

unit = GWh

6.2. CHALLENGES

CHALLENGE #1: Lack of detailed data on construction materials

The amount and types of materials used in the C&D sector, the current building stock, and waste generated in Toronto and exported outside of the city are largely unknown, with very little data to help understand the types and quantities of materials. To create a material flow picture for this analysis, estimates were calculated using different methodologies which are documented in Appendix A. GHG emissions reported in the MFA only focus on operational emissions from this sector and exclude the significant carbon emissions embodied in construction materials.

The lack of detailed data on material consumption, stock, and waste limits the ability of the sector to implement effective resource management practices. Improving data and reporting on local construction and demolition activities and waste materials profiles by building type would allow for more accurate insights to be derived to reduce their impact. For example, more accurate embodied energy profiles for buildings can help replace carbon-intensive materials like concrete and steel, with wood, hempcrete,[101] or recovered materials from other industries (e.g. recovery of ash from biomass energy plants for use in cement and in the brick industry).

There are many challenges to estimating embodied carbon emissions. Life Cycle Assessments (LCAs) of building materials, which often take the form of Environmental Product Declarations (EPD) measuring the embodied impacts of construction products, typically have to follow country-specific standards. Manufacturers face different EPDs in different countries, increasing costs and confusion in the market. Harmonization of environmental databases is a difficult challenge, but not impossible. Both industries and cities have been instrumental in pushing for new innovations and approaches to solve these issues and revolutionise the buildings and construction sector towards a net-zero future, tackling embodied carbon emissions.[102]

CHALLENGE #2: Low diversion rates for construction and demolition waste materials

Mining new materials comes at a significant environmental cost, and there are opportunities for the sector to reduce its negative impacts by making better use of the stocks of resources that have already accumulated in urban areas. In Canada, there are well-established reuse and recycling technologies and markets for materials like cardboard, metals, clean wood (i.e. unpainted, unstained, untreated and glue free), and most engineered wood. These materials, which account for 33% of the total waste flow, could, therefore, be diverted from Toronto landfills, assuming end markets for those materials exist.[103]

Where end-markets are difficult to find, there could be other opportunities to close material cycles. In particular, wood waste from the construction sector could become a valuable asset for the energy sector and be used as fuel. A few projects in Canada are already active in this direction.[104] Drywall (9%) and asphalt roofing (10%) also show high potential for diversion in some regions of the country, although a degree of support is required to make their recycling processes economically viable.[105] Being principally a municipal waste utility, currently, the City of Toronto accepts drywall waste from residential sources and a significant amount of metals (some of which could be generated by the C&D sector, although the City does not currently track drop-off waste sources) at its drop-off depots. There is potential to divert these materials in the region, however, scaling up the City's C&D management would require a significant change in its operating model. Collaborating and aligning with the private sector is important to support such efforts to increase C&D diversion and recycling.

These precedents and recycling opportunities demonstrate that diversion can improve for some materials. Other materials like aggregates and soil are more complex to divert, but attention could be directed to support and improve available processing technologies.

Aggregates

Aggregate materials are inert materials that resist compressive load like sand, clay, gravel, and crushed stone. In the MFA, this type of material is included in the 'Mixed Materials' flow and it is rarely diverted from landfill. Only about 7% of aggregate used in Ontario is made up of recycled material. By contrast, some European countries use up to 20% recycled aggregate.[106] A lack of policies and specifications for using reclaimed aggregates are often the reason why large volumes of recyclable aggregate end up in landfills, as they often prohibit or severely limit the reuse of recycled aggregates in construction projects. The City of Toronto encourages the use of recycled aggregate materials more than other municipalities in Ontario and has developed specifications for recycled aggregate use in base and subbase for pavements, hot mix asphalt, and backfill materials (Technical Standard (TS) 1010).[107] However, policies have not developed further in recent years and still do not allow recycled aggregate to be used for new ready mix concrete.[108] New policy development has been challenged by the fact that Ontario lacks an organization to provide third party certifications for sustainable, environmentally and socially responsible aggregate extraction. Furthermore, health and safety considerations, as well as certain regulatory requirements, prevent the City of Toronto from considering recycled aggregate in all possible applications. The untapped potential for the aggregates industry is significant. A better understanding of the verification and standards available is required to help bring this to scale in both public and private sector operations.

If Ontario could achieve aggregate construction material recycling rates like those seen in Europe, the province could theoretically avoid extracting up to 33 million tonnes of new aggregate per year.[109] This would yield considerable environmental benefits by removing tens of thousands of trucks from the roads that are hauling virgin aggregates from remote sources (reducing emissions and wear and tear on the roads), avoiding the impacts of extracting new aggregates, replacing more carbon-intensive petroleum products to produce asphalt, and extending the useful life of landfills by keeping massive quantities of aggregate material out of them.[110]

Construction fill and excess soil

Conservative estimates show that the quantity of excess construction fill in Ontario could be as high as 25.8 million m3 per year.[111] For a number of reasons, a large portion of this enormous amount of excavated soil is unnecessarily landfilled, or sent to storage sites outside of the city rather than being reused on-site, increasing costs and GHG emissions associated with transport. A study on excess soil management in Ontario found that soil disposal from 24 projects (the majority of which concentrated in the GTA) travelled the equivalent of more than 25 times the distance of the Trans-Canada highway while emitting more than 300 tonnes of CO_2.[112] Moreover, on average, handling and disposal of excess soil represents 14% of total project value for all 24 projects, for a total of $46 million.[113] For the Eglinton Light Rail Transit (LRT) line project alone, over 2 million cubic metres of excess soil will have been excavated and 200,000 cubic metres of soil required for backfill.[114] Excess soil management costs for this project have been estimated to be as high as $65-100 million, depending on variables such as distance, loads, and landfill costs.[115]

Despite the massive amount of excess soil generated in Ontario, this type of material is often overlooked when quantifying C&D waste. Statistics Canada does not account for excess soil and the reliability of construction-related data is deteriorating.[116] As demand for high-rise building and major infrastructure projects is increasing in Toronto, a great deal of excess soil from excavation can be expected in the coming years. Better monitoring and managing this type of waste is necessary both at municipal and provincial level. The Province is already promoting management best practices in the sector[117] and recently introduced a new regulation for municipalities to reuse excess soil on-site.[118] The City assists with this challenge by accepting "clean" soils for reuse for cap maintenance material at closed landfill sites, mainly Keele Valley and Brock West. The City also reuses clean soil in some public projects, including Ashbridges Bay Landform and Port Lands Flood Protection Landform.[119] Increased management capacity and planning, however, will be required, for example, to match supply and demand of excess soil throughout the city.[120] This effective matching of supply and demand is particularly pertinent as the material is often associated with sizeable requirements for physical space for storage. While increased management capacity can facilitate effective onsite reuse of excavation materials, proactive planning in the type and design of Toronto's built environment could also help to reduce excess soil generation. The City of Toronto's water and sewer capital program expects more than 800,000 cubic metres of fill to be generated by the end of the decade, and only about 20 to 30 sites around the Toronto area are prepared to accept more than a few truck loads of clean fill. All are located far from the city, which increases transport costs, and all charge high tipping fees (~$50-$100/10m3).[121]

The Province of Ontario has recently increased requirements under O. Reg 406/19 which will require all project owners to retain control over excess soils from cradle to grave, as well as track and document the reuse location of the material.

New requirements will be phased in starting in 2021, and by 2025, the landfilling of clean soil will be prohibited in Ontario. While consistent with a circular economy framework, this new regulation will increase financial and contract management requirements on industry parties in the short term, including the City of Toronto. Opportunities exist to promote excess soil reuse strategies and monitor other industry responses to the new regulations to ensure positive circular outcomes are achieved and to minimize negative externalities.

CHALLENGE #3: Lack of systems to upscale the diversion of C&D waste

As a municipal solid waste utility serving primarily residential clients, the City's Solid Waste Management Services Division does not currently prioritize the construction sector in its program. In the past, the City has faced challenges in implementing new diversion programs for C&D materials (such as shingles, clean wood, etc) because appropriate and stable secondary markets to make diversion programs financially viable often do not exist.[122] For example, the City of Toronto previously attempted to collect clean wood, but difficulties arose when treated wood mixed at transfer stations, given that there were no markets for mixed wood. Separating shingles without nails also proved to be challenging.

Another challenge to increasing C&D waste division is the fact that private sector initiatives to construct and operate C&D recycling facilities in the Greater Toronto Area (GTA) have failed due to economics as landfill disposal remains the most affordable option.[123] Additionally, a major barrier to effective separation of construction materials at the source is the lack of space on-site, as well as lack of information about sustainable demolition practices. There is a significant lack of space in urban environments to ensure that materials are sorted into separate waste streams at construction sites, as C&D waste is typically collected in a single mixed stream. Design for disassembly and reuse is often overlooked and generally perceived as more expensive than demolition.[124] This type of design, along with selective deconstruction plans for existing buildings aimed at salvaging and reusing high value materials and components, presents a great opportunity in Toronto.[125]

Toronto is experiencing the largest amount of construction activity of any city in Canada.[126] Despite the challenges presented here, more attention should be given to material and waste flows coming from this sector. New developments in Toronto are already subject to Tier 1 requirements of the Toronto Green Standard, which requires construction and demolition waste be managed in accordance with O. Reg 103/94 (this regulation applies to large construction projects only). However, compliance with and monitoring of provincial regulation is often a challenge. Based on the findings of the MFA, opportunity still exists to improve C&D waste outcomes in Ontario.

The City's voluntary measures have and will continue to play an important role in fostering sustainability and innovation in construction and demolition activities. For example, the voluntary measures in Tier 2 of the Toronto Green Standard require diversion of C&D waste. Similarly, projects seeking LEED status may also be enhancing their construction waste diversion. Established end-markets and effective data management and material separation at source are required to enable increased diversion, along with further consideration of regulatory and financial incentives to make circular business models viable.

6.3. BAU PROJECTIONS

The 'business as usual' (BAU) analysis for the Construction sector aims to analyse the current and future material flows resulting from the MFA diagram, both regarding the input flows (material consumption) and the output flow (C&D waste), if no further action is taken.

Toronto is experiencing more construction activity than any other city in Canada,[127] and most of this is being driven by construction of multi-residential buildings and large-scale mixed-use projects.[128] Between 2014 and 2018, the City added almost 900,000 square metres of non-residential space – mostly offices – from large projects alone (over 50,000 square metres).[129] Additionally, a large portion of activity in the institutional and public sector comes from federal and provincial expenditures on public transit infrastructure projects in the Toronto region (i.e. the Eglinton Crosstown Light Rail Transit (LRT) line), as well as various investments in hospitals and healthcare facilities that have received significant renovations in recent years. Currently, there are over 800 private and public sector projects under construction or in preconstruction, the majority of which is clustered in downtown Toronto.[130] Looking at trends for the GTA as a whole, development in the non-residential sector is forecast to be at its highest in 2020 and 2026, driven by major public transportation and other infrastructure projects, and health-sector investments. Construction is expected to slow from 2025 to 2029, as major projects wind down.[131] Although the COVID-19 pandemic will undoubtedly affect the trajectory of the construction sector, it is nevertheless out of the scope of this analysis to forecast such impact.

Following a drop in new low-rise single-family home construction in 2019, as well as a decline in apartment housing starts, the residential sector is expected to average a +6.7% in 2020-2024, and +2.2% in 2025-2029.[132] Low-rise starts should return to 2018 levels and high-rise starts are expected to be sustained by strong migration-driven population growth, market confidence, and a lower interest rate outlook, contributing to increases in both renovation and new housing investments.[133] However, the COVID-19 pandemic may influence these trends.

The following graph illustrates the future development of material consumption by the construction sector based on these projections. Total material consumption is based on the total inputs used by the construction sector in Toronto, as estimated for the MFA, downscaled from Exiobase national-level data based on Toronto's labour data. Exiobase refers to 2011 data. Total material consumption after 2011 is then modeled based on employment growth data retrieved from Toronto Employment Survey Summary Tables for the period 2011-2019,[134] and BuildForce Canada's Construction and Maintenance Looking Forward provincial report for the period 2020–2029.[135] Employment growth is a good indicator of the change in activities in the construction sector that will likely impact material consumption. Labour productivity, measured as the total volume of output produced per unit of labour (employee) in the construction sector has been stagnating since over the past few decades. Therefore, it is safe to assume that there is a relatively stable relationship between building projects and people employed in the sector. However, it is still important to note that employment is not the only factor that could influence material consumption. This analysis is not meant to predict the actual change in activity for this sector, but only to give a rough estimate of how much materials could be flowing within Toronto in the next 10 years.[136]

The analysis (Figure 2) shows that, due to an ambitious schedule of infrastructure projects and continued immigration-driven population growth, material consumption of the construction sector will continue to grow. Growth is expected to peak in 2024, when the expected material consumption could be as high as 18 million tonnes of materials.

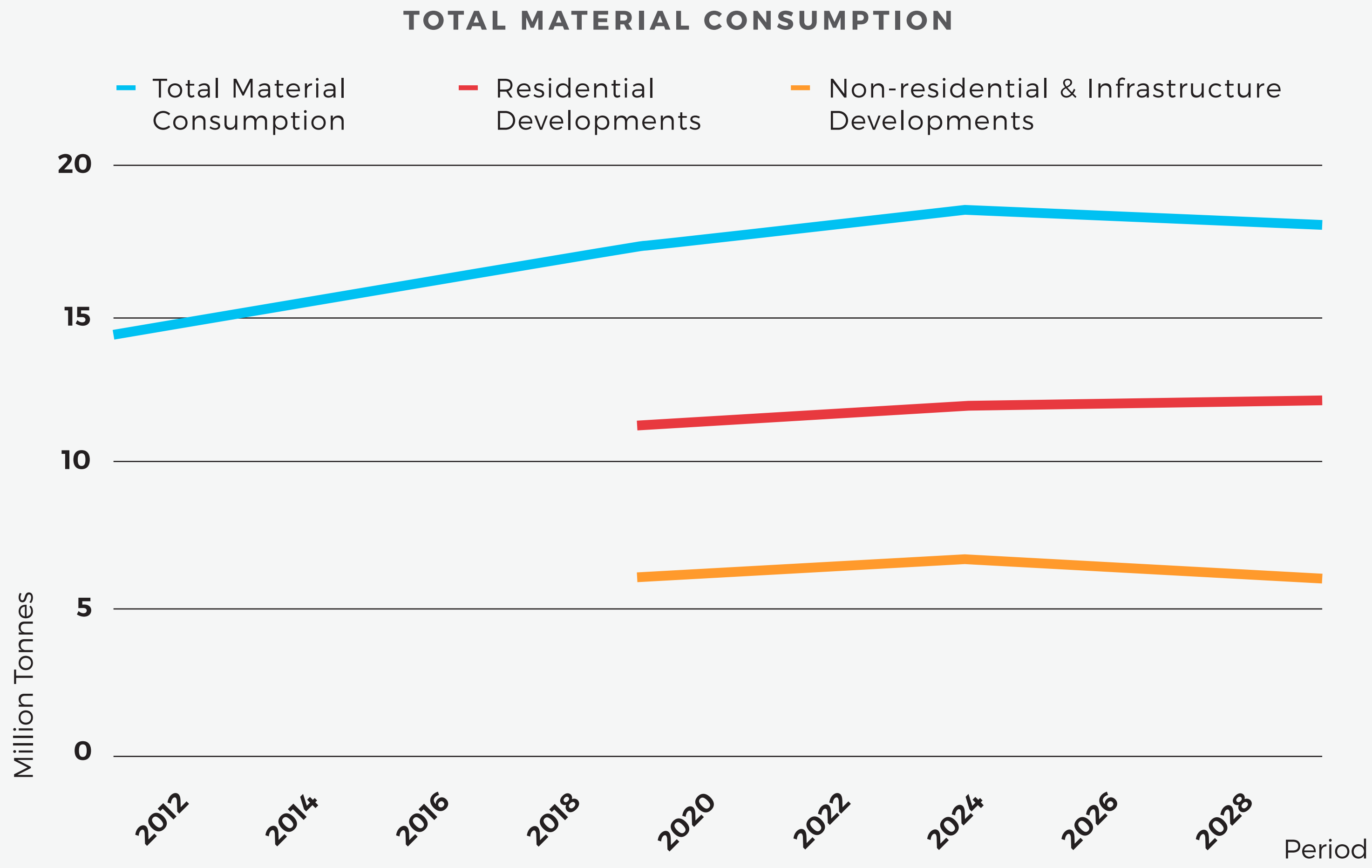


Figure 2. Projected total material consumption for the Construction sector, solely based on anticipated employment growth

As material consumption increases, waste generation will likely follow (Figure 3). For this reason, this section not only presents an analysis of future material consumption but also of C&D waste generation, again, based on employment data. In the 2020-2024 period, C&D waste is likely to grow due to residential and non-residential developments. However, as growth in the non-residential sector will temper, C&D waste from non-residential developments is likely to decline in the 2025-2029 period, and only residential C&D waste will continue to increase.

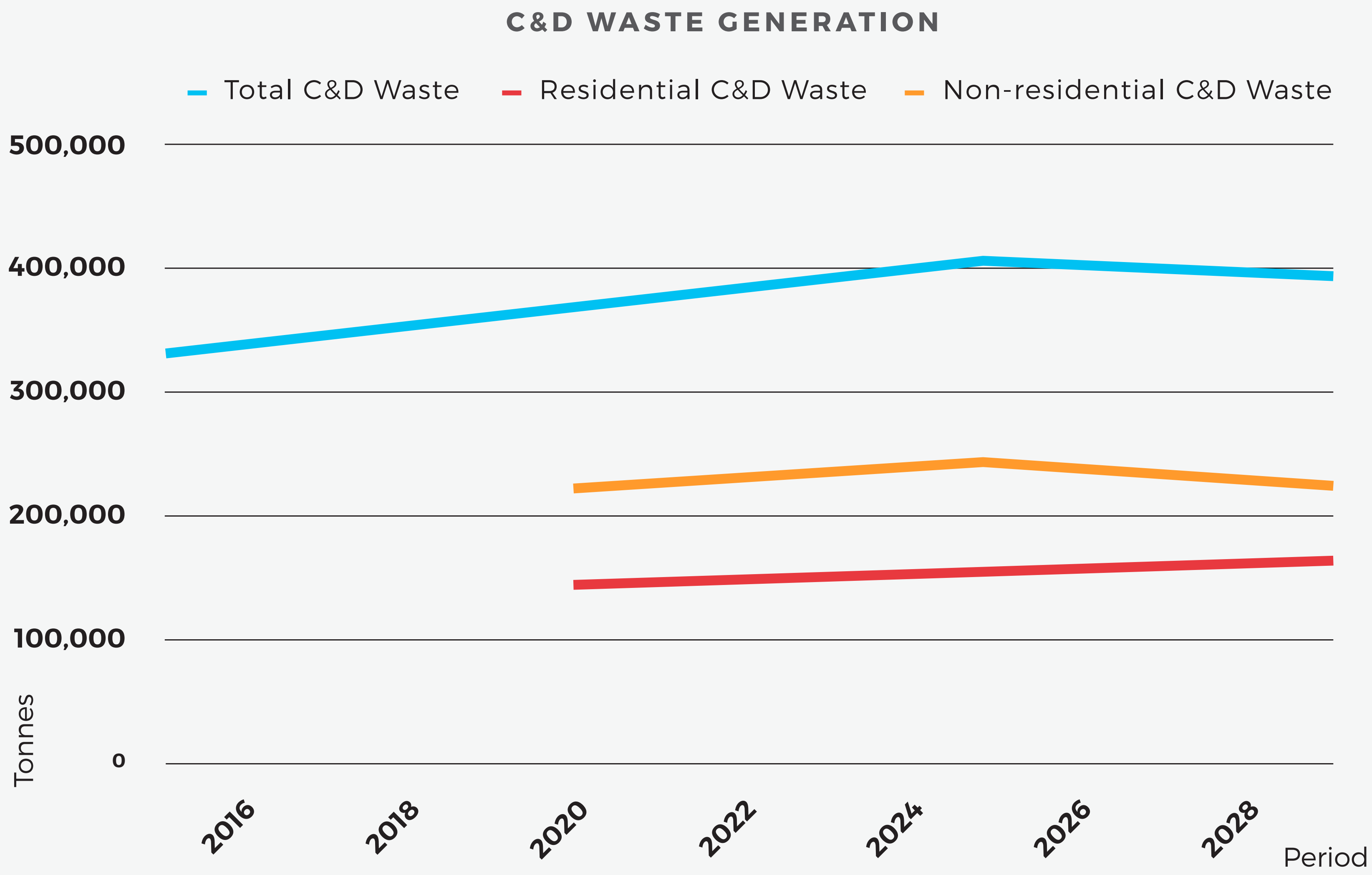


Figure 3. Projected total waste generation for C&D waste, solely based on anticipated employment growth for the Construction sector

Since 2006, the City of Toronto has worked towards the promotion of sustainable buildings. The 'Toronto Green Standard' (TGS), a list of measures to be taken in building and site design initially introduced as a voluntary standard, evolved into a requirement to be met by any new development applications. The TGS includes five categories of performance: air, energy, water, ecology and waste. At present, Tier 1 performance measures are required. Tier 2-4 are voluntary. All performance measures are revised and updated every four years to better address environmental targets. The latest version introduced a four-tiered framework to provide a clear path to achieve near zero GHG emissions buildings by 2030.[137] Construction waste management, water, stormwater, and irrigation efficiency, and district energy connection are only few of the many performance measures that align with circular economy goals.

The TGS is a step in the right direction, but it only applies to new developments and not to existing structures. Through TransformTO: Toronto’s Climate Action Strategy, the City is looking into what actions can be taken and what authority the City of Toronto has to address the environmental performance of existing buildings. The data gap issue identified in this analysis may constitute a challenge for future effective action.

7 FOOD SYSTEM MFA

In Toronto, the total estimated amount spent on food is about CAD 7 billion per year.[138] Food represents about 13% of total household expenditure. The carbon emissions associated with food consumption per person have an estimated footprint[139] of 0.78 global hectares (gha)[140] (out of a total carbon footprint of 2.8 gha per Toronto resident), with the highest scoring sub-categories being meat and animal products. In Canada, total indirect emissions[141] associated with household spending on food and beverages account for a quarter of all indirect household emissions (second only to indirect emissions from household energy consumption).[142] Given the importance of food in daily life and its high environmental footprint, many community-led and business initiatives focus on the topic, promoting zero-waste and sustainable consumption practices to the public. This suggests that there could already be a good level of awareness among residents around key topics like waste and sustainable consumption.

For these reasons, the researchers and the City of Toronto have selected the food system for further analysis. The MFA for this sector reveals how food materials flow through each area of the food system and illustrates the dynamic link between households, food services, and food processing. By identifying value losses, the MFA helps to identify where the City of Toronto has the ability and jurisdiction to implement potential circular solutions to effectively influence those flows and reduce resource consumption, intensity, and food loss and waste, while decreasing direct and indirect emissions from food.

System boundaries and data considerations

- The MFA considers the food system of the City of Toronto. All steps of the food value chain, from production to distribution and consumption, are considered. It is important to note that, however, not all steps of the value chain occur solely within City's boundaries, but are here considered to show what lays behind the food consumed within the City. For example, although there are more than 100 food growing gardens on City of Toronto property,[143] Toronto is highly urbanized, and relatively little land is dedicated to food production and manufacturing. Instead, food retail and consumption are the steps of the food value chain that mainly take place at city-level. Additionally, some data on employment and economic value is available at the Greater Golden Horseshoe (GGH) area (Figure 4).

- Food waste is defined as both food waste and food loss (FLW). "Food Waste" consists of food that is discarded during distribution, retail, and food service, and subsequently in the home. "Food Loss" is the discarding of food that occurs from post-harvest up to, but not including, food service and retail.[144] Food waste in this analysis includes, therefore, waste from production, through to processing and manufacturing, to consumption (see Glossary).
- Total food waste is calculated based on the 2014 Provision Coalition study "Developing an Industry Led Approach to Addressing Food Waste in Canada".
- Emissions are calculated following the methodology outlined by the 2019 Second Harvest technical report on "The Avoidable Crisis of Food Waste". Emissions are calculated for all steps of the food value chain.
- Food availability is calculated from 2019 Statistics Canada data, adjusted based on population.
- All other data is derived from publicly available municipal-level data and/or literature reviews of provincial and national studies. All studies, reports, and calculation methods are documented in the reference list in the annex of this report (Appendix B) and in the methodology document (Appendix A).

7.1. MATERIAL FLOWS OVERVIEW

The MFA for the food system focuses on the whole value chain, from primary production to end-of-life, and includes food loss and waste (FLW). Two forms of FLW occur along the food chain: 1) planned (unavoidable) FLW – (such as animal bones); and 2) unplanned / post-processing (avoidable) FLW (such as apples that reach the store but are not purchased due to bruising in transit).[145]

The results of the MFA estimate that total food waste disposed of in the City of Toronto could be as high as 628,500 tonnes, that is approximately 30% of the food produced in 2019.[146] Most of this waste ends up in landfills. The Recycling Council of Ontario estimates that over 30% of waste disposed of in landfills can be composted or redirected.[147] Reducing FLW is necessary to reduce economic costs and environmental impacts related to food. The costs of FLW include, among others, unnecessary transportation, energy, water, fertilizer, machinery and equipment, packaging, labour, and capital invested. In Canada, almost 2.2 million tonnes of edible food is wasted each year, costing Canadians in excess of $17 billion.[148] Environmental impacts include greenhouse gas emissions, air pollution, deforestation, global ocean and freshwater eutrophication caused by agricultural fertilizers, as well as freshwater withdrawals and food related plastic packaging pollution, just to name a few. Canada's 2.2 million tonnes of avoidable household food waste is equivalent to 9.8 million tonnes of CO_2 and 2.1 million cars on the road.[149] The social aspect of food waste also ties to economic and environmental considerations, as food insecurity affects almost 1 in 5 Toronto households (18.5%).[150]

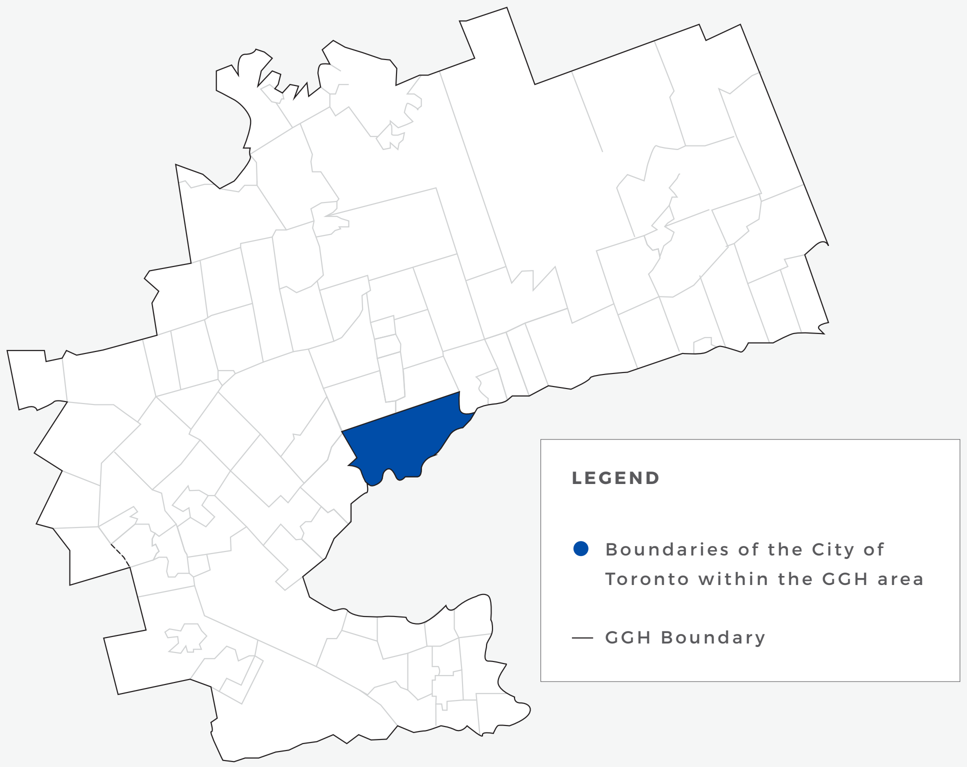
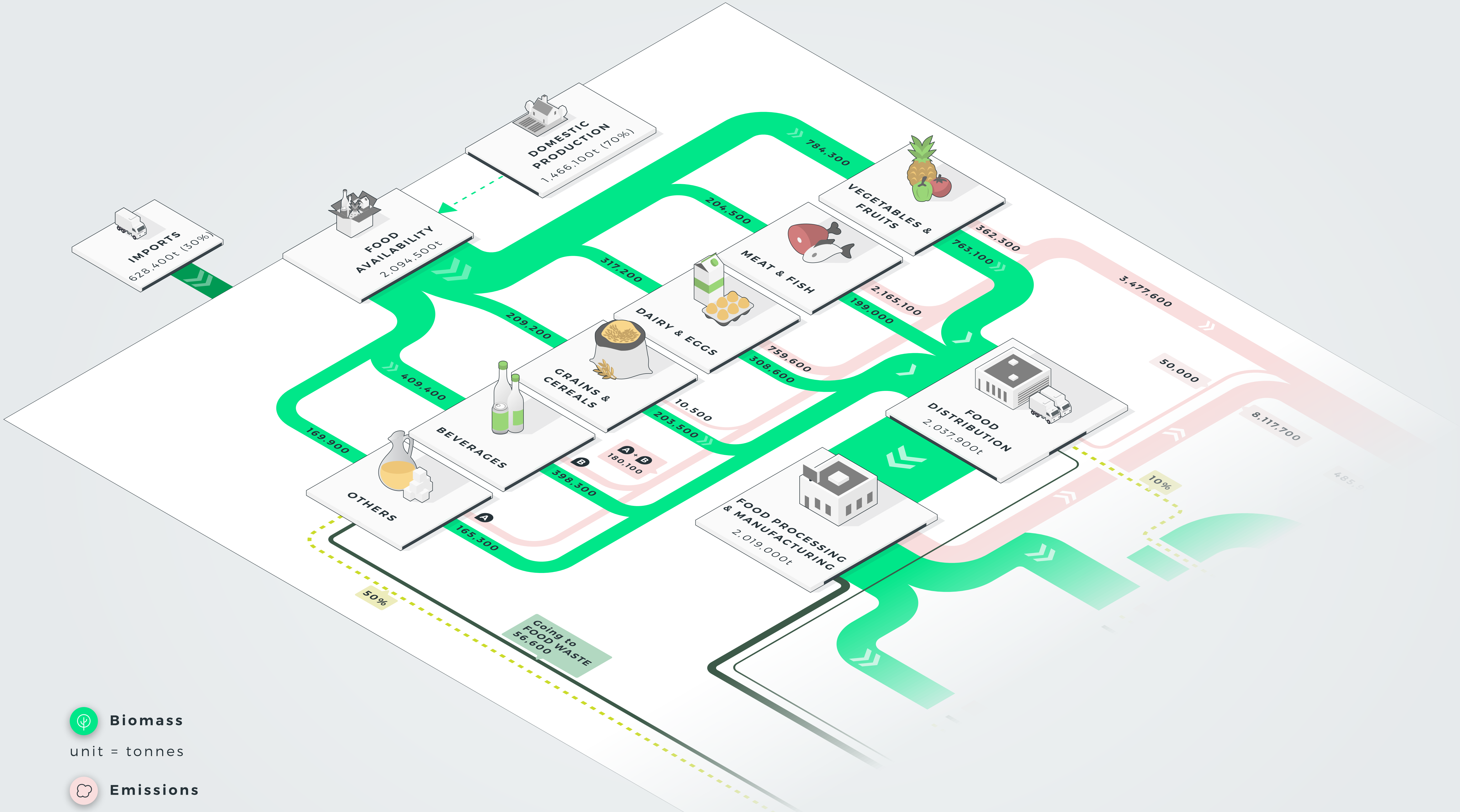


Figure 4. City of Toronto area (in blue) Vs. Greater Golden Horseshoe (GGH)



Biomass

unit = tonnes

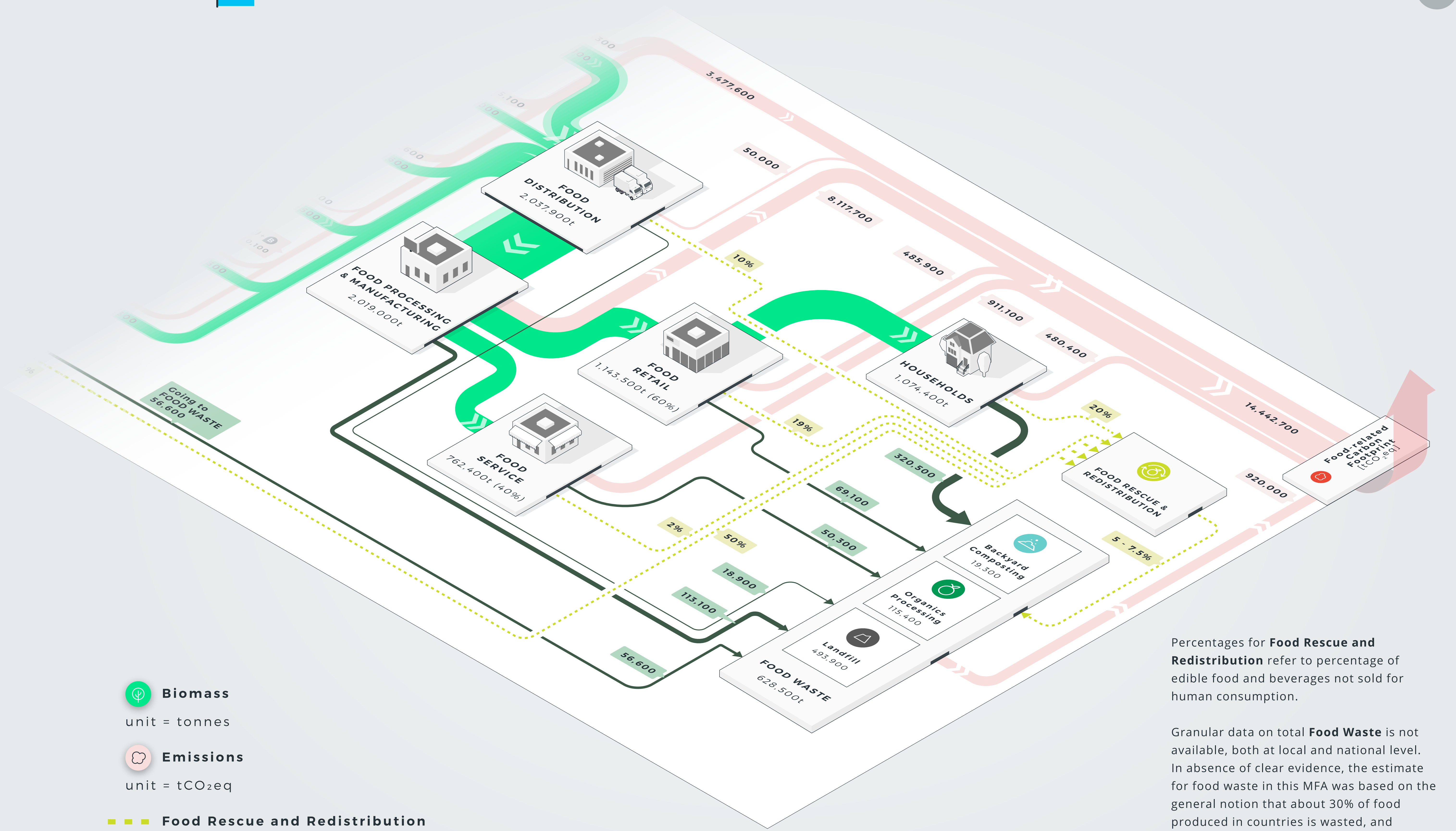
Emissions

unit = tCO_2eq

Food Rescue and Redistribution

unit = %

FOOD SYSTEM MFA



Biomass
unit = tonnes

Emissions
unit = tCO_2eq

Food Rescue and Redistribution
unit = %

Percentages for **Food Rescue and Redistribution** refer to percentage of edible food and beverages not sold for human consumption.

Granular data on total **Food Waste** is not available, both at local and national level. In absence of clear evidence, the estimate for food waste in this MFA was based on the general notion that about 30% of food produced in countries is wasted, and validated in consultation with experts and various stakeholders.

Food availability

Food availability is the amount of food that is physically present in a country for human consumption, including processed food products imported for consumption, as well as products produced within the region. In this MFA, food availability is calculated by downscaling national data provided by Statistics Canada.[151] Vegetables and fruits represent 37% of foods available in the country, followed by beverages (20%), dairy and eggs (15%), meat and fish, and grains and cereals (10% each).[152] As of 2007, about 70% of food bought in Canadian supermarkets and stores was produced domestically.[153]

Although Toronto is highly urbanized and relatively little land is dedicated to agriculture, the food and farming sector in the Greater Golden Horseshoe (GGH)—a secondary region of Southern Ontario, Canada, which includes the Greater Toronto Area (GTA)—contributes significantly to the region and national food economy. There are 19,266 farms located in the GGH, employing 35,584 full-time year-round workers for total agricultural revenue of more than CAD 12 billion annually.[154] In the GGH, food production focuses mainly on grains and cereals (oats and barley) and vegetables and fruits. All vegetable deficits (products for which local supply does not meet demand), in fact, could be met by provincial production without imports.[155] However, a 2018 RUAF/FAO study showed that foods that are domestically produced in Ontario (i.e. carrots, apples, and potatoes) often leave the region while comparable foods are imported. Additionally, large retail grocery chains annually widen their private label offerings, many of which are manufactured elsewhere and imported into Canada.[156] This is likely due to lack of mid-scale infrastructure, adding to the negative environmental impact of long-range transportation. Ontario's Agriculture and Food Strategy is working towards replacing imports with Ontario grown and processed products, developing and supporting ethnic markets, creating local food networks.[157]

In terms of environmental impact, the results of the MFA show that the food supply of Toronto is responsible for nearly 3.5 million tCO_2e of annual food-related carbon emissions.[158] FLW in production accounts for roughly 9% of waste across the supply chain.[159] Most of the FLW can be considered planned (unavoidable loss). However, 5% of edible produce is left unharvested and can be considered avoidable FLW.[160] In produce production, where the donation of unsold edible foods is highest, only 50% of unsold edible food and beverages is currently rescued.[161]

Food distribution

The food distribution sector comprises a variety of companies and organizations that collect food from producers, store it in warehouses, and then distribute it to manufacturers, retail stores, and food service establishments. Food merchant wholesalers in the GGH employ 35,794 people, while farm product and beverage wholesalers add another 5,000 jobs.[162] In terms of environmental impact, more than 50,000 tonnes of food-related carbon emissions and 3% of food waste generated within the system are attributable to distribution.[163] All food waste generated during distribution is considered avoidable.[164] Second Harvest estimates that the median percentage of unsold edible food and beverages rescued is 10% in this sector.[165]

Food processing and manufacturing

This sector comprises all those establishments that transform raw food materials into ingredients and further into products. It involves basic preparation of foods for markets (e.g. washing, trimming vegetables), basic packaging (e.g. canning), and more complex food preparations following recipes and using multiple ingredients (i.e. preparing meals or pasta sauces). The GGH has over 21,615 people employed in food manufacturing jobs, which is almost 17% of all food-related jobs in Canada.[166] In the City of Toronto alone, there are over 1,000 registered companies that produce food and beverage products, employing over 65,000 individuals in the Census Metropolitan Area.[167,168] The GGH is also a significant aggregation, distribution, storage, and processing centre for food across the whole province of Ontario. The estimated value of the food processing and manufacturing sector in the province is CAD 15 billion (2018).[169]

In terms of environmental impact, the results of the MFA show that the food processing and manufacturing emits nearly 8.1 million tCO_2e per year[170] and food loss accounts for roughly 18% of total waste across the food value chain.[171] A study by Second Harvest estimates that 19% of FLW in processing and 55% in manufacturing is avoidable.[172] Most FLW at this stage consists of field crops and produce, but also meat and poultry. The main causes of waste in processing and manufacturing are the poor quality of inputs, resulting in spoilage, and conservative date codes (e.g. "best before" dates). Moreover, a recent study found that food rescue and redistribution often do not occur at the food processing and manufacturing stage, as many actors in these sectors do not typically donate edible foods not sold for human consumption.[173]

Food service

The food service sector comprises businesses, institutions, and companies responsible for preparing meals outside the home (i.e. hotel, restaurants, and institutions). In Ontario, the food service sector is valued at almost CAD 41 billion annually.[174] In terms of environmental impact, the results of the MFA show that the food service sector emits over 911,100 tCO_2e annually and generates 8% of the total waste in the food value chain. 35% of FLW in the food service sector can be defined as 'plate waste' (i.e. percentage of served food that is discarded), which is avoidable. Most FLW at this stage consists of field crops and produce, grains and meat/poultry. The main causes of waste in this sector are similar to those in the food processing and manufacturing and food retail sectors, that is conservative date codes and unavoidable waste from food preparation (cutting, peeling, etc.). On average, only 2% of edible food or beverages not sold for human consumption is rescued from food services for redistribution.[175] Second Harvest estimates that the median percentage of unsold edible food and beverages rescued is 2% in the food service sector.[176]

In restaurants, cafeterias and fast-food outlets across the province of Ontario, food waste can account for well over 50% of total waste streams.[177] Most of the food waste from these establishments ends up in the residual waste stream, and food waste is the largest component of residual waste streams from the IC&I sector.[178] These establishments typically send their food waste and its associated packaging to landfill because it is the lowest cost option. Additionally, the organics processing capacity in the province of Ontario is limited[179] and only restaurants with annual gross sales of +$3 million are required by provincial law to perform waste audits.[180] For this reason, most businesses in the food service sector do not usually quantify the amount of food waste they generate, and they struggle to understand the value that is lost. As the amount spent on food outside the home is steadily increasing, measures to improve the management of food waste generated by the food service industry are becoming more important to avoid economic value loss and negative environmental impacts.[181]

Food retail
Most of the jobs in the food value chain in the GGH area are concentrated in the food service sector, and only 3% of those are in retail.[182] The retail sector comprises the sale of food products to the public. In terms of environmental impact, the results of the MFA show that the food retail sector emits nearly 485,900 tCO_2e annually, and accounts for 11% of food waste in the system.[183] On average in Ontario, organics constitute 35% of total waste generated by the sector, 13% of which is food waste.[184] 100% of the food waste generated in the food retail sector is considered avoidable and suitable to be redistributed or rescued.[185] In retail, spoilage is the most common cause of FLW, and this is most prominent in fresh produce. Conservative date codes are the second most significant cause of FLW in retail, mainly in meat and poultry. On average, Second Harvest estimates that the median percentage of unsold edible food and beverages rescued is 19% in the retail sector.[186]

Household consumption
In 2009, Canadians represented about 0.5% of the global population, produced about 1.5% of the global food supply, and consumed about 0.6% of world food production.[187] The daily per capita supply of calories in Canada (3,494 kcal) is higher than in Europe (3,367 kcal).[188] This is mainly due to the fact that the Canadian diet is more meat- and dairy-intensive than the average European diet.[189] At the same time, consumption of vegetables and fruits in Canada is also high. As noted above, about 12% of household income is spent on food in Toronto. Most household expenditures are spent on meat and dairy, although there is an increasing tendency towards foods like produce and grains.[190]

On average, Canadian households throw away CAD 1,766 worth of food per year.[191] In Canada, household food waste accounts for 51% of waste that occurs within the food system.[192] A curbside waste audit in the Greater Toronto Area discovered that 40% of the food waste that residents throw out is avoidable (53% of avoidable food waste is leftovers that could have been eaten, and the remaining 47% is untouched food).[193] In Toronto's single-family households avoidable food waste accounts for an even higher share (over 50%) of all food waste generated per year. Fruits and vegetables make up the largest portion (42%) of this waste, by weight.[194]

Food waste diversion
The results of the MFA indicate that the food waste problem could be as big as 628,500 tonnes, that is 30% of food available for consumption.[195] Accurate estimates for total food waste in the region constitute a major data gap. Granular data on total food waste is not available, both at local and national level. In absence of clear evidence, the estimate for food waste in this MFA is based on the general notion that about 30% of food produced in Canada—similarly to the rest of the world—is wasted.[196] However, the estimated total food waste modelled for this study ranged from 200,000 to 1.1 million tonnes, based on different estimates and data sources identified during the analysis. The decision to model 628,500 tonnes of food waste in this MFA was made in consultation with various food system subject matter experts and because the general notion that 30% of food produced in countries is wasted was in line with other mainstream sources and comparable to other countries such as the United States. Additional research should address this data gap and further explore food waste generation along the value chain.

Food waste is the single biggest waste stream found in disposed residual IC&I waste across the country (25%).[197] The IC&I sector typically uses landfill as the main disposal method because of its cost-effectiveness and lack of available organics processing capacity in the region.[198]

To date, efforts to reduce food waste in Toronto have focused on food waste produced in households.[199] The City of Toronto's Green Bin program helps to divert single-family household food waste from landfills. Food waste in the Green Bin is processed together with organics at two city-owned organics processing facilities (Disco Road and Dufferin). High-quality digestate is made into compost derived from this process and is used in parks and gardens. Some of it is given back to the public for free at Community Environment Days.[200] From a data perspective, it is difficult to separate food waste from the organics inflow at these two facilities. For the purpose of this analysis, it is assumed that 71% (~115,400 tonnes) of the Green Bin material collected and managed by the City is food waste, based on single-family home waste audit data provided by the City of Toronto.[201] The City also encourages residents to reduce food waste through education and to divert food waste through backyard composting, a low-tech, cheap and easy approach. In 2019, around 19,300 tonnes of waste was diverted via such activities.[202]

Toronto's Green Bin Program is one of the most successful organic diversion programs on the continent and will help divert millions of tonnes of organic material from going to landfill. Almost 80% of food waste is correctly disposed of in the Green Bin.[203] By capturing the remaining 20%, residents can help increase organics diversion rates, while at the same time reducing organics contamination in other waste streams. Additionally, the program can leverage on its success and good residential customer base foundation to grow, at least on the residential side. Many Torontonians who live in non-City serviced multi-residential units do not have access to a food and organic waste diversion program.[204] In fact, residential programs for food diversion across the region serve mostly single-family dwellings.[205] With urban densification, more municipalities across the region are piloting or have initiated multi-unit residential organic diversion programs. The City of Toronto has started preliminary exploration into the possibility of designing mandatory diversion approaches to all multi-residential buildings, regardless of service provider.[206] In order to do this, however, the organics processing capacity of the region would need to increase considerably.

It is important to note that FLW is significantly higher for sources outside the City's control, where there are no mandatory organics diversion programs in place. The City of Toronto, via the Green Bin program, shows higher capture rates for food and organic waste than in the private waste management sector, where the low cost of landfill disposal poses a considerable financial barrier to encouraging participation in enhanced diversion programs.[207]

Food rescue and redistribution
The MFA diagram does not specifically address the total amount of food that is rescued and redistributed, as it is focused on FLW, and food that is rescued is not considered waste. However, in Toronto there are many community and non-government-organization (NGO) efforts to divert surplus food, including the City's own Community Reduce and Reuse Programs[208], as well as Second Harvest, Not Far From The Tree, and Forgotten Harvest. Second Harvest is Canada's largest food rescue program. The organization estimated that only 14% of edible foods lost and wasted along the value chain are presently rescued for redistribution.[209] The research also found that between 5% and 7.5% of rescued food is lost during redistribution for various reasons (i.e. spoilage, conservative date codes, storage and inventory losses, etc.).

During the last fiscal year, Second Harvest alone rescued more than 10,000 tonnes (22.3 million pounds) of food. Of that, only 1.6% was deemed unfit for human consumption and classified as organic waste. The remainder was distributed to non-profits and charities for their food redistribution programs, as well as vendors who can use the organic waste for animal feed. The organization is exploring other opportunities and partnerships/social enterprise models to use this organic waste to potentially generate revenue for their operations.

Emissions

The production, transportation, processing, storage and distribution of food requires energy and releases significant volumes of greenhouse gases. Depending on how food waste is managed, the greenhouse gases emitted by decomposing organic matter can also be significant. Total emissions from food waste management (~920,000 tCO_2e) are calculated based on the National Zero Waste Council 2017 report. This estimate is based on the assumption that only 3% of food waste in Canada is processed via anaerobic digestion.[210] To account for the fact that the City of Toronto does divert food waste via anaerobic digestion and by incentivizing backyard composting, the quantity of diverted food waste is excluded from the emission estimate, which is therefore estimating only emissions from food waste going to landfill.

The MFA shows that when all the flows of food within Toronto are accounted for, the total food-related carbon footprint could be as high as 14.4 million tCO_2e per year.

7.2. CHALLENGES

CHALLENGE #1: Embodied emissions and ecological footprint of food

Food is a highly impactful consumer good, responsible for a significant fraction of the embodied emissions and ecological footprint of household products. The vast majority of the ecological footprint from food products consumed in Toronto stems from dairy products, meat and fish, and other foods like sugar, oils, and fats.[211] Beef and cheese specifically are the top two contributors to GHG emissions.[212] If there is no further climate action within the food sector, it has been estimated that the emissions impacts from farming, food production, processing, transportation and waste will increase by 38% by 2050.[213] A global study shows that about 11% of GHGs from the food system could be reduced if food waste was prevented.[214] Canadians have already started moving towards a more sustainable diet. The greater availability of milk substitutes like almond and soy have been eating into milk's former market share.[215] Whether for reasons of health, environment, animal welfare, price or the inventive and effective marketing of plant-based products the number of Canadians questioning the role of meat in their diets has never been higher.[216] The next steps in food policy development will be crucial to spur consumers' engagement and increase this momentum.

Addressing the embodied impacts is in-line with the City of Toronto's vision for a sustainable food system: "Healthy food for all, sourced as regionally as possible, and as sustainably produced, processed, packaged, and distributed as possible".[217] Specifically, reducing meat consumption and other above-mentioned high-impact food products is one of the main actions proposed by the C40 Good Food Cities Declaration, signed by the City of Toronto in 2019. By signing the C40 declaration, Toronto also committed to reduce food waste. Notwithstanding, strategies aiming to influence Torontonian diets should be mindful that food practices and diets are not homogeneous, and food strategies must be culturally-appropriate and sensitive to the diversity of cultures.

CHALLENGE #2: Food rescue and redistribution

Increasing the amount of food that is rescued throughout the chain can provide immediate social and environmental benefits for the City of Toronto. Rescue and redistribution organizations have the potential to provide meals and financial support to many low-income families in need. Moreover, by avoiding food waste generation, improving food rescue and redistribution may reduce budget pressures for the City of Toronto, if it reduces the need to expand capacity of organic processing facilities.[218]

There is considerable potential to increase the amount of food that is rescued throughout the value chain, particularly in processing and manufacturing. A recent report by Second Harvest estimates that more than 50% of edible food could be rescued from produce farmers, 78% from produce packers, 100% from processors and manufacturers, 90% from distributors, 81% from retailers, and 98% from the food service sector.[219] Since meat and protein constitute a high share of edible food being lost and wasted, improving food rescue and redistribution can positively influence the previous challenge identified in this document.

The greatest opportunities identified by the report lie in improving value chain communication and coordination. This includes, for example, retailers providing greater clarity to stores about forecasted deliveries that stores could, in turn, use to improve their rescue and donation practices. In addition, Second Harvest reports that a considerable opportunity exists to improve the communication and coordination of redistribution systems, resulting in improved performance and more effective use of existing infrastructure.[220]

CHALLENGE #3: Food waste and value loss through the food value chain

Overall, food waste from businesses, supermarkets, and households represent an estimated 30% of all waste in landfills[221], the vast majority of which stems from households. Evaluating this problem holistically, food waste should ideally follow a cascading hierarchy of value (commonly referred to as the "Food Recovery Hierarchy"); starting with reducing food surplus and waste, followed by feeding people with good quality surplus food (e.g. via food banks and other channels), then using the remainder for animal feed, extraction of nutrients and other beneficial materials, and finally composting. As little as possible should end up incinerated or in a landfill.[222] Currently, only a very small share of the overall food waste in Toronto is avoided or directly managed and distributed to high-value applications for new product development (e.g. creating new food products from by-products like milk permeate or coffee cherry skins), or animal feed.[223] The City of Toronto handles its food waste via its Green Bin Program. Organic waste is processed via anaerobic digestion.

In Canada, households account for 51% of food waste that occurs within the food system.[224] Although the City of Toronto manages household food waste in a sustainable way through anaerobic digestion and encouraging backyard composting, many IC&I food waste generators as well as many residents of non-City serviced multi-residential units do not have access to food waste diversion programs. Expanding access to such programs could be especially pertinent in healthcare, retail, and accommodation and food service sectors, in which organics constitute more than a third of total waste. However, as previously mentioned in this report, processing capacity and collection frequency would need to be addressed when considering alternatives to disposal in these sectors, and some of these factors may lie outside of the City's jurisdiction.

Decomposing food waste can produce methane (a potent greenhouse gas) if it is incorrectly placed in the garbage and directed to landfills. Ensuring adequate organics diversion service coverage of both residential and IC&I sources is an important aspect of this challenge.

7.3. BAU PROJECTIONS

The following graphs illustrate the future projection of total food consumption and total food waste in Toronto based on population growth projections for the future. It is important to note that this projection is a simplified model that does not consider complexities like demographic or economic changes. Nor does it include changes in health and other food-related trends, as well as the increasingly globalized food chain continue to transform Canadian diets and attitudes towards food. As these factors are complex to model, the model only offers total food consumption projections, but does not model the consumption of food by type (i.e. fruits, meat, animal products, grains) over time.

The inputs of the Food System material flow analysis ('Food availability') does not show how much food is consumed, but rather how much is available for consumption before waste and spoilage. In order to illustrate the future projection of total food consumption, 'Food consumption' is derived from Exiobase, and not based on 'Food availability' derived from Statistics Canada. Total food consumption in Canada is calculated by aggregating 'Final consumption expenditure by households' and food consumed by 'Hotels and restaurants', giving a good estimate of total food consumed at the end of the food value chain. Data is then transformed in consumption per capita and converted to a Toronto scope using population data 2011-2020 and 2021-2030 projections reported by the Canadian Centre of Economic Analysis (CANCEA) and the Canadian Urban Institute (CUI).[225]

The analysis (Figure 5 & 6) shows that by 2030, Toronto could be home to 3.56 million people. This equates to a total food consumption of 1.6 million tonnes of food per year and a total food waste of over 738,300 tonnes. With more mouths to feed and the growing global demand for food, agriculture in the GGH area will need to increase production and yields, or progressively rely more on food imports to meet this demand. However, the impacts of climate change — higher temperatures, extreme weather, drought, increasing levels of carbon dioxide and sea level rise — may threaten to decrease the quantity and jeopardize the quality of food supplies worldwide. Food is intimately connected to climate change. Climate change impacts food production and sustainability, while at the same time the global food system directly contributes to climate change and environmental degradation.[226]

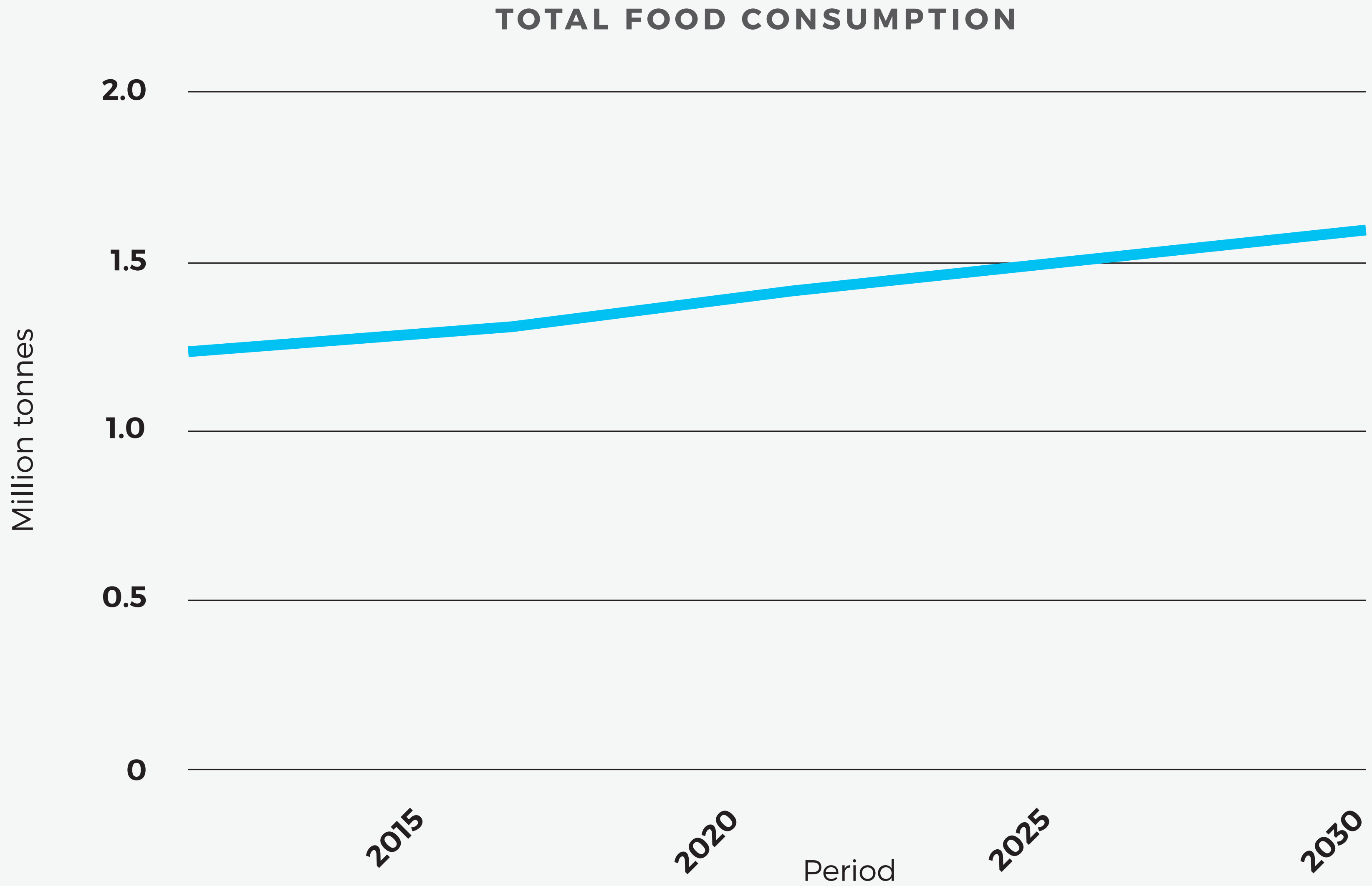


Figure 5. Projected total food consumption for the City of Toronto, solely based on anticipated population growth

Figure 6. Projected total food waste generation for the Food System of the City of Toronto, solely based on anticipated population growth

The City of Toronto recognizes these issues and has identified food as a lever to accomplish the City's strategic goals, and sustainable diets are a vehicle to achieve ecological and public health.[227] Changes in dietary patterns can, in fact, have a significant impact on reducing global emissions. Specifically, the City of Toronto recognizes that reducing meat intake, especially red meat, and increasing intake of plant-based foods (vegetables, tubers, pulses, legumes, whole grains, nuts, seeds, and fruits) would be beneficial.[228] Still, the promotion of healthy, sustainable diets needs to be culturally-appropriate and take into consideration the many factors that influence what foods people consume, including socioeconomic and sociocultural factors. Increasing awareness and targeting certain social norms, while respecting cultural, religious and Indigenous traditions, is crucial.[229] Shifting towards more sustainable diets is not only an opportunity to decrease the impacts of climate change worldwide, but also an opportunity for achieving multiple aligned public health goals in Toronto.

8 NEXT STEPS

Building on the initial assessment of Toronto's economic and policy landscape, as well as household consumption (found in the Landscape Analysis), this report provides a deeper quantitative assessment of the current state of material circularity in three sectors: Waste Management, Construction and Food Systems. The added level of insight provided by the Material Flow Analyses conducted on these three sectors contributes to a shared understanding of the resource metabolism of the sectors in Toronto, and provides an evidence base to further reflect on some of the key challenges and barriers in moving towards a more circular economy.

As described in the introduction of this report, Material Flow Analyses offer a static 'snapshot' of material inputs and outputs to a given sector or part of an economy. While this kind of analysis is valuable for understanding the volumes, material composition, and relationships between material inputs and outputs, there are a number of complementary approaches that could further enhance the insights generated from MFAs:

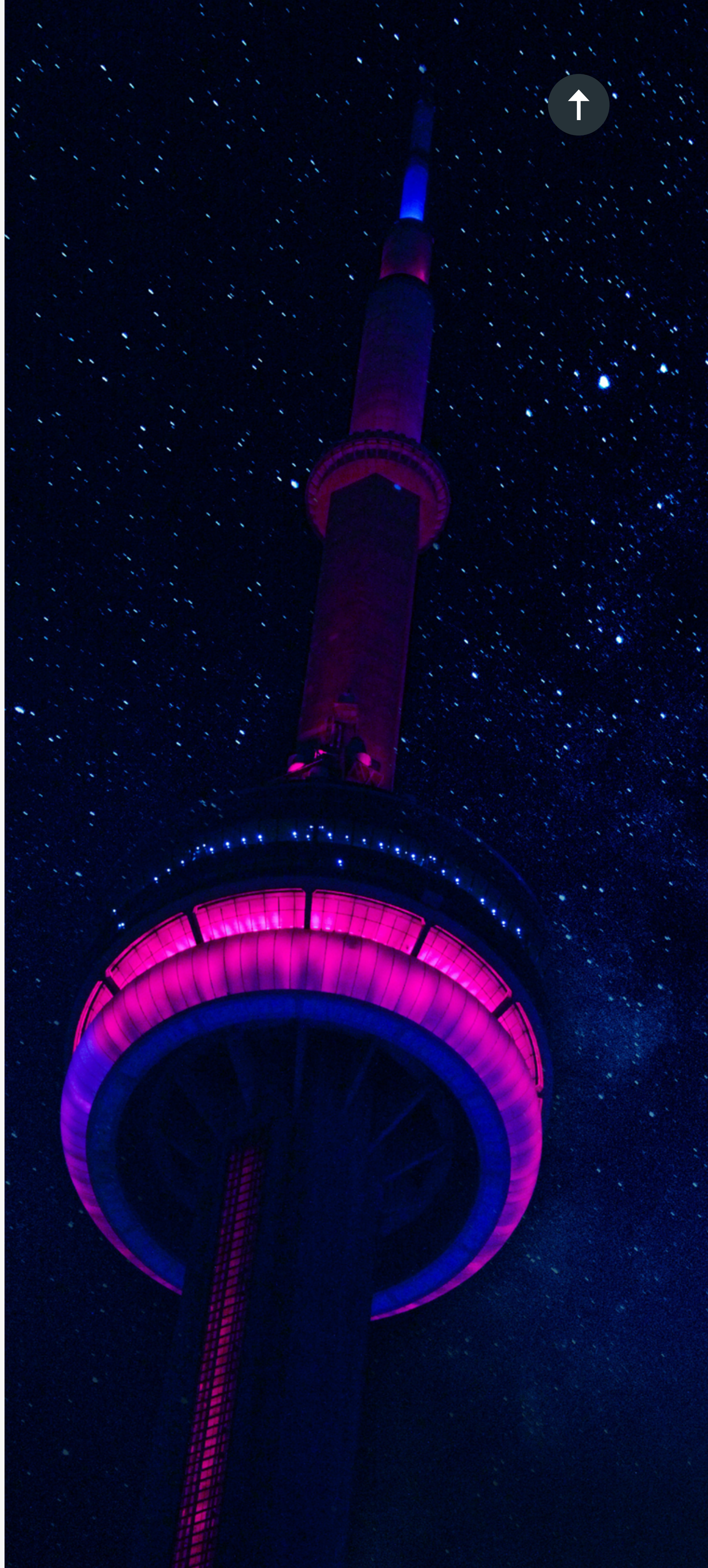
GEOSPATIAL MAPPING (GIS)

Geospatial mapping (GIS) can provide greater insight into where materials originate, how they move through an urban environment, or where they are stored, processed, or added to stock (i.e. buildings). Such an analysis can be used to determine opportunities for urban mining, possible industrial symbiosis, or higher value channels for reuse or recycling.

LIFE CYCLE ASSESSMENTS (LCA) OR ECOLOGICAL FOOTPRINTS (EC)

Life Cycle Assessments (LCA) or Ecological Footprints (EC) can provide much greater detail and insight into the environmental impacts associated with material flows within an MFA. Such an approach can be particularly valuable for mapping the most impactful material flows and prioritising strategies for mitigation, such as material substitution, improved sourcing and procurement, or avoidance. LCAs can also be used to analyse the impact of specific locally produced products or construction projects in order to reduce their lifetime impact.

Building on the analysis and interpretation of the challenges presented in this report, the researchers intend to draw on their expertise and experience from other circular city scans to identify key considerations in transitioning Toronto towards a circular economy in the following Task (4). The final task of this project will provide support to the City on how to best chart a path forward toward a more circular economy in Toronto.



1. City of Toronto (n.d.). Working towards a Circular Economy. Retrieved from: https://www.toronto.ca/services-payments/recycling-organics-garbage/long-term-waste-strategy/%20working-toward-a-circular-economy/

2. NAICS (n.d.). NAICS & SIC Identification Tools. Retrieved from: https://www.naics.com/

3. For the construction sector, this category also includes bricks and aggregates.

4. Due to limited data availability, emissions for the construction sector only include 'operational emissions' (cradle-to-gate) and do not consider consumption-based emissions or embodied carbon emissions.

5. This study relies on existing Emissions data and modelling, and did not generate new modelling. A comprehensive list of data sources used in this study can be found in Appendix A.

6. Energy use is only represented as a separate flow in the Construction sector MFA. Construction is a well defined industrial sector and energy use data is available on Statistics Canada. Energy use was not included in the Waste Management sector because of the complexity of the waste management system represented. Estimating energy use by this sector requires piecing together different parts of a linear value chain that would need too many specific data points not currently available and too fragmented to offer a complete picture. The Waste Management sector, therefore, focuses only on solid waste management. The same applies for the Food System sector (although some supplemental data on energy and water consumption is included in Appendix A).

7. The term "diversion" is generic in nature and not intended to match the methodology used to calculate municipal diversion rates in the Provincial Blue Box Datacall overseen by the Resource Productivity and Recovery Authority.

8. Landfills in Ontario have operating conditions and need to apply for Environmental Compliance Approval (ECAs) that require strict gas, leachate, and other environmental controls to mitigate downstream impacts.

9. World Bank (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. Retrieved from: https://openknowledge.worldbank.org/handle/10986/30317

10. Both national and Toronto estimates of per capita waste generation are inclusive of both municipal- and Industrial, Commercial, and Institutional (IC&I) wastes, not of C&D waste.

11. TransformTO (2017). TransformTO: Climate Action for a Healthy, Equitable & Prosperous Toronto. Implementation Update 2017 and 2018. Retrieved from: https://www.toronto.ca/wp-content/uploads/2019/06/98c7-TransformTO-Implementation-Update.pdf

12. Government of Canada (2018). Municipal solid waste: a shared responsibility. Retrieved from: https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/municipal-solid/shared-responsibility.html

13. TransformTO (2017). TransformTO: Climate Action for a Healthy, Equitable & Prosperous Toronto. Implementation Update 2017 and 2018. Retrieved from: https://www.toronto.ca/wp-content/uploads/2019/06/98c7-TransformTO-Implementation-Update.pdf

14. City of Toronto (2017). Long Term Waste Management Strategy. Retrieved from: https://www.toronto.ca/wp-content/uploads/2017/10/9803-Final-Long-Term-Waste-Management-Strategy.pdf

15. The City of Toronto reports its diversion rate using the generally accepted diversion reporting principles utilized in Ontario. The City of Toronto provides a full suite of diversion programs to its customer base, which is primarily residential. Although the City of Toronto does offer various diversion programs to non-residential customers, the City does not collect every waste material stream from these sources (i.e. electronic waste, hazardous waste etc. are not managed due to operational and resourcing constraints which include ECA limitations on the management of these materials from non-residential sources). The City of Toronto also directly accepts waste (primarily garbage) from non-residential sources at its transfer stations and does not have information on other material streams that a non-residential drop of customer may generate. For this reason, it is impossible to provide an accurate calculation of the City's non-residential diversion rate: the City has no data to estimate diversion that could be occurring outside of its system. Thus, the diversion figures presented in this MFA include only annual diversion reporting rates representing residential diversion.

16. Environment and Climate Change Canada (2020). National Waste Characterization Report. Retrieved from: http://publications.gc.ca/collections/collection_2020/eccc/en14/En14-405-2020-eng.pdf

17. RPRA (2019). Datacall Report 2019. Retrieved from: https://rpra.ca/wp-content/uploads/Datacall_Report_2019_Web_FNL.pdf

18. Eurostat (2018). Municipal Waste Statistics. Retrieved from: https://ec.europa.eu/eurostat/statistics-explained/index.php/Municipal_waste_statistics

19. Reported diversion rates for provincial and European averages may also include a small portion of commercial and institutional waste.

20. Statistics Canada (2018). Waste Management Industry Survey: Business and government sectors, 2018. Retrieved from: https://www150.statcan.gc.ca/n1/daily-quotidien/210308/dq210308d-eng.htm

21. Waste Today (2019). How Toronto is minimizing its footprint through landfill gas collection. Retrieved from: https://www.wastetodaymagazine.com/article/toronto-landfill-gas-green-lane-landfill/

22. Data provided by the City of Toronto.

23. Statistics Canada (2016). Waste Management Industry Survey. Retrieved from: https://www150.statcan.gc.ca/n1/en/catalogue/16F0023X

24. Based on data provided by the Ontario Ministry of the Environment, Conservation and Parks (MECP) including data from the Resource Productivity and Recovery Authority, Statistics Canada and U.S. State government agencies (Michigan, NY and Ohio).

25. Data on total MR units was provided by the City of Toronto and calculated based on 2018 Tax Roll data and 2018 and 2019 Solid Waste Application Portal (SWAP) data. See Appendix B.

26. City of Toronto (2019). Residential 2019 waste audit data. Retrieved from: https://www.toronto.ca/services-payments/recycling-organics-garbage/solid-waste-reports/

27. City of Toronto (2019). Residential 2019 waste audit data. Retrieved from: https://www.toronto.ca/services-payments/recycling-organics-garbage/solid-waste-reports/

28. City of Toronto (2020). Mixed Waste Processing Study Update. Retrieved from: https://www.toronto.ca/legdocs/mmis/2020/ie/bgrd/backgroundfile-146477.pdf

29. City of Toronto (2017). Long Term Waste Management Strategy. Retrieved from: https://www.toronto.ca/wp-content/uploads/2017/10/9803-Final-Long-Term-Waste-Management-Strategy.pdf

30. See Appendix B for more information on how this is calculated.

31. See Appendix A.

32. More information on how this was calculated can be found in Appendix A and B of this report.

33. RIS International Ltd (2005). The Private Sector IC&I Waste Management System in Ontario. Retrieved from: http://kelleherenvironmental.com/wp-content/uploads/2012/07/ICIPrivateSectorWasteStudy.pdf

34. City of Toronto (2017). Long Term Waste Management Strategy. Retrieved from: https://www.toronto.ca/wp-content/uploads/2017/10/9803-Final-Long-Term-Waste-Management-Strategy.pdf

35. Kelleher Environment (2020). Industrial, Commercial and Institutional, Construction and Demolition and Agricultural Waste Projections for Ottawa [Final Draft]. Provided by the City of Ottawa.

36. Wood that is unpainted, unstained, free of glue, and untreated.

37. Statistics Canada (2016). Waste Management Industry Survey. Retrieved from: https://www150.statcan.gc.ca/n1/en/catalogue/16F0023X

38. The IC&I sector, C&D projects, and multi-unit residential buildings are regulated under Ontario Regulation 103/94 (O. Reg. 103/94 – Source Separation Programs).

39. Dillon Consulting (2018). Review of Diversion Options Report. retrieved from: https://cdn.wasteconnections.com/cms/ridge-landfill/Diversion_Options_DRAFT_Dec2018.pdf

40. EPA (2017). Sustainable Management of Construction and Demolition Materials. Retrieved from: https://www.epa.gov/smm/sustainable-management-construction-and-demolition-materials

41. Kelleher Environment (2020). Industrial, Commercial and Institutional, Construction and Demolition and Agricultural Waste Projections for Ottawa [Final Draft]. Provided by the City of Ottawa.

42. Yard waste is categorized as 'Other' by the referenced study as should therefore be represented in the 'Biomass' flow. Due to lack of granular data on the composition of the 'Other' category it was not possible to separate this flow.

43. Statistics Canada (2018). Waste materials diverted, by type and by source. Retrieved from: https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=3810013801

44. Kelleher Environment (2020). Industrial, Commercial and Institutional, Construction and Demolition and Agricultural Waste Projections for Ottawa [Final Draft]. Provided by the City of Ottawa.

45. Statistics Canada (2019). Municipal wastewater systems in Canada, 2013 to 2017. Retrieved from: https://www150.statcan.gc.ca/n1/daily-quotidien/190625/dq190625c-eng.htm

46. City of Toronto (2019). Wastewater Treatment Plants 2019 Annual Reports. Retrieved from: https://www.toronto.ca/services-payments/water-environment/managing-sewage-in-toronto/wastewater-treatment-plants-and-reports/

47. City of Toronto (2016). Biosolid Management. Retrieved from: https://www.toronto.ca/services-payments/water-environment/managing-sewage-in-toronto/biosolids-management

48. Korinjoh, A. M. (2017). A Sustainability Assessment Review Of The Highland Creek Wastewater Treatment Plant (hctp) Biosolids Management Class Environmental Assessment (2016): Sustainable Assessment Leverage Points Analysis. Retrieved from: https://yorkspace.library.yorku.ca/xmlui/bitstream/handle/10315/34853/MESMP02844.pdf?sequence=1&isAllowed=y

49. Based on data provided by the Ontario Ministry of the Environment, Conservation and Parks (MECP) including data from the Resource Productivity and Recovery Authority, Statistics Canada and U.S. State government agencies (Michigan, NY and Ohio).

50. Ontario regulations 103/94 (Source Separation Programs); 102/94 (Waste Audits and Waste Reduction Work Plans); 3Rs Regulations (Reg. 101/94 to 103/94).

51. Kelleher Environment (2020). Industrial, Commercial and Institutional, Construction and Demolition and Agricultural Waste Projections for Ottawa [Final Draft]. Provided by the City of Ottawa.

52. City of Toronto (2017). Long Term Waste Management Strategy. Retrieved from: https://www.toronto.ca/wp-content/uploads/2017/10/9803-Final-Long-Term-Waste-Management-Strategy.pdf

53. City of Toronto (2016). Project No.872: Multi-Residential Audits. Retrieved from: https://thecif.ca/projects/documents/872-Toronto_Final_Report.pdf

54. City of Toronto (2018). State of Toronto's Blue Bin Recycling Program. Retrieved from: https://www.toronto.ca/legdocs/mmis/2018/pw/bgrd/backgroundfile-113576.pdf

55. City of Toronto (2018). State of Toronto's Blue Bin Recycling Program. Retrieved from: https://www.toronto.ca/legdocs/mmis/2018/pw/bgrd/backgroundfile-113576.pdf

56. City of Toronto (2018). State of Toronto's Blue Bin Recycling Program. Retrieved from: https://www.toronto.ca/legdocs/mmis/2018/pw/bgrd/backgroundfile-113576.pdf

57. City of Toronto (2020). Mixed Waste Processing Study Update. Retrieved from: https://www.toronto.ca/legdocs/mmis/2020/ie/bgrd/backgroundfile-146477.pdf

58. EPA (2020). New International Requirements for Export and Import of Plastic Recyclables and Waste. Retrieved from: https://www.epa.gov/hwgenerators/new-international-requirements-export-and-import-plastic-recyclables-and-waste#:~:text=As%20of%20January%201%2C%202021,prior%20notice%20and%20consent%20requirements

59. Statistics Canada (2018). Waste Management Industry Survey: Business and government sectors, 2018. Retrieved from: https://www150.statcan.gc.ca/n1/daily-quotidien/210308/dq210308d-eng.htm

60. Canadian Council of Ministers of the Environment (CCME) (2019). Canada-wide action plan on zero plastic waste. Retrieved from: https://www.ccme.ca/files/Resources/waste/plastics/1289_CCME%20Canada-wide%20Action%20Plan%20on%20Zero%20Plastic%20Waste_EN_June%2027-19.pdf

61. Government of Ontario (2019). Ontario Developing Roadmap to Support Compostable Product Innovation in Plan to Tackle Plastic Litter and Waste. Retrieved from: https://news.ontario.ca/en/release/52639/ontario-developing-roadmap-to-support-compostable-product-innovation-in-plan-to-tackle-plastic-litte

62. Ellen MacArthur Foundation. (2013). Towards the Circular Economy Vol. 2: opportunities for the consumer goods sector. Retrieved from: https://doi.org/10.1162/108819806775545321

63. NOLAN-ITU. (2002). Biodegradable Plastics - Developments and Environmental Impacts. Retrieved from: http://www.europeanplasticfilms.eu/docs/AustralianReportonBiodegradablePlastics.pdf

64. Napper, I. E., & Thompson, R. C. (2019). Environmental Deterioration of Biodegradable, Oxo- biodegradable, Compostable, and Conventional Plastic Carrier Bags in the Sea, Soil, and Open-Air Over a 3-Year Period. Environmental Science & Technology, 53, 4775–4783. Retrieved from: https://doi.org/10.1021/acs.est.8b06984

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66. Statistics Canada (2018). Waste Management Industry Survey: Business and government sectors, 2018. Retrieved from: https://www150.statcan.gc.ca/n1/daily-quotidien/210308/dq210308d-eng.htm

67. Government of Ontario (2019). Producer responsibility for Ontario's waste diversion programs. Retrieved from: https://www.ontario.ca/page/producer-responsibility-ontarios-waste-diversion-programs

68. Giroux Environmental Consulting (2020). State of waste management in Canada. Prepared for: Canadian Council of Ministers of Environment. Retrieved from: https://www.ccme.ca/files/Resources/waste/wst_mgmt/State_Waste_Mgmt_in_Canada%20April%202015%20revised.pdf

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ANAEROBIC DIGESTION

Anaerobic digestion is a type of waste management in which microorganisms break down food and organic waste under anaerobic conditions (e.g. in the absence of oxygen). Material is broken down into digester solids and biogas (mostly consisting of methane), which can be used for energy generation or upgraded to renewable natural gas. Digester solids can be further processed into high quality compost.

ECOLOGICAL FOOTPRINT

The ecological footprint of a material or activity refers to the total impact that it has on the environment, expressed as the amount of land required to sustain their use of natural resources. The global hectare (gha) is a measurement unit for the ecological footprint.

EMBODIED CARBON

Embodied carbon is the sum of all the greenhouse gas emissions (GHG) resulting from the whole life cycle of materials, from mining and harvesting, to processing and manufacturing, as well as transportation and installation. This concept goes beyond measuring the carbon footprint of products, and includes many more impact categories to fully understand the effects of materials on the ecosystem.

FOOD LOSS AND WASTE (FLW)

Food Loss and Waste (FWL) encompasses food lost and/or wasted at every step of the value chain. “Food Loss” refers to the discarding of food that results from decisions and actions by stakeholders in the value chain from post-harvest up to, but not including, food service and retail. “Food Waste” typically refers to food that is discarded resulting from decisions and actions by distributors, retailers, food service providers and households.

INDUSTRIAL, COMMERCIAL AND INSTITUTIONAL (IC&I)

The Industrial, Commercial, and Institutional (IC&I) sector refers to a categorisation of economic sectors, and is commonly used in the Ontario province to categorise types of waste producers. For the purposes of this study, the IC&I sectors include: Hospitals, Hotels and Motels, Office Buildings, Restaurants, Retail Shopping Establishments, Retail Shopping Complexes, Educational Institutions, and Large Manufacturing Establishments. The main difference in the IC&I categorization for the use of this study, when compared to the Ontario classification (O. Reg. 103/94) is the omission of Multi-residential Buildings. This sub-sector is included within the residential classification of this study, leaving the IC&I sector in this analysis to include only non-residential activities. However, multi-residential waste (regardless of who collects it) is considered IC&I waste under Province’s definition in O. Reg. 103/94.

MATERIAL CYCLES

Closed material cycles (or closed-loop material cycle (CLMC)) refer to material flows in which elements can be recovered or recycled through natural or industrial processes. In a circular cycle, there is nearly no waste and almost everything is reused or repurposed to add value.

URBAN METABOLISM

Urban metabolism is a multi-disciplinary and integrated concept that encompasses all technical and socio-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste. Similar to biological organisms and ecosystems, cities cycle and transform incoming raw material flows and energy flows (i.e. food, water and fuels) into physical structures, biomass and waste. Factors such as urban structure, climate, quality and age of building stock, urban vegetation and transportation technology can all influence the rate of a city’s metabolism.

APPENDIX A

METHODOLOGY GUIDE

Appendix A should be used to understand how information visualized in the MFA diagrams was calculated and how materials flow from left to right in the diagram.

It includes a Microsoft Excel file with all data sources and assumptions used to calculate each number represented in the MFAs.

The Waste Management sector is divided into two different sheets:

- WASTE MANAGEMENT – A

  The first sheet (labeled "Waste Management – a") represents waste generators and the type of management they are served by (private vs. City)

- WASTE MANAGEMENT – B

  The second sheet (labeled "Waste Management – b") represents accounting for solid waste management after collection (diversion vs. landfill) and outputs of solid waste treatment (biogas, recycling products, etc.).

APPENDIX B

DATA APPENDIX

Appendix B gathers all information collected during the analysis into a Microsoft Excel file. The file reports different conflicting data sources encountered, stores additional information not included in this report (but potentially relevant in the contexts related to the three sectors analysed), and collates the raw data and methodology followed to downscale statistics from bigger databases like Exiobase and Statistics Canada.

Appendix A should be used as the main reference to understand the material flows in the MFA visuals.

Appendix B can be used in addition when more detailed information is required for specific data points.