USDN FINAL REPORT

ECOCITY FOOTPRINT TOOL PILOT

JANUARY 2018

# ecoCity Footprint Tool Pilot

...ecological and carbon footprint analysis for achieving one planet living

FUNDED BY THE USDN INNOVATION FUND

PREPARED BY: BCIT Cora Hallsworth Consulting

# SUMMARY

## Objective and Outcomes

The purpose of the ecoCity Footprint Tool Pilot Project was to further refine and test the ecoCity Footprint Tool with five communities and assess its potential for broader use by Urban Sustainability Directors Network (USDN) members.

The following project outcomes were achieved:

1. The ecoCity Footprint Tool was enhanced and refined through:
    - Modifications to align with the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC).
    - Collection of additional data that can serve as proxy data for other communities.
    - Preparation of supporting user-guidance materials.
2. Ecological footprint (EF) and consumption-based emission inventories (CBEI) were prepared for each of the five pilot communities.
3. Next phases for the Tool's development were identified, including opportunities to create an online version of the Tool, and refine policy analysis and scenario building functionality.

## Lessons Learned

The 2017 pilot project revealed the following:

- A strong appetite amongst USDN members to learn more about their community's consumption impacts, and desire for a Tool that will facilitate this knowledge in a way that does not further burden already stretched municipal staff.
- Municipalities, even those in British Columbia which are supported by the Province of BC's Community Energy and Emissions Inventory, experience challenges accessing local data from utilities and corporations in a timely manner. These challenges are overcome by collaborating with other governments to access data collectively and by establishing long-term agreements with data providers.
- The data collection process serves as a powerful instrument for capacity building and for engaging staff and broader stakeholders to consider their community's global impacts on sustainability. This opportunity will be even more powerful when staff can directly access and manipulate the Tool.
- Tool utilization encourages pilot communities to initiate or broaden their greenhouse gas (GHG) mitigation efforts, particularly relating to food and lifecycle impacts of consumables. Pilot communities are also very interested in exploring stakeholder engagement opportunities and neighbourhood level challenges, similar to what was undertaken in Vancouver's Green Bloc Challenge (see sidebar).

**GREEN BLOC** *is an innovative ecological footprint challenge that is being piloted in four Vancouver neighbourhoods. The challenge uses a streamlined version of the ecoCity Footprint Tool and allows community members to measure their household ecological footprint, develop neighbourhood action plans, and deliver neighbourhood enhancing (and footprint-reducing) projects in their communities. The first pilot neighbourhood – Riley Park – already reduced their footprint by 12% between 2013 and 2015.*

*http://greenbloc.lighterfootprint.ca/*

## Impact on Team Members

**Victoria (Pilot Lead City)**

The City of Victoria has been focused on GHG mitigation for the past few years, and recently released its draft Climate Leadership Plan. The City now intends to refresh sustainability planning initiatives. The results from the eF Tool will provide a baseline to inform these efforts. The big takeaways for the City was learning how much food and textiles, and consumption in general impacts GHG emissions and the City's broader global footprint. Over the next year, the City plans to use the EF and CBEI inventory results to inform its sustainable mobility plan and solid waste management plan. The City also hopes to further explore the impacts of embodied energy in buildings and infrastructure.

**Saanich**

Saanich staff report that the entire process, from data collection to analyzing the resulting outputs, has been extremely valuable for informing work within the municipality. The CBEI and ecological footprint results have led to:

- Action items related to food waste, diet, consumption habits, and local data collection are being incorporated within the draft Saanich Agriculture and Food Security Plan.
- Integration of consumption-based considerations within the scope of Saanich's updated Climate Plan (in development 2018-2019).
- Input to communication material regarding climate action (in development).
- An interest and commitment to developing local sources of data, supported by regional collaboration.

Saanich staff see great value in working with the ecoCity Footprint team on the next phase of Tool development to enable the District to easily monitor and clearly communicate the CBEI and EF on a regular basis to help inform actions (programs, policies, etc.).

**North Vancouver**

Through the ecoCity pilot project, participating staff at the City of North Vancouver have become more aware of managing their community's emissions and environmental footprint, in terms of the role and impact of food waste. Staff report that this will have an impact on City policies going forward and how much emphasis will be placed on tackling food waste.

**Iowa**

Iowa reports that ecoCity Pilot project involvement provided City staff and residents a better understanding of what is consumed in the city and how food and consumables relate to GHGs and land use. The inventory results and summary report are helpful in clarifying the significance of food consumption and the importance of it as a priority area for Iowa's upcoming Climate Action and Adaptation Plan. Iowa City plans to continue using this data to help residents evaluate their lifestyles and footprint. The City plans to undertake a neighborhood challenge for residents to reduce their footprint, similar to Vancouver's Green Bloc initiative, as well as an educational campaign about textiles and clothing. Iowa is also interested in exploring how to get more granular data on local food.

**Vancouver**

The City of Vancouver is using the completed research results from this grant in three ways. First, it has enabled the City to report on its progress towards meeting its Greenest City Lighter Footprint goal. Second, it has provided quantitative data which the City can use to make policy decisions about action items that will close the gap

towards meeting the Lighter Footprint target. The tool results have also been used in a research report produced by the One Earth Initiative Society which included policy recommendations. Third, the calculation of the CBEI inventory is feeding into a discussion about whether, and how, the City will begin to report on Scope 3 GHG emissions. In addition to using the results to determine future policy directions, the City is participating in a study entitled, "Consumption and Urban De-carbonization: New Tools and Approaches" which is funded by the Carbon Neutral Cities Alliance and aims to clarify the process of designing and translating CBEIs into meaningful policies to reduce consumption-based emissions.

**British Columbia Institute of Technology (BCIT)**
BCIT staff plan to engage more cities in the future to build on the work of the pilot. Current and anticipated initiatives are summarized below.

## Follow on Work and Funds Leveraged

As noted above, each of the cities are exploring opportunities to utilize CBEI and EF to inform planning and stakeholder engagement efforts relating to climate action, sustainability and zero-waste initiatives.

BCIT and Cora Hallsworth Consulting will continue to work with the pilots on stakeholder engagement initiatives, using the inventory results to engage community stakeholders in working with the city to advance One Earth ecoCities. For example, they plan to work with One Earth and Bioregional on stakeholder engagement initiatives in one or more pilot communities. Vancity Credit Union has also provided funds to further Tool development and stakeholder engagement. Additional funding is being sought from other sources, including the Federation of Canadian Municipalities and other philanthropic organizations.

BCIT and Cora Hallsworth Consulting are also exploring opportunities to:

- Engage the business community in ecological footprinting, and in particular assessing how the Tool could be applied in a business context.
- Develop an app to accompany the tool to better engage individuals.
- Launch an Ecocity Institute or Centre of Excellence at BCIT to build further capacity for development and application of the Tool.

## Budget Summary

The project was completed on time and on-budget. A detailed record of expenditures of grant funds, including a comparison of actual expenses to the proposed budget is included in APPENDIX B: EXPENDITURES.

## Supporting documents and products

Through this project the following reports and products have been prepared:

- USDN Final Report
- Summary Reports for the five pilots
- Webinar recordings: Orientation webinar (https://youtu.be/h-XsGQWmg-w) and two observing city webinars (June 2017: https://youtu.be/BN4WgzfCRWE; Jan 2018: https://youtu.be/hyzrqKN4n0E )
- Software Scoping Report
- ICLEI Livable Cities Presentation (http://www.livablecitiesforum.com/wp-content/uploads/2014/04/Hallsworth-ICLEI-2017-ecoCity-presentation-FINAL.pdf)

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## Acknowledgements

This report has been prepared by Cora Hallsworth (Principal, Cora Hallsworth Consulting) and Dr. Jennie Moore (Associate Dean, School of Construction and the Built Environment, BCIT); with contributions from our Researchers: Ryan Mackie (CHC), Emery Hartley (BCIT), Jeremy Javier (BCIT), Jennifer Rae Pierce(BCIT), Daniel Southwick (Iowa City); our advisors: Allison Ashcroft (Network Coordinator, CUSP), Babe O'Sullivan (USDN), Philip Mansfield (Graphical Memes) and editing provided by Paramdeep Nahal (BCIT). The project team would also like to thank our pilot cities and our observing cities for their contributions to this project.

Pilot Cities Representatives:

- Steve Young, City of Victoria (USDN Lead City)
- Caroline Jackson, City of North Vancouver
- Jordan Tam, City of North Vancouver
- Lloyd Lee, City of Vancouver
- Leslie Ng, City of Vancouver
- Wendy Avis, City of Vancouver
- Rebecca Newlove, District of Saanich
- Brenda Nations, Iowa City

Observing Cities:

- Gaithersburg MD
- Kauai HI
- Portland, OR
- Squamish, BC
- Philadelphia, PA
- Cupertino, CA
- Emeryville, CA
- Oakland, CA
- Cincinnati, OH
- Santa Monica, CA
- Flagstaff, AZ
- Edmonton, AB

We would also like to thank the many individuals who supported our data collection efforts and participated in meetings, including Devin Causely (Federation of Canadian Municipalities), Ken Porter (Province of BC), Ben Finkelstein (Province of BC), Ted Sheldon (Province of BC); Meagan Meaney (ICLEI) and Michael Dean (ICLEI); as well as many staff members from our pilot cities and regional governments.

And, a very special thank you to the Funder of this pilot project, the Urban Sustainability Directors Network.

## ACRONYMS

| | |
|---|---|
| AFOLU | Agricultural, Forest, and other Commercial Land Uses |
| BCIT | British Columbia Institute of Technology |
| CBEI | Consumption-Based Emission Inventory |
| EF | Ecological Footprint |
| eF Tool | ecoCity Footprint Tool |
| FOD | First Order Decay |
| gha | Global Hectares |
| gha/ca | Global Hectares per Capita (person) |
| GHG | Greenhouse Gas |
| GPC | Global Protocol for Community-Scale Greenhouse Gas Emission Inventories |
| HS | Harmonized System 10-digit merchandise codes by origin |
| IPCC | Intergovernmental Panel on Climate Change |
| IPPU | Industrial Products and Pollutants |
| LFG | Landfill Gas |
| MC | Methane Commitment |
| tCO2e | Metric Tonnes Carbon Dioxide |
| USDN | Urban Sustainability Directors Network |
| VKT | Vehicle Kilometers Traveled |
| WIP | Waste In Place |

## DEFINITION OF TERMS

| | |
|---|---|
| BASIC and BASIC+ | Reporting levels in the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). |
| Built Area | For the ecoCity Footprint Tool, Built Area is the total municipal boundary excluding natural areas, where a natural area is a non-serviced area, and excluding the Built Area relating to transportation, which is reported separately. |
| $CO_2e$ | Carbon dioxide equivalent ($CO_2e$) expresses the impact of each different greenhouse gas (CH4, N2O, etc) in terms of the amount of $CO_2$ (carbon dioxide) that would create the same amount of warming. This enables reporting total greenhouse gas emissions in one measurement. |
| Embodied Energy | The energy used in creating and delivering a particular material (e.g., consumable good or infrastructure), including the energy used for extraction of raw materials, manufacturing and transportation of the end product. |
| Embodied Materials | Materials that are utilized in the manufacture of a consumable product or infrastructure, but that do not end up in the finished product. Examples are manufacturing wastage and temporary features used during manufacture. |
| Operating Energy | The energy used in the function of a product, building, vehicle, etc. |
| Scope 1-3 | GHG emissions that are generated in-boundary (Scope 1), from grid supplied energy (Scope 2), and generated out-of-boundary (Scope 3). |
| Urban Metabolism | A study of the flow of energy and materials through the urban system. |

# INTRODUCTION

With the support of the Urban Sustainability Directors' Network (USDN) Innovation Fund, the ecoCity Footprint Tool (eF Tool) was refined and pilot tested with five USDN members. This work was led by the British Columbia Institute of Technology (BCIT) with the support of a project manager and a team of advisors; the City of Victoria is acting as the lead USDN city.

**This final report provides a summary of deliverables completed to date on the ecoCity Footprint Tool Pilot, including:**

- **An overview of progress made on enhancements to the eF Tool**
- **Lessons learned from pilot testing the eF Tool**
- **A preliminary eF Tool User's Guide**
- **Next steps in developing and applying the Tool**

## Background

A beta version of the ecoCity Footprint Tool was created as part of Dr. Jennie Moore's 2013 UBC PhD thesis (Phase 1). In 2017 (Phase 2), with the support of the USDN Innovation Fund and a Sustainable Consumption Grant, the Tool has been further refined and tested with five USDN members (City of Victoria, City of Vancouver, City of North Vancouver, District of Saanich, and Iowa City). In subsequent phases, BCIT will pursue the roll-out of an online version of the Tool;[1] ongoing improvements to the Tool (including further acquisition of pre-populated data and enhanced scenario capacity); the creation of a peer exchange network; and testing with additional communities. These phases are further elaborated in Figure 1, below.

| | | | |
|---|---|---|---|
| 1 | IDEATION, CONCEPT DEVELOPMEN | 2006-2008 | **Concept Design, Research, and Development**<br>The ecoCity Footprint Tool was conceived and designed as part of Dr. Jennie Moore's 2013 University of British Columbia PhD thesis; the tool is initially designed in a BC context with 2006 data specific to Vancouver, BC. |
| | PROTO TYPE / TEST | 2009-2013 | **Prototype Testing and Proof of Concept**<br>A prototype of the tool is tested by the City of Vancouver working with Dr. Jennie Moore as part of UBC PhD thesis. The findings are used by the City's Greenest City Action Team in the development of Vancouver's Quick Starts Report and Vancouver 2020: A Bright Green Future 2009-2011. |
| 2 | EVALUATION, REFINEMENT | 2017 | **Tool Enhancement, Process Refinement, Scoping for Scaled Adoption**<br>The initial tool was **enhanced** and **refined** to address the needs and capacity limitations of Cities, including:<br>**enhanced** functionality to support preparation of a GPC compliant GHG inventory; enhancing user guidance; pre-populating the Tool with data. Refinements were tested with 5 USDN communities. |
| | | 2017 | **Issues and Opportunities Analysis for Scaled Adoption: T**he Tool was piloted with *Iowa City, to explore the Tool's capacity within a US context* (this component was funded by the Sustainable Consumption Working Group). Observing cities were also engaged to inform Tool development to increase the applicability of the Tool to other regions in North America. Early stage software scoping was conducted to define user requirements and functionality. |
| 3 | BEST PRACTISE STANDARDIZATION, WIDESPREAD ADOPTION | 2018 | **Software Development, Implementation Plan**<br>Expand pre-population of tool for other jurisdictions, enhance scenario analysis capacity, tool development, implementation strategy (training and capacity building), long term strategy (financing and resourcing tool and software maintenance/updates/hosting, etc.). |
| | | 2018 | **Policy Design and Development Peer Exchange**<br>In-depth peer exchange with Phase 2 cohort around policy and program development using the inventories and scenario building functionality of Tool. |
| | | 2019 + | **Adoption and Maintenance Support**<br>A long term hosting and maintenance plan will be implemented as defined in previous phases. |

**Figure 1: Phases of Development and Implementation of the ecoCity Footprint Tool**

[1] For the current excel based version of the tool, the tool creator, Dr. Jennie Moore, must enter and manipulate the data.

## PROJECT DELIVERABLES

The purpose of the project was to further refine and pilot test the ecoCity Footprint Tool, and assess its potential for broader use by USDN members. This report summarizes the results and lessons learned in completing the project deliverables noted below.

**Deliverable 1: Tool Enhancement: Process Refinement, Scoping for Scaled Adoption**

1. Tool enhancements:
    - The Tool has been modified to align with the tool with Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC.
    - Opportunities to refine policy analysis and scenario building have been explored.
    - Proxy data has been loaded into the Tool that could be used for other communities.
2. User guidance documentation has been prepared.
3. Pilot testing:
    - The Tool has been tested with five USDN members, and each member now has ecological footprint and consumption-based emission inventories.

**Deliverable 2: Issues and Opportunities Analysis for Scaled Adoption**

4. Engagement of observing cities and other stakeholders.
5. Scoping for the next phase of Tool development and implementation has been undertaken.

The project was completed on time and on-budget. A detailed record of expenditures of grant funds, including a comparison of actual expenses to the proposed budget is included in APPENDIX B: EXPENDITURES.

# 1. TOOL ENHANCEMENTS

Through the 2017 pilot project, enhancements have been made to the ecoCity Footprint Tool (eF Tool), including:

- Exploration of opportunities to refine policy analysis and scenario building capacity of the Tool.
- Collection of data which can serve as proxy data for use by other communities.
- Refinements to the Data Collection Sheets and Tool modifications to align it with the GPC.

The project team has explored potential opportunities to include automated scenario building capacity into the Tool. These improvements will be implemented in future iterations of the Tool. Data collected for the five pilot communities can also be used as proxy data for communities of similar size and structure.

The following summarizes the most significant modifications to the Tool, namely the adjustments to align the Tool with the GPC.

## *Alignment with the GPC Protocol*

Cities are increasingly challenged with increasing sustainability and climate action reporting burdens arising from the measurement, reporting, and progress monitoring of sectoral GHG inventories and other sustainability indicators. These take valuable time away from project implementation efforts. Presently, cities are struggling to meet the data reporting commitments they have made as signatories to the Global Covenant of Mayors for Climate & Energy (in North America, formerly known as the Global Compact of Mayors), and namely the requirement to submit annual community GHG inventories consistent with the standard.[2] Most municipalities lack the tools and resources to comply with these high standards.

Therefore, the eF Tool has been modified to provide GPC reporting functionality, to support municipalities in their efforts to meet these reporting guidelines, and to eliminate the need to enter data into multiple tools and/or to conduct multiple inventories.

The GPC ascribes two levels of reporting: BASIC and BASIC+.[3] For the purposes of pilot testing, researchers focused on collecting data to meet BASIC level reporting; however, a significant amount of data required for BASIC+ reporting has also been collected, and the eF Tool has been modified to meet the BASIC+ level and meet scope 3 level reporting.

## *GPC Guidelines*

The GPC requires emissions to be summed by scope, where:[4]

- Scope 1 includes in-boundary / territorial emissions
- Scope 2 includes grid-supplied energy emissions (generated in-boundary or out-of-boundary)
- Scope 3 includes out-of-boundary emissions (including distribution losses from grid-supplied energy)

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[2] The GPC, led by WRI, C40 Cities Climate Leadership Group, and ICLEI, has become the international standard and framework for accounting and reporting city-wide greenhouse gas emissions. The intention of the GPC is to standardize GHG data collection, analysis, and disclosure. (See: World Resources Institute, C40 Cities, ICLEI. (2014). *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories*. Retrieved from http://www.ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities)

[3] For communities new to reporting to the Compact/Covenant, requirements for BASIC are lowered for their first three years of reporting.

[4] The Scope totals cannot be added together, as emissions from grid-supplied energy may be double counted in Scope 1 and Scope 2.

The BASIC level reporting includes:

- Stationary Energy Scope 1 and Scope 2 emissions (except energy supplied to a grid)
- Transportation Scope 1 and Scope 2 emissions
- Waste Scope 1 and Scope 3 emissions (except in-boundary waste generated outside the city)

The BASIC+ level reporting includes all Basic level requirements plus:

- Stationary Energy and Transportation Scope 3 emissions
- Scope 1 emissions from industrial processes and product use (IPPU) and agriculture, forestry and land use (AFOLU)

For Scope 3 emissions that are tracked by a city, but are not tracked in the GPC, the category "Other Scope 3" is included. These are not included in BASIC or BASIC+ reporting. There is however, a column to add Other Scope 3 emissions to the BASIC+ total to show all tracked emissions for the city.

### *Tool Modifications*

Modifications to meet GPC guidelines included the addition of data quality keys and notation keys, the adaptation of data inputs and categories, the addition of new data sets, and the structuring of outputs to meet reporting requirements.

#### Data Quality and Notation Keys

The GPC protocol recommends the use of Data Quality Keys and Notation Keys based on the criteria outlined in Table 1 and Table 2. Within the eF Tool, all data points used for GPC reporting now include these keys.

Table 1: Data Quality Keys Recommended by GPC

| Data quality | Activity data | Emission factor |
|---|---|---|
| High (H) | Detailed activity data | Specific emission factors |
| Medium (M) | Modeled data with robust assumptions | More general emission factors |
| Low (L) | Highly modeled or uncertain data | Default emission factors |

Table 2: Notation Keys Recommended by GPC

| Notation key | Definition |
|---|---|
| IE | Included elsewhere |
| NE | Not estimated |
| NO | Not occurring |
| C | Confidential |

#### Data Inputs and Categories

Sectors and subsectors in the ecoCity Footprint Tool have been organized to be more consistent with the GPC guidelines. For example, composting emissions is now referred to as "Biological Treatment of Waste (Composting) Facility". This allows for use of the GPC guidance documentation by communities to determine what operating emissions to include in each category when compiling data for the eF Tool.

## Data Set Additions

Additional data sets were added, such as Fugitive Emissions from natural gas systems within the city boundaries, transmission and distribution losses from electricity, and emissions from Agriculture, Forestry, and Fishing activities.

## Reporting Outputs

Additional reporting output tables and charts have been added to facilitate GPC reporting. New tables and pie charts now report inventory results by scope. Sample reporting tables are shown in the tables and figure below.

### Table 3: Sample GPC Global Summary Table

| GHG Emissions Sources (By Sector) | | Total GHGs (metric tons, i.e., tonnes CO2e) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Scope 1 | Scope 2 | Scope 3 | BASIC | BASIC+ | BASIC+ S3 |
| Stationary Energy | Energy use (all emissions except I.4.4) | 403,043 | 418,763 | 43,300 | 821,806 | 865,106 | 865,106 |
| | Energy generation supplied to the grid (I.4.4) | 0 | | | | | |
| Transportation | All II emissions | 125,403 | 0 | 20,902 | 125,403 | 146,305 | 146,305 |
| Waste | Waste generated in the city (III.X.1 and III.X.2) | 0 | | 21,937 | 21,937 | 21,937 | 21,937 |
| | Waste generated outside the city (III.X.3) | 0 | | | | | |
| IPPU | All IV emissions | 0 | | | | 0 | 0 |
| AFOLU | All V emissions | 0 | | | | 0 | 0 |
| Other Scope 3 | All VI emissions | | | 181,704 | | | 181,704 |
| Total | | 528,446 | 418,763 | 267,843 | 969,146 | 1,033,348 | 1,215,052 |

### Table 4: Sample GPC Detailed Summary Table

| Equivalent to GPC Table 4.3 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ref # | Scope | GHG Emissions Source (by sector and sub-sector) | Notation ke | Gases (tonnes) | | | | | Data Quality | |
| | | | | $CO_2$ | $CH_4$ | $N_2O$ | Total CO | $CO_2$(b) | AD | EF |
| I | | Stationary energy | | | | | | | | |
| **I.1** | | **Residential buildings** | | | | | | | | |
| I.1.1 | 1 | Emissions from fuel combustion within city boundary | | 83,566 | 0 | 0.000 | 83,566 | | | |
| I.1.2 | 2 | Emissions from grid-supplied energy consumed within boundary | | 90,617 | 8 | 1.129 | 91,133.26 | | | |
| I.1.3 | 3 | Emissions from transmission and distribution losses from grid-supplied energy consumption | | 9,370 | 9370 | 0.117 | 9,423 | | | |
| I.2 | | Commercial and institutional buildings and facilities | | | | | | | | |
| I.2.1 | 1 | Emissions from fuel combustion within city boundary | | 102,907 | 0.000 | 0.000 | 102,907 | | | |
| I.2.2 | 2 | Emissions from grid-supplied energy consumed within boundary | | 116,949 | 9.99 | 1.46 | 117615 | | | |
| I.2.3 | 3 | Emissions from transmission and distribution losses from grid-supplied energy consumption | | 12,093 | 1 | 0 | 12,161 | | | |
| I.3 | | Manufacturing industries and combustion | | | | | | | | |
| I.3.1 | 1 | Emissions from fuel combustion within city boundary | | 36,588 | 0.00 | 0 | 36588 | | | |
| I.3.2 | 2 | Emissions from grid-supplied energy consumed within boundary | | 208,826 | 18 | 3 | 210014 | | | |
| I.3.3 | 3 | Emissions from transmission and distribution losses from grid-supplied energy consumption | | 9 | 0 | 0.269 | 21715 | | | |
| I.4 | | Energy industries | | | | | | | | |
| I.4.1 | 1 | Emissions from energy used in power plant auxiliary operations within city boundary | | 181,372 | 17 | 2 | 179,982 | | | |
| I.4.2 | 2 | Emissions from grid-supplied energy consumed in power plant auxiliary operations within boundary | | 0 | 0 | 0 | 0 | | | |
| I.4.3 | 3 | Emissions from transmission and distribution losses from grid-supplied energy consumption in power-plant auxiliary operations | | 0 | 0 | 0 | 0 | | | |
| I.4.4 | 1 | Emissions from energy generation supplied to the grid | | 0 | 0 | 0 | 0 | | | |
| 1.5 | | Agriculture, forestry and fishing activities | | | | | | | | |
| 1.5.1 | 1 | Emissions from fuel combustion within city boundary | | 0 | 0 | 0 | 0 | | | |
| 1.5.2 | 2 | Emissions from grid-supplied energy consumed within boundary | | 0 | 0 | 0 | 0 | | | |
| 1.5.3 | 3 | Emissions from transmission and distribution losses from grid-supplied energy consumption | | 0 | 0 | 0 | 0 | | | |
| 1.6 | | Non-specified sources | | | | | | | | |
| 1.6.1 | 1 | Emissions from fuel combustion within city boundary | | 0 | 0 | 0 | 0 | | | |
| 1.6.2 | 2 | Emissions from grid-supplied energy consumed within boundary | | | | | | | | |
| 1.6.3 | 3 | Emissions from transmission and distribution losses from grid-supplied energy consumption | | | | | | | | |
| 1.7 | | Fugitive emissions from mining, processing, storage, and transportation of coal | | | | | | | | |
| 1.7.1 | 1 | Emissions from fuel combustion within city boundary | | | | | | | | |
| 1.8 | | Fugitive emissions from oil and natural gas systems | | | | | | | | |
| 1.8.1 | 1 | Emissions from fuel combustion within city boundary | | | | | | | | |
| II | | Transportation | | | | | | | | |
| II.1 | | On-road transportation | | | | | | | | |
| 2.1.1 | 1 | Emissions from fuel combustion within city boundary | | 111,359 | 1,417,966 | ###### | 111,359 | | | |
| 2.1.2 | 2 | Emissions from grid-supplied energy consumed within boundary | | 553 | 0.047203 | 0.0069 | 0 | | | |
| 2.1.3 | 3 | Emissions from portion of transboundary jouneys occuring outside city, and transmission distribution losses from grid-supplied energy consumption | | 0 | 0 | 0 | 14,044 | | | |
| 2.2 | | Rail | | | | | | | | |
| 2.2.1 | 1 | Emissions from fuel combustion within city boundary | | 0 | 0 | 0 | 0 | | | |
| 2.2.2 | 2 | Emissions from grid-supplied energy consumed within boundary | | 0 | 0 | 0 | 0 | | | |
| 2.2.3 | 3 | Emissions from portion of transboundary jouneys occuring outside city, and transmission distribution losses from grid-supplied energy consumption | | 0 | 0 | 0 | 0 | | | |

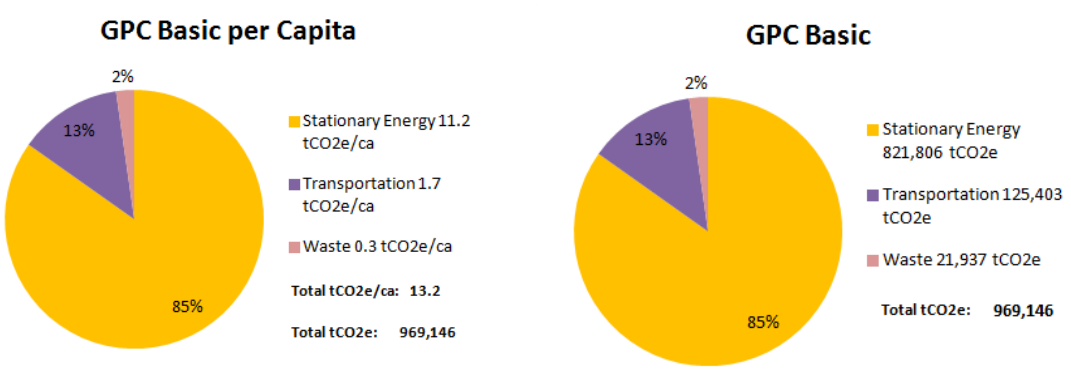


**Figure 2: Sample GPC Pie Charts**

## 2. ECOCITY FOOTPRINT TOOL USER'S GUIDE

An ecoCity Footprint Tool User's Guide is included in Appendix A. The contents of this User's Guide will form a stand-alone document. It will also be integrated into the online version of the eF Tool, providing background on the Tool and data collection guidance.

## 3. PILOT TESTING & SOFTWARE SCOPING

Throughout the pilot project, input was obtained from the pilot cities, observing cities, and other stakeholders to inform future development of the Tool. This input was obtained through:

- Pilot testing with the five communities,
- Broader stakeholder engagement (including convening of webinars), and
- Convening of a scoping workshop with the five pilots and other key stakeholders.

**Pilot Summary Reports** have been prepared for each of the five pilot communities. These reports summarize the ecological footprint and GHG emission inventory results and recommendations for policy and planning interventions.

**Stakeholder engagement** included preparation of an orientation webinar; delivery of webinars; presentation at the ICLEI[5] Livable Cities Conference; and additional one-on-one meetings with stakeholders.

A **Scoping Workshop** was held in Victoria in October 2017 to explore opportunities for the next phase of work. Results of this workshop have been incorporated into the above noted Summary Reports and into a **Software Scoping Report.** The Software Scoping Report was created by the project team's software specialist, Graphical Memes, and Cora Hallsworth Consulting.

[5] ICLEI is the International Council for Local Environmental Initiatives.

# LESSONS LEARNED

## *Highlights*

- Amongst the Pilots, Observing Cities, non-USDN cities, and other stakeholders, there is a strong appetite for the Tool and the knowledge it imparts, particularly in better understanding consumption-based emissions.
- Both the EF and CBEI highlight the need for a broader consideration of impacts beyond the current focus on climate mitigation. The process of collecting data and creating an EF and CBEI opens the opportunity to expand from GHG emission reduction to sustainable consumption and one-planet living objectives.
- Results emphasize the advantage of collaborative learning between communities, other levels of government, and internally. Participating in the data collection and sharing results amongst city staff provides the opportunity to seed new ideas across city planning efforts.
- Data collection can be an onerous undertaking and in many cases it can be challenging to access, but the process provides an important learning and capacity-building opportunity. This opportunity will be even more powerful when staff can directly access and manipulate the Tool. For difficult to obtain data, proxy data can be used to help a maximum number of communities can undertake these inventories.
- Participating directly in the data collection process also builds the desire to obtain better, more complete, timelier, and more relevant data.

## Overview

The following provides a detailed overview of lessons learned during the project, including:

- An assessment of target user needs,
- An assessment of the level of effort required for municipalities to use the Tool (in its current format),
- Challenges and opportunities associated with data collection, and
- Potential for further Tool and process modifications.

## Target User Needs

Throughout the pilot project, the Tool target user's needs were evaluated by the team. We found that stakeholders are interested in all outputs of the eF Tool, but some outputs are of greater interest than others. In general, the order of output interests are:

(1) Consumption-based Emission Inventory (CBEI)
(2) GPC Inventory
(3) Ecological Footprint (EF)
(4) Urban Metabolism

This ranking could in part be a result of the level of knowledge stakeholders have with each of these types of inventories. If a municipality were to become aware of the potential applications for urban metabolism and EF inventories, it is likely that their interest level would increase.

A growing number of municipalities are signing on to the Global Covenant of Mayors, and as such, are required to create GPC compliant inventories. For example, half of the cities participating in our June webinar are signatories to the Global Covenant of Mayors.

Many municipalities experience challenges in collecting and reporting on climate and sustainability metrics. Since access to data and limited staff time are significant barriers, the overarching objective of the ecoCity Footprint Tool is to simplify data collection and reporting for the target user by providing:

- Be **easy to use,** with sufficient user guidance, and a straight forward forms-based interface.
- **Customized reporting** including a series of tables, pie charts, and/or diagrams to meet reporting needs and presented in alignment with municipal planning areas of responsibility (e.g., food, buildings, transportation, consumables and waste, water) and by sector (e.g., residential, industrial, commercial, and institutional).
- Expanded **pre-loaded datasets** (including proxy data) and links to sources. Although proxy data limits policy analysis capacity, its provision would enable smaller communities that have less access to resources to prepare an inventory.
- **Updates** at regular intervals.
- **Scenario analysis** functionality.

Pilot communities are also interested in obtaining a **neighbourhood-scale version** of the ecoCity Footprint Tool, a prototype of which was created and tested in a Vancouver neighbourhood through the Green Bloc Project (see textbox, p.i).

There is also interest in pursuing opportunities to present **consolidated requests** for data on behalf of municipalities within a particular geographic region, as is currently provided by the Province of BC for energy and emissions data. This approach could also work in other North American jurisdictions that have limited numbers of utilities.

## Effort to Participate

The variability in time required for data collection amongst the municipalities was a result of how much of the data is readily available for the particular community, and the level of interest of the municipality in ensuring data is locally sourced (rather than based on regional averages and/or proxies). For example, most of the municipalities already had current GHG inventories, and some of the municipalities had extensive GIS data available. The following provides a rough estimate of the time required to use the current version of the Tool, based on the experience of the five pilot communities.

- Student research assistants each spent about 100-200 hours collecting data, participating in and supporting meetings, and supporting report preparation.
- City lead members spent anywhere from 20 hours to 100 hours supporting data requests and participating in meetings.
- Additional staff from the municipality spent a total of 20 to 80 hours supporting data requests.
- Regional and Provincial government staff spent an additional 20 to 40 hours supporting data requests.
- Cora Hallsworth, Project Manager, and Dr. Jennie Moore, Project Director, provided a significant amount of support to the project.

In the current format of the Tool, researchers are provided data collection worksheets. Dr. Moore then uses this information to enter data into the Tool. In the next phase of Tool development, the goal is to provide a version of the Tool that can be directly used by the municipal staff, and which contains built-in user guidance. We

anticipate that this will greatly reduce the amount of time required to collecting and inputting data for each community.

For this pilot, five students were hired and individually assigned to each of the communities. The capacity and level of success of the student Research Assistants was affected by their level of access to municipal contacts, their existing knowledge base, and their experience working with municipal data and these types of inventories. For the pilot, the Iowa student was in-house at the municipality, while all the BC pilots' researchers worked remotely. In addition, the Iowa City student had already worked on the City's GPC inventory. This level of access and prior knowledge-base proved to be highly advantageous to the project, ensuring data collection went smoothly.

Desirable skill sets for research assistants (RAs) participating in this work include:

- Exceptional skills with data including adeptness at working with conversions and undertaking data analysis.
- High level of professionalism as required for collecting data from municipal staff and from other stakeholders.
- An engineering student is likely ideal, as this training builds abilities that are essential to this work, including: adeptness working with data/math, ability to find data sources and interpret them, to extract what is needed, and to make necessary assumptions.
- Experience working in a municipal setting and/or working with GHG inventories. If the data is not provided in an extracted format, GIS skills are also necessary for certain aspects of the work.

## Data Challenges

For most of the highest impact categories, data required to populate the eF Tool was accessible, and much of it is already being collected for other planning purposes (such as for greenhouse gas mitigation planning). However, there are some data sets that have limited availability – such as transportation, food, and some of the data specific to the EF assessment.

Municipalities are also challenged with accessing local data from utilities and other corporations in a timely manner. While much of the data is available at the city-scale, some, such as data relating to waste and water services, are under the purview of other levels of government or are contracted privately. In these cases, the data may not be as readily available, and it might not be adequately disaggregated to the municipal level.

Limitations associated with certain data sets should be contextualized with their relative significance to the community-wide footprint and GHG emissions. In many cases, some of the data sets that are difficult to access will have negligible impact overall (e.g., operating energy at landfills); therefore, it would be reasonable to focus efforts on those areas of significant impact (e.g., vehicle-based transportation).

### *Summary of Key Challenges*

1. ***Data availability limitations*:** Some data sets presented challenges, for example:
   - Municipalities do not currently collect data on food consumption at the local level.
   - Most jurisdictions do not have reliable estimates for personal and commercial vehicle transportation (i.e., Vehicle Kilometres Travelled).
   - Waste data is often available at the regional level, rather than at the municipal level.
   - Many municipalities do not have detailed infrastructure data (i.e., material composition and built-area estimates of this infrastructure).
2. ***Data format incompatibility:*** Some of the data was not available in disaggregated format (i.e., broken down by sector or material type). For example, the eF Tool requires some of the data to be in a different format from how it is collected for a GPC inventory (i.e., some of the data was already in units of $tCO_2e$, but the Tool requires raw data for input into the urban metabolism and the EF components).
3. ***Limited training:*** There was limited time to thoroughly train researchers and cities on the theory and practise of EF and CBEI assessments. With improved guidance and data links embedded in the tool, it will be possible to further streamline the data collection process and possibly to obtain more refined data sets.
4. ***Challenges accurately representing resident consumption:*** For communities that act as a service centre for neighbouring communities, or support high levels of tourism, it can be challenging to isolate the impact of the local resident population from consumption associated with tourists and regional residents. This is the case for two of our pilots, Vancouver and Victoria (see textbox). Opportunities to address this issue could be addressed in future studies, for example, by normalizing the inventory results with GDP data.

**VICTORIA AND VANCOUVER** *function as regional service centres lending to them having higher impacts than that of neighbouring communities. Tourists, visitors and residents from neighbouring communities travel to these centres for work and entertainment, generating waste, and using energy while they do so. This means that the waste generation and energy use associated with the commercial sector in these cities are inflated due to their functionality as a service centre. In the future, it would be interesting to explore the possibility of using GDP to scale the estimates of waste generation and energy use associated with the commercial sector so that it can be attributed more appropriately. To illustrate this point, we know that 23% of the Greater Victoria regional population resides in Victoria, but the City's contribution to the regional GDP is more than double this amount.[1] Similarly, 25% of Metro Vancouver's population resides in Vancouver, while Vancouver is responsible for approximately 40% of the regional GDP.[1]*

### *Sectoral Challenges*

The following summarizes specific data limitations, gaps, and challenges associated with collecting data for the Tool.

#### Food

Food consumption and food-kilometers statistics are not available at the local level; therefore, national averages must be used as a proxy.

### Buildings and Stationary Energy

- For some of the pilots, the number of commercial and institutional buildings were not readily available and commercial and institutional building numbers were difficult to separate from mixed-use residential buildings. This information is required when generating an estimate of the embodied energy and embodied materials of a built environment.
- The method by which data is reported by utilities does not always align with data input requirements for the Tool (i.e., utilities report energy consumption by rate class, which results in some multi-family residential buildings being aggregated with commercial buildings and institutional buildings being aggregated with commercial buildings). In addition, some community accounts, such as the City of North Vancouver and District of North Vancouver, are sometimes aggregated within both communities.
- There is no usage data available for alternative heating sources (e.g., oil and wood-burning appliances). Instead of usage data, modeled estimates are used.

### Consumables and Waste

For a community, waste collection, waste management, composting, and recycling are rarely handled exclusively by one entity. The collection and management of waste may be contracted privately, and/or certain portions of the waste stream are handled by different levels of government (i.e., served by a combination of municipal and regional services). This makes it challenging to ensure that all waste quantities are being accounted for and it also makes it challenging to obtain built area, operating energy, and direct emission estimates from a variety of service providers. As a result:

- Operating energy and built area estimates for waste facilities were omitted from the inventories. Based on previous studies this was deemed to be of negligible contribution to the footprint.
- Composition of the recyclables stream was not available for half of the BC pilots.
- As a proxy for the consumption of goods, waste generation data could be an underestimate of actual consumption, since waste data does not reflect the growing trend of storing food at home. Dr. Moore is interested in exploring opportunities to create a 'hybridized' approach for consumables which would be informed by regional or national sales data.

### Transportation

Transportation limitations are a significant reason why developing a GPC compliant BASIC+ inventory is difficult for communities. For the pilot communities, these challenges and limitations include:

- Aviation, ferry, and cruise ship travel estimates were not available at the local level; rather, they are based on regional and/or national averages. A travel demand survey would be required to access better estimates for this form of travel.
- Personal vehicle transportation data was based on State-wide averages for Iowa City. For someof the BC pilots, it was based on vehicle ownership data combined with average Province-wide VKT estimates per vehicle. In both cases, this assumes local travel habits are comparable to state/province averages, which limits its use to inform local policy.
- Off-road vehicles are not required to be insured, which makes their use difficult to track. Also, their fuel usage does not have an associated road tax, making it just as difficult to track.

### Infrastructure

Some communities have limited access to built area, infrastructure, and material composition information.

### *Learning Associated with Application in a US Context*

Unique issues associated with using the Tool with a US city have been identified through this pilot project; specifically relating to data sources, units of measurement, and terminology variance.

#### Data Sources

In general, the research team found that data sources were comparable to those available in Canada. The sources identified will be useful for other US communities that are seeking to develop their own inventories.

State- or national-level data was used in cases where local data was not available. It is assumed many other US cities would also rely on these state- or national-level sources (e.g., national food-consumption statistics, national aviation-usage estimates, and state-level vehicle miles traveled).

#### Units of Measurement

The Tool was built in Canada and requires data to be entered in metric units; whereas in the United States, imperial units of measure are standard. Therefore, an extra step is required to convert units from imperial to metric so that the appropriate values are entered into the Tool. Similar to Canada, international reporting protocols and initiatives use metric measurements (i.e., GPC and the Global Footprint Network), so it is ideal to have the data reported in metric units. However, Iowa City expressed interest in having the metrics reported in units familiar in the United States and suggested that it would be useful if the Tool could have these conversions automated.

#### Terminology Discrepancies

There are terminology differences between the US and Canada. As a result, the Iowa City research team did not always understand the terminology and acronyms used in the Tool. Discrepancies that required clarification are outlined in Table 5.

**Table 5: Summary of Terminology Differences**

| ecoCity Footprint Tool Term | Iowa/ US equivalent |
|---|---|
| Dwellings | Apartments/homes<br>(required clarification that dwellings referred to housing units, rather than the entire building) |
| ICI (Industrial, Commercial, Institutional) | Used in the US, but in some applications the common acronym used is C&I (Commercial and Industrial; which excludes the institutional component) |
| MURBS (Multi-unit residential buildings) | MF (Multi-family residential) (both terms are used in Canada) |
| Product Stewardship | Deposit return programs |
| DLC (demolition and land clearing) | C&D (construction and demolition) |
| Green waste | Yard waste |
| Coach house | Accessory dwelling |
| Row house | Townhouse |
| Liquid waste | Wastewater (both terms are used in Canada) |
| Emission intensity | Emission factor (both terms are used in Canada) |
| Ferrous, other | White goods |
| Roads and streets, lanes | Interstate, freeway, city streets |

Clarification was also required in both Canada and US contexts. For example, the distinction between wet and dry landfills was unclear. Also, USDA has different categories for grains than what is used in Canada.

## Data Collection Opportunities

Data collection opportunities, as listed, were identified to improve upon the data collection process and to obtain more refined data.

- Vancouver is planning to conduct a food survey to derive local food estimates. Similar surveys could be conducted by the other pilots for their future inventories; or, the BC pilots could use the Vancouver results as a better proxy than the national average for future inventories.
- A regional travel survey could be conducted to estimate aviation, rail, and boat/ferry travel. Many communities already conduct transportation demand surveys, focused on ground travel, but they typically do not collect data on these regional modes of travel. Victoria and Saanich are currently participating in a regional origin-destination transportation survey that will provide local data.
- Efforts could be undertaken to match building-use records available through the BC Assessment Authority with detailed utility data to better differentiate between commercial and residential buildings. These records could also be used to split accounts that have been aggregated as commercial into the appropriate residential multifamily and commercial categories.
- Municipalities and regional governments could require private waste management, recycling, and compost service providers to report waste stream composition data as part of their contract terms.
- Municipalities could work as a regional cluster to present a unified voice for data collection and collaboration.
- Dr. Moore is exploring opportunities to create a “hybridized” approach that will evaluate consumable goods by combining waste data with regional sales data, or household consumption surveys, in a way that avoids double counting and captures the benefits of both approaches.

## Process Refinement

Key takeaways for ensuring an efficient data collection process:

- A simplified data collection template with user guidelines is essential. This should include a streamlined master data request list (indicating required units) in a modular approach so that specific components of the data requests can easily be provided to different data holders. In addition, for each data set, the eF Tool should indicate which agency is typically the provider of this particular data (i.e., municipal department staff, regional government, provincial/state government, private contractor, etc.). This approach will be built into the new online data entry forms that will be built in the next phase of work.
- At the outset of the research phase of the pilot, the team consulted with municipal staff to determine which sources are available in-house, which sources the researcher should approach independently, and which sources would be important for the municipality to contact directly. This helps to avoid duplication of data requests and provide for relationship management. This is an essential step in the research process as municipal staff rely on internal and external data providers to support a range of

their reporting and monitoring efforts. It is critical to manage these relationships and to be respectful of time demands.

- It would be ideal if users of the Tool aggregate their data requests to external data providers (e.g., utilities and vehicle insurance companies) to minimize demands on time and to ensure consistency of data requests. In BC, this is already being done by the Province of BC.
- Participants have requested improvements to the background information given to data providers. This backgrounder explains the EF and CBEI concepts and their potential applications.

## Future Tool Improvements

As informed by this pilot project, future improvements to the ecoCity Footprint Tool will be explored, including:

- Creating a simplified user interface by replacing the Data Collection Sheets with input forms. The tool will be more accessible by incorporating these forms into a Web application.
- Expanding pre-loaded data sets and guidance documentation related to data sources.
- Adding automated scenario analysis functionality to estimate the impact of sustainable consumption policies and programs.
- Expanding the Tool's capacity to handle data in different units and further streamlining terminology by removing or explaining acronyms, or by using more generic terms.
- Exploring opportunities to facilitate data collection and reporting by enabling the eF Tool to interface with other data sources. For example, by enabling the eF Tool to feed into other reporting tools that are becoming commonly used by municipalities (e.g., the CIRUS Tool developed by C40).
- Integrating the Meta Flow (sankey diagram) software as a means of visualizing urban metabolism. Especially for project managers and policy makers, this would serve as a useful output and could inform sustainable consumption and circular economy objectives.
- Providing a snapshot or dashboard view of all inventories.
- Exploring opportunities to create a 'hybridized' approach for consumables which would be informed by regional or national sales data.

# OUTCOMES AND IMPACTS

### Table 6: Success Metrics

| Key Deliverables | Summary of Completed Tasks | Success Metrics |
|---|---|---|
| **1. Tool Enhancement, Process Refinement, Scoping for Scaled Adoption** | | |
| 1.1 **Enhance functionality of the Tool** for:<br>1.1.a) GPC compliance<br>1.1.b) Policy analysis / scenario building<br><br>1.2 **Refine process for Cities using the Tool**, by:<br>1.2.a) Pre-populating Tool with data<br>1.2.b) User guidance documentation<br><br>1.3 **Test** with pilot communities | · GPC compliance review<br>· Modification of data entry sheets<br>· Hired Research Assistants<br>· Meetings with Pilots and Research Assistants: Kick off meeting, orientation meetings, and meetings to discuss data needs<br>· Modification of Tool for GPC compliance<br>· Data collection<br>· Preparation of user guidance documentation<br>· Testing with pilots<br>· Scenario building for five pilots (including exploration of opportunities for automated scenario functionality)<br>· Results meetings with pilots<br>· Preparation of Feedback report for pilots | **GPC compliant tool:** Modifications complete<br><br>**% of data collected:** 100<br><br>**Feedback reports for pilots:** complete |
| **2. Issues and Opportunities Analysis for Scaled Adoption** | | |
| 2.1 **Assess replicability/adaptability** to other jurisdictions, through:<br>2.1.a) Integrating results of Iowa City Pilot<br>2.1.b) Engagement of observing cities<br><br>2.2 **Early stage software scoping** to define user requirements and functionality<br><br>2.3 **Early stage implementation /feasibility scoping** | · Creation of a recorded orientation presentation; available at: https://youtu.be/h-XsGQWmg-w<br>· Hosted webinars for observing cities and stakeholders [June 6th and Jan 26th] and uploaded to BCIT YouTube and USDN site; circulated to observing cities and stakeholders: June 2017 webinar: https://youtu.be/BN4WgzfCRWE ; Jan 2018 webinar: https://youtu.be/hyzrqKN4n0E<br>· Presented at the ICLEI Canada conference in Victoria (Sept 2017): http://www.livablecitiesforum.com/wp-content/uploads/2014/04/Hallsworth-ICLEI-2017-ecoCity-presentation-FINAL.pdf<br>· Hired web/IT consultant for software scoping<br>· Software scoping report completed<br>· Scoping workshop completed | **# observing cities in the wings, ready to adopt:** 14<br><br>**Phase 3 project plan:** Submitted in USDN Innovation Fund Proposal |
| **3. USDN reporting** (Impact report, and quarterly updates, etc.) **and project management** | | |

| | | |
|---|---|---|
| | · Completed Quarterly Reports and Final Report<br>· Team check-in meetings | **Meet USDN reporting requirements:** 1st, 2nd and 3rd quarterly reports and final report submitted<br>**Project delivered on-time and on-budget:** achieved |

**Table 7: Impacts**

| Metric | Performance |
|---|---|
| Depth | |
| Enhancement of eF Tool that will grow the sustainable consumption field of practice | Modifications completed and tested; tool will enable reporting on a broader set of environmental and climate action metrics (consumption-related impacts and ecological footprint, as a complement to typical GHG emissions inventories). |
| Ease of use for cities based in British Columbia and in other North American jurisdictions | Clear feedback obtained through the pilot will contribute to a more user-friendly 2.0 version that includes data collection for GPC Scopes 1, 2 and 3. |
| Identification of next steps for Phase 3, including identification of costs and partners | Submitted in USDN Innovation Fund proposal (Nov 2017), but refinements are ongoing. |
| Breadth | |
| Number of observing cities in the wings, ready to adopt an innovation according to their local planning | 14 |
| Number of Cities engaged in piloting the tool | 5 |
| Percentage of compiled data required to populate footprints for pilot communities | 100% |
| Number of Cities using tool to inform policy/planning decisions | 5<br>(all USDN pilot communities) |
| Number of Cities using the tool to meet Global Covenant reporting requirements | None<br>(current pilots had parallel efforts underway to complete GPC inventories) |

## NEXT STEPS

Goals for the next phase of work are to:

- Roll-out an accessible version of the Tool, either via an online platform or in a downloadable format.
- Establish a peer-exchange group consisting of the current pilot communities and future users of the Tool. This network will provide the opportunity to share in the learning of how the EF and CBEI results can be used to inform policy and planning at the municipal level.
- Continue to evolve the functionality of the Tool, including interactive scenario analysis capacity and adding the capacity to enable the evaluation of the footprint impact associated with land use changes.

Each of the pilot cities are exploring opportunities to utilize CBEI and EF to inform planning and stakeholder engagement efforts relating to climate action, zero waste and other sustainability initiatives.

BCIT and Cora Hallsworth Consulting will continue to work with the pilots on stakeholder engagement initiatives, using the inventory results to advance one-earth ecoCities. The project team is currently exploring and/or initiating the following initiatives:

- Initiating work with Vancity Credit Union to engage the business community and explore how the Tool could be applied in a business context, so that the private sector can better assist cities in achieving their sustainable consumption goals.
- Working with One Earth and Bioregional on a stakeholder engagement initiative in one or more of the pilot communities.
- Exploring the development of an app to accompany the tool to better engage individuals.
- Further improving to the Tool and worksheets.
- Launching an Ecocity Institute or Centre of Excellence at BCIT to build further capacity for development of the ecoCity Footprint Tool

# APPENDIX A: USER'S GUIDE

***The following presents content that will form a stand-alone document, and that will also be integrated into the online version of the eF Tool.***

## CONTEXT

Dr. Jennie Moore, Associate Dean at the British Columbia Institute of Technology (BCIT), created the ecoCity Footprint Tool (eF Tool) as part of her PhD under the supervision of Dr. William Rees, founder of the ecological footprint concept. The goal in creating the eF Tool was to support policy-related decision-making aimed at reversing global **ecological overshoot**, namely by creating a community-scale **ecological footprint** using locally sourced data**.** A prototype of this eF Tool was used by the City of Vancouver. The outputs from the Tool are highly valued by the City and are informing the strategies, actions, and monitoring methods for their "Greenest City 2020 Action Plan".

The Tool was originally conceived for ecological footprint utility, but it also generates an urban metabolism, a traditional 'territorial' greenhouse gas (GHG) emission inventory, and a consumption-based emissions inventory. These inventories provide critical data to inform sustainable-consumption and climate mitigation efforts.

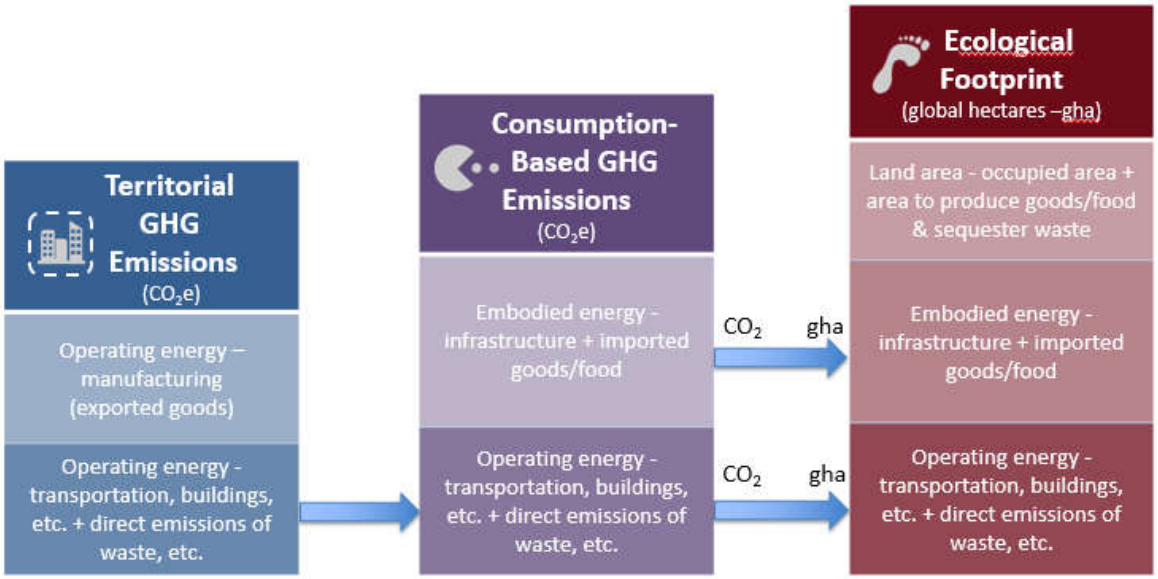


**Figure 3 Comparison of the GHG Emission Inventories and Ecological Footprint Approaches**

### What is an Urban Metabolism?

The urban metabolism traces the flow of energy and materials through the urban system, and yields the data to inform the footprint and consumption inventory. The urban metabolism can be depicted visually using a SANKEY diagram (see below).

### What is a Territorial GHG Emissions Inventory?

Since the late 90's governments have typically created greenhouse gas emissions inventories using an in-boundary or territorial approach, which identifies emissions from sources within the region, plus electricity.

### What is a Consumption-Based Emissions Inventory?

The consumption approach includes emissions released to produce goods and services consumed within a region, regardless of where they were originally produced. That is, it estimates global emissions resulting from local consumption habits. Typical emissions inventories include only emissions from sources within a given region's borders; however, with the globalization and integration of our economy, a significant amount of the emissions from the production, disposal, and transport of a region's goods occur in other regions. CBEI results can demonstrate the scale to which we are off-loading consumption-related emissions on to other jurisdictions. This will help encourage strategies that maximize global emission reductions. This form of inventory is of growing interest to governments that are keen to broaden and deepen their sustainability and climate-action efforts.

### What is an Ecological Footprint?

The ecological footprint is an estimate of how much biologically productive land and water area an individual or population needs to produce all the resources it consumes and to absorb the waste it generates. It is measured in global hectares (gha) per capita, where a global hectare is a biologically productive hectare with globally averaged productivity for a given year.

## How Does the eF Tool Work?

Many existing ecological footprint and consumption-based greenhouse gas (GHG) inventory tools use the 'compound method' (a top-down approach that uses national and/or econometric data). But, the eF Tool uses the 'component method', which emphasizes the use of community-based data, and aligns with traditional spheres of planning at the local government level (see Figure 5, below). Real consumption data, collected through an **urban metabolism** study, provides the utility needed to directly link policy intervention to emission outputs at the local government scale. This provides a clear and transparent understanding of how city functions, across all sectors and service areas, affect the footprint. It also enables scenario analyses to forecast which policy interventions and changes could enable reductions in the city's energy and material flows, greenhouse gas (GHG) emissions, and ecological footprint.

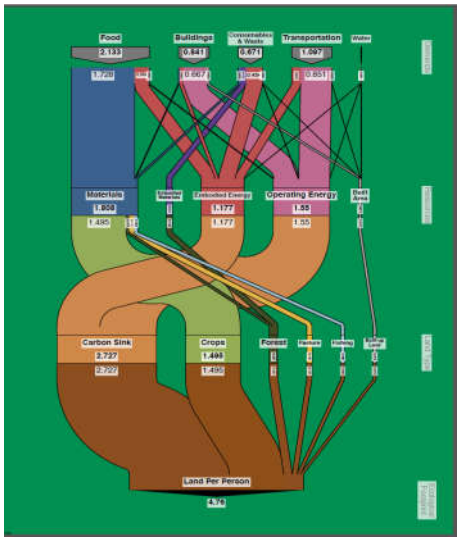


Figure 4: SANKEY Diagram Illustrating an Urban Metabolism

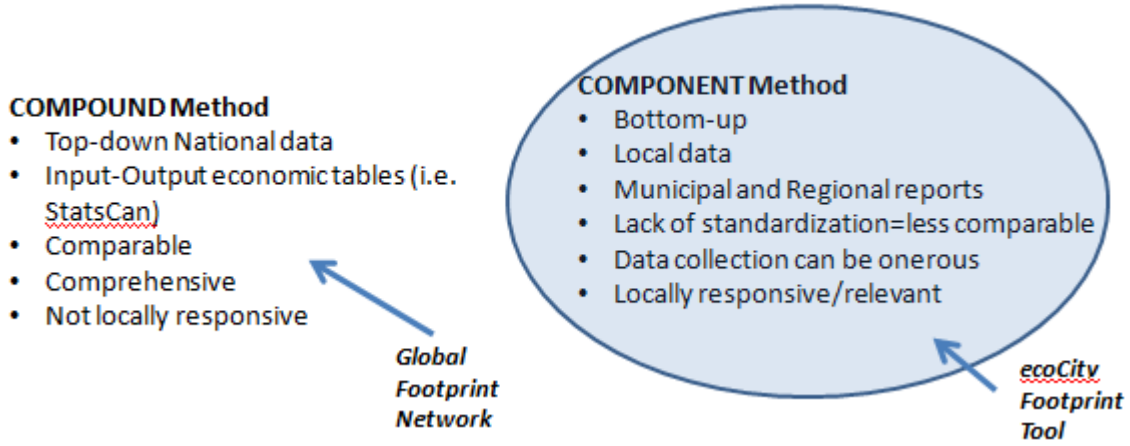


**Figure 5 Two methods for calculating the Ecological Footprint**

## ecoCity Footprint Tool Application

Exploring consumption-based inventories and ecological footprints is a way for governments to broaden and deepen their sustainability and climate-action efforts. In particular, they provide a more robust understanding of emission sources and ecological impacts, and they can directly inform sustainable-consumption efforts.

The eF Tool also has the potential to help streamline data collection and reporting due to its capacity to create multiple outputs: the consumption-based inventory, the territorial inventory, as well as the ecological footprint.

## DATA COLLECTION GUIDANCE

The following provides a detailed summary of the methodology and sources utilized in creating piloting city ecological footprint and GHG inventories. It also presents challenges and opportunities associated with the data collection process.

***A detailed overview of the methodology by which ecological footprints are generated in the ecoCity Footprint Tool are provided in Dr. Moore's thesis: Moore, Jennie Lynn (2013). Getting Serious About Sustainability: Exploring the Potential for One-Planet Living in Vancouver. A thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy, School of Community and Regional Planning, University of British Columbia. Available at: http://pics.uvic.ca/sites/default/files/uploads/publications/moore_jennie-UBC_0.pdf***

### *Research Principles*

The following guidelines were applied when making decisions about data sources:

i. **Accuracy:** The goal is to achieve a high degree of accuracy, where accuracy is the degree of closeness to a measured value's actual value (this is in contrast to precision, in which the goal is to have measurements conform with one another).

ii. **Subsidiarity:** Locally produced data is preferred, especially when local authorities trust the source's validity and use it to inform policies and management practices. Locally derived data reflect the nuance of the local community being profiled and can resonate more readily with local authorities who use these same data points to inform their work.

iii. **Conservatism:** In cases where two data sources equally meet the accuracy and subsidiarity criteria, the final decision is based on which data point represents a more conservative estimate. The purpose of this approach is to avoid overstating consumption amounts.

### *Data Inputs*

The ecoCity Footprint Tool is aligned with the typical spheres (or categories) of municipal planning. As such, data is collected on the total inputs, in terms of materials, embodied energy, operational energy and built area for each of these categories (see Figure 6). Each of these inputs are evaluated sectorally – that is by residential, institution, commercial and industrial sectors. The eF Tool employs a bottom-up approach, prioritizing the use of community- and regional-scale data sources. However, in cases where local data is not available, assumptions or proxies are utilized.

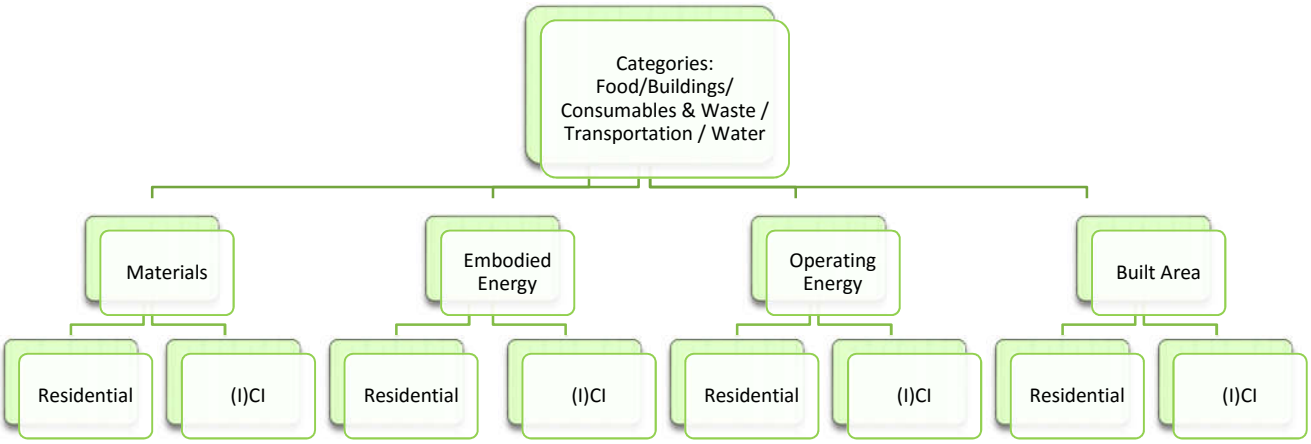


**Figure 6: Data Inputs**

Table 8 summarizes the range of data collection needs, and the following sections provide guidance on how these data sets can be collected.

**Table 8: Overview of Data Inputs**

| CATEGORY | INPUTS | EF | CBEI | TERRITORIAL GHG INVENTORY |
|---|---|---|---|---|
| **Food**<br>*Food available is measured as a proxy for food consumption and import distances are used to estimate food-kilometers traveled. Energy associated with the production and transportation of imported food is then estimated.* | Embodied energy and materials associated with food production (energy and materials used to produce and transport food) | ✓ | ✓ | × |
| | Land used to produce food | ✓ | × | × |
| **Buildings and Stationary Energy**<br>*The embodied materials, embodied energy, operating energy, and the built area associated with residential, industrial and commercial buildings are evaluated to establish a material-flow analysis, assess the direct and embodied carbon, and evaluate the ecological footprint of these buildings.* | Operating energy used by buildings and related infrastructure | ✓ | ✓ | ✓ |
| | Embodied energy and embodied materials of buildings | ✓ | ✓ | × |
| | Built area associated with buildings | ✓ | × | × |
| **Consumables and Waste**<br>*Data is collected on the quantity of solid and liquid waste generated by sector (residential, industrial, commercial and institutional) and by material type; method in which materials are managed (i.e., landfilled, incinerated, recycled, composted); energy consumption and emissions associated with waste management facilities, and transportation of waste; material composition and built area associated with waste management facilities.* | Operating energy used in waste management facilities and hauling waste | ✓ | ✓ | ✓ |
| | Direct emissions from waste facilities | ✓ | ✓ | ✓ |
| | Embodied energy and materials associated with consumables (as inferred by waste stream) | ✓ | ✓ | × |
| | Built area associated with waste management | ✓ | × | × |

| CATEGORY | INPUTS | EF | CBEI | TERRITORIAL GHG INVENTORY |
|---|---|---|---|---|
| **Transportation**<br>*Evaluates the embodied materials and embodied energy of physical transportation infrastructure and vehicles, operating energy (fuel consumed by vehicles), and physical built area occupied by transportation infrastructure. Data is collected for private and commercial vehicles; transit; aviation travel; marine travel and off-road vehicle use.* | Operating energy associated with to transportation (fuel use for private and commercial vehicles; aviation; marine vessels and off-road vehicles) | ✓ | ✓ | ✓ |
| | Embodied energy and embodied materials associated with personal vehicles and transportation infrastructure | ✓ | ✓ | × |
| | Built area associated with waste management | ✓ | × | × |
| **Water**<br>*Evaluates the embodied materials, embodied energy, operating energy, and built area impacts of the water distribution and purification system relied on by the municipality.* | Operating energy used in treating and conveying water | ✓ | ✓ | ✓ |
| | Embodied energy and embodied materials associated with water infrastructure | ✓ | ✓ | × |
| | Built area associated with water management | ✓ | × | × |

## *Outputs*

Outputs from the eF Tool include: (1) ecological footprint (EF), (2) Consumption-Based Emission Inventory (CBEI), (3) Global Protocol for Community scale GHG emission inventories (GPC) compliant inventory, and (4) urban metabolism. Formulas have been built into the tool to create the four different inventories noted above. Each inventory is summarized with a series of tables, pie charts and/or diagrams. Data is presented by the categories noted in the above table and by the sectors used for municipal planning (residential, institution, commercial and industrial).

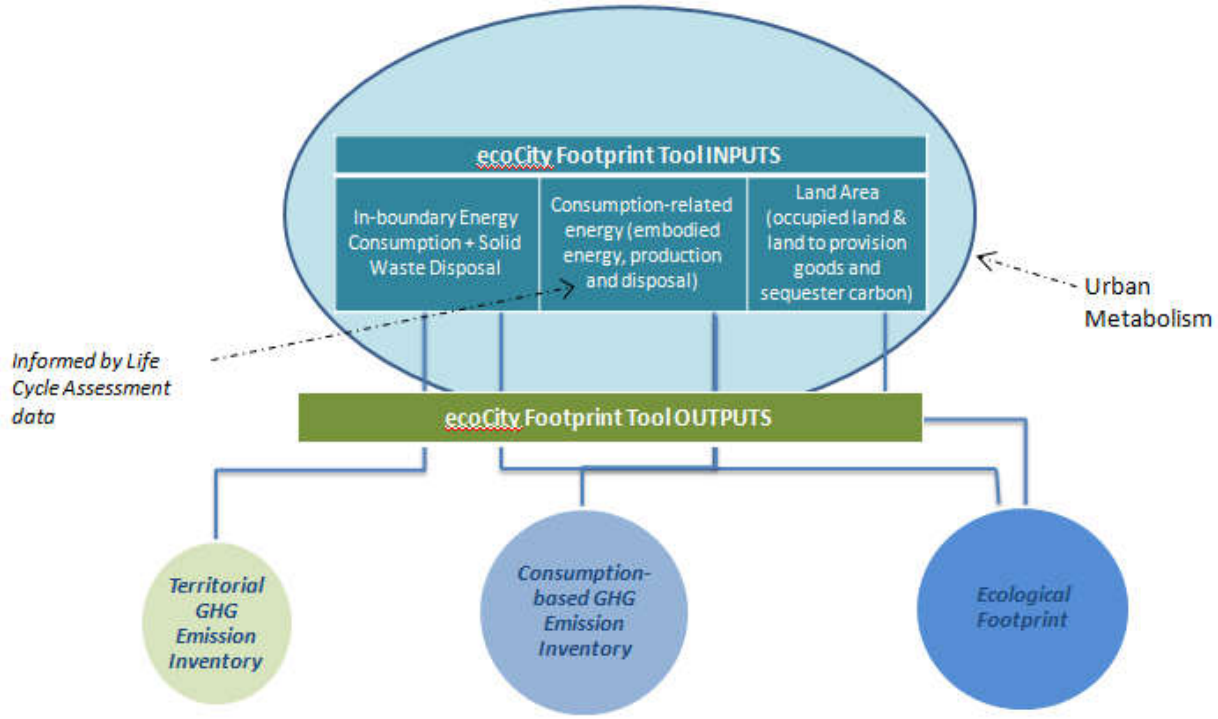


**Figure 7: Tool Structure, Inputs and Outputs**

## Population

The number of people living in the municipality should be based on data from the census year closest to the reporting year. In some cases, a ratio of the municipal population to the regional is also required in order to attribute a portion of the ecological and carbon footprint that is a result of regional services.

### Canadian Sources

Statistics Canada. (Feb 8, 2017). *Census Profile, 2016 Census*. Retrieved from http://tinyurl.com/ydg48p58

### US Sources

United States Census Bureau: https://www.census.gov/

## Food

Food consumption estimates are obtained and import distances are used to estimate food kilometers travelled. The energy and material impacts resulting from the production and transportation of food is then estimated.

### *Embodied Materials and Embodied Energy [Food]*

### Methodology & Sources

Food consumption data is not typically collected at the local level. However, national sources, such as Statistics Canada and the US Department of Agriculture, provide data on the total consumption of food by type (e.g., dairy, potatoes, beef, etc.). In the absence of local data, these sources can be used to generate per capita estimates of consumption by food type, which can then be pro-rated to the study community's population. Life Cycle Assessment data, which is built into the ecoCity Footprint Tool, then generates estimates of the embodied energy and materials of the food, by type.

### Canadian Sources

Statistics Canada data from CANSIM Table 002-0011 documents food availability per person by year. Disaggregated food items are organized into larger food groups to estimate average food consumption per-capita by food type.

Statistics Canada. (n.d.). *Table 002-0011: Food available in Canada, annual (kilograms per person, per year unless otherwise noted).* CANSIM (database). Retrieved on May 30, 2017, from http://www5.statcan.gc.ca/cansim/a47

### US Sources

National average daily per capita food consumption can be obtained from:

United States Department of Agriculture. (July 2013). *Retail commodity intakes: Mean amounts of retail commodities per individual, 2007-08.* Retrieved from https://www.ars.usda.gov/ARSUserFiles/80400530/pdf/ficrcd/FICRCD_Intake_Tables_2007_08.pdf

Natural Resources Defense Council (NRDC). (2012). *Wasted: How America Is Losing Up to 40 Percent of Its Food from Farm to Fork to Landfill*. Retrieved from https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf

Statista. (2017). *Per capita consumption of cocoa beans in the United States from 2000 to 2015*. Retrieved from https://www.statista.com/statistics/184209/per-capita-consumption-of-cocoa-beans-in-the-us-since-2000/

Huffington Post. (2011, June 27). *By the numbers: What Americans drink in a year.* Retrieved from http://www.huffingtonpost.com/2011/06/27/americans-soda-beer_n_885340.html

United States Environmental Protection Agency. (2016). *America's food waste problem.* Retrieved from https://www.epa.gov/sciencematters/americas-food-waste-problem

### Challenges and Opportunities

As noted above, there is little data on food consumption available at the local level. The use of national level statistics provides limited ability to track and monitor the impact of local efforts to reduce a community's food related GHG and EF impacts.

One opportunity to collect local-level data is to implement a food survey. In 2017, City of Vancouver plans to undertake a localized food survey, which may subsequently be incorporated into the Metro Vancouver Food Waste Survey in 2019. BC communities in the same geographic region as Vancouver may choose to use the results of this survey as a more representative example of food consumption (i.e., use Vancouver per capita results as a proxy). Other communities may seek to pursue conducting a similar survey in their region.

## *Operating Energy [Food-Kilometers]*

### Methodology & Sources

A simple, but rough estimate for food-kilometers can be obtained from online calculators (e.g., https://www.foodmiles.com/). A complex, but more accurate, approach is to adopt the methodology that was used in Dr. Moore's thesis (2013), which was used to generate estimates for the BC pilots. This methodology is outlined in "Kissinger's International Trade Related Food Miles – The Case of Canada" (Kissinger, 2012). Through this methodology, national statistics are obtained on the total amount of imports by food type and origin. For both travel by land and sea, an average food-kilometer value is determined for each specific category of food. This is done using a weighted average in order to calculate fuel consumption and the resultant GHG emissions.

In Canada, this data can be obtained from the Canadian CHASS (Computing in Humanities and Social Sciences) Trade Analyzer Database, which tracks Canadian import totals based on Harmonized System (HS) 10-digit merchandise codes by origin (country or US state) and province of clearance. In the US, this data can be accessed from the US Department of Agriculture.

#### Canadian Sources

Kissinger, M. (2012). International trade related food miles: The case of Canada. *Food Policy, 37*(2), 171-178. doi:10.1016/j.foodpol.2012.01.002

CHASS Trade Analyser Database. Retrieved August 2017, from http://datacentre.chass.utoronto.ca/

Mileage-Charts. (n.d.). Retrieved August 2017, from http://www.mileage-charts.com/chart.php?p=index&a=NA

SEA-DISTANCES.ORG. (n.d.). *Sea distances / port distances*. Retrieved September 2017, from https://sea-distances.org/

Statistics Canada. (n.d.). *Table 002-0011: Food available in Canada, annual (kilograms per person, per year unless otherwise noted).* CANSIM (database). Retrieved on May 30, 2017, from http://www5.statcan.gc.ca/cansim/a47

Statistics Canada. (n.d.). *Table 002-0010: Supply and disposition of food in Canada, annual (tonnes unless otherwise noted).* CANSIM (database). Retrieved on September 17, 2017, from http://www5.statcan.gc.ca/cansim/a47

### US Sources

United Stated Department of Agriculture. *U.S. food imports.* Retrieved from https://www.ers.usda.gov/data-products/us-food-imports/us-food-imports/

Weber, C.L., & Matthews, S.H. (2008). Food-miles and the relative climate impacts of food choices in the United States. *Environmental Science & Technology, 42*, 3508–3513.

### Challenges and Opportunities

Similar to food consumption, the biggest challenge concerning food-kilometers is the lack of readily available data sources at the local level. Unless generic, online calculators are used, the quantification of food-kilometers can be complex. The use of national import data to approximate average, representative distances for the entire food category limits insights on transportation impacts associated with food.

## Buildings and Stationary Energy

Evaluates the embodied materials, embodied energy, operational energy, and the built area associated with residential, industrial and commercial buildings in order to establish a material-flow analysis.

### *Embodied Materials and Embodied Energy [Buildings and Stationary Energy]*

### Methodology & Sources

The number of commercial, institutional and residential buildings as well as an estimated composition of each building type are required to evaluate the embodied materials and embodied energy associated with the building stock. Average lifespan of buildings is also required in order to amortize the carbon and ecological footprint impacts over the lifespan of the buildings. Residential units are divided into categories depending on building types (e.g., single family detached house, apartment, etc.). Commercial and industrial buildings are differentiated based on height, as this is a significant indicator of their material composition.

Many assumptions for embodied energy calculations are pre-loaded into the ecoCity Footprint Tool, and are based on Dr. Moore's previous (2013) ecological footprint study for the City of Vancouver. In the Tool an archetype (building type) has been defined for each building type, which assigns an average life-span, floor area, and material composition for that particular archetype. Material composition estimates for the various building archetypes were developed using the Athena Impact Estimator for Buildings Tool. The archetypes created for the 2013 study can be used as a proxy or the Athena model can be utilized to generate customized archetypes for the community.

### Sources

Material composition data and average lifespan of buildings may be available from municipal and regional planning and/or engineering departments. (For example, this information was compiled by City of Victoria as part of seismic studies.)

National census data provides a detailed count of housing units. In British Columbia, the BC Assessment Authority can provide information on commercial, industrial and institutional building stock.

Statistics Canada. (Feb 8, 2017). *Private Dwellings Profile, 2016 Census*. Retrieved from http://tinyurl.com/y82sb66z

Athena Sustainable Materials Institute. (n.d.). *Impact Estimator for Buildings Tool*. Retrieved from https://calculatelca.com/software/impact-estimator/

### Challenges and Opportunities

Information on commercial and industrial building stock may not always be available in the format required for entry into the tool. Specifically, this information is often available in the form of total square footage, and there is sometimes a lack of information on the number of buildings. Many municipalities do not have information on the average age of building stock, nor on the material composition of the stock.

Some municipalities have very detailed data on their building stock. (For example, Victoria collects this information to inform disaster preparedness.)

## *Operating Energy [Buildings and Stationary Energy]*

### Methodology & Sources

Data is required on the annual consumption of electricity, natural gas, and other heating fuels, broken down by sector. Estimates of the energy lost through transmission and fugitive emissions[6] are also collected or estimated. Provincial or state specified emissions factors are used to calculate carbon footprints.

Stationary Energy and Transmission Loss

Stationary energy-use data should be collected from the primary utility providers in the community. If this information is not available, the use of energy-use intensity archetypes could be applied. In the future, this proxy data will be made available in the eF Tool.

The utilities should also be able to provide an estimated transmission loss factor. For example, BC Hydro's estimated transmission loss rate is currently 7.5%. Total losses would be calculated as shown in the equation below:

(total energy in MWh) x (0.075) = energy loss through transmission
Where total energy in MWh = (energy used in boundary) / (0.925)

Fugitive Emissions

Fugitive emissions for natural gas systems can be requested directly from the utility. For example, Fortis BC's approach is to estimate GHG emissions based upon the number of customer meter sets at the municipality, relative to the total system. This factor is then applied to the total vented and fugitive emissions in order to determine the fugitive- and vented-related emissions for a specific region. The Intergovernmental Panel on Climate Change (IPCC) also provides emission factors that can be used in the absence of local values.

Most operating energy data of electricity, including energy loss, fugitive emissions, and emissions intensity, can be obtained directly from energy utilities. Data for other fuel sources, such as heating oil, propane, and wood, are not centralized and must either be collected by a municipality or estimated using studies. In BC, the provincial government collects energy consumption data as part of the Community Energy and Emissions Inventory (CEEI). This includes compiling data from utilities and estimating the consumption of other fuels. However, the most recent data currently available through the CEEI is for 2012. Data of this age does not meet the requirements for GPC reporting and is also of limited use for municipal planning. The Province is currently exploring new legislative opportunities to ensure this data is kept up to date.

### Sources

IPCC. (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 2: Energy., Chapter 4, Table 4.24 and 4.25*. Retrieved from http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

[6] Fugitive emissions are leaks or otherwise unintended losses or escapes of gas that occur during the delivery to the end user.

### Canadian Sources

BC Ministry of Environment. (2016). *2016/17 B.C. best practices methodology for quantifying greenhouse gas emissions: Including guidance for public sector organizations, local governments and community emissions.* Retrieved from http://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/methodology/2016-17-pso-methodology.pdf

### US Sources

U.S. Energy Information Administration, https://www.eia.gov/

## Challenges and Opportunities

The method by which data is reported by utilities does not always align with data needs for the Tool (i.e., utilities report energy consumption by rate class, which results in some multi-family residential buildings being aggregated with commercial buildings and institutional buildings being aggregated with commercial buildings).

There is often limited tracking of wood burning appliances, yet these technologies have a high impact on air quality and GHG emissions. Data on their use and number may help municipalities evaluate the importance of targeting these sources for reducing air contaminants and GHG emissions.

## *Built Land Area [Buildings and Stationary Energy]*

## Methodology & Sources

Built area for this component includes the area that has been built up for residential, industrial, and commercial use (with the exception of roads-related built area, which is captured separately within the transportation component of the footprint assessment). Calculations of total built area can typically be obtained directly from the municipality or regional government, or extracted from GIS files. Some communities have conducted permeability studies which can provide useful information on the total amount of paved surface area.

### Sources

GIS data is typically available on municipal open data websites or directly from staff. In the lower mainland of BC, this information is reported in the Metro Vancouver Land Use Fact Sheets.

In the Capital Regional District of BC, supplementary data on impermeable surfaces can be accessed through the Habitat Acquisition Trust's website:

Caslys Consulting Ltd. (2013). *Capital Regional District land cover mapping: 1986, 2005, and 2011 Summary report*. Retrieved from http://www.hat.bc.ca/attachments/CRD_2011_land_cover_summary_report_final.pdf

## Challenges and Opportunities

Built area represents one of the most significant local ecological impacts that municipal policy can directly affect. Active tracking of built area can provide information on the availability of land area to provide important ecological services such as water retention and air purification.

## Consumables and Waste

**Data is collected on:**

- the type and quantity of solid and liquid waste generated in the municipality by sector (residential, industrial, commercial and institutional) and by material type;
- the method in which these materials are managed (i.e., landfilled, incinerated, recycled or composted);
- the energy consumption and emissions associated with the waste management facilities and the transportation of the waste; and
- the material composition and built area associated with waste management facilities.

**The various outputs draw from different components of this data set:**

- The GPC inventory includes direct GHG emissions associated with handling solid and liquid waste.
- The CBEI includes the embodied emissions associated with the production and transport of the materials that were consumed. It also includes the direct emissions associated with disposing the waste stream, yet does not include the impact of the recyclables stream, as this would be captured within the LCA of the consumed goods and would otherwise result in double counting of impacts.
- The ecological footprint includes the CBEI emissions plus the impact of the built area associated with handling the waste stream.

### Calculating Landfill Emissions

The eF Tool contains built-in emission factors for the various waste management options; however, the following describes methodologies currently in practise if a municipal seeks to undertake its own analysis. There are three methods discussed in the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories* (GPC) and the *2006 IPCC Guidelines for National Greenhouse Gas Inventories:* Methane Commitment (MC), First Order Decay (FOD), and Landfill Gas Recovery (LFG Recovery). The GPC only covers MC and FOD methodologies, but LFG Recovery is also an accepted method within the protocol. The *2006 IPCC Guidelines* covers FOD and LFG Recovery, but has dropped the MC as a recommended method. In the *Revised 1996 IPCC Guidelines,* the MC method had been the default recommended method. The methane and carbon dioxide emissions from solid waste are from organic sources. Therefore, all carbon dioxide emissions, either from flaring methane, energy generation, or direct, are considered biogenic and not included in the inventory total. Only the direct methane emissions are included.

#### Landfill Gas Recovery

When LFG capture is in place, total methane emissions can be assessed by measuring the LFG captured using a meter and estimating the capture rate efficiency. The capture rate efficiency estimate is based on the capture technology used and can be refined by conducting studies directly measuring methane levels above the capture system. The LFG captured can also be estimated based on the capture system used, but this is far less accurate then metering. LFG Recovery can be the most accurate method and is recommended to validate the FOD method if it is being used.

The methane concentration in LFG is typically assumed to be 50%; however, by the time the LFG is captured the concentration will change due to factors such as dilution from air and $CO_2$ absorption. Published values from landfills in California, USA were around 45% methane. The LFG concentration also changes over time, but is relatively constant over the time that capture systems would be in place (a chart showing a typical emission profile is provided by the US EPA (https://www.epa.gov/lmop/basic-information-about-landfill-gas).

#### First Order Decay (Also called Waste in Place (WIP))

The FOD model estimates actual annual emissions from the landfill. The model is based on the historical mass of waste disposed and the amount of degradable organic carbon (DOC) in the waste. The *2006 IPCC Guidelines* provide three tiers (options) for conducting an FOD based on data availability, where: in Tier 1, default values are used; in Tier 2, default values are combined with some level of local data; and in Tier 3, only local data is relied on.

If available, activity data from waste composition studies should be used; otherwise, bulk solid waste data can be used with default composition parameters. IPCC also provides a spreadsheet for FOD calculations.

#### Methane Commitment

The MC model estimates all current and future emissions from solid waste and assigns it to the year it was deposited. Historical waste disposal data is not required for this method and results do not estimate actual emissions. The model is based on the total waste deposited and the DOC it contains.

### *Embodied Materials, Embodied Energy, and Operating Energy [Consumables and Waste]*

#### Methodology & Sources

The embodied materials and embodied energy associated with consumables is derived by evaluating the community's waste stream. Other tools use national level econometric data, but the eF Tool uses waste data because this data is available at the municipal level, and can be more easily used to inform municipal policy and planning decisions. However, the advantage of using municipally-sourced data is balanced with the challenge that using waste as a proxy for consumption does not capture all possible consumption occurring in the community. This is because some of the materials do not make it to the municipality's waste stream and are therefore unaccounted for. Dr. Moore is exploring the creation of a hybridized methodology which would be informed by both waste data and econometric data.

Solid waste data is collected disaggregated by sector (e.g., residential, multi-unit residential, and industrial/commercial), material type, and destination (i.e., landfill, incinerator, recycling, or composting). Data should be obtained from municipal or regional governments, or in some case private contractors who handle the waste stream. Data is often reported in Solid Waste Management annual reports, and/or waste composition and waste audit studies/reports. Where community-level data is not available, regional data sources must be pro-rated to the local population. Typically, landfill emissions will be calculated by the managing authority and methodologies are provided here for reference only.

Volume flows of liquid waste are used to calculate direct emissions from the liquid waste stream.

Data on beneficial use of landfill gas (LFG) and biogas from incinerators and liquid waste systems should also be collected; this will inform the urban metabolism assessment and be used to determine how much of the waste stream emissions are being offset.

Estimates of the material composition of the solid and liquid waste infrastructure, and average lifespan of the infrastructure is required to calculate the embodied energy and embodied materials associated with this infrastructure. This typically includes roads, pumping stations, and pipes. This data can be obtained directly from the municipality or regional government, or in some cases it must be obtained from the private contractors that provide the service. If a large number of facilities are used, it may be difficult to collect this information, in which case this estimate can be excluded from the assessment as it is likely to have a relatively low overall impact on the community's footprint. An estimate of the embodied materials and embodied energy of the waste infrastructure is derived in the Tool using LCA values for the various material types in place.

Operating energy can be obtained directly from public works staff if the facility is handled by the government; otherwise, it can be obtained from the service provider. Fuel used on-site and in transporting waste to sites will need to be accessed from the fleet manager or field operations staff.

#### Canadian Sources

Multi Material BC. (2015). *Annual report 2015*. Retrieved in July 2017, from https://recyclebc.ca/wp-content/uploads/2017/02/MMBCAR2015.pdf

#### US Sources

U.S. Energy Information Administration, https://www.eia.gov/

### Challenges and Opportunities

Monitoring the waste stream is an essential element of understanding urban metabolism and material flows for communities, but there can be challenges in accessing this data:

- Many municipalities contract out waste and recycling collection and handling and therefore, this data often needs to be collected from outside entities.
- Sectoral breakdowns and waste composition data may not always be available.
- In BC, composition data for recycled materials is currently not being provided by RecycleBC, a province wide recycling agency. RecycleBC is currently reviewing its data collection and sharing protocols and if municipalities begin to express interest in the material composition of their recycled materials it is possible RecycleBC will make that data more widely available. The Province is currently re-negotiating its contract with RecycleBC so there is now an opportunity to request making the provision of this data a requirement in the contract renewal.

### *Solid and Liquid Waste Built Area [Consumables and Waste]*

### Methodology & Sources

An estimate of the built area for each solid and liquid waste facility is required to calculate the ecological footprint. Built area data is available through facilities' annual reports, municipal and regional government GIS data sources, and satellite mapping.

### Challenges and Opportunities

For facilities located within the municipal boundary, built area data may already be included in the overall municipal calculation and therefore should not be included to avoid duplication. Also, if there are many small private facilities used by the municipality, the impact of the built area of these facilities are small and may be of negligible impact., Thus if the data is not readily available they can be excluded from the inventory.

## Transportation

Evaluates the embodied energy of physical transportation infrastructure and vehicles, operating energy (fuel consumed by vehicles), and physical built area occupied by transportation infrastructure.

### *Embodied Materials and Energy, and Built Area [Transportation]*

### Methodology & Sources

Built area for transportation includes road length and paved right-of-way width. The quantity of roadway and the road material composition is used along with LCA data to evaluate the embodied energy and embodied materials of transportation infrastructure. Road lengths and material composition can be accessed from the municipality.

Road area and length can be obtained from GIS data sources. LCA data that identifies the embodied energy of paving materials is built into the Tool and is based on Dr. Moore's thesis research (2013).

### Challenges and Opportunities

Large portions of city surfaces are paved, yet surface materials are not consistently, uniformly, or currently listed and tracked across jurisdictions. Paved or impermeable surfaces represent a loss of important ecosystem services, represent a significant source of $CO_2$, and reduce the esthetic qualities of an area.

## *Operating Energy [Transportation]*

## 1. Road Transportation

### Methodology & Sources

#### Personal and Commercial vehicles

Data requirements include Vehicle Kilometers Traveled (VKT), number of vehicles per class, average mileage for each vehicle class, and emissions factors for each vehicle class.

In some locations, vehicle odometer readings are collected by vehicle insurance agencies or through air quality programs. From this information, energy consumption associated with vehicle travel can be derived directly from these readings. Where this information is not available the methodology for estimating fuel use is to multiply the total number of vehicles of each type by average VKT values and by relevant fuel consumption factors. Emissions factors are used to convert total fuel use to $tCO_2e$.

Additional data, obtained from origin-destination studies or travel diaries, is useful to evaluate what portion of travel is in-boundary vs. out of boundary. This assessment is useful to inform a GPC BASIC+ inventory, which allocates transportation emissions by scope.

#### Transit

If available, fuel consumption and emissions factors should be obtained from local transit authorities. Data may need to be pro-rated based on population if it is a regional service. In-boundary vs. out of boundary travel would need to be estimated using results from transportation surveys if one has been conducted with this level of detail.

#### Off-road vehicles

Some jurisdictions may have estimates for off-road vehicle fuel consumption as part of their regional air quality planning. For example, in the Vancouver region, this data is compiled for the Lower Fraser Valley Emissions Inventory.

### Sources

Origin-destination travel surveys conducted by local and regional governments can be used to allocate emissions between in and out of boundary sources.

Provincial or state air quality programs may track this data (e.g., in the past, BC had an AirCare program that used to track odometer readings). Alternatively, insurance brokers may be able to provide vehicle registration numbers by type of vehicle.

Regional transit authorities can provide fuel use and emissions intensity for their operations.

### Canadian Sources

In BC, average VKT data can be obtained from the crown insurance company of British Columbia (ICBC). This information is also reported in the Province of BC's CEEI. The Province of BC is currently in discussion with ICBC to determine methods to obtain VKT data province-wide.

In BC's lower mainland transit VKT and emissions data is collected by Translink.

### US Sources

Average fuel efficiency per vehicle type:

United States Department of Energy. (n.d.). Maps and Data. Retrieved from https://www.afdc.energy.gov/data/

U.S. Energy Information Administration, https://www.eia.gov/

### Challenges and Opportunities

Personal vehicle transportation estimates are often based on State-wide or Province-wide averages for vehicle travel, combined with vehicle registration data. This assumes local travel habits are comparable to state/province averages and does not help to inform local policy.

Estimates of off-road vehicle emissions can be challenging to derive as these vehicles are not registered for road tax, which is the simplest method of estimating personal vehicle fuel usage.

## 2. Marine Transportation

### Methodology & Sources

Marine transportation includes private vessels, passenger ferries, and cruise ship activities. Private vessel emissions require an estimate of the number of vessels registered and owned by residents and commercial entities for the municipality and the annual fuel use associated with these vessels. Emissions are then calculated using the total fuel use and the emissions factors for marine gasoline and diesel.

For commercial vessel consumption serving a regional population (such as ferries), totals will need to be apportioned to the community's residents. This can be apportioned based on estimates of the population served.

### Canadian Sources

Private vessels registered in a given port are available through the national boat registry run by Transport Canada.

### US Sources

In Washington State, fuel use by private vessels and private ferry services can be estimated using data from the *Marine Vessel Air Emissions study for BC and Washington Sate (2000-2001)*.

### Challenges and Opportunities:

Marine emissions from large, private companies, including cruise ships and private ferry services, are not readily accessible. These emissions sources could be a significant contributor towards a consumption-based emissions inventory as well as for a GPC BASIC+ inventory.

## 3. Air Travel

### Methodology

Air travel for a consumption-based emissions inventory requires estimates of the kilometers of flight movement, average plane occupancy, and emissions factors for: seat class; commuter, national, and international flight lengths; and different plane classes. The methodology adopted for the eF Tool pilot

communities is based on the approach described in *A Greenhouse Gas Emissions Inventory and Ecological Footprint Analysis of Metro Vancouver Residents' Air Travel* (Legg et al., 2013).

For municipalities with small local airports, use of estimates from the local airport would result in a significant underestimate of airplane travel. This is because residents are likely to travel to, or connect to larger international airports for much of their air travel. In these cases, it is best to derive per capita estimates from national averages.

If the community is in close proximity to an international airport it may be possible to obtain data from the airport authority. Information should be requested on:

- Total number of passenger flights, by plane type and by flight distance,
- Average load factor (for example, in Canada: Air Canada's 2015 load factor was 84% and WestJet's 2015 load factor was 80% (Statistics Canada, 2016).)
- Residential Scale Factor, which is an estimate of how much of the travel is attributable to local residents.

Flight distances are multiplied by the number of passengers by seat class per destination to estimate total passenger-kilometers by flight and seat classification.

Some locations also have marine air transportation. Information for this travel should be accessed by local providers, specifically: total flight movements; average flight length; plane type and, if available, percentage of travelers that are local residents. Fuel use can be calculated using the Airport Carbon and Emissions Reporting Tool, V.4.

#### Sources

Flight data, including destination and aircraft type can be obtained by local airport authorities.

Average fuel use per flight: *Airport Carbon and Emissions Reporting Tool, V.4*. (http://www.aci.aero/About-ACI/Priorities/Environment/ACERT)

Emission Factors: United Kingdom Department for Environment, Food & Rural Affairs (UK DEFRA)

#### US Sources

US per capita average yearly air miles traveled can be obtained from:

- Carboncounter.org
- Bureau of Transportation Statistics. (n.d.). Table 1-40: U.S. Passenger-Miles (Millions). See: https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_40.html

#### Challenges and Opportunities

Airport emissions are well tracked, but it can be challenging to properly determine what percentage of these emissions are attributable to local travellers. In addition, airports currently report emissions based on the first 3,000 feet of flight; however, for a CBEI, impacts from the entire flight should be included.

## Water

Evaluates the embodied energy, operating energy, and built area impacts of the water distribution and purification system relied on by urban environments.

### *Embodied Materials and Embodied Energy [Water]*

#### Methodology

Most water treatment materials are tracked and available from regional water utilities. The water treatment materials of interest for embodied energy calculations include the length and material of pipes, the number of pump stations used for distribution, water catchment infrastructure (including intakes, tunnels, and dams), and access roads used to access the watershed area. The total volume of water available through the reservoirs, as well as daily demand on those reservoirs, is important for material flow accounting.

The ecoCity Footprint Tool has built-in assumptions from previous research (Moore, 2013) that enable the calculation of the embodied energy of materials utilized in the water system infrastructure.

#### Sources

Municipal water authority data is comprehensive, but it is not always publicly accessible; thus, it must be requested from the responsible municipal or regional government.

### *Operating Energy [Water]*

#### Methodology

Data is collected on the natural gas, electricity, and transportation fuels used annually in operating municipal water utilities. This data may need to be attributed based on percentage of the serviced population.

#### Sources

This data is tracked and documented by public utilities and is sometimes presented in annual reports and online publications; otherwise, it must be requested from the responsible municipal or regional government.

### *Built Area [Water]*

#### Methodology

Area calculations for water infrastructure includes the roads (length and width), buildings and dams, and protected area and reservoir area. These are generally available directly through regional water utilities.

#### Sources

Water utilities can provide most of the needed data.

## IPPU and AFOLU

Industrial Products and Pollutants (IPPU) and Agricultural, Forest, and other Commercial land uses (AFOLU) are important dimensions of a GPC compliant BASIC+ inventory. The ecological footprint and CBEI output however does not include these sources, as energy use and emissions from these sectors are already captured in the evaluation of consumables and waste.

### *Agriculture Emissions*

The majority of agriculture emissions are from soil management (fertilizer), enteric fermentation, and manure management and are only required in a GPC BASIC+ inventory. If the community is pursuing this level of reporting, these emissions can be estimated using Agriculture Canada's Holos Model. This model is a whole-farm model and software program that estimates greenhouse gas (GHG) emissions based on information entered for individual farms or for a region.

Agriculture operating emissions (such as diesel, natural gas and electricity used for machinery) is required for a GPC BASIC inventory. However, operating emissions typically account for only 7% of farm emissions[7] and therefore are not well captured in the Holos model. Also, agriculture operating emissions for natural gas and electricity are likely already accounted for in commercial emissions data accessed from utilities.

As noted above, farm based emissions would not be included in a CBEI or EF because this would double count emissions that are already captured in the food footprint/CBEI.

## Sources

Agriculture and Agri-Food Canada. (n.d.). Holos Software Program 3.0. Retrieved July 2017 from http://www.agr.gc.ca/eng/science-and-innovation/results-of-agricultural-research/holos-software-program/?id=1349181297838

Statistics Canada. (n.d.). CANSIM, Census of Agriculture. Retrieved from: http://www5.statcan.gc.ca/cansim/a03?lang=eng&pattern=004-0200..004-0242&p2=31

[7] Iowa State University. (n.d.). Global warming – agriculture's impact on greenhouse gas emissions. Retrieved from: https://www.extension.iastate.edu/agdm/articles/others/takapr08.html

# APPENDIX B: EXPENDITURES

### Table 9: Summary of Budget and Expenditures

| Key Deliverables | USDN Budget Spent/ Remaining (US Dollars): |
|---|---|
| **1 Tool Enhancement, Process Refinement, Scoping for Scaled Adoption**<br>1.1 Enhance functionality of the Tool for:<br>1.1.a GPC compliance<br>1.1.b Policy analysis / scenario building<br>1.2 Refine process for Cities using the Tool, by:<br>1.2.a Pre-populating Tool with data<br>1.2.b User guidance documentation<br>1.3 Test with pilot communities | **USDN Innovation Fund contribution: $75,953**<br>In-kind contributions from pilots: $ 20,576<br>**Total cost: $96,529** |
| **2 Issues and Opportunities Analysis for Scaled Adoption**<br>2.1 Assess replicability/adaptability to other jurisdictions, through:<br>2.1.a Integrating results of Iowa City Pilot<br>2.1.b Engagement of observing cities<br>2.2 Early stage software scoping to define user requirements and functionality<br>2.3 Early stage implementation /feasibility scoping | **USDN Innovation Fund contribution: $27,731**<br>In-kind contributions from pilots: $ 0<br>**Total cost: $27,731** |
| **3 USDN reporting (Impact report, and quarterly updates, etc.) and project management** | **USDN Innovation Fund contribution: $9,154**<br>In-kind contributions from pilots $ 0<br>**Total cost: $9,154** |
| TOTAL COST: | **$133,414** |
| INKIND: | $20,576 |
| **TOTAL USDN Innovation Fund Contributions:** | **$112,838** |

## Funds Leveraged

BCIT and Cora Hallsworth Consulting have accessed additional support to continue this work:

- Vancity Credit Union has provided some funds for further Tool development and stakeholder engagement.
- They will be working with One Earth and Bioregional on a stakeholder engagement initiative in one or more of the pilot communities.
- Additional funding is also being sought from other sources, including the Federation of Canadian Municipalities and other philanthropic organizations.