Estimating consumption-based greenhouse gas emissions at the city scale

A guide for local governments

SEI report
February 2019

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Cover photo: PET bottle caps © Graiki / Getty

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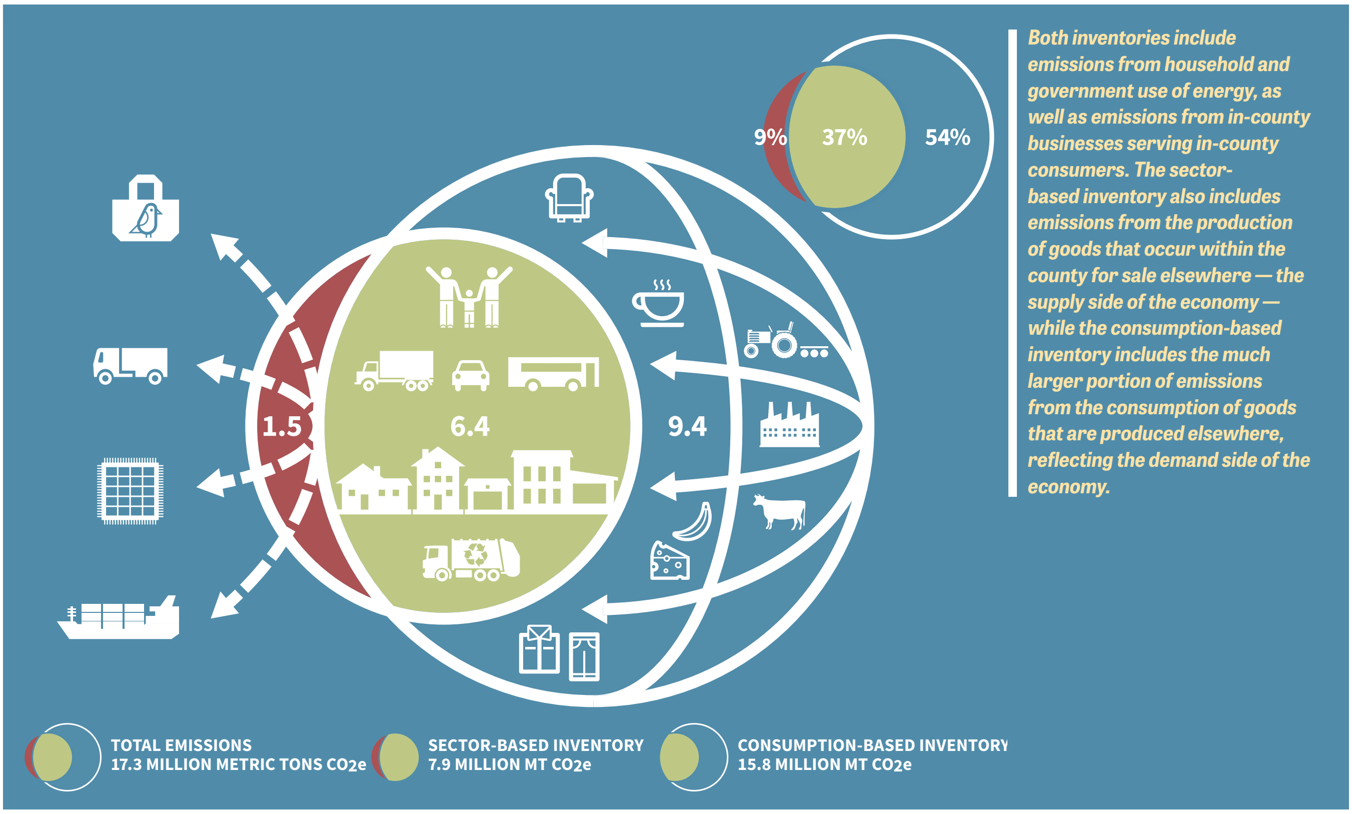
Acknowledgements

The authors thank Babe O’Sullivan and the Carbon Neutral Cities Alliance for their support in developing this guidebook.

Introduction

Numerous cities around the world have been exploring their carbon footprint using consumption-based emissions inventories (CBEIs) (Millward-Hopkins et al. 2017; Erickson et al. 2012; BSI 2013; Jones and Kammen 2015). These inventories differ from the territorial (or "sector-based") approach typically used to calculate urban greenhouse gas (GHG) emissions, because they include emissions generated outside city borders to produce goods and services for urban residents (Figure 1). These upstream emissions can be significant, and they are often commensurate with the amount of emissions created within the city itself (Pichler et al. 2017; C40 Cities 2018). A CBEI can lead to insights about where local consumption gives rise to emissions outside a city's borders, and suggest additional opportunities for reducing emissions.

Figure 1. Comparison of the emissions included in a consumption-based inventory (bigger circle) compared to a standard (territorial or "sector-based") emissions inventory



Source: Portland, Oregon's Climate Action Plan

This report provides an overview of what CBEIs are and how they can be used (i.e., the kinds of insights they can generate, as well as their limitations). It also describes the primary methods for constructing a CBEI, including "rough approximation" methods that can be used where more intensive methods are impractical.

In four sections, this memo:

1. Briefly summarizes the basics of a CBEI;
2. Reviews the key insights generated from CBEIs conducted in cities to date;
3. Describes the tools and approaches a city government could use for assembling a CBEI; and
4. Outlines considerations in choosing among different tools and approaches.

An overarching consideration is whether and how the methods used to develop CBEIs inform the prioritization and development of local climate actions, including policies and other interventions that drive changes in consumer behaviour.

The basics of consumption-based greenhouse gas emissions

A consumption-based emissions inventory (CBEI) is a calculation of all of the greenhouse gas emissions associated with the production, transportation, use and disposal of products and services consumed by a particular community or entity in a given time period (typically a year). In this way, a CBEI can create a comprehensive emissions "footprint" of a community.

Cities around the world have been exploring their carbon footprint using consumption-based emissions inventories. This report provides an overview of what CBEIs are and how they can be used.

At the most basic level, the calculation of a CBEI entails two main inputs: a measure of what is consumed, multiplied by a measure of how many GHG emissions are associated with each unit of consumption. For example, if a community consumes one million tons of cement each year, and producing and transporting each ton of cement released 1 ton of CO_2, the community's CBEI would include 1 million tons CO_2 associated with cement consumption, regardless of whether that cement was produced inside or outside the community's jurisdictional boundaries. The same basic approach would apply for a unit of any other product or service, whether that be broccoli (there is about 1 ton CO_2 per ton of broccoli), beef (more like 20 tons CO_2 per ton of beef), or ballet tickets.

A full CBEI would, in principle, estimate the emissions for all of the products and services consumed in a city (or by a city's residents). However, this can prove challenging in practice, because calculating consumption-related emissions can be highly complex. Communities consume thousands of different types of products and services, and the emissions associated with each of these is affected by many decisions made by different actors throughout their life cycles (e.g. production, transportation, distribution, use and disposal). It would take a substantial amount of effort to track and understand the emissions associated with every unit of consumption to create an accurate CBEI – and any estimate is likely to become obsolete as production processes and supply chains change over time (sometimes month-to-month or week-to-week).

Fortunately, cities can now produce relatively simple estimates of CBEIs, thanks to recent innovations in the tools available. Furthermore, cities have completed enough CBEIs (including as part of a recent study by C40 Cities) to enable insights about what kinds of policy-relevant information can be distilled, even where methods are less precise or have limited resolution in certain consumption categories (C40 Cities 2018).

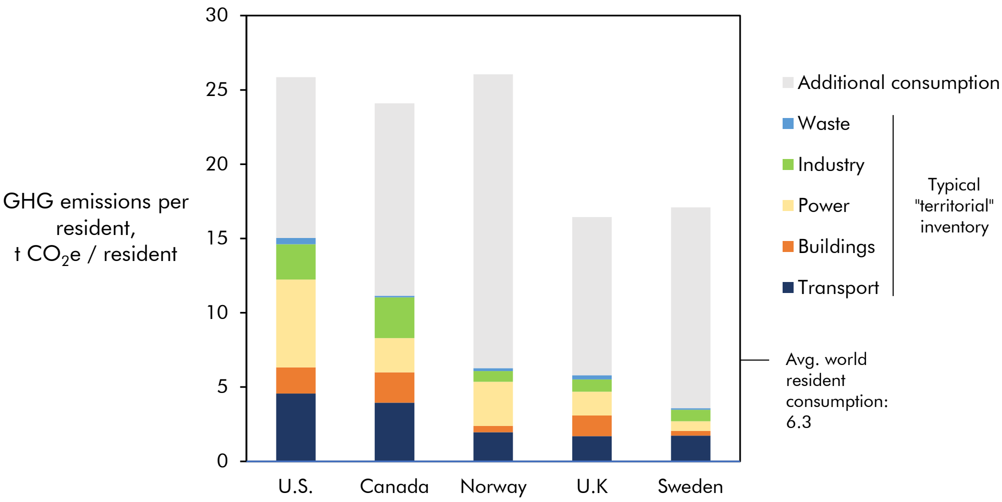
The sections that follow provide some of these key insights, as well as further information for policy-makers interested in conducting CBEIs for their own communities.

Key CBEI insights

One of the first insights of a CBEI for most cities (at least those cities without substantial heavy industry within their borders) is that a full emissions footprint can be substantially higher than a typical, territorial greenhouse gas emissions inventory. This is because the emissions associated with goods consumed in cities are often released outside the city during production and transportation, such as in the course of mining or growing raw materials, processing and manufacturing these materials into products, and packaging and delivering them to consumers.

For example, Figure 2 shows that a CBEI for cities in North America (U.S. and Canada) is typically about twice as high as "territorial" emissions, or emissions that occur primarily within a city's geographic boundaries; such emissions are associated with local transportation, buildings, power, industry (if any), and waste. The ratio of consumption-based to territorial emissions in European cities can be even larger, as territorial emissions in many European cities are even smaller than North American cities (on a per-person basis),

Figure 2. Estimated typical consumption-based GHG emissions inventories for cities in selected countries active in the Carbon Neutral Cities Alliance



Source: SEI estimates. Estimates of a typical city/town inventory based on each country's national GHG emissions inventory, as submitted to the United Nations Framework Convention on Climate Change (UNFCCC),[1] combined with country population data from the World Bank's Development Indicators. Emissions associated with consumption based on the Eora global multiregional input-output database (Lenzen et al. 2013). Average world resident consumption based on the EDGAR dataset maintained by the European Commission.

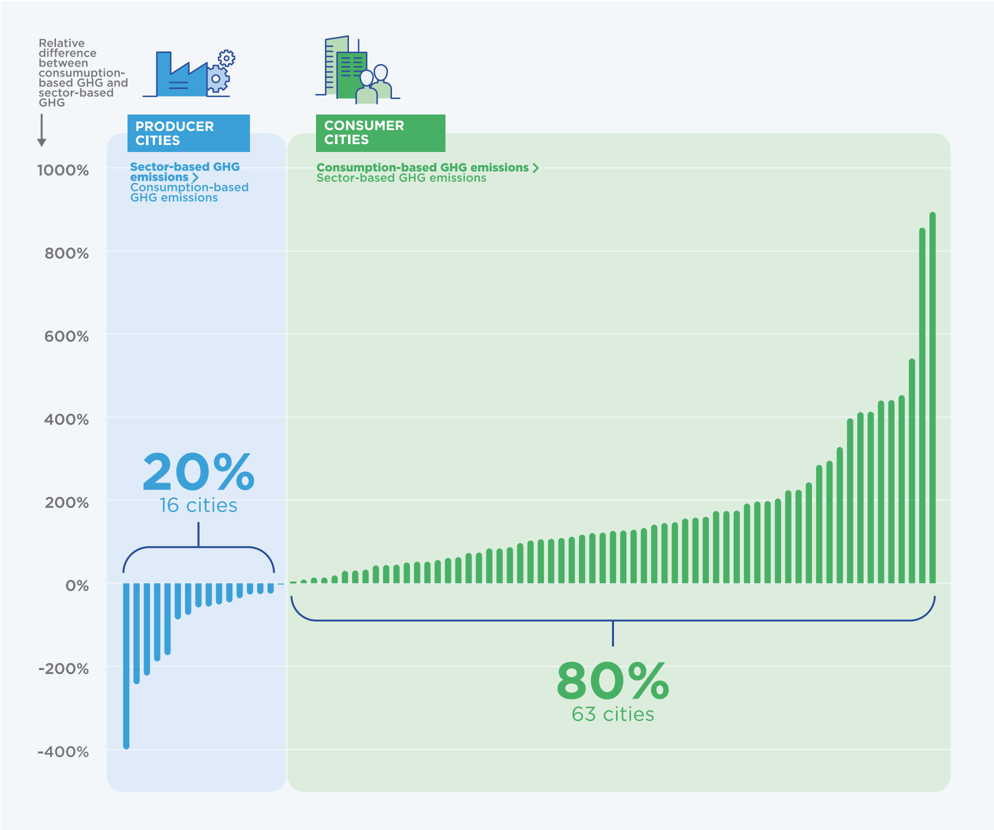
C40 Cities' recent study of consumption-based emissions applied a common methodology to 79 cities around the world and found similar results. For the sample of cities examined, CBEIs were 60% higher on average than territorial GHG inventories (C40 Cities 2018). This average, however, masks considerable variation among individual cities. For some, mostly in Europe and North America, the ratio is much higher; for others, primarily in Asia and Africa, consumption-related emissions are lower than territorial emissions. Figure 3 shows the relative distribution of C40 cities. Cities with higher territorial emissions are effectively net "exporters" of emissions, either because they produce more than they consume, or their production is more GHG-intensive than their consumption (or both).

The second key insight from calculating CBEIs is that for cities in relatively wealthy, industrialized countries, the full footprint of residents' consumption is — unsurprisingly — far higher than the global average. As shown in Figure 2, consumption-based emissions associated with residents in the U.S., Canada, Norway, UK, and Sweden are all at least twice as high — and up to four times as high — as the global average. This implies that industrialized countries should take more responsibility for mitigating global climate change, as contributions to GHG emissions are not distributed evenly.

A third main finding is that certain types of consumption consistently dominate a CBEI. Figure 4 shows that emissions from car travel, building heating, and power consumption each average at least 2 tons CO_2e per person in the U.S. But this is already well known from the standard, territorial GHG emissions inventories of cities. The unique contribution of a CBEI perspective is the expanded emphasis placed on goods, food, services, and air travel, each of which also is generally responsible for another 2 tons or more of CO_2e per person. (Depending on how new building and infrastructure construction are categorized, these too may contribute another 2 tons or more per person).

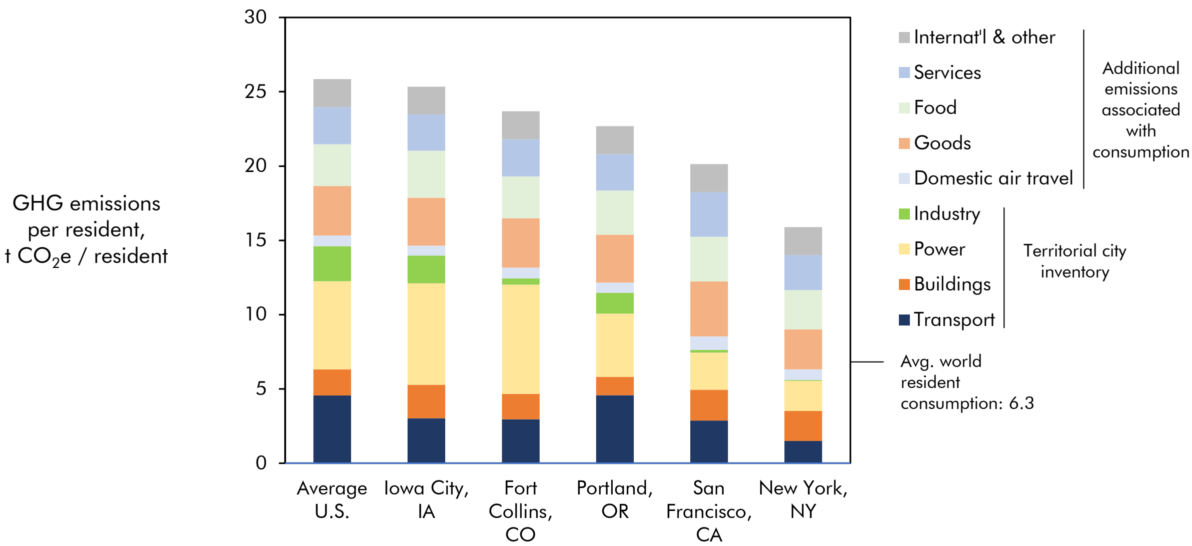
1 To approximate the emissions associated with the GHG emissions inventory or a typical city or town, we compiled the emissions from the national inventories that are mostly commonly included in city inventories and that are more strongly associated with urban economies. These included the following emissions inventory categories, which are readily reported in national inventories following IPCC accounting protocols (IPCC 2006): 1A1 (Power), 1A2 (Manufacturing), 1A3b (Road Transport), 1A4 (Buildings), and 5A (Waste).

Figure 3. Variation in the ratio of CBEIs to territorial GHG inventories in 79 cities



Source: C40 Cities (2018)

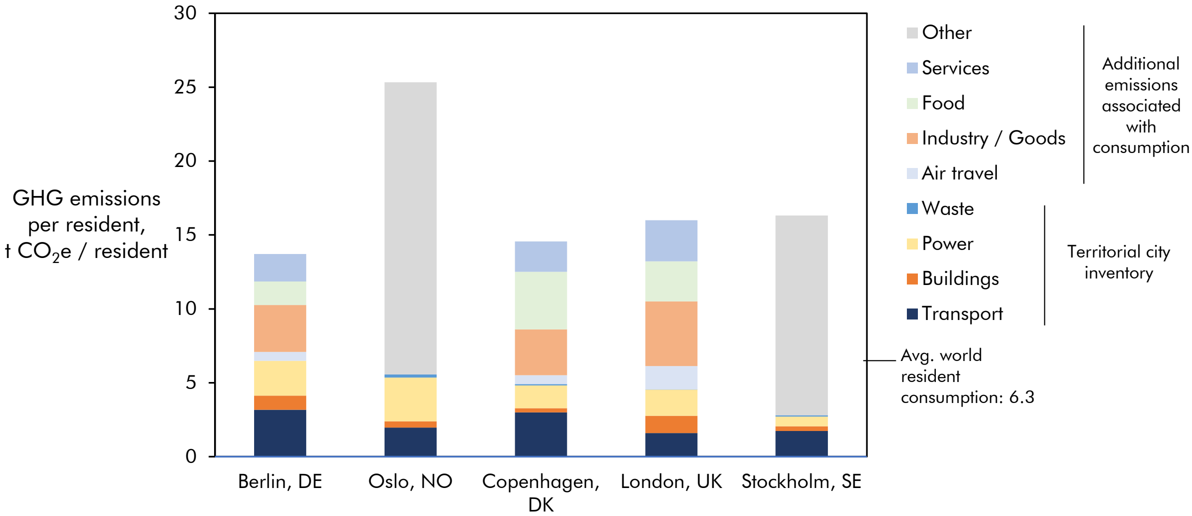
Figure 4. Estimated consumption-based GHG emissions inventories for selected U.S. cities



Source: SEI estimates based on data sources as follows. Estimates of a typical city/town inventory drawn from U.S. Department of Energy National Renewable Energy Laboratory (NREL)'s City Energy Profile tool, supplemented with estimates of additional emissions associated with consumption from coolclimate.org, and combined with population estimates from the U.S. Census Bureau's American Community Survey (Jones and Kammen 2014). Some double counting may occur between territorial and consumption-based categories.

These findings hold true for cities in other high-income countries, as well. For example, a detailed study of subnational regions in the European Union found that consumption-based emissions for food, goods, and services in Berlin, Copenhagen, and London also amounted to at least 2 tons CO_2e per person in each of those categories (Figure 5) (Ivanova et al. 2017).

Figure 5. Estimated consumption-based GHG emissions inventories for selected European cities



Source: SEI estimates. Estimates for Berlin, Copenhagen, and London are derived from the EXIOBASE database (Ivanova et al. 2017). Estimates for Oslo and Stockholm inherited from Figure 2.

The broad categorization of emissions shown in Figure 4 provides useful insights into the major sources of consumption-based emissions for most cities. However, these categories also paint an incomplete picture of city emissions patterns. Within each category, some types of goods are more emissions-intensive than others (e.g. meat production has a larger emissions footprint than other types of food) (Ripple et al. 2014). Such categorization also treats all residents' consumption as equal, whereas in reality, consumption levels tend to vary widely within cities (e.g. research shows that high-income households typically have a larger consumption footprint than lower-income households) (Jones and Kammen 2011; Eisenstein 2017; Wiedenhofer et al. 2017). In addition, the majority of emissions associated with different goods and services can occur at different life-cycle phases; for example, most emissions from food are associated with production, whereas for appliances the majority of emissions result from use. Such distinctions can be important when considering and prioritizing policies and other interventions.

More detailed approaches to creating a CBEI can help uncover some of the nuances in urban consumption patterns, which can be helpful when translating the CBEI into policy actions. In the following section, we describe common approaches to estimating a CBEI, to help city planners understand the strengths, limitations, and types of insights provided when following different CBEI estimation approaches.

Developing a CBEI for your city

All approaches to developing a CBEI follow the same basic methodology outlined above:

1. Estimate how much of each good or service is consumed within city boundaries (or by a city's residents, regardless of boundaries)

2. Multiply that by how many GHG emissions are released in the course of producing, transporting, consuming, and (in some cases) disposing of each unit of good or service.

Where approaches differ is in how they define and estimate these two basic quantities. Broadly speaking, consumption can be estimated in one of three distinct ways:

1. Using spending data (e.g., dollars spent on a good or service);

2. Using physical data, based on either:

    - Actual units of a good or service consumed (e.g., tons of cement, pounds of broccoli, number of attendees at ballet performances, etc.), measured using consumer surveys or other data; or
    - The mass or quantity of a good that is disposed (e.g. as refuse in a landfill), measured using waste audits.

The life-cycle GHG emissions associated with a particular good or service can also be estimated in different ways, depending in part on how consumption is quantified.

Using spending data and input-output models

Cities typically choose to use spending data to estimate consumption, in conjunction with using an "input-output" model to estimate GHG emissions. Input-output models are used in economic analysis to map — for a particular region (e.g., national or subnational areas) — the types and relative amounts of intermediate goods and services ("inputs") needed to produce other goods and services that are ultimately consumed ("outputs"). In essence, the models consist of very large tables showing the interdependencies of hundreds of categories of goods and services. Data are usually denominated in expenditures and revenues for different economic sectors, meaning that consumption is generally expressed in terms of consumer spending. By associating GHG emission factors with a range of different inputs, the models can be used to estimate total GHG emissions per dollar spent on final goods and services, and can also help identify the most emissions-intensive phases of a good's or service's life cycle (e.g. production, transportation, or use).[2]

A key advantage of using input-output models is that they can generate consumption-based GHG emissions estimates for a full range of goods and services consumed within a community, making them particularly suitable for constructing a full CBEI. A number of input-output models exist that can be used to create CBEIs. Some common examples are shown in Table 1.

Table 1. Examples of common input-output models used in developing CBEIs

United States	Global
• EIO-LCA • IMPLAN • USEEIO (maintained by U.S. EPA)	• EXIOBASE • WIOD • EORA • GTAP GMRIO

These input-output models have been used as the basis for CBEIs in a number of cities (such as Portland, Seattle, San Francisco, and London) (Erickson and Tempest 2014; BSI 2014). For its study, C40 Cities used the global multi-region input-output (GMRIO) model — from the Global Trade Analysis Project (GTAP) — to consistently calibrate city expenditure data and estimate emissions for multiple cities across different countries (C40 Cities 2018). However, these models tend to be technically complex, so their use is typically undertaken by researchers or consultants on behalf of cities, rather than by internal city staff.[3]

2 Input-output models supplemented with GHG emission and other environmental indicator data are often referred to as "environmentally extended input-output models" (EEIOs)

3 That said, the very simplified approach to generating CBEI estimates in Figures 2 through 4, as drawn from pre-existing studies using such models, could be applied with little specialized knowledge and still yield directional insights.

Using physical data and process-based "life cycle" analyses

Different methods for estimating GHG emissions are usually required when consumption is estimated using data on actual quantities of goods and services consumed or disposed (options 2a and 2b, above). This is because it can be difficult to match specific (often local) consumption data to the amounts and categories of expenditures used in an input-output model. The most common approach in these cases is to use process-based "life-cycle" analysis (LCA) to estimate the full emissions associated with the production, use and, in some cases, the disposal of the good or service (Greenhouse Gas Protocol 2011). These analyses must be tailored to the specific good or service in question, making them cumbersome for constructing a full CBEI consisting of many goods and services. The use of actual consumption (or disposal) data combined with LCA can sometimes yield a more accurate picture of consumption-based emissions, as well as insight into alternative production processes, which in turn may be useful for designing policies tailored to particular types of consumption.

Table 2 provides a summary of possible data sources, GHG estimation methods, benefits, challenges, and the level of effort associated with each method of estimating consumption levels.

Table 2. Summary of alternate methods of estimating consumption emissions for a CBEI

	Using spending data and input- output models	Using physical data and process-based life-cycle analysis	
Data sources	• Consumer spending data (national, regional, or local)	• Consumption surveys • Utility billing data	• Waste audit data
Benefits	• Can use consumer spending data that are often widely available from national statistical offices • Partly for this reason, generally allows for the generation of a full CBEI • Consistent data collection by national agencies means cities can compare their consumption patterns relative to other cities • "Input-output" models can also be used to identify the most emissions-intensive phases of a product's lifecycle	• Allows for the most specific and (in principle) measurable consumption levels • Can facilitate evaluation of consumption alternatives, since it is easier (in principle) to evaluate alternative production methods for a physical item than for an amount of spending	• Many cities already have estimates of materials disposed through waste composition studies • More responsive to local shifts in behaviour
Challenges	• Requires a complicated "input-output" model of the country's economy (and ideally the world's) to attribute emissions to different kinds of goods and services • Spending data are almost always downscaled, not actually tracked at the local level (or, if local data exist, they are difficult to match to the spending categories defined in I/O models)	• Provides an incomplete picture of a city's CBEI, since not much data is available on the total flow of physical goods into a city (data tends to be available only for a few major commodities) • Likely untenable for estimating the entire CBEI of a city, since requires a separate (usually complex) life-cycle analysis of the emissions associated with each physical good	• Provides an incomplete picture, since many, if not most, items and services consumed are not thrown away • Lack of standardization in waste auditing makes it challenging to compare consumption between jurisdictions
Level of effort	• Can be as little as one day using existing analyses. Custom analyses require 6+ months to develop	• Can be expedient for materials where both consumption levels and emissions intensity is known • But where emissions intensity not known, can take several months per material	• Can be expedient in areas where waste consumption data are already available and emissions-intensity can be estimated

Limitations, considerations, and a hybrid approach

One potential drawback to using input-output models to estimate consumption-based emissions for a community is that they often lack resolution at the city level. First, the input-output models themselves are often defined at a much larger scale (e.g. national), meaning that they may not capture local or regional variations in how goods and services are produced (and associated differences in GHG emissions). Second, consumer spending data consistent with these models are often only available at the same or similar scale, meaning they will not capture local variations in consumer spending behaviour. Various methods can be used to "downscale" spending data to local levels, but these can be imprecise, and GHG emissions estimates will still generally reflect production patterns on the scale at which an input-output model was constructed.

Depending on the methods used, some of the same "scaling" issues can arise when using a life-cycle analysis (LCA) to estimate GHG emissions. For example, a process-based LCA can lack resolution specific to a city or region, particularly if a good or service used in a city doesn't conform to the "typical" production patterns assumed in calculating life-cycle emissions. In general, however, these approaches are better at achieving locally tailored consumption and emissions estimates.

One compromise, adopted in a number of cities, is to pursue a hybrid approach that combines different methods to produce a comprehensive CBEI with local resolution for some consumption categories. For example, the ecoCity Footprint Tool — applied to Vancouver, B.C. and other Canadian cities (as well as at least one US city, Iowa City) — uses local activity (utility bills, transportation surveys) and waste composition data when available. But it supplements this with national data or archetypal types of consumption to fill gaps in local data (Moore et al. 2013; Moore and Hallsworth 2017). Likewise, Gothenburg, Sweden estimates household consumption by combining activity data from national agencies (such as odometer readings from national car registries) with locally-collected survey data from residents on their behaviour and technology choices (Bolin et al. 2013; Nässén et al. 2015; City of Gothenburg 2014). C40 Cities used city-specific industrial output data to scale national emission factors within the GMRIO model, and estimated household energy and transportation emissions using city-specific usage data (C40 Cities 2018). In all three cases, a hybrid of both national statistics and local data are used to create a full picture of consumption patterns.

All of these methods can be quite complex and time consuming for individual cities. Fortunately, there are resources available that cities can use to approximate consumption-based emissions and generate rough — but still useful — CBEIs. For example, in the United States, consumption-based emissions estimates for cities and zip codes are readily available through the "CoolClimate" calculator (www.coolclimate.org). This tool estimates locally specific patterns of consumer spending, transportation, and household energy use (using "downscaled" national data) and combines this with national input-output analysis and fuel emissions factors from the EPA and other sources to estimate GHG emissions. In some cases, regional studies of consumption-based emissions may offer a good approximation of emissions within a particular community, especially where regional and community boundaries are largely congruent. Regional CBEIs have been calculated for the European Union (Ivanova et al. 2017), and prefecture-level estimates exist in Japan (Hasegawa et al. 2015). In addition, consumption-based emissions analyses exist for many cities worldwide, and these could be used as the basis for constructing CBEIs in other communities (see Wiedmann et al. (2016) for a list of cities where consumption-related emissions have been calculated. This list continues to grow).

Even simpler methods are also possible, such as using existing estimates of national household consumption emissions (Milito and Gagnon 2008). A city could also re-organize a national territorial GHG inventory into categories that roughly approximate types of consumption (such as re-categorizing "industry" emissions as emissions from "goods") and assume that national patterns apply to a given city's residents (U.S. EPA 2009). Utilizing national inventories is unlikely to provide as much accuracy as the methods previously discussed;[4] however, this simpler approach can be a useful way to get a sense of the scale of the impacts (much like in Figure 2 and Figure 4 above) and, in many cases, may provide enough of a basis for initial policy development.

Table 3 provides some illustrative examples of the different strategies cities have used to construct CBEIs. Some cities have relied on adapting pre-existing analyses to local conditions (such as Eugene and Minneapolis), while others have worked with researchers to conduct more detailed analyses (such as London, Vancouver, and Gothenburg). These examples also differ in the types of data and estimation approaches used (e.g. local data, national data, or a hybrid of both). There is no singular method that is the "best" approach for conducting a city-scale CBEI. In the following section, we outline some of the factors that cities may want to consider when deciding which approach to follow.

4 For example, a re-categorized national territorial GHG inventory can fail to capture emissions associated with goods or services that arise in multiple inventory sectors, such as the many sources of emissions associated with food that occur not on farms but instead at food processing facilities (industry), during transport (on trucks or even airplanes), in buildings (e.g. grocery stores), and in the waste stream (methane at landfills). Simple inventory re-organization efforts can also miss emissions associated with international imports and exports.

Table 3. Illustrative examples of CBEI approaches taken by cities

City	Strategy for estimating consumption-based emissions	Approach and data used
Eugene, OR, US[5]	**Adapt existing estimates**: Eugene used a downscaled consumption and emissions model originally created for the State of Oregon, and adjusted this with local data where available.	**Data**: Spending and physical units **Approach**: The Oregon CBEI estimates emissions associated with goods and services using a regionally calibrated input-output analysis. Eugene estimates for buildings and transport were refined using local petroleum, natural gas, and electricity use.
Minneapolis, MN, US[6]	**Adapt existing estimates**: Minneapolis generated emissions estimates from the "CoolClimate" tool, and then adjusted with local utility data.	**Data**: Spending and physical units **Approach**: The CoolClimate tool uses data from U.S. transportation and household consumption surveys to estimate local demand for goods and services. Minneapolis estimates were refined using local natural gas and electricity use.
Gothenburg, Sweden[7]	**Work with research partners**: Researchers estimated the carbon footprints of typical low, average, and high-income residents. Gothenburg used these estimates to set targets per resident for consumption-based emissions reduction.	**Data**: Physical units **Approach**: Household consumption patterns were modelled using data collected in a detailed survey of residents behaviour and technology choices, supplemented with data from utilities and national registries (e.g. car odometer readings and building energy efficiency registers).
London, UK[8]	**Work with research partners**: London's CBEI was estimated by researchers as a case study for the development of a new British Standard for specifying city-level emissions (PAS 2070) (BSI 2013).	**Data**: Spending **Approach**: London's CBEI estimates consumption-based emissions with an input-output analysis using national household and government spending data.
Vancouver, BC, Canada[9]	**Work with research partners**: Researchers estimated the City of Vancouver's "ecological footprint". The emissions component of this footprint will be used to generate the city's CBEI.	**Data**: Physical units and waste audits **Approach**: Vancouver's footprint draws from local resource use data when available (e.g. utility data, transportation surveys, building area, waste produced). When unavailable, national proxies are used (e.g. food consumption).
San Francisco, CA, US	**Work with research partners**: San Francisco's most recent CBEI (2015) was developed by the researchers who developed the "CoolClimate" tool, providing high-resolution insights into consumption patterns by neighbourhood.	**Data**: Spending and physical units **Approach**: Relied on combination of local consumption data, state-wide consumer surveys, and national econometric data. Identified variations in consumption by location, income, and household size.

Choosing a CBEI estimation approach: key considerations

The appropriate CBEI estimation approach will differ in each city, based on the resources and data available, and on the ways in which the city hopes to use the data. Here we outline some of the questions city planners might ask, and factors that a city might consider, before developing a CBEI.

Purpose and audience

First, it is important to ask *why* the city needs to create a CBEI and *who* the audience is, as these will help guide the choice of data and approach.

5 (Stanton et al. 2011; Allaway 2015; Good Company 2017)
6 (Jones and Kammen 2014; City of Minneapolis 2012)
7 (Bolin et al. 2013; Nässén et al. 2015; City of Gothenburg 2014)
8 (Greater London Authority 2014; BSI 2014)
9 (Moore et al. 2013; Moore and Hallsworth 2017)

Educating residents

If a city simply needs a breakdown of major consumption categories to educate residents about their emissions footprint, or to develop a rough basis for prioritizing actions, then relying on pre-existing analyses, or on national or regional consumption emissions may be sufficient. For example, Minneapolis and Lake Oswego both used data from the CoolClimate tool to estimate emissions from household consumption (City of Minneapolis 2012; Good Company 2012). This information enabled them to inform residents about their consumption impact, and “discover the highest-leverage areas for change and plan both short- and long-term GHG reductions” (Good Company 2012).

City comparisons

Alternatively, if the goal is to compare a city to its peers, then analysts should prioritize the use of a more standardized approach (e.g. using multi-regional data that is comparable across cities, and similar categorization of consumption). This was the approach used by C40 Cities in its recent study, which developed CBEIs for multiple cities following the PAS 2070 standard (BSI 2013; C40 Cities 2018). Another recent study applied an alternative standardized approach to assess CBEIs in Berlin, Delhi, Mexico City, and New York (Pichler et al. 2017).

Local policy development

For cities that want to use CBEIs as a basis for informing local policy design and evaluation, or for undertaking programs and projects aimed at reducing a city’s carbon footprint, more detailed and tailored approaches may be necessary. For example, if the aim is to track consumption of different goods and services for the purposes of evaluating whether citizens are changing consumption behaviour, or whether a particular policy intervention has worked, then locally sourced data on goods consumed or waste generated is necessary, because downscaled national data cannot be used for this purpose. The City of Vancouver’s use of waste data to estimate consumption, for instance, means that consumption levels can more easily be tracked over time by watching whether municipal waste levels rise or fall (Moore et al. 2013; Moore and Hallsworth 2017). However, one of the drawbacks of approaches that estimate consumption by counting waste is that it may miss important areas of consumption (e.g. many kinds of services, like air travel or entertainment), thus providing an incomplete emissions picture. Furthermore, it may lead to waste reduction policies and targets being prioritized over other policy options, in part because consumption is viewed primarily through a waste lens.

A hybrid approach may be a good compromise, to balance the need for a comprehensive inventory against the need for responsive data that informs policy design and evaluation. A city could use data from an input-output model to get a comprehensive picture of consumption emissions, as well as insight into the most emissions-intensive life-cycle phases of products and services (allowing more tailored policy interventions). This could then be coupled with local data for select indicators to enable more detailed tracking of consumption patterns and lifecycle emissions (e.g. concrete can be a used as a proxy for construction activity, or meat consumption as a key source of food emissions) (Sinclair 2013). Local data and LCA analyses can be used to inform policies specific to certain goods and services, and may also allow better monitoring and assessment of the performance of policies over time (especially since expenditure data and input-output modelling results may be infrequently updated).

Data, resources, and technical capacity

A second consideration is the *availability of data, resources, and technical capacity* to undertake an emissions inventory. A city should assess whether there are pre-existing analyses available for their region, and what data and models exist (regionally and nationally) that can be used to construct a CBEI. Staff availability and technical capacity to create or update a CBEI should also be factored into decision-making. Cities should be wary of spending excessive time and resources trying to get precise consumption estimates at the expense of implementing policies that actually reduce consumption emissions — especially in cases where pre-existing analyses provide a good approximation of local consumption. If resources are limited, it may be prudent to use a relatively simple inventory approach to identify key sources of emissions, and then select a few key indicators to track consumption patterns.

Ultimately, all cities who create a CBEI do so because they want to reduce consumption emissions. The CBEI should be seen as a tool to support emissions reduction, not just a standalone accounting exercise.

Developing a policy relevant CBEI

Finally, a key lesson from cities who have developed their own CBEIs is that thinking about *policy relevance* in the development stage is critical for ensuring the CBEI is useful for policy and planning purposes. For this purpose, two key questions to ask are:

What categorization of emissions will be most useful for identifying and developing policy actions?

Different inventories, developed using different methods, will report emissions using different groupings of consumption. While there is not a single prescribed approach for categorizing CBEIs, the following general guidance may be helpful to consider:

- **Travel or transportation**: break into different modes, such as air travel, personal cars and trucks, and public transportation.
- **Housing or home**: distinguish between construction, home appliances, (non-energy) utilities, and energy consumption for heating and cooling.
- **Goods**: break up into defined categories, such as clothing, furniture, and electronics.
- **Services**: try to divide into distinct categories, such as transportation services (e.g., car rentals, air travel, and public transit); home and vehicle maintenance; communications; health care; banking; and entertainment.
- **Food and beverages**: separate out food and beverages with high emissions (particularly meat and dairy), and restaurant food consumption from other food purchases.

These are only general guidelines, and data limitations may prevent disaggregation of all of these categories. Overall, the goal should be to categorize the CBEI into groupings that provide insights needed to develop appropriate policy solutions.

Whose consumption should be targeted?

The majority of consumption in most cities will be from households, and households will usually be the primary target of consumption-based emissions policies. However, other key sources of consumption include local government itself, and local businesses and industry. There are good reasons to treat these emissions separately. Government purchasing decisions can have an outsize effect, in terms of supporting markets for sustainable goods and services, so tackling this as a distinct category is important. Likewise, business and industry have unique opportunities to reshape production and consumption. Separating out these other categories of “consumers” in a CBEI can help identify additional targets for policy action.

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